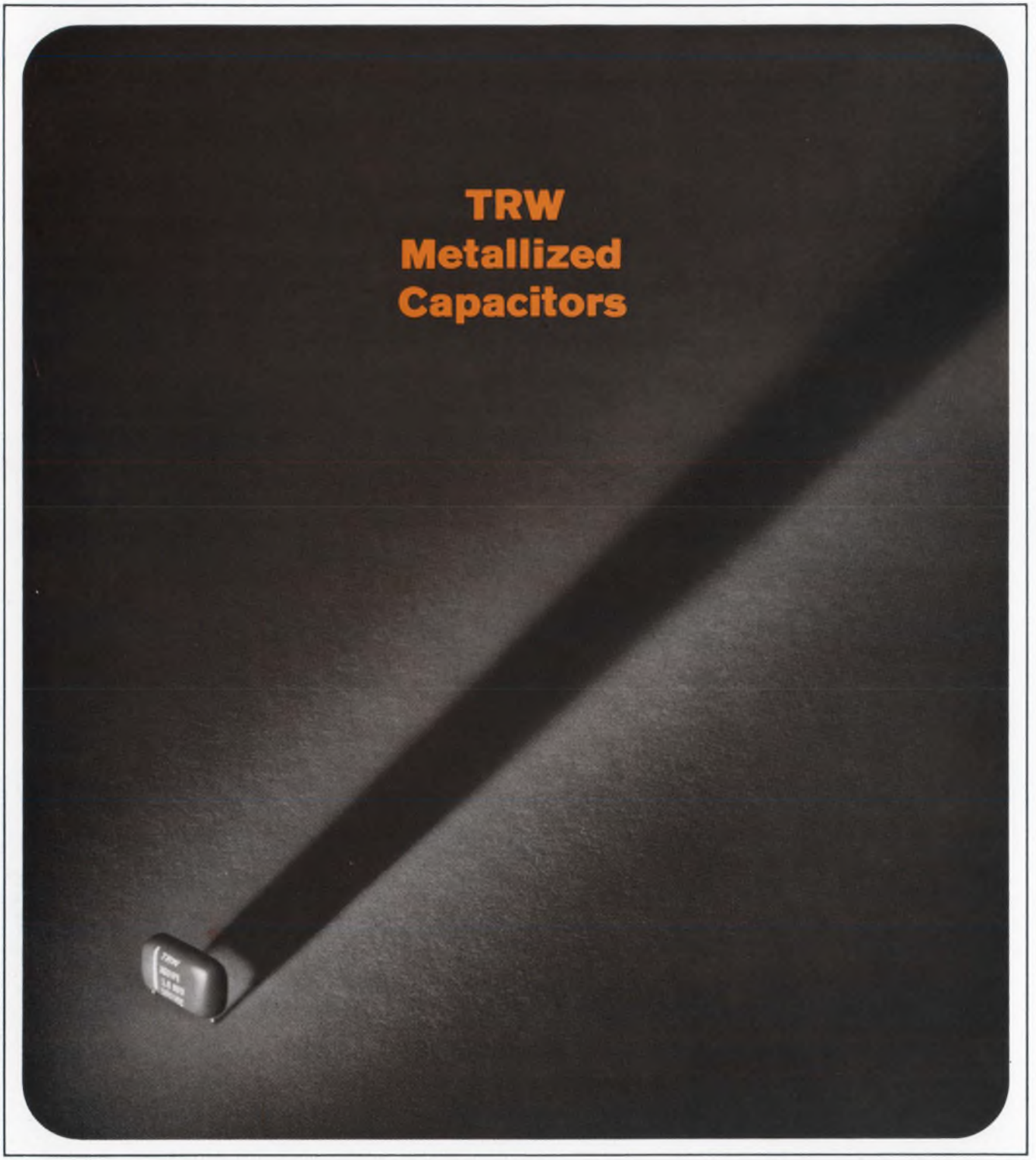
VOL. 17 NO. 3

Electronic Design

FOR ENGINEERS AND ENGINEERING MANAGERS

FEB. 1, 1969

Interactive computing is leading toward new modes of thinking and of solving problems. Human imagination is backed up by a computer's speed and memory. The way in which intellectual work is performed may change as a result of programs like the Stanford Research Institute one illustrated here. See page 25.



. . . stand tall

Type X601PE Metallized Mylars typify TRW's stature in advanced metallized dielectrics.

They're smaller and lighter... *metallized!* Tough and rugged... *epoxy sealed!* Ideal for printed circuits... *save space!*

TRW offers many additional styles and dielectrics for demanding Military and Industrial needs.

Product information is available from TRW Capacitor Division, TRW INC., Box 1000, Ogallala, Nebraska. Phone (308) 284-3611. TWX: 910-620-0321.

TRW

INFORMATION RETRIEVAL NUMBER 232

THE COUNTER REVOLUTION GOES ON AT HP

Feature for feature, you can't find a better universal counter

The new Hewlett-Packard 5325B Universal Counter gives you more counting features for your money than any other counter. And its extreme flexibility lets you do all the jobs a counter can do without plug-in accessories. Measure frequency to 20 MHz, time intervals from 100 ns to 10^8 s, and period, multiple period, ratio and multiple ratio. Time interval stop and start signals can be from common or separate inputs, with separate trigger level, slope and polarity controls for each.

Only the 5325B guarantees a very narrow trigger level threshold band—less than 1.0 mV—to prevent false counts when the trigger level setting is marginal.

Integrated circuits designed specifically for electronic counters simplify internal wiring and reduce primary power requirement to less than 35 watts. Therefore, the 5325B requires no cooling fan and operates from 50 Hz to 400 Hz power.

Another feature is readout blanking: it blanks all zeros to the left of the most significant digit—simplifies and speeds readout interpretation.

Still another: it generates two types of oscilloscope markers, which not only mark the start and stop points of an interval, but also intensify the entire measured segment when desired.

One more thing. Some counters can give you wrong time interval answers when the time interval stop signal unknowingly disappears or its trigger level is set too high. The 5325B won't respond incorrectly under such conditions—it will simply keep counting and not present a new reading.

These features, together with *standard* remote programming, BCD output that's stored for recording and readout while a new measurement is made, sampling rate down to 100 μs, 0.1 μs—10 s gate time, and excellent time base stability make the new 5325B Universal Counter an outstanding instrument. Yet the price is only $1300.

Call your local HP field engineer for more details. Or write Hewlett-Packard, Palo Alto, Calif. 94304; Europe: 1217 Meyrin-Geneva, Switzerland.

02828

HEWLETT hp PACKARD

ELECTRONIC COUNTERS

INFORMATION RETRIEVAL NUMBER 2

Systron-Donner's new portable counts every cycle at frequencies right up through 500 MHz. It's the sure, simple way to measure the higher frequencies because it's fully automatic—no more heterodyning, no more tuning, no more calculating.

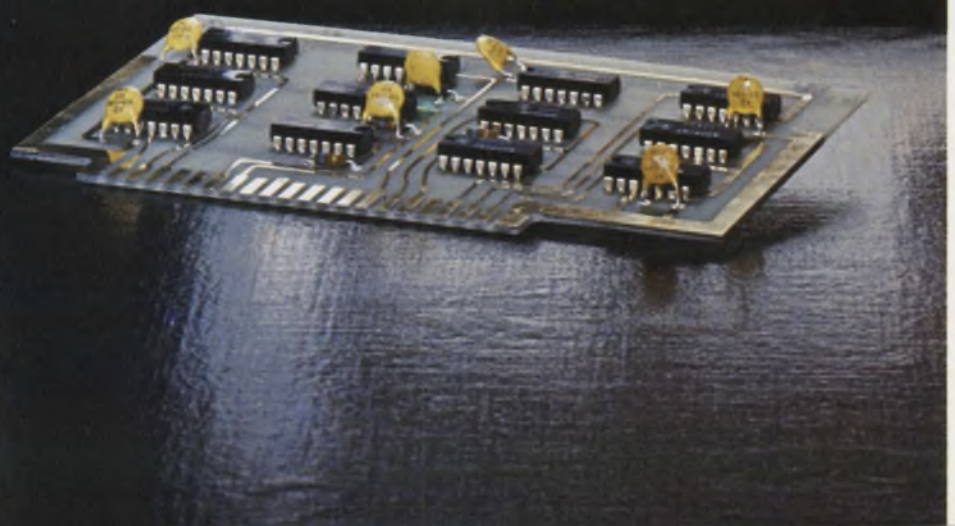
Model 7015 costs only $1975—$300 less than equipment using the older heterodyne techniques. So you get instant final-answer readings and save money too.

This new portable can be yours with a wide choice of oscillators, ranging in stability from the standard 3 parts in 10^7 per week to ultra-high stability of 5 parts in 10^{10} per 24 hours.

For complete information contact Measurements Division, Systron-Donner Corporation, One Systron Drive, Concord, California 94520. Phone (415) 682-6161.

First portable with top counting range: 500 MHz!

SYSTRON DONNER



Another first. One of 135 Systron-Donner instruments

- Electronic counters
- Pulse generators
- Microwave frequency indicators
- Digital clocks
- Memory testers
- Digital voltmeters
- Time code generators
- Data generators
- Analog computers
- Digital panel meters
- Microwave signal generators
- Laboratory magnets
- Data acquisition systems
- Microwave test sets

VOL. 17 NO.
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FOR ENGINEERS AND ENGINEERING MANAGERS
FEB. 1, 1969

NEWS

TECHNOLOGY

PRODUCTS

Departments

COVER CREDIT: Augmented Human Intelligence Research Center, Stanford Research Institute

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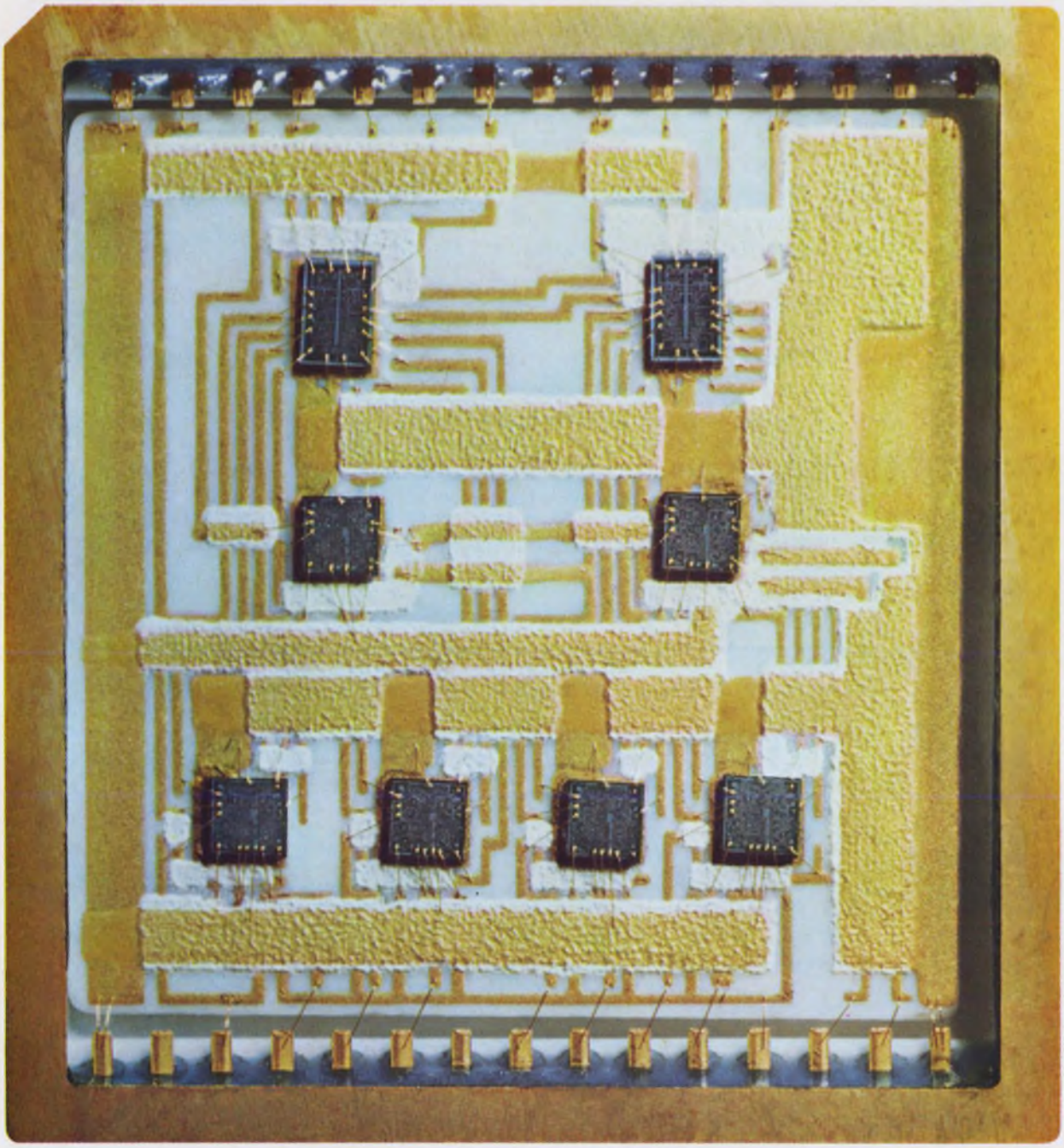
Fairchild can make more hybrids in



an hour than you can use in a month.

We can make any hybrid, in any quantity, using any method: Thick film. Thin film. Thin film on silicon.

We can make them faster than anyone in the industry. And deliver them quicker to anyone in the world.

We'll take any functions you need and package them any way you want. Our list of hybrid components has everything from a simple diode to a complex LSI array.

For your less complex applications, we have a line of off-the-shelf standard hybrids priced like discretes.

If this commitment makes sense in general, we'd like to send you the whole story in detail. Our brochure is called Fairchild Hybrid Microcircuits. It can give you more ideas in an hour than you could use in a year. Write for it.

FAIRCHILD SEMICONDUCTOR

Fairchild Semiconductor/A Division of Fairchild Camera and Instrument Corporation//313 Fairchild Drive, Mountain View, California 94040 (415) 962-5011 TWX 910-379-6435

INFORMATION RETRIEVAL NUMBER 4

circuit problems?

Signalite Glow Lamps have solved problems in these areas:

• Voltage Regulation & References • Photo-Cell Drivers • SCR Triggering
• Timing • Photo Choppers • Oscillators • Indicator Lights • Counters
• Voltage Dividers • Surge Protectors • Logic Circuits • Flip-Flops
• Memory • Switching • Digital Readouts

Signalite glow lamps combine long life, close tolerance and economy, and are manufactured with a broad range of characteristics to meet individual application requirements. For a creative approach to your design problem . . . contact Signalite's Application Engineering Department.

ULTRA HIGH LEAKAGE RESISTANCE. Devices with leakage resistance in excess of 10^{12} ohms are available for circuits requiring this property. Such applications would include sample and hold for A to D conversion, and capacitor memory systems.

SEE Signalite Application News for TYPICAL APPLICATIONS

PHOTO-CELL APPLICATIONS The A074 and A083 have been designed for use with Cadmium Sulfide or Cadmium Selenide photocells. Applications include photo choppers, modulators, demodulators, low noise switching devices, isolated overload protector circuits, etc. Speed of operation is limited only by the photo-cells.

SEE Signalite Application News for TYPICAL APPLICATIONS

SIGNALITE APPLICATION NEWS

is used to communicate new and proven techniques and applications of Signalite's neon lamps and gas discharge tubes. Signalite Application News provides a forum for an exchange of ideas to keep the design engineer aware of the versatility of neon lamps and their many applications. Copies are available from your Signalite representative or by contacting Signalite.

INFORMATION RETRIEVAL NUMBER 95

VOLTAGE REGULATORS BETTER THAN 1% ACCURACY These subminiature voltage regulators are used in regulated power supplies, as reference sources, photomultiplier regulators, oscilloscopes calibrators, etc. They are available in voltages from 82 to 143 V. They are used in multiples as regulators in KV ranges.

See Signalite Application News for TYPICAL APPLICATIONS.

NEON TIMERS The bi-stable characteristics and high leakage resistance of Signalite's special glow lamps make them ideal as a component for timing circuits. The basic circuit resembles a relaxation oscillator network.

SEE Signalite Application News for TYPICAL APPLICATIONS

Signalite

INCORPORATED

NEPTUNE, NEW JERSEY 07753
(201) 775-2490

A General Instrument Company

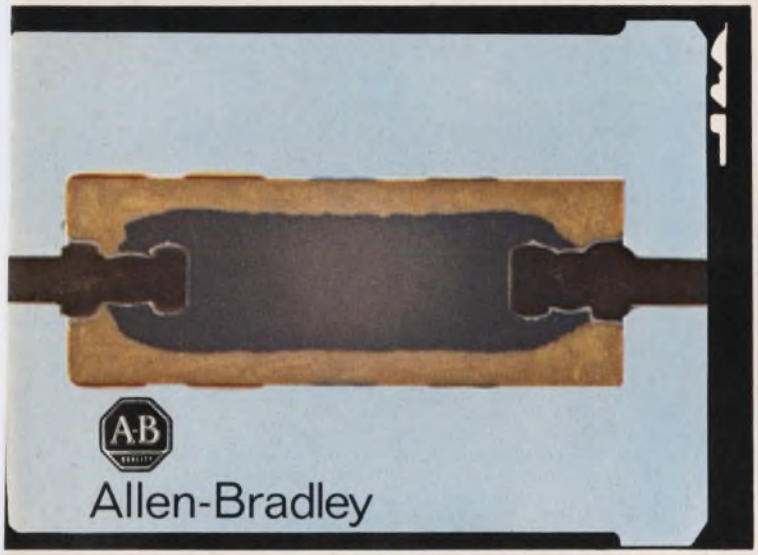
313

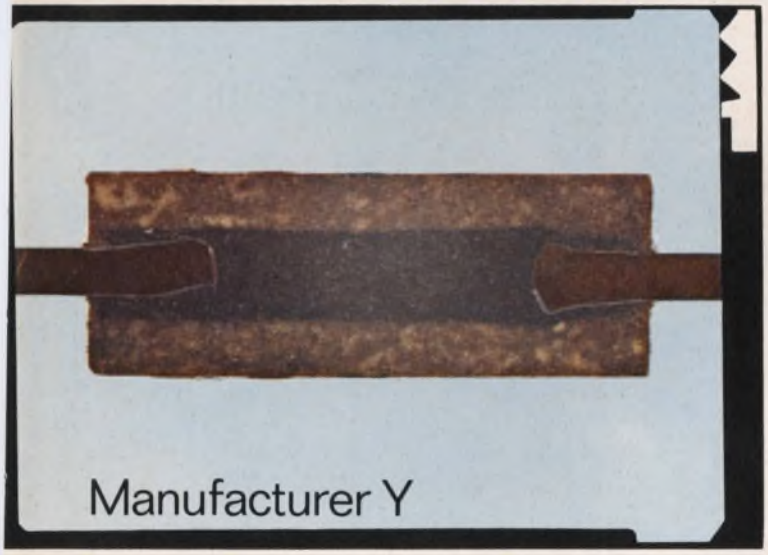
INFORMATION RETRIEVAL NUMBER 5

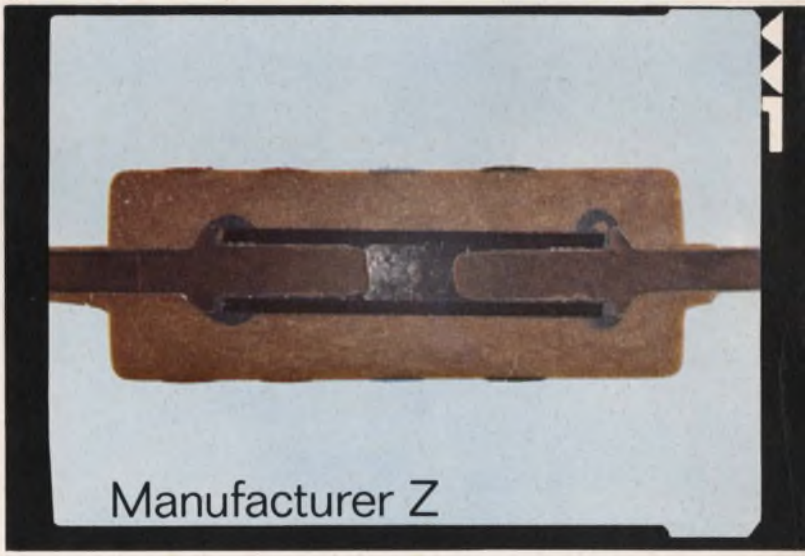
INFORMATION RETRIEVAL NUMBER 6 ►

with your reputation at stake, which resistor line would you specify?

take a close look—there'll be no question







The above illustrations are from unretouched photomicrographs taken of four ½-watt fixed resistors. Compare the anchoring of the leads, the seal provided by the insulating jacket at the ends, the homogeneity of the resistance material, the sharp color code bands—and decide for yourself.

For more details on Allen-Bradley hot-molded resistors, please write for Technical Bulletin 5000: Allen-Bradley Co., 1344 South Second Street, Milwaukee, Wis. 53204. In Canada: Allen-Bradley Canada Ltd. Export Office: 630 Third Avenue, New York, N. Y., U.S.A. 10017.

1067E-4

A-B hot-molded fixed resistors are available in all standard resistance values and tolerances, plus values above and below standard limits. **A-B hot-molded resistors meet or exceed all applicable military specifications including the new Established Reliability Specification.** Shown actual size.

QUALITY ELECTRONIC COMPONENTS

A-B ALLEN-BRADLEY

Dual Darlington diff amp array

RCA-CA3050 and CA3051 now offer the circuit designer another significant opportunity to work with the inherent device match of monolithic construction PLUS the flexibility of RCA building-block arrays. On a single chip, in a dual-in-line package, each type offers:

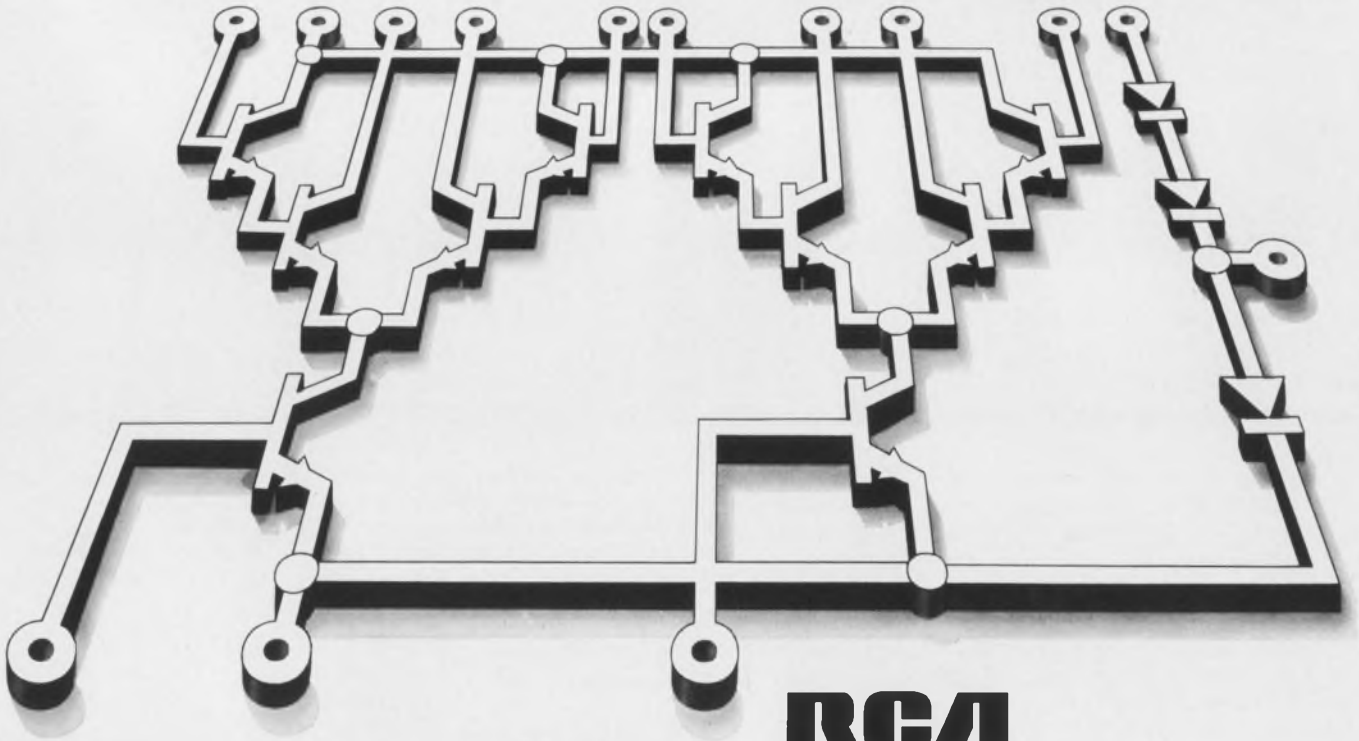
- independently accessible inputs and outputs
- diode temperature compensation of constant-current-transistor bias
- high input impedance—460 KΩ typ
- low input offset current—70 nA max
- low offset voltage—5 mV max
- low input bias current—500 nA max

Get the feel of real design freedom with CA3050 or CA3051 for matched dual amplifiers, dual sense amplifiers, dual Schmitt triggers, doubly balanced detectors and modulators, and a multitude of applications that call for matched device performance from DC to 20 MHz.

For more information, contact your local RCA Representative or your RCA Distributor. For technical data, write RCA Electronic Components, Commercial Engineering, Section ICG-2-1, Harrison, New Jersey 07029.

Ask About These Linear Transistor Arrays from RCA

CA3018	Darlington pair, plus 2 independent transistors	$ .98 (1,000 units)
CA3018A	Tight-spec version of CA3018	$1.35 (1,000 units)
CA3026	High gain dual diff ampl array for DC to 120 MHz	$1.25 (1,000 units)
CA3036	Dual Darlington array	$ .89 (1,000 units)
CA3045	Darlington pair plus 3 transistors in dual-in-line ceramic package	$1.50 (1,000 units)
CA3046	Dual-in-line plastic package version of CA3045	$ .98 (1,000 units)

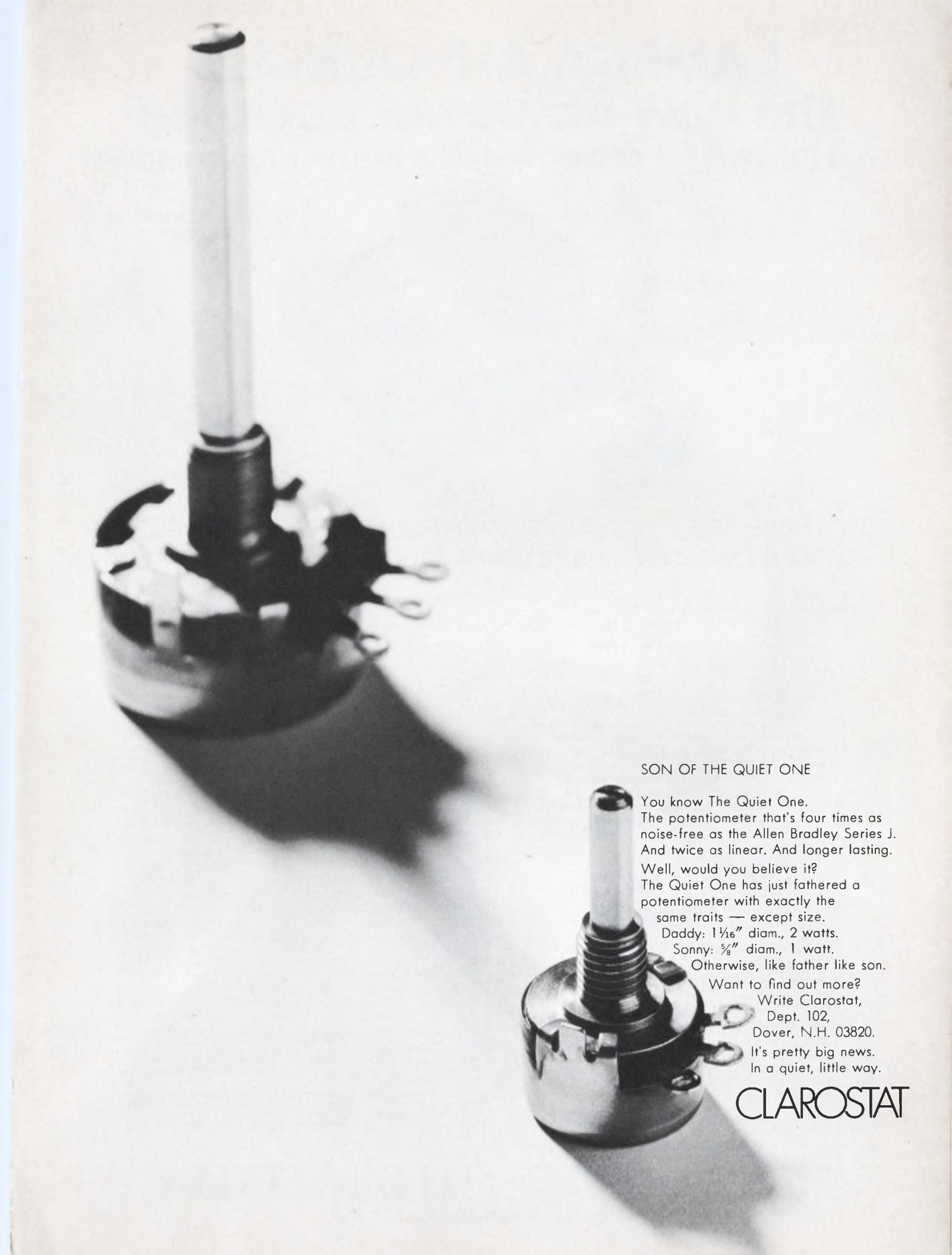


RCA-CA3050 in 14-lead dual-in-line ceramic pkg $2.25 (1000 units)
RCA-CA3051 in 14-lead dual-in-line plastic pkg $1.65 (1000 units)

RCA
Integrated Circuits

INFORMATION RETRIEVAL NUMBER 7

INFORMATION RETRIEVAL NUMBER 8 ►



SON OF THE QUIET ONE

You know The Quiet One.
The potentiometer that's four times as noise-free as the Allen Bradley Series J. And twice as linear. And longer lasting.

Well, would you believe it?
The Quiet One has just fathered a potentiometer with exactly the same traits — except size.

Daddy: 1 1/16" diam., 2 watts.
Sonny: 5/8" diam., 1 watt.

Otherwise, like father like son.

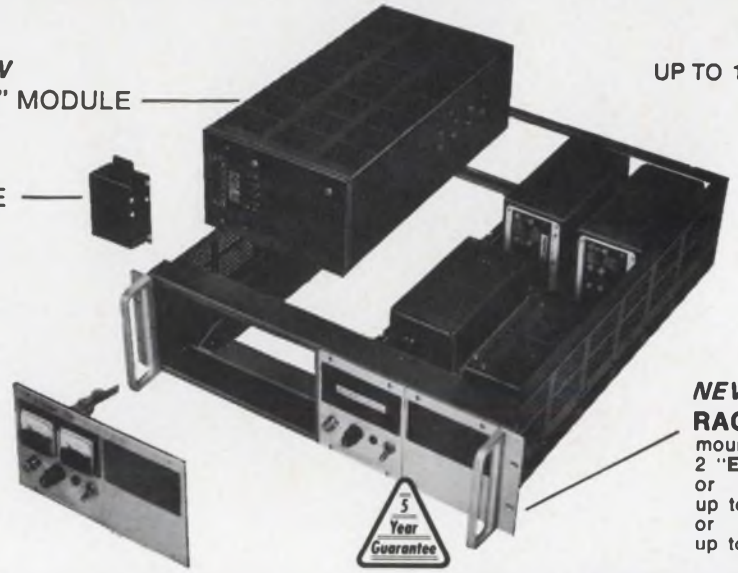
Want to find out more?
Write Clarostat,
Dept. 102,
Dover, N.H. 03820.

It's pretty big news.
In a quiet, little way.

CLAROSTAT

LAMBDA ANNOUNCES the new EE power package

with the highest power available in a half-rack module!



NOW THERE ARE 7 VERSATILE 5 YEAR-GUARANTEED CONVECTION-COOLED LM SERIES MODULES—IN STOCK—ONE DAY DELIVERY.

FEATURES OF NEW "EE" POWER PACKAGE

- **MEET MIL. ENVIRONMENT SPECS**
  Specify Lambda with assurance of meeting military requirements
  • RFI—MIL-I-16910 • Vibration: MIL-T4807A
  • Shock: MIL-E-4970A Proc. 1 & 2
  • Humidity: MIL-STD-810 Meth. 507
  • Temp. Shock: MIL-E-5272C (ASG) Proc. 1
  • Altitude: MIL-E-4970A (ASG) Proc. 1
  • Marking: MIL-STD-130 • Quality: MIL-Q-9858
  Fungus Proofing (optional):
  all models available with MIL-V-173 varnish for all fungi nutrient components at $10.00 surcharge.
- **THERMALLY PROTECTED AND SHORT CIRCUIT PROOF**
- **NO VOLTAGE SPIKES OR OVERSHOOT** on turn-on, turn-off, or power failure.
- **WIDE INPUT VOLTAGE AND FREQUENCY RANGE** 105-132 VAC, 45-440 Hz with 10% derating for 50 Hz operation. (205-265 VAC, optional at no extra charge).
- **LINE REGULATION:** .05% + 4mV
- **LOAD REGULATION:** .03% + 3mV
- **RIPPLE AND NOISE:** 1mV rms; 3mV p-to-p
- **TEMP COEFF.:** .03% / °C
- **HIGH PERFORMANCE OPTION**
  All models available with these specifications at $15.00 surcharge:
  LINE REGULATION: .01% + 1mV
  LOAD REGULATION: .02% + 2mV
  RIPPLE AND NOISE: 0.5mV rms; 1.5mV p-to-p with 60 Hz input
  TEMP COEFF.: .01%/°C

NEW ACCESSORIES FOR "EE" PACKAGE

- **Rack Adapters**
  LRA-7 • 5¼"H x 19"W x 21"D. Price $70.00
- **Chassis Slides**
  Add suffix "-CS" to LRA Model number and add $50.00 to price.
- **Panels**
  5¼" x 8⅜" Metered panel MP-50. Price $55.00
  5¼" x 8⅜" Non-metered panel P-50. Price $35.00
  Add $10.00 for fungus proofing.
- **Overvoltage Protectors**

LM-OV-7	3-8V	4 7/16"H x 2 13/16"W x 1 13/16"D	$75.
LM-OV-8	6-20V	4 7/16"H x 2 13/16"W x 1 13/16"D	75.
LM-OV-9	18-70V	4 7/16"H x 2 13/16"W x 1 13/16"D	75.

Package EE 4 15/16" x 7½" x 17"

WIDE RANGE

Model	ADJ. VOLT. RANGE VDC	MAX AMPS AT AMBIENT OF: [1] 40°	50°	60°	71°	Price
LM-EE-0-7	0–7	16	13.5	11.2	9.2	$320
LM-EE-0-14	0–14	10.2	8.6	7.3	6.1	320
LM-EE-0-32	0–32	5.2	4.4	3.8	3.2	320
LM-EE-0-60	0–60	2.7	2.45	2.15	1.85	320

FIXED VOLTAGE

Model	ADJ. VOLT. RANGE VDC	MAX AMPS AT AMBIENT OF: [1] 40°C	50°C	60°C	71°C	Price [2]
LM-EE-3	3 ±5%	33.0	29.0	25.0	20.5	$320
LM-EE-3-P-6	3.6±5%	32.0	26.0	22.0	18.3	320
LM-EE-4	4 ±5%	32.0	26.0	22.0	18.3	320
LM-EE-4-P-5	4.5±5%	31.0	24.6	20.8	17.3	320
LM-EE-5	5 ±5%	31.0	24.6	20.8	17.3	320
LM-EE-6	6 ±5%	30.0	24.6	20.8	17.3	320
LM-EE-8	8 ±5%	28.0	23.5	19.7	16.5	320
LM-EE-10	10 ±5%	24.0	20.4	16.8	13.8	320
LM-EE-12	12 ±5%	21.0	19.0	16.1	13.2	320
LM-EE-15	15 ±5%	19.0	18.0	15.5	12.7	320
LM-EE-18	18 ±5%	16.5	14.8	12.4	10.1	320
LM-EE-20	20 ±5%	15.2	13.7	11.8	9.7	320
LM-EE-24	24 ±5%	14.0	12.5	10.8	9.0	320
LM-EE-28	28 ±5%	13.0	11.5	9.8	8.2	320
LM-EE-36	36 ±5%	10.4	9.8	8.6	7.1	320
LM-EE-48	48 ±5%	7.7	7.1	6.5	5.4	320
LM-EE-100	100 ±5%	3.3	3.0	2.5	2.1	350
LM-EE-120	120 ±5%	3.0	2.7	2.2	1.9	350
LM-EE-150	150 ±5%	2.2	2.0	1.75	1.50	350

NOTES:

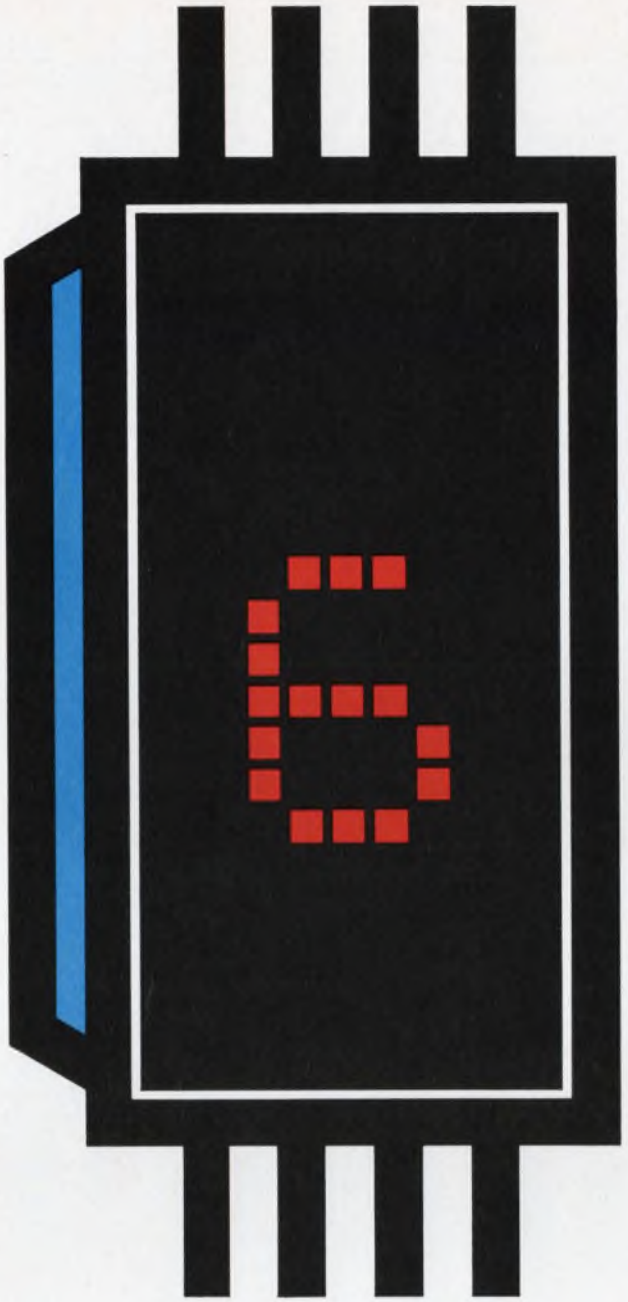
[1] Current rating is from zero to I max. Current rating applies over entire output voltage range. Current rating applies for input voltage 105-132 VAC 55-65 Hz. For operation at 45-55 Hz delete 40°C rating. For operation at 360-440 Hz consult factory for ratings and specifications. For 50 Hz operation derate 10%.

[2] Prices F.O.B. factory, Melville, N. Y. All specifications and prices subject to change without notice.

Write, wire, or call to order direct, for information, or for new Lambda Power Supplies catalog. LAMBDA Electronics Corp., 515 Broad Hollow Road, Melville, L. I., New York 11746, TEL. 516-694-4200, TWX 510-224-6484.

LAMBDA

INFORMATION RETRIEVAL NUMBER 10



Surprise package
(1″ x ½″ x 1/10″)

It's a completely new way to display digital information. The Hewlett-Packard solid state numeric display packs everything in one, small unit only 1"x 0.5"x 0.16". Gallium arsenide phosphide diodes and an IC driver/decoder chip deliver bright red numerals—bigger than life, visible for yards.

This new "total package" also gives you the edge on cost. You don't have to buy driver elements, or anything else. No special interfacing is needed. Only four line 8-4-2-1 BCD input and less than five volts to drive it. The modules are available in three-character packages, too.

The Hewlett-Packard solid state numeric display is ideal for instruments requiring smaller, tighter display panels. Or any application demanding either low power or resistance to shock and vibration, without catastrophic failures.

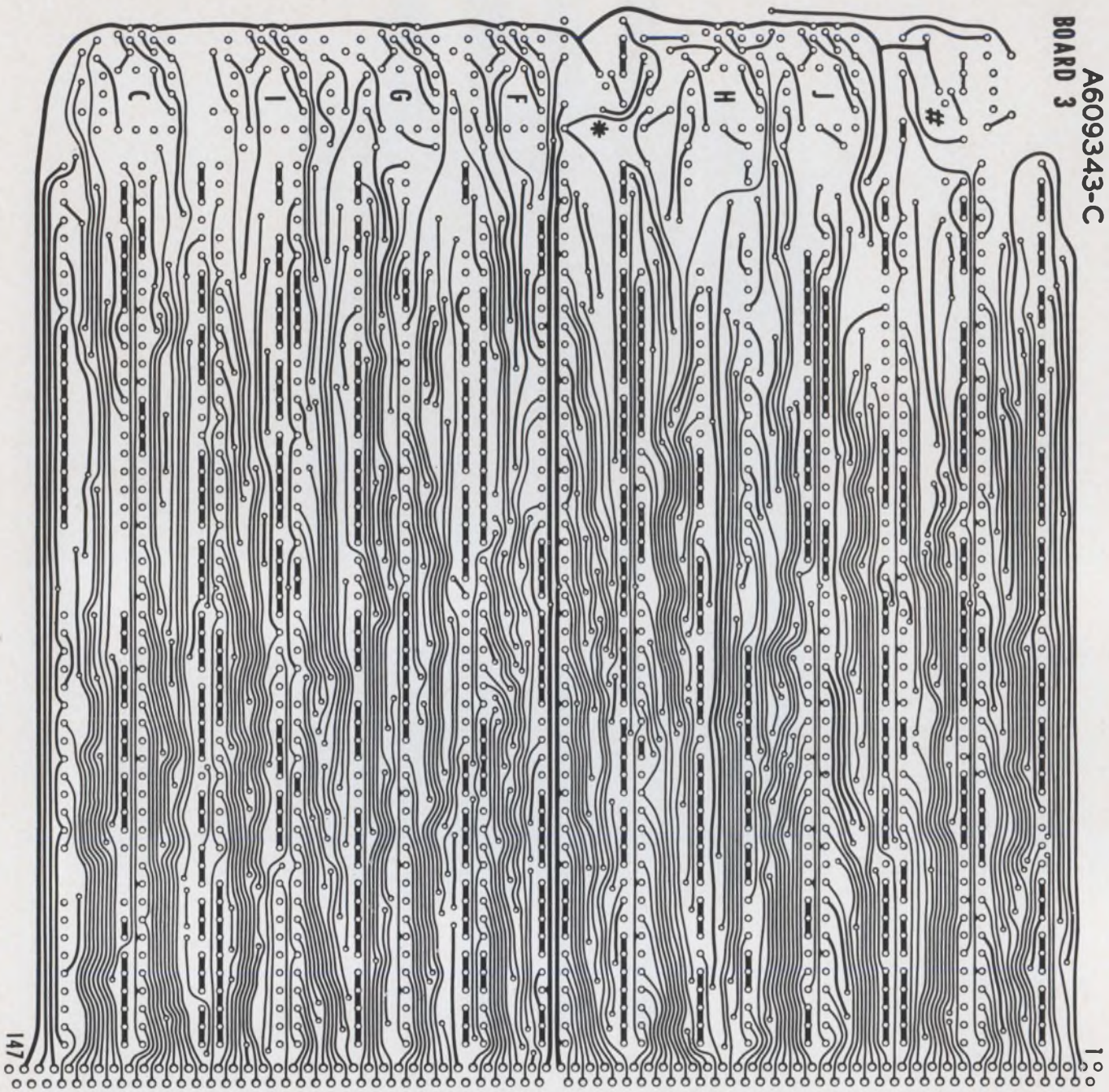
Get more information about the new technology for numeric indicators. Call your local HP field engineer or write Hewlett-Packard, Palo Alto, California 94304; Europe: 1217 Meyrin-Geneva, Switzerland.

HEWLETT hp PACKARD

SOLID STATE DEVICES

01810

INFORMATION RETRIEVAL NUMBER 11



Our printed circuits speak for themselves

...by the millions. Write for "An Engineer's Guide to Printed Circuit Board Design." Address: Printed Circuits, Lockheed Electronics Company, 6201 East Randolph Street, Los Angeles, Calif. 90022.

LOCKHEED ELECTRONICS COMPANY

A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

INFORMATION RETRIEVAL NUMBER 12

INFORMATION RETRIEVAL NUMBER 13 ►

Programmable.

Universal; extended range
7 nanosecond pulse resolution
Full 50 MHz counting
Programmability, BCD output...

all for only $1285.

Our new model 110A offers you a broader range of operational advantages than any other counter/timer in its price range.

Front-panel functions are tailor-made for programming with our Model 501A Programmer (shown at right) or can be readily selected by virtually any contact-closure or logic-level source.

The extended frequency range, dc to 50 MHz, of the Model 110A together with such advantages as: provision for use of an external time base; internal time base, marker, and gate outputs; the inherent reliability of our "4th generation" integrated circuit design, plus our usual 2-year warranty all combine to assure you the versatility, the reliability, and integrity of performance you have come to expect from Monsanto. The price is only $1285.00, FOB West Caldwell, N. J. Eighth digit optional.

MODEL 501A DIGITAL PROGRAMMER

For a demonstration, or for full technical details, call your local Monsanto Field Engineer or contact us directly at Monsanto Company, Electronic Instruments, West Caldwell, New Jersey 07006, (201) 228-3800.

Monsanto

Designer's Datebook

MARCH 1969

Sun	Mon	Tue	Wed	Thu	Fri	Sat
						1
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APRIL 1969

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6	7	8	9	10	11	12
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27	28	29	30			

For further information on meetings, use Information Retrieval Card.

Feb. 19-21
Solid-State Circuits Conference (Philadelphia) Sponsor: IEEE, Univ. of Pennsylvania; L. Winner, 152 W. 42 St., New York, N. Y. 10036

CIRCLE NO. 433

Mar. 12-14
Microwave Technique Conference (Cologne, Germany) Sponsor: IEEE; H. H. Burghoff, Stresemann Allee 21, VDE-Haus, 6 Frankfurt/Main 70, Federal Republic.

CIRCLE NO. 434

Mar. 24-27
IEEE International Convention (New York City) Sponsor: IEEE; J. M. Kinn, 345 E. 47 St., New York, N. Y. 10017

CIRCLE NO. 435

Mar. 25-27
Conference on Lasers and Optoelectronics (Southampton, England) Sponsor: IEE; IEE, Savoy Place, London W. C. 2, England.

CIRCLE NO. 436

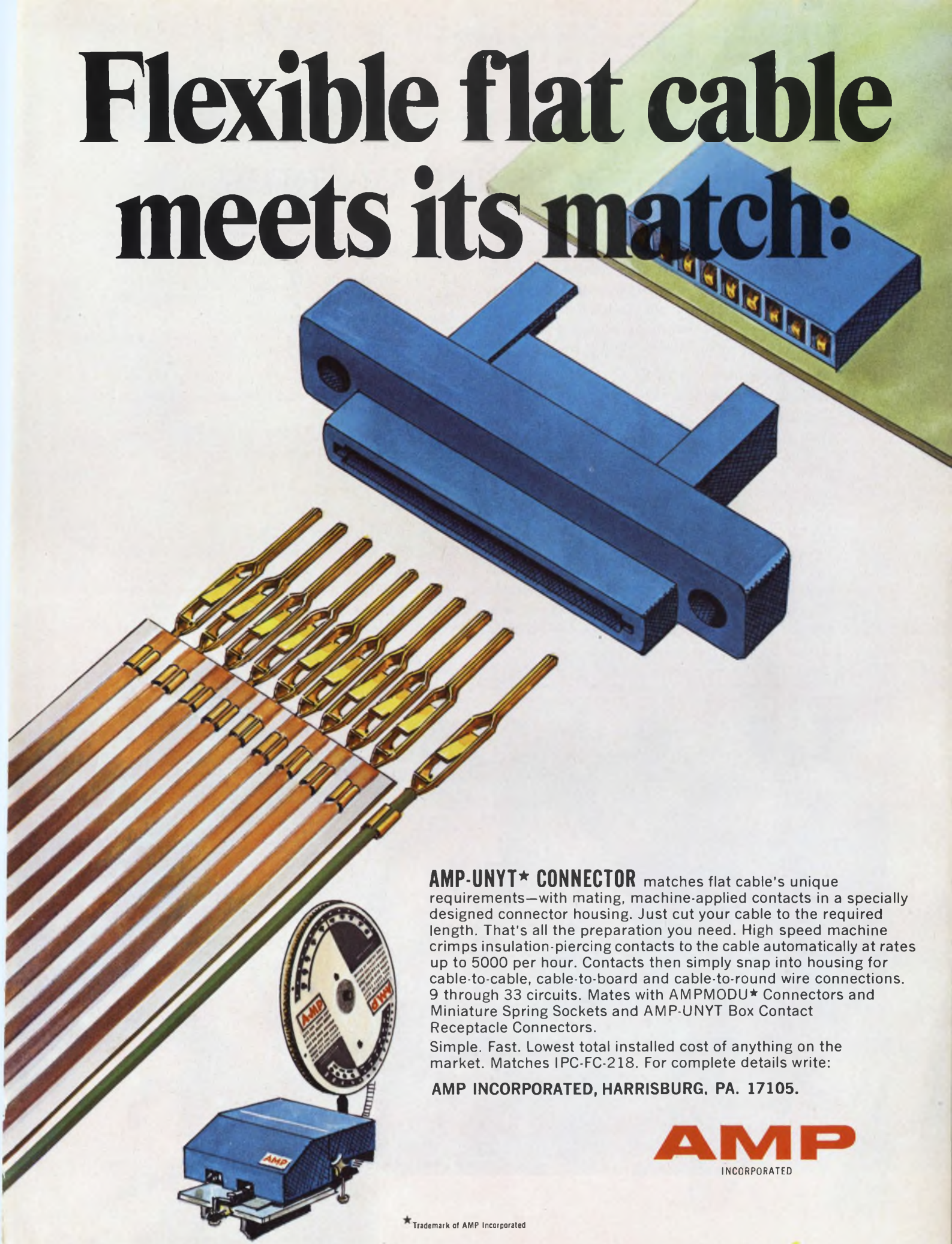
Apr. 15-18
International Magnetics Conference (Amsterdam, the Netherlands) Sponsor: G-MAG; U.F. Gianola, Bell Telephone Labs., Murray Hill, N.J. 07971

CIRCLE NO. 437

Apr. 16-18
Geoscience Electronics Symposium (Washington, D. C.) Sponsor: G-GE; Maurice Ringenback, Weather Bureau, ESSA, Gramax Bldg., Silver Spring, Md. 20910

CIRCLE NO. 438

Flexible flat cable meets its match:



AMP-UNYT★ CONNECTOR matches flat cable's unique requirements—with mating, machine-applied contacts in a specially designed connector housing. Just cut your cable to the required length. That's all the preparation you need. High speed machine crimps insulation-piercing contacts to the cable automatically at rates up to 5000 per hour. Contacts then simply snap into housing for cable-to-cable, cable-to-board and cable-to-round wire connections. 9 through 33 circuits. Mates with AMPMODU★ Connectors and Miniature Spring Sockets and AMP-UNYT Box Contact Receptacle Connectors.

Simple. Fast. Lowest total installed cost of anything on the market. Matches IPC-FC-218. For complete details write:

AMP INCORPORATED, HARRISBURG, PA. 17105.

AMP
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Help IBM develop large-scale data processing systems.

We need Logic Designers to develop the hardware for large-scale scientific systems, designed to solve complex problems having extremely large computational loads. Loads that are found in such areas as weather forecasting, radiation burst effects, or signal processing.

Imaginative new concepts.

Advanced concepts in system architecture are being explored to achieve exceptionally high data processing rates.

You would work on the design and development of systems hardware and its integration into the overall system.

If you qualify, you could get in on the ground floor of important advances in large-scale computation.

You should have an E.E. degree (or its equivalent) and two years' experience in large-scale scientific or commercial data processing systems, including logic design.

Grow with IBM.

This development program is just one of the many we have at IBM's Federal Systems Division, located near Washington, D.C.

For example, we are deeply involved with the manned space program. Working on systems to analyze delicate seismological disturbances. And designing many new real-time, on-line information systems.

It has been these kinds of advanced programs that have kept IBM a leader in the information processing industry.

Call or write.

Learn more details. Call Jim Dunn at (301) 921-7724 collect any weekday between 9 and 4:30. Or, if you prefer, send a brief letter or resume to him at IBM Corporation, Federal Systems Division Headquarters, Dept. CB1020 18100 Frederick Pike, Gaithersburg, Md. 20760.

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product report
sampling

NEW 25-ps SAMPLING

35-ps TDR, 18-GHz TRIGGERING . . . . . and MORE!

NEW

NEW

NEW

NEW

Type S-4
25-ps RISETIME

The new Type S-4 Sampling Head features a 25-ps risetime, DC-to-14 GHz bandwidth, and a 50-Ω input impedance. This step-ahead measurement capability gives increased detail and resolution when making fast pulse measurements.

Type S-4 Sampling Head $795

Type S-50
25-ps PULSE GENERATOR

The new Type S-50 Pulse Generator Head has a 25-ps risetime, +400 mV amplitude and a pulse duration of 100 ns. The Type S-50 and Type S-4 comprise a high-resolution, 35-ps TDR measurement system.

Type S-50 Pulse Generator Head . . . $475

Type S-51
18-GHz TRIGGERING

The new Type S-51, 1-to-18 GHz Trigger Countdown Head provides stable oscilloscope triggering to 18 GHz. With the Type S-4 Sampling Head, stable displays to 14 GHz and above are possible.

Type S-51 Trigger Countdown Head . . $450

Type S-3
SAMPLING PROBE HEAD

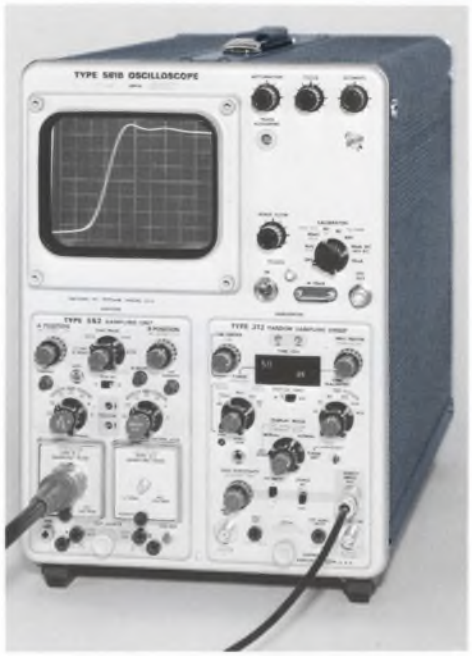
The new Type S-3 Sampling Probe Head has a 350-ps risetime and an input impedance of 100 kΩ paralleled by 2.3 pF. The Type S-3 is designed to measure high impedance signal sources and is easy to use when probing into miniature circuits.

Type S-3 Sampling Probe Head $395

Type S-2
50-ps RISETIME

The Type S-2 Sampling Head features a 50-ps risetime with a terminated 50-Ω input impedance and standard GR874 input connectors.

Type S-2 Sampling Head $325



The Tektronix Type 561B Oscilloscope with the Type 3T2 Random Sampling Sweep and the Type 3S2 Dual-Trace Sampling Unit features new measurement capabilities with plug-in and extendable Sampling Heads. Six Sampling Heads are presently available offering a step ahead in measurement performance, designed to meet your changing measurement needs.

Type S-1
350-ps RISETIME

The Type S-1 Sampling Head is a 350-ps risetime, 50-Ω unit that combines low displayed noise with an excellent transient response.

Type S-1 Sampling Head $275

please turn page for additional information

Making the Measurement . . . TEKTRONIX 25-ps Sampling Oscilloscope

NEW! 25-ps Risetime

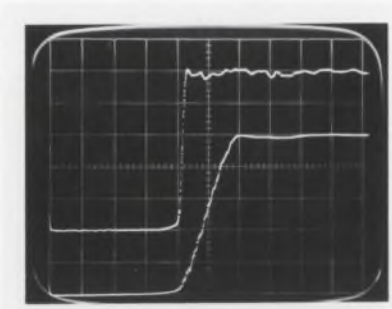
The Type S-4 offers for the first time 25-ps measurement capabilities in an oscilloscope. This state-of-the-art measurement performance provides increased detail and resolution of your fast pulse displays. The photograph shows the same pulse displayed with the 25-ps Type S-4 (upper trace) and a 350-ps unit (lower trace). Note the difference in detail of the pulse characteristics displayed by the Type S-4 with its 25-ps risetime performance.

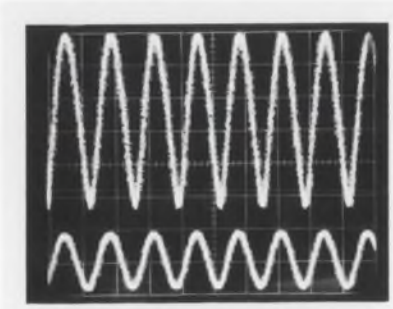
NEW! 14-GHz Displays

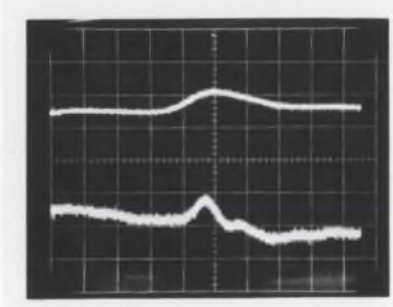
For the first time, you can see displays to 14 GHz on an oscilloscope. Using the Type S-4, DC-to-14 GHz Sampling Head with the Type S-51, 1-to-18 GHz Trigger Countdown you can see how your circuit is really performing. Two Type S-4 Sampling Heads used in the Type 3S2 (XY mode) let you measure phase shift to 14 GHz. The photograph shows the loss due to a 3-ft coaxial cable transmitting a 15-GHz signal. Sampling Heads can be used at your signal source eliminating losses due to cables.

NEW! 35-ps TDR System

The Type S-4, 25-ps Sampling Head and the Type S-50, 25-ps Pulse Generator comprise a high-resolution 35-ps TDR System. The double exposure photograph shows a comparison of a 100-ps TDR System (upper trace) and the new 35-ps TDR System (lower trace). Note the better resolution with the 35-ps Type S-4/S-50 TDR System.







Mix or Match!

Sampling Heads may be mixed or matched. High frequency signals and fast risetime pulses must be generated and transmitted in low impedance circuits. The Type S-1, S-2 and S-4 Sampling Heads have a terminated 50-Ω input providing excellent termination for your fast risetime pulses and a choice of risetime capabilities. Add the Type S-3 Sampling Probe Head with its 100-kΩ, 2.3 pF input impedance when it is necessary to measure high impedance signal sources.

For a demonstration, call your local Tektronix field engineer or write: Tektronix, Inc., P. O. Box 500, Beaverton, Oregon 97005.

A Choice of Oscilloscopes

Tektronix offers a choice of sampling oscilloscopes designed to satisfy your measurement needs. Select the Type 561A Oscilloscope with an 8 x 10-cm CRT and illuminated internal graticule for conventional displays. The Type 564 Storage Oscilloscope offers the added advantage of split-screen storage. Storage is especially useful when sampling low repetition rate signals, making TDR measurements and for signal comparison. The Type 568/230 Digital Readout Oscilloscope provides digital readout of measurements without operator interpretation or error. Measurements include voltage, risetime, delay time, pulse width and many other specific measurements, readout directly in four-digit resolution.

Random Sampling

Type 3T2 Random Sampling Sweep provides all the measurement capabilities of a conventional (sequential) sampling sweep, plus it features the added advantage of random sampling operation. When used in the random sampling mode, the triggering event may be displayed on screen without the use of delay lines or a pretrigger. The Type 3T2 has a calibrated sweep range from 100 μs/div to 200 ps/div, extending to 20 ps/div with the X10 magnifier.

Plug-ins for a Plug-in

The Type 3S2 Dual-Trace Sampling Unit features a choice of six Sampling Heads that provide new convenience and versatility when making fast pulse measurements. The Sampling Heads can be plugged into the Type 3S2 or used remotely, eliminating losses due to cables. An interchannel delay control compensates for signal cables or other external delays between channels. Select the performance you need today and update your measurement capabilities with new Sampling Heads in the future.

Type 561B Oscilloscope $560
Type 564B Storage Oscilloscope . $995
Type 568/230 Digital Oscilloscope $4125
Type 3T2 Random Sampling Sweep $1000
Type 3S2 Sampling Unit $850
Type 285 Power Supply $150
(powers one S-50 or S-51)

U.S. Sales Price FOB Beaverton, Oregon

Tektronix, Inc.

committed to progress in waveform measurement

HAPPENINGS IN ELECTRONICS

February, 1969

YOU GET THESE 24 DEVICES IN THE MCK1500 KIT: 1-24

MOTOROLA TYPE NO.	DESCRIPTION	TEMP RANGE	VALUE* FOR 2
MC1520G	Operational Amplifier	−55 to + 125°C	$ 19.50
MC1539G	Operational Amplifier	−55 to + 125°C	22.50
MC1709G	Operational Amplifier	−55 to + 125°C	25.50
MC1533G	Operational Amplifier	−55 to + 125°C	25.50
MC1560G	Voltage Regulator	−55 to + 125°C	45.00
MC1437L	Dual Operational Amplifier	0 to + 75°C	13.00
MC1710G	Differential Comparator	−55 to + 125°C	22.50
MC1540G	Sense Amplifier	−55 to + 125°C	45.00
MC1711G	Dual Differential Amplifier	−55 to + 125°C	36.00
MC1541L	Dual Sense Amplifier	−55 to + 125°C	54.00
MC1510G	Video Amplifier	−55 to + 125°C	24.00
MC1554G	Power Amplifier	−55 to + 125°C	28.50
	Total Value		$361.00
	MCK1500 Kit Price		94.50
	You Save (on devices alone)		$266.50

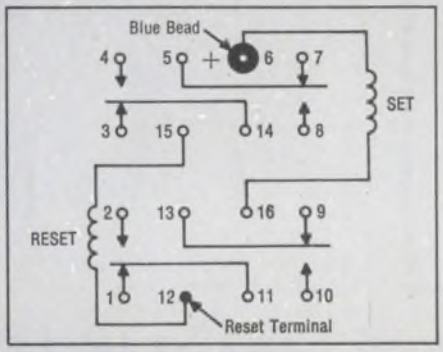
*As of current published prices, 1-24 quantities.

The *Compleat Designer* by Motorola.

Not since Izaak Walton's *Compleat Angler* has anyone offered the *Designer* as *compleat* a tract on linear integrated circuits as Motorola's MCK 1500. You get two-each of 12 different LIC devices covering the nine major linear applications (see box score on left). You get a *compleat* technical library, including all the data sheets, application notes, and selection information on the entire Motorola LIC line. You get all this in a sturdy, leatherette carrying case that protects everything for as long as you use the kit. But what you don't get, is the $361 price as per current published prices. You pay only $94.50 for this *compleat* LIC kit now available from Schweber for immediate shipment. Circle #241 for more information.

GE 4-pole magnetic-latching relay makes bow.

GE has complemented its DPDT magnetic-latching relay (3SAM) with a 4PDT version (3SBM). It is the world's smallest 4-pole double throw 2-amp magnetic-latching relay (.610 x .610 x .320"). These relays feature a permanent magnet to latch the armature in position once the movable contacts are switched, thus assuring operation from short power pulses and low power drain. The relays are available with single or dual coil arrangements. In single coil operation, contacts are switched from one position to the other by reversing the applied polarity; in dual coil operation, one coil acts to "set" the contacts and the other coil acts to "reset" them. (See diagram.) Contact ratings: DC resistive 2 amps at 28v., DC inductive 0.3 amps at 28v. (L/R not greater than 0.002); AC resistive 0.5 amps at 115v., AC inductive 0.125 amps at 115v. (enclosure isolated from ground). Base list price of single coil 3SAM $17.50, dual coil 3SAM $19.50; single coil 3SBM $32, dual coil 3SBM $36. Slight adder for mounting choice. GE's popular family of sealed, microminiature relays is the most complete in the industry. Circle #242 for catalog.



Review of new catalogs.

Fairchild Semiconductor's "Discrete Device Condensed Catalog of 1969" is now available from Schweber. Within its 55 pages, you will find a complete listing of Fairchild diodes and transistors classified into specific categories which are summarized in a table of contents. Electrical characteristics are 'condensed' into a single horizontal line per device with the emphasis on 'condensed.' There are no performance curves, applications, or test data. For a compact, handy classification of Fairchild discrete devices circle #243. All devices in this catalog are available off-the-shelf from Schweber. Alpha Industries offers a 2-color, 8-page brochure describing a complete line of Integrated Semiconductor Modules for use in all types of stripline and coaxial RF structures from DC to 18 GHz. This catalog describes the electrical and mechanical details of several types of switch modules from SPST to SP6T, and also includes digital phase shifter modules. A detailed theory and applications section is provided, in addition to numerous photographs, drawings and performance curves. All devices listed are available from Schweber. Circle #244.

A free evaluation kit.

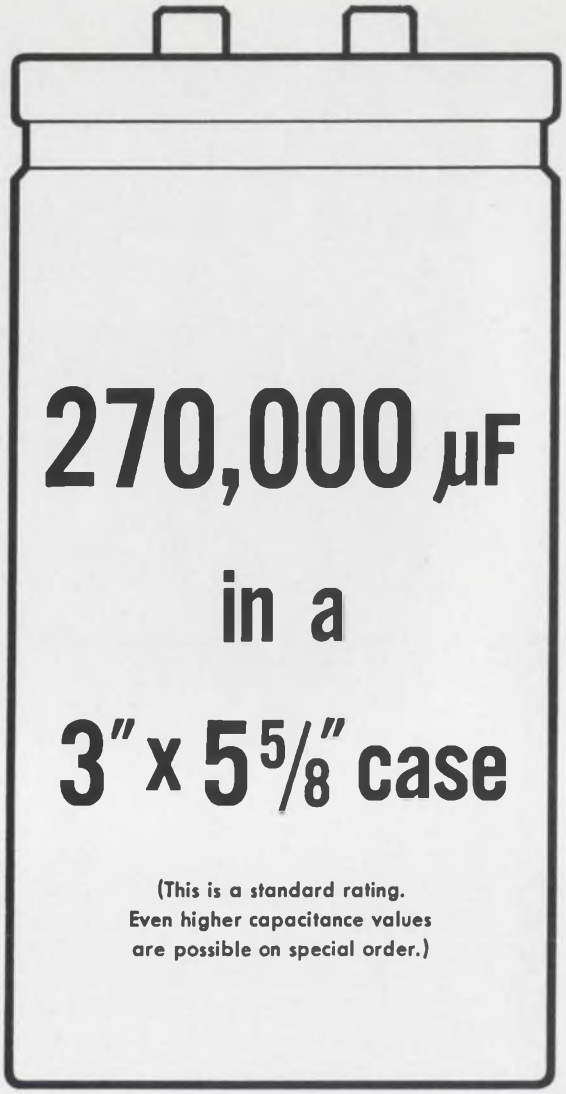
Why be satisfied with constant-voltage under varying current conditions, when you can also get constant-voltage under fluctuating temperature conditions? It takes a particular kind of Zener Diode to do both; namely, a temperature-compensated reference diode. So...we've made up a little evaluation kit which includes a sample Motorola 1N825, an 8-page application note on Design Considerations and Performance of 0-TC Diodes by Motorola engineers, and data sheets of same. The kit is free from Schweber if you circle #245.

Cannon-ITT connector guide.

"Who can assemble 100,000 different kinds of Cannon connectors in 24 hours!" Don't try to answer this question unless you first obtain a Cannon connector guide. This will help you select the proper connector series from the four groupings listed: Rectangular Rack/Panel; Circular; Microminiature; and Special Applications. Go to one of these four headings in the guide. Below each heading are several blocks listing the various connector series. Check your requirements such as size and number of contacts, their terminations, connector size and coupling method, and environmental requirements. For detailed product data and ordering information obtain the proper detailed catalog from Schweber. In the meantime circle #246 for your Connector Guide.

SCHWEBER ELECTRONICS

Latest news on new products and prices from Schweber Electronics, Westbury, N.Y. 11590 . . . Edited by Sam Kass



POWERLYTIC® CAPACITORS ARE PACKED WITH CAPACITANCE!

Improved Capacitance Capability
Type 36D aluminum electrolytic capacitors now have as much as 60% more capacitance in a given case size than previously available.

Higher Operating Temperature
Improved Powerlytic capacitors may now be operated at 85 C.

High Ripple Current Capability
Ideal capacitors for use in "brute-force" filtering and pulse discharge applications. Single capacitors are capable of handling up to 20 or more amps rms at 25 C, 120 Hz.

Superior Seal and Safety Vent
Beaded aluminum can is crimped onto a rubber gasket recessed in a rigid molded cover, providing an expected operating life in excess of ten years. Pressure-type safety vent employs silicone rubber for reliable, predictable release of excess pressure.

Choice of Insulating Tubes, Terminal Styles
In addition to the standard bare case, Type 36D capacitors are available with a clear plastic tube or with a Kraftboard tube. Tapped terminals in two different heights, as well as solder lug terminals are available.

For complete technical data, write for Engineering Bulletin 3431B to Technical Literature Service, Sprague Electric Co., 347 Marshall Street, North Adams, Mass. 01247

SPRAGUE COMPONENTS

CAPACITORS	PULSE TRANSFORMERS	CERAMIC-BASE PRINTED NETWORKS
TRANSISTORS	INTERFERENCE FILTERS	PACKAGED COMPONENT ASSEMBLIES
RESISTORS	PULSE-FORMING NETWORKS	BOBBIN and TAPE WOUND MAGNETIC CORES
INTEGRATED CIRCUITS	TOROIDAL INDUCTORS	SILICON RECTIFIER GATE CONTROLS
THIN-FILM MICROCIRCUITS	ELECTRIC WAVE FILTERS	FUNCTIONAL DIGITAL CIRCUITS

48C-8130R1

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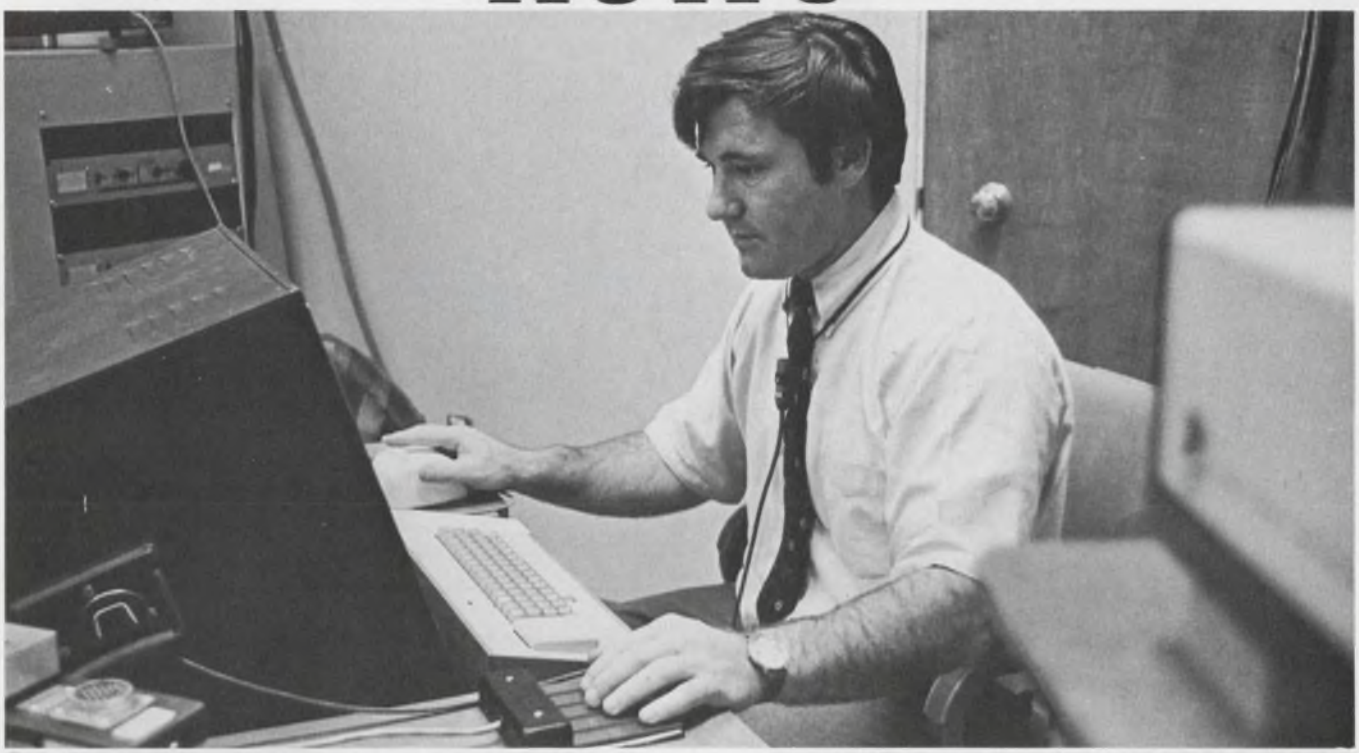
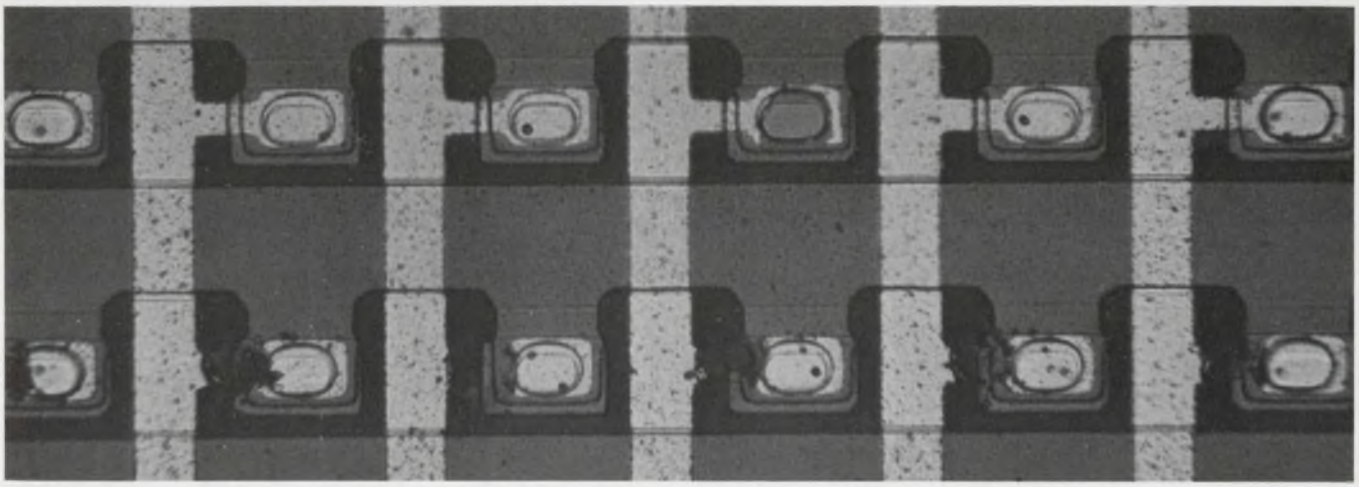
INFORMATION RETRIEVAL NUMBER 17

News



Spellbound by a graphic console, a Stanford Research Institute designer churns data into a computer by means of a "mouse" (right hand) and five "piano keys." This permits text to be written and modified without his eyes leaving the screen. Details on p. 25

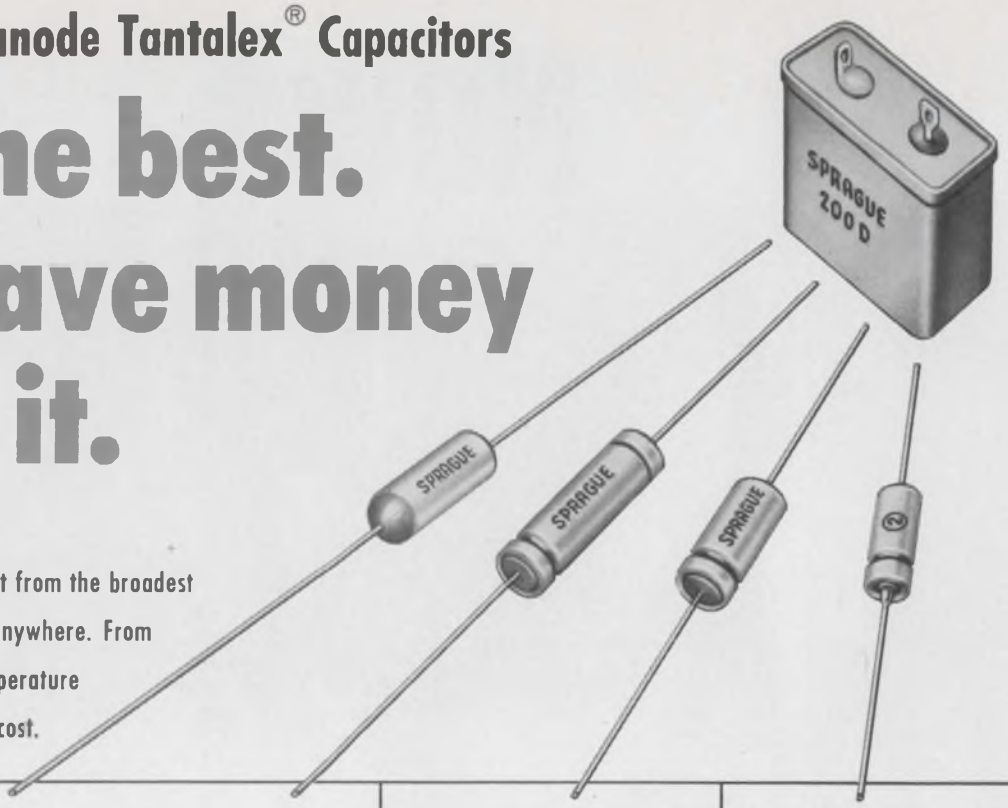


Silicon-on-sapphire memory was automatically fabricated by a computer-controlled laser operation at considerable savings in time and cost. See p. 34

Also in this section:

Wet-sintered-anode Tantalex® Capacitors

Buy the best. And save money doing it.



Here's how: Select from the broadest line of tantalum capacitors anywhere. From Sprague. The lower your temperature requirement, the lower your cost.

For operation to + 85 C		For operation to + 125 C	For operation to + 175 C
Type 145D	**Type 109D**	**Type 130D**	**Type 137D**
Volumetric efficiency up to 210,000 μF-volts per cubic inch. For use in miniature commercial/industrial printed wiring boards, packaged circuit modules, and wherever else cost and space are prime considerations. Elastomer end seal capped with plastic resin insures against electrolyte leakage and lead breakage. Available in voltage ratings from 6 to 75 VDC.	A superior design that meets all the basic military requirements for capacitors within this temperature limit. There is no compromise in quality. Voltage ratings from 6 to 150 VDC. **For extra large values of capacitance, use Type 200D or 202D package assemblies, which consist of several 109D - type capacitor elements in a hermetically-sealed case.**	Exceptional electrical stability due to chemical inertness of tantalum oxide film to specific electrolytes used, low diffusion of TFE-fluorocarbon elastomer seal, and special aging for 125C operation. Voltage ratings from 4 to 100 VDC. **Dual temperature ratings of Type 200D and 202D package assemblies give you extra high capacitance values for +125 C operation.**	Proven glass-to-metal hermetic seal qualifies these outstanding capacitors for use in satellites, missiles, and other critical aerospace applications. They have greater volume efficiency than has been previously available for wet-sintered-anode capacitors in this temperature range. Type 137D capacitors exhibit extremely low leakage currents. Available in voltage ratings from 2 to 150 VDC.
INFORMATION RETRIEVAL NO. 821	INFORMATION RETRIEVAL NO. 822	INFORMATION RETRIEVAL NO. 823	INFORMATION RETRIEVAL NO. 824

Select the capacitor type that meets your temperature requirements. That's how to save money. Specify Sprague Tantalex® Capacitors. That's how to get the best.

For complete information on Type 145D Capacitors, write for Engineering Bulletin 3750 (Type 109D, Bulletins 3700F and 3700.2; Type 130D, Bulletins 3701B and 3701.2; Type 137D, Bulletin 3703A; Type 200D and 202D, Bulletin 3705B) to the Technical Literature Service, Sprague Electric Company, 347 Marshall St., North Adams, Mass. 01247.

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THE BROAD-LINE PRODUCER OF ELECTRONIC PARTS

News Scope

U. S. 1970 budget raises spending for electronics

The electronics industry shouldn't find too much fault with the final budget request of the Johnson Administration. Proposed expenditures for fiscal 1970 for both electronics procurement and R&D are up slightly, compared with the total for fiscal '69.

Rises have been requested for electronics spending in the Commerce, Defense and Transportation Departments, while the NASA budget remains level. These four Federal organizations account for the bulk of the expenditures.

For the Defense Dept., the trend is evident whether looking at functional or program breakdowns. For example, expenditures for intelligence and communications have increased nearly $200 million, with a total request for $6.2 billion. Similarly, total R&D obligational authority has risen from $8.1 billion to $8.6 billion. Procurement has risen from $24.5 billion to $25.1 billion. And it's important to note that both R&D and procurement expenditures are heavily weighted toward electronic system needs.

On the R&D side, heavy expenditures either begin or continue for the Advanced Manned Strategic Aircraft, the two new F-14 and F-15 fighters, the VSX antisubmarine warfare aircraft, several air-to-surface missiles, the Airborne Warning and Control System, the Sentinel ABM system, and the Poseidon and Minuteman III strategic missiles.

Strategic weapons development, which has been on the back burner for the last few years while tactical weapons were being pushed, is emphasized in fiscal 1970. Just before leaving office, Defense Secretary Clark Clifford expressed concern over the rapid growth of the Soviet force of ICBMs—a situation already decried by the incoming Defense Secretary, Melvin R. Laird.

On the procurement side, the greatest increase is for the Navy, with over $2.4 billion assigned for advanced ship building. In addition the procurement of aircraft and missiles continues at a high rate.

The total NASA request is for $3.88 billion, or essentially the same as that approved by Congress last year. Of this amount, approximately $3.2 billion is for R&D and facilities. Over $2 billion of the NASA funds are earmarked for the manned space flight programs, and three-fourths of this is for Apollo alone. The rest is for further progress in building the Saturn-I orbital workshop and the associated Apollo telescope mount.

Another $500 million would be used by NASA for space science applications. A new effort this year is to be the Earth Resources Technology Satellite, a long-delayed effort. In addition nearly $300 million in spending is proposed for tracking and data acquisition. If NASA can get the request through Congress, it would also like to move to a flight model of the NERVA nuclear engine.

The Dept. of Transportation budget has been increased to $246 million for research alone. The total for '69 was $177 million. Most of the increase will go to the Coast Guard for the National Data Buoy System; to the Federal Aviation Administration for air traffic control and noise abatement, and to the Urban Mass Transportation Administration.

The Commerce Dept. largely holds its own, with an R&D budget of about $85 million. Most of this is for the Environmental Science Services Administration, for use in meteorological satellites and World Weather Watch program.

Federal efforts to attack growing crime in the nation are also reflected strongly in the budget. For the electronics industry, there is a $8.2-million request for research—double last year's request. These funds would be assigned largely to the National Institute of Law Enforcement.

Executive sees upswing in consumer IC market

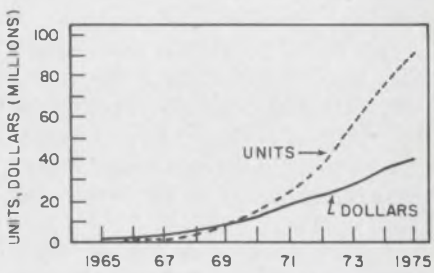
A growing consumer integrated-circuit market is forecast by Chris Goodman, Marketing Manager-U.S.A., Motorola Semiconductor Products, Inc. He predicts a steady rise that will make for a $23.5-million market by early 1972.

"The picture is changing," Goodman told a marketing luncheon given by H. H. Scott, Inc., in New York City. Progressive semiconductor vendors are tempting the entertainment industry by developing ICs to satisfy the standard requirements of selected types of consumer equipment."

Typical of these circuits is the MC 1304 fm multiplex demodulator, used in the new H. H. Scott 342C 100-watt fm stereo receiver. This circuit, and others like it, are expected to generate a market for standard consumer ICs.

"Wide acceptance of ICs by the consumer industry has been slow in coming," Goodman conceded, "because the linear circuits required are complex, and standardization is difficult. The consumer-product manufacturers have not been stimulated by competition to finance the development of ICs for their own use, and the IC vendors have been reluctant to develop the circuits without some assurance of subsequent high-volume contracts."

But with the advent of con-



A rosy outlook predicted for ICs in the consumer area.

sumer-product ICs, the outlook for vacuum tubes is increasingly cloudy, Goodman continued.

"The tube market for home electronics will decrease," he said, "in both dollar value and unit volume. There won't be enough tubes left in entertainment equipment to make a dent in the numbers game by 1973."

Tubes, Goodman forecast, will account for only 15% of the dollars spent by home-electronics manufacturers in 1975.

The Motorola marketing executive also predicted an increase in the use of voltage-variable capacitive diodes. "We've just about whipped the last remaining problems," he reported. "We will be able, in 1969, to inexpensively match two or more diode units to provide satisfactory frequency tracking."

And another component that Goodman expects to be used increasingly is the MOSFET. "These devices are superior to tubes," he said, "even in noise and cross-modulation characteristics, while they maintain the conventional advantages of transistors. We have now licked the two big problems—danger of damage during manufacturing and lack of long-term stability—and our sales of these devices are mushrooming."

Air Force takes over backup unit for Sage

A computerized center, newly built on sand dunes in North Carolina, has been turned over to the Air Force as the first unit in an air-defense system that would take over if Sage is ever destroyed.

The standby system, called Buic III (Backup Interceptor Control), will ultimately stretch throughout the United States and Canada (see "Redesign Strengthens Air Defense Backup," ED 19, Sept. 12, 1968, p. 25).

The first unit, built at Fort Fisher Air Force Station, N. C., provides a second line of defense against airborne threats to the East Coast from Atlantic City, N. J., to Savannah, Ga.

Buic III site at Fort Fisher, N. C., stands ready to take over for Sage.

Fourteen more Buic III sites are to become operational soon at other strategic points in the U. S.

F-14 contract worth billions to Grumman

Production of the Navy's VFX aircraft, now designated F-14, is expected to bring in at least $10 billion to the prime contractor, Grumman Aircraft Engineering Corp., Bethpage, N.Y.—and considerably more if the Air Force decides to buy the fighter, too.

The supersonic, carrier-based plane will have tandem seating for its two-man crew, a variable-geometry wing (swing-wing), a completely flat underside, flanked by two ski-like rails to carry bombs, rockets or missiles.

The F-14A, B and C will all be equipped to carry three air-to-air missile types—the Phoenix, that was developed by Hughes Aircraft for the deceased, overweight F-111B, the Sidewinder and the Sparrow III.

Last summer in congressional hearings, the Navy said the avionics for the F-14A and B would be the same that were developed for the F-111B. Since then, however, considerable changes seem to have been made. Although Grumman won't go into detail, a company official says that avionics specifications for the F-14A and B are set and industry will soon be competing for electronic subsystem contracts. (Grumman was the "associated contractor" for the F-111B, with General Dynamics acting as prime.) A new avionics concept is planned for the F-14C.

Total funding in fiscal year 1969 for the F-14 R&D was $160 million. In the 1970 budget, $225 million was requested for R&D and $239 million for leadtime production.

The next step is for Defense Secretary Melvin R. Laird to submit cost and design characteristics of the Grumman F-14 to House and Senate committees this week. Some Washington sources believe that the award may draw criticism because of Grumman's association with the canceled F-111B.

U.S. urged to set up oceanographic agency

A new, NASA-like agency has been proposed to direct the nation's oceanographic and atmospheric programs in the next decade at an estimated cost of $8 billion.

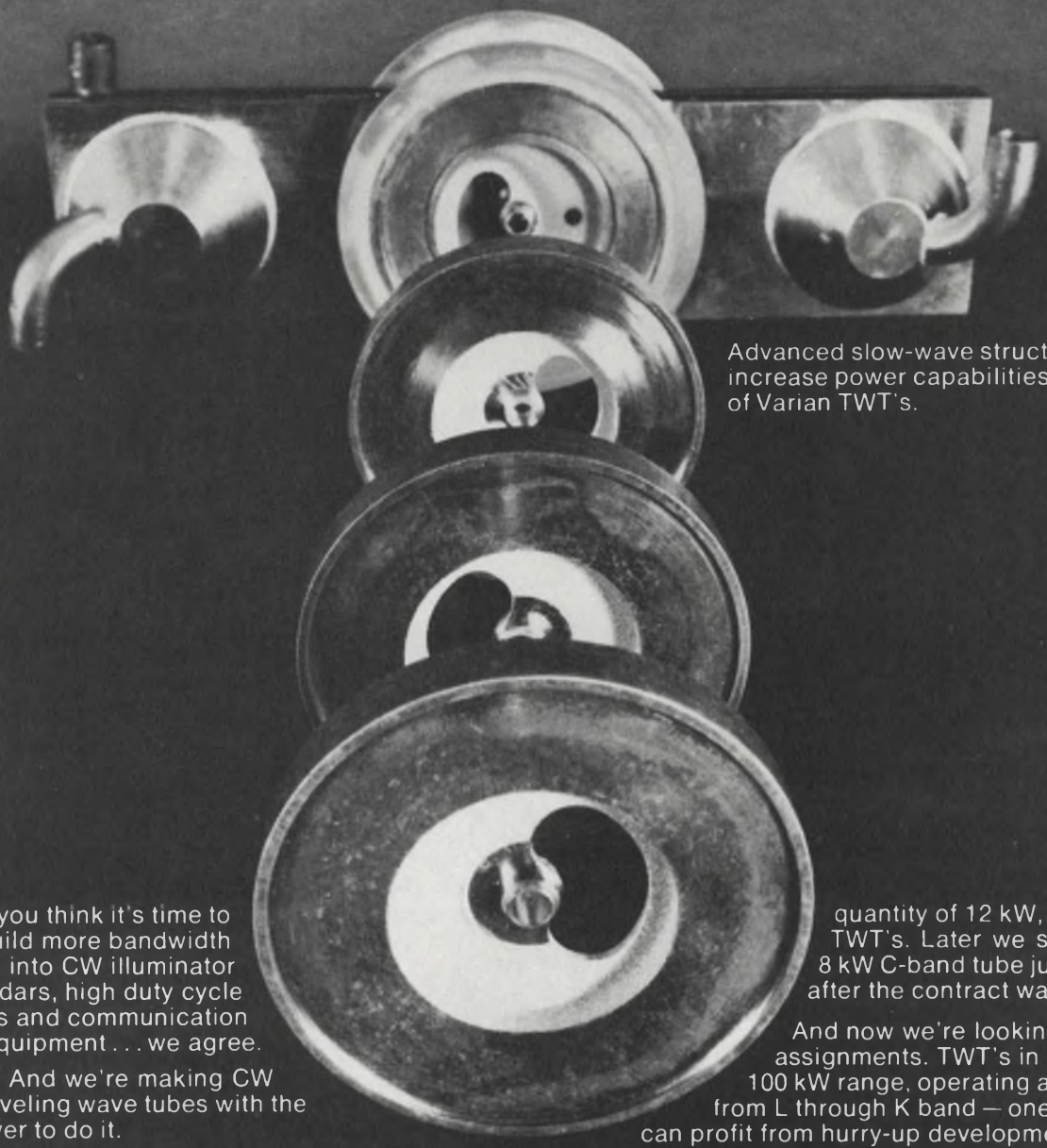
The recommendation is in a long-awaited report, "Our Nation and the Sea," by the Federal Commission on Marine Science, Engineering and Resources. The 15-man group, established by President Lyndon B. Johnson in 1966 at the request of Congress, urges the union of many existing Federal organizations into one entity that would be called the National Oceanic and Atmospheric Agency.

The commission members included experts varying from naval and oceanographic interests to the fields of education and law. The panel chairman was Dr. Julius A. Stratton, former Ford Foundation chairman and a past president of the Massachusetts Institute of Technology.

Although the commission recommends a trebled effort by the U.S. over the next 10 years—from the present $773 million a year to over $2 billion a year by 1980—Stratton stresses: "We are not proposing a crash program or an expenditure of great magnitude."

The commission's consensus, he emphasizes, is that "the time has come to move ahead" on a unified and purposeful national oceanographic effort.

More bandwidth for high power CW systems.



Advanced slow-wave structures increase power capabilities of Varian TWT's.

If you think it's time to build more bandwidth into CW illuminator radars, high duty cycle radars and communication equipment . . . we agree.

And we're making CW traveling wave tubes with the power to do it.

We've been working on high performance TWT's for quite a while, mastering slow-wave structures, their relation to total tube design, and setting up computer-aided procedures to optimize performance and cut design time. It's paid off.

Early last year we developed and delivered a quantity of 12 kW, S-band CW TWT's. Later we shipped an 8 kW C-band tube just 5 months after the contract was awarded.

And now we're looking for new assignments. TWT's in the 2 to 100 kW range, operating anywhere from L through K band — ones that can profit from hurry-up development.

Like to know more? Talk to our TWT Division, 611 Hansen Way, Palo Alto, California 94303, or any of the more than 30 Varian Electron Tube and Device Group Sales Offices throughout the world.

varian
twt division

TWO GREAT CONDUCTIVE PLASTIC PRECISION POTENTIOMETERS FROM BOURNS

MODEL 3438
SINGLE TURN
$8.00*

Units Shown Actual Size

MODEL 3501
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INFORMATION RETRIEVAL NUMBER 20

Man-Computer 'Partnerships' Explored

Interactive techniques are sought to show that computers can augment human intelligence

Robert Haavind
Managing Editor

In a room at Stanford Research Institute in Menlo Park, Calif., several designers sit at television monitor consoles, engrossed in messages that are continually being painted across the screens. The messages are aspects of design that each man is working on, and the designers are constantly expanding the messages by operating two devices.

One is a five-key instrument that the user taps with the fingers of his left hand. The other is a white plastic object with three buttons on top that can be rolled over the desk top beside the display. A dot on the screen moves in synchronism with the rolling of this plastic "mouse."

The goal of these SRI designers is to develop system techniques that would permit people to use the computer as an "intellectual partner" in their daily work. Whether the worker is a circuit designer, computer programmer, manager or scientist, such system methods would enable him to couple the powerful calculating, organizing and memory capabilities of a large computer to his own thinking.

This mode of computer use, called interactive computing, differs radically from the way in which most computers are used today. In batch processing, today's normal procedure, a complete problem is analyzed to develop an approach suitable for computer solution. Then a program is written and fed into the computer, and, when all calculations have been completed, final answers are delivered. No changes can be made while the problem is running, unless they have been called for in the program.

By contrast, in interactive computing the user could observe intermediate results at various steps of the computing process. Then he could make changes, or even completely redirect the solution. Or he could actually work the problem out himself, using the computer only when calculations had to be made, or alternate choices evaluated.

This approach is being pursued at SRI, Lincoln Laboratory, and other research centers. The SRI team is using the present version of their interactive computing system to achieve further development of the system. They are, in effect, using the system to develop the system!

Things that annoy or impede progress often become the next area for improvement. And in the process of making the improvements, the team members recognize needs for further improvements.

"Intellectual bootstrapping" is the term used by Douglas Englebart (see cover), principal investigator for the Center, in describing this approach.

Dr. Englebart envisions the computer as a tool that can allow men's minds to reach new levels of achievement. Thus his program at SRI is known as the Augmented Human Intellect Research Center.*

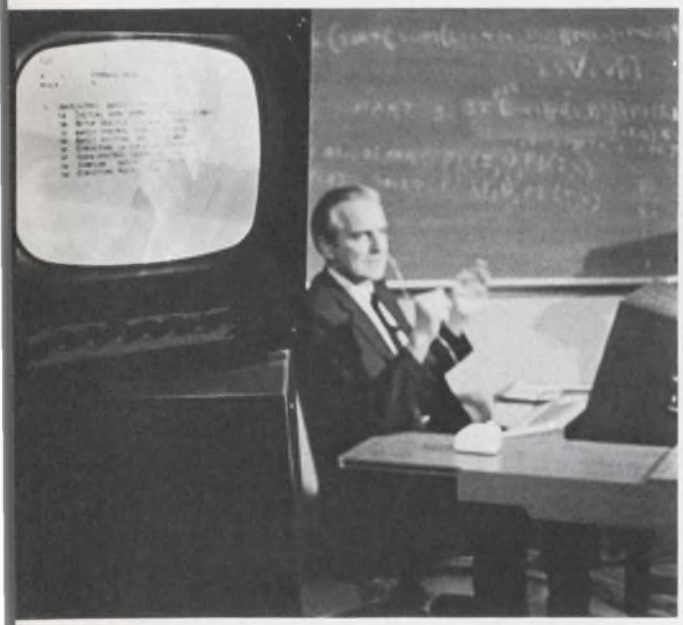
The ways in which intellect can be enhanced involve more powerful methods for structuring, storing and retrieving, and manipulating large amounts of information. Thus bits of data, portions of articles, reports or books, notions, suggestions, insights and other types of information can be assembled in random fashion over a long period of time. Yet all these pieces can be organized in several ways as they

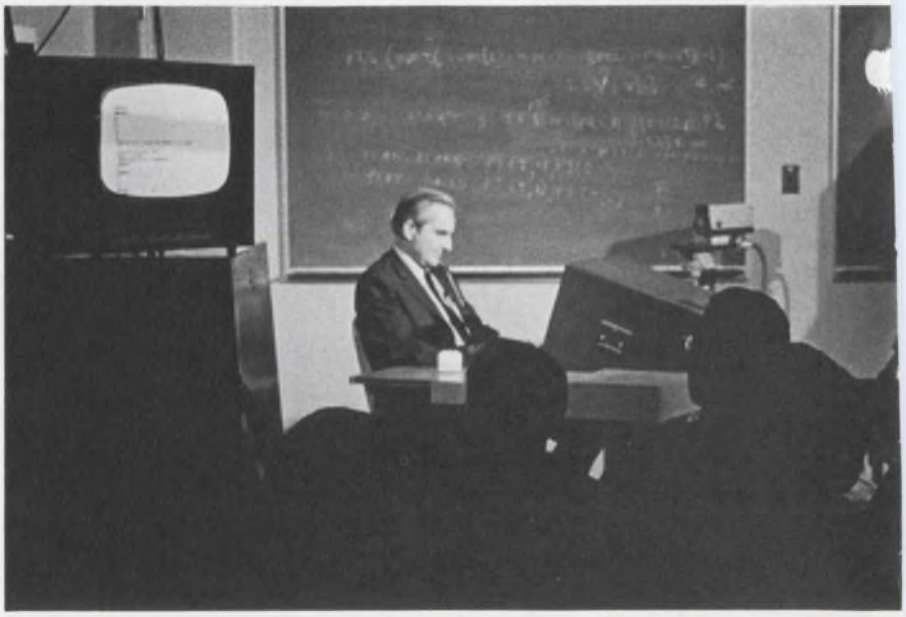
* Sponsored by Advanced Research Projects Agency (Information Processing Techniques); NASA's Langley Research Center, and Rome Air Development Center.

SRI researchers demonstrate the use of interactive computing with graphics for group discussion of a system design. General files, as well as individual files, all in the process of development, can be examined, modified or added to by the group. The system being designed is the system they are using.

Can computers augment intelligence?
Can intellectual workers, given the proper tools to interact easily and rapidly with a computer, enhance the quality of their thinking? Definitely, contends this team of SRI researchers, who are shown here using some of the tools described in this article. To prove their point, they are using their own tools to further the development of their system—a form of intellectual bootstrapping. In this fashion, they are steadily removing annoyances and blocks to achievement, and restructuring their computer languages, programs, and hardware.

SRI photos by Carl J. Moore





(**interactive,** *continued*)

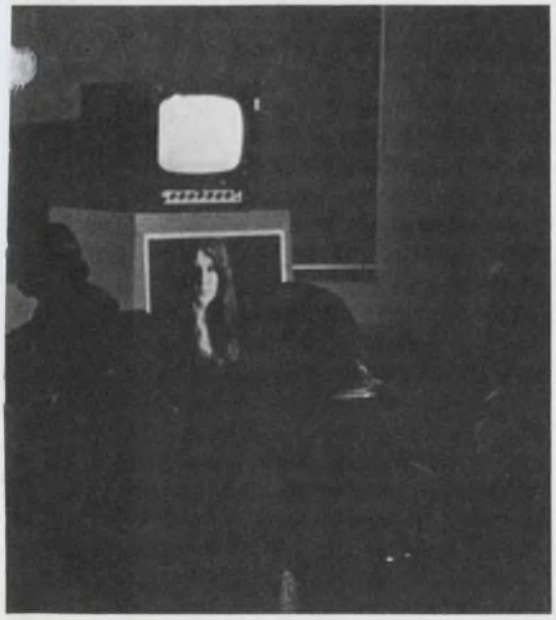
pertain to various aspects of a complex project, so they can be retrieved in seconds any time later by following any one of several trails. Another gain might be made in the structuring of complex arguments so that the person himself, or some other person, can review at any time the steps that led to some conclusion.

Whether the SRI group proves the validity of this contention or not, most of the other researchers in the field agree they have already moved ahead of any other research group in the ability to organize and manipulate textual information rapidly. Because of this capability, the SRI system has been chosen by the Defense Dept.'s Advanced Research Projects Agency to be the information center for the agency's nationwide computer network.

So far the SRI Center has dealt only with textual information, although it is now just beginning to investigate graphics. So why are they using display consoles?

Speed is critical to improving performance, thus allowing more difficult problems to be attacked in an interactive fashion. The graphic display is presently the fastest means available.

But a graphic console is not a panacea. They can be very expensive, and techniques must be carefully worked out so that the operator can proceed smoothly.



(**interactive,** *continued*)

The SRI system approach includes special provisions that attack both of these problems. The heart of the system is a Scientific Data Systems 940 time-shared computer. The system includes a 65-K, 24-bit core memory with a 4.5-megabyte swapping drum and a 96-megabyte disc file. Text drawn from the computer is displayed on a high-resolution, 5-inch CRT. This is then picked up by a precision (875-line) closed-circuit television system camera. Two character generators each feed up to six precision CRT-TV camera combinations. The TV cameras each feed a 17-inch television monitor in the center's "workshop."

This display approach is unique and offers several important advantages. A low scan-beam current can be used in the cameras, so that a short-term image storing effect is achieved. This allows the display on the monitor to be rewritten, or refreshed, as few as 15 times a second without noticeable flicker to the eye. This is vital because the need to refresh a television display—continuously 30 to 40 times a second with normal phosphors—cuts down on the maximum amount of data that can be presented at one time. The cost of a small CRT-TV camera, amplifier-controller and monitor is about $5500 per work station. This compares with about $10,000 needed to buy a similar-sized random-deflection CRT.

Also, the expensive part of the system is centrally located. Additional monitors that could tie into the television camera could be added for about $600 each.

The mouse rolls

The five-key handset and mouse mentioned earlier are crucial elements in user convenience. The mouse has two wheels, set at right angles, beneath it. As these wheels spin, they drive X and Y potentiometers that control coordinate selection on the monitor. A dot on the screen moves in accordance with these signals. Thus the user can move his dot to some point on the screen, and then start to write in a message at that point.

One way to write in is through the use of a keyboard. But the five-key handset allows the user to enter data quickly without looking away from the screen. The handset operates according to binary codes. Thus an "A" is typed in by pressing the left thumb, a "B" by pressing the left forefinger, a "C" by tapping both of these at once. Now, if the right buttons are pressed on the top of the mouse, the operator can begin to write in lower-case letters or, alternatively, numerals or a set of special symbols. In addition the keys can be used to enter control instruction.

The combination of the two units allows the user to intersperse text and various symbols with control actions.

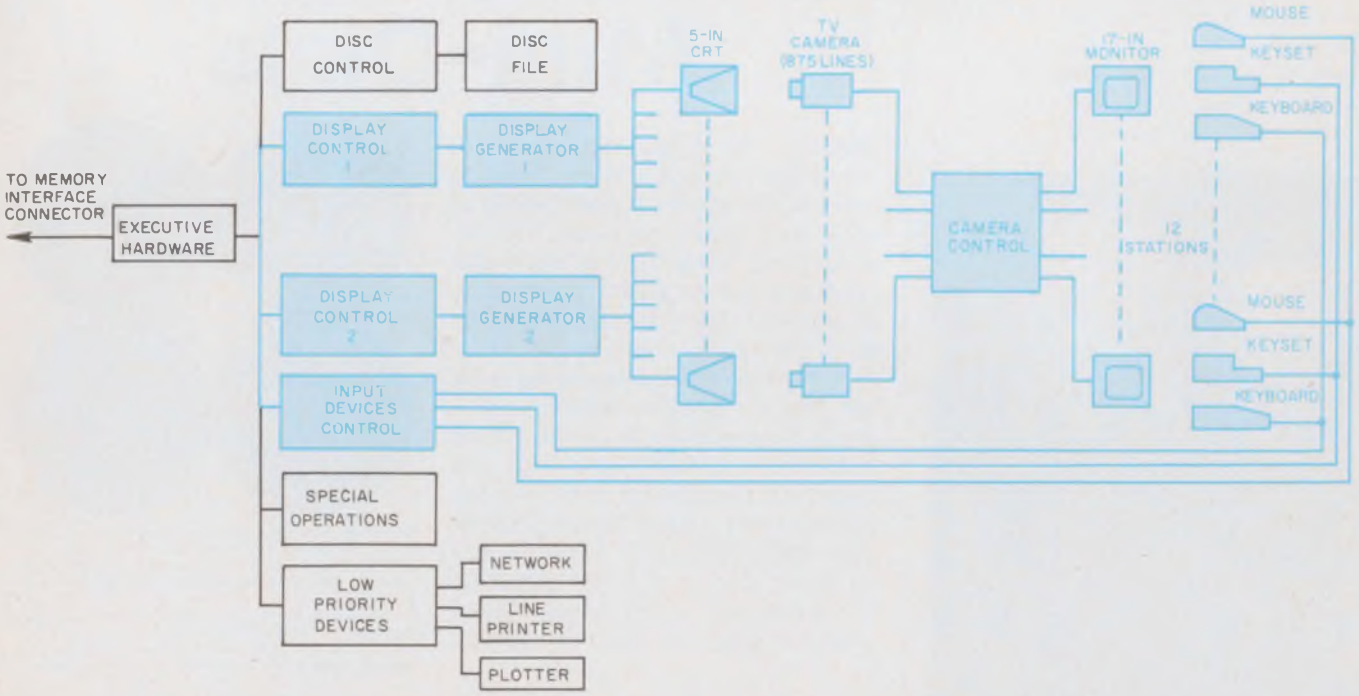
It is clear that some training is needed to become proficient at using the SRI equipment. In addition some mneumonics and programing details must be memorized. Note the group of memory aids pasted around the periphery of a display unit in one of the photographs on page 26.

It's like driving a car

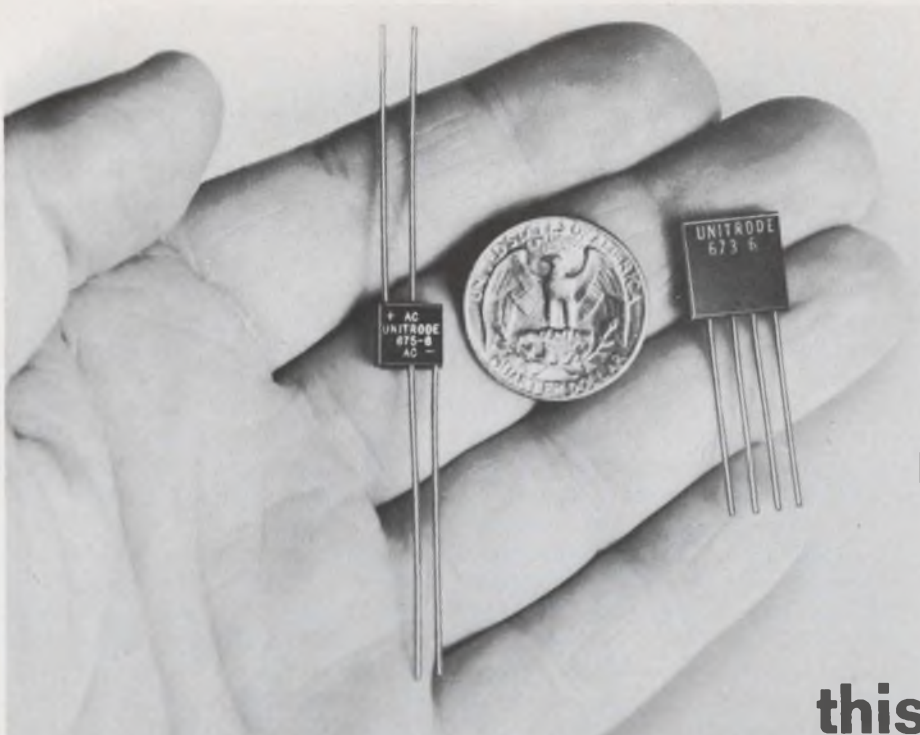
David Casseres, technical writer for the center, describes learning to use the system as being somewhat like learning to drive a car (he drives a small standard-shift foreign car.)

"But it makes you feel that if you only knew how to fly, you could become a jet pilot," Dave says.

The answer to evolving interactive computing systems that give the user the "jet pilot" feeling is



1. **On-line computing system** used at SRI includes 5-inch precision CRTs whose presentations are picked up by a high resolution TV camera and then transmitted to one or more 17-inch monitor consoles. This keeps costs down for expanding the number of user-consoles, since these cost only about $600 each.



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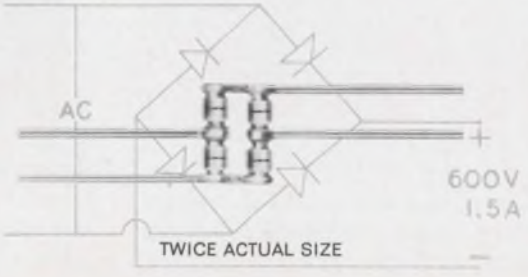

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INFORMATION RETRIEVAL NUMBER 22

(**interactive,** *continued*)

not a hardware problem, says Dr. Walter Sutherland of Lincoln Laboratory, Lexington, Mass.

Dr. Sutherland says the hardest thing to achieve is a software system that does not require the user to be aware of the programing. One reason this is so difficult is that each type of user needs the system for different things. Often he is not even aware of these requirements until he actually starts going to work on his specific problems. Thus the need is for a general system that incorporates all the things that will be needed for many different types of activity, and that allows different sorts of functions to be easily added as the need for them becomes apparent.

The types of computer languages that are being developed for this sort of activity must thus be highly modular and they must be very carefully structured.

Fortran, for example, the most widely used of computer languages, is highly internally linked so that changes or additions must be carefully considered.

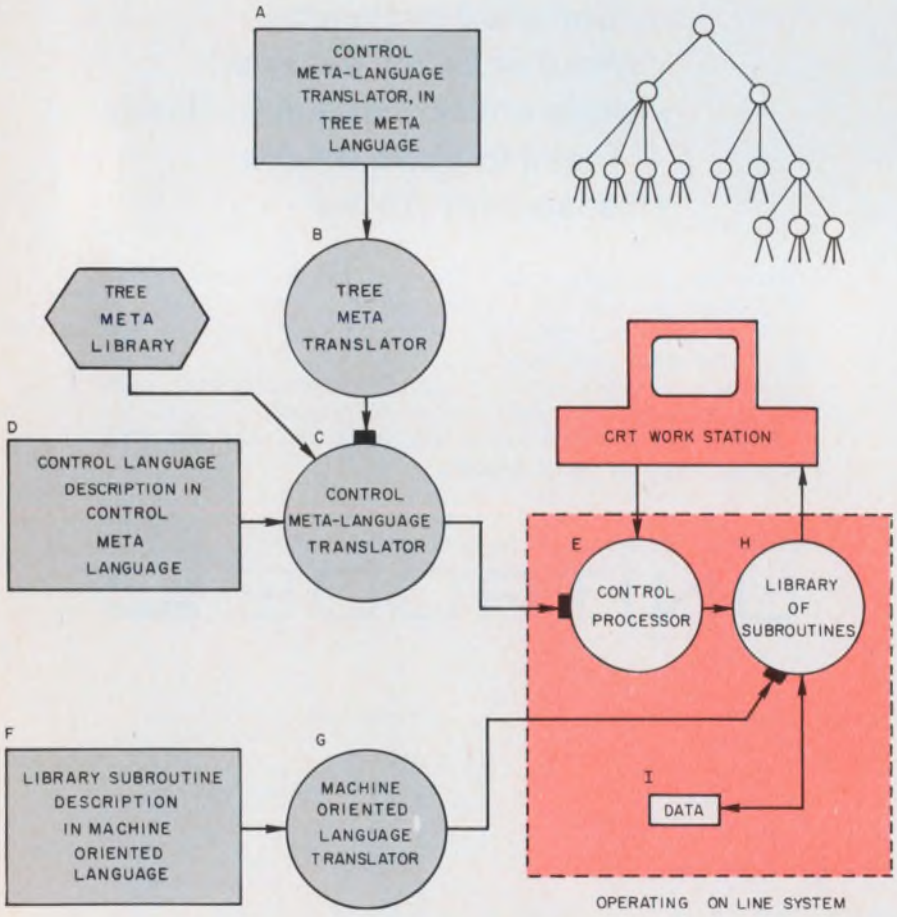
The structure problem was the first to be faced in starting to organize the augmentation system concept. Early time-sharing systems had organized material in "pages," a carryover from the structure of printed books. But this did not prove to be efficient, primarily because of the long time intervals expended on continually swapping large amounts of material between core and drums.

Dr. Engelbart chose to organize material in a tree structure because of its advantages for structuring stored files. An analogy might be the title of a book, the chapter titles, then the subheads within a chapter. Thus an initial screen presentation might give the title and chapter titles. The user would then select a chapter title, and the list of subheads within that chapter would appear.

In addition the actual material included under any particular heading is broken into arbitrary pieces called "statements." The length of a statement is limited by the amount of material that will fit on a single screen presentation. Some statements, however, may be only simple portions of a sentence. In one case, the material might be a portion of an article that the user wants to store. In the second case, the user of the system may be formulating his thoughts as he does early work on some problem.

The basic organization of material is expressed with a sequence of numbers and letters. For example, statement 1C4B6, is the sixth member of group B under the fourth member of category C, etc. In addition a statement can begin with a word in parentheses, and then that word becomes the title of the statement. Then, in any other statement, that statement can be referred to by the same title in parentheses. Another way in which statements can be identified is by means of placing a marker, some symbol, next to one or more statements. This allows a user to gradually build up additional organizational schemes for his material.

Several other schemes for moving around within a large file are provided. Statements before or after the statement being viewed, or at the head or tail of the particular subcategory can be called.



2. **A hierarchy of languages** help give the on-line graphical interaction system its flexibility. The tree structure used for organizing information for quick retrieval (upper right) is a basic principle upon which the system is designed.

Unfurling the scroll

If the user always went through his file in the normal sequence, it would be like looking at a long scroll, unfurling a frame at a time. There are three ways in which he can vary this movement through the file: level clipping, line truncation and content filtering.

In level clipping, all statements will be skipped whose level is below a specified point in the hierarchy. Thus, if the third level were specified, no statements below the third level—that is, below 3 or C—would appear.

A truncation command tells how many lines of each statement to show. A "1" says that only the first lines will appear, for example. Content filtering is performed by specifying statements that the user wishes to view by means of a high

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INFORMATION RETRIEVAL NUMBER 23

(**interactive,** *continued*)

level content-analysis language. For example, statements in which the words "memory" and "allocation" appear within four words of each other might be drawn out.

These sorts of operations, and the basic functions involved in doing such things as deleting characters, words, lines or statements, are accomplished by a variety of system languages. The subroutines performed by the SDS 940 are written in a special machine-oriented language (MOL) developed by the SRI group (see Fig. 2).

When working on line, the Control Processor (E in Fig. 2) receives and processes successive user actions. It calls subroutines from the library (H) to do such things as locating data in the file, manipulating working data or constructing displays based on the sorts of commands described previously. These library subroutines (in H) are produced from machine-oriented language programs (F) which are translated by the MOL translator (G).

This combination of languages permits programmers to modify existing functions, or to perform a reasonable range of changes or additions to the functions, often by simply revising the control language record.

The SRI designers are now facing some of the tricker problems in getting their system to work smoothly. Each user is assigned a certain number of data blocks on a storage drum. As he adds to his working file places are developed for each additional statement at the proper place in the file. If some data are no longer required, he can not at present "close the gap" left when he eliminates information. Thus some provision will have to be evolved to sort out the holes left in the file by deletions, and to close it up. Also the present scheme does not allow jumping from branch to branch in doing content searches. The system must travel up a set of connected branches to the top of the tree, and then down a new set of branches.

The widespread use of interactive computing will thus have to await considerable further development, both at SRI and elsewhere, to reach economic feasibility for most organizations. ■■

An hour's work with an interactive computing system . . .

How will designers of the future make use of the emerging interactive computing systems? Here is a theoretical preview, based on techniques now under investigation.

Andy Handy, design engineer, settles down before a display screen at one side of his desk. After flicking the equipment on, he types in his identification. The screen displays a number of queries, to which he enters the date, the titles of the programs he is using, identification of the system he is helping to design and the subsection and a particular circuit.

In a moment an unfinished circuit appears on the screen. At various points there are waveshapes and small response curves. Andy had left it in an incomplete state the day before. At the top of the screen a message blinks: "SYSTEM CHANGE." As Andy presses buttons, the circuit becomes a box linked to other boxes, and then a group of these become another box linked to more boxes. Finally a new set of boxes appears, representing the composition of the entire complex system. Blinking at the top of the screen now is a block of text and numerals with the words "SYSTEM CHANGE" for a title.

With some quick key-tapping, Andy returns to the section he is working on and draws forth details of the effects of the overall system change on his own subsection. Now he zooms back in on the circuit he had started to work on.

After examining some response curves and trying some parameter variations, Andy decides that he is going to have to make some basic modifications if the circuit is going to work at all. Recalling an article, a technical report and a portion of a book—information he read in the last couple of years and that might have some bearing on his problem—he taps some keys and brings a listing onto the screen. Choosing an item from this listing, he obtains a new listing, from which he makes another choice. After several steps in this fashion, the article is displayed.

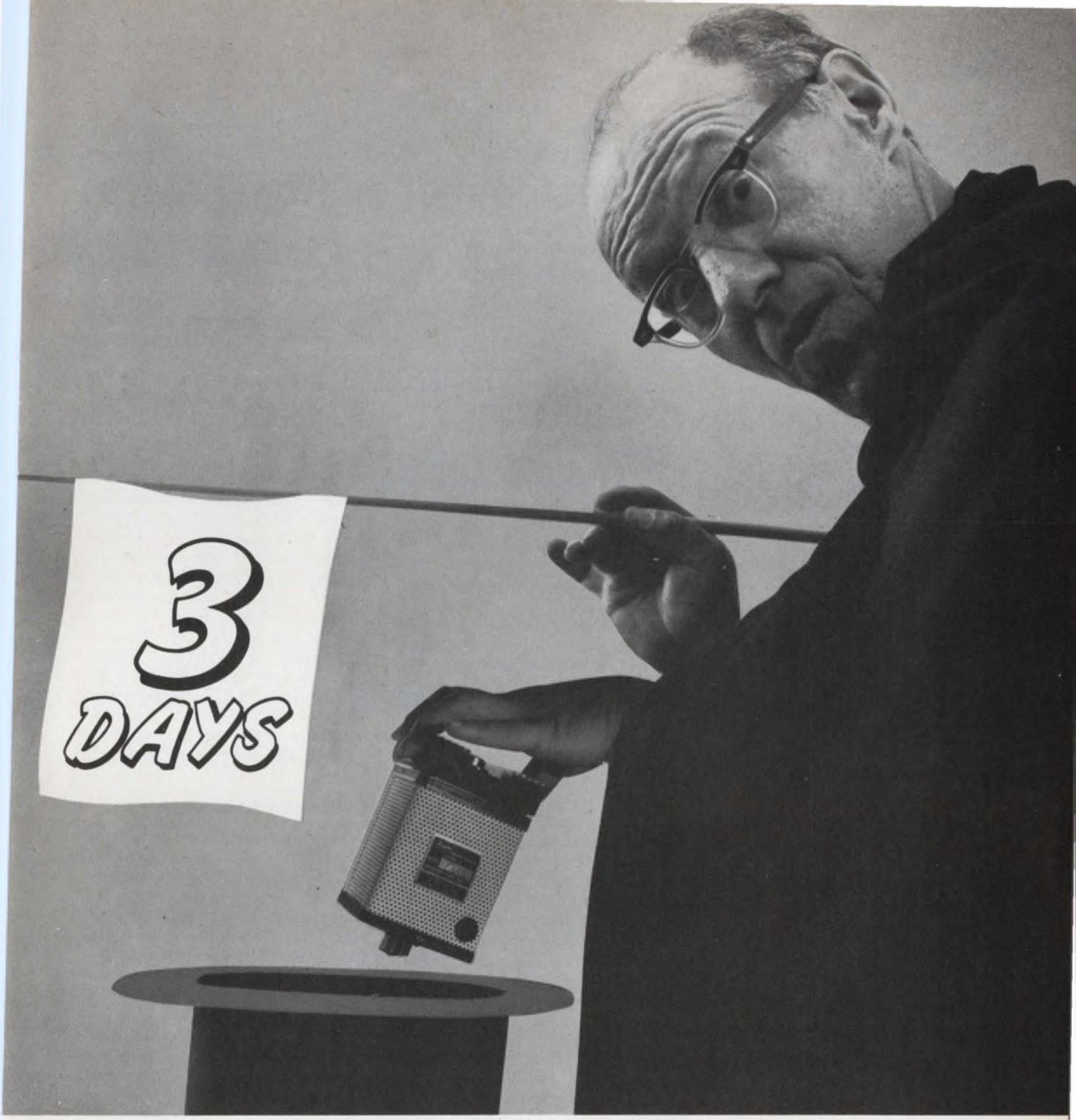
He shifts page by page until he comes to the part he's interested in, and makes some coded notes at the bottom of the screen to use as a reminder when he returns to his circuit work. He rapidly locates the technical report and the portion of the book, and in each case makes some more notes labeled with a code similar to the one he used for the notes on the article.

Now he returns to his circuit, cancels a portion of it, displays his notes and quickly works out a new configuration. He assigns values, observes responses, changes values, sets up an iterative procedure to reach an optimum response condition and then sits back for a few seconds. Then the word "SOLUTION" blinks on the screen, and a set of values appears next to the various elements of the circuit.

Satisfied, he begins to draw from a computer-stored file in sequence, pages of catalog data on the types of parts involved in his finished circuit. He sets up some cost/performance equations for a section of the circuit and rapidly narrows his choices.

Returning to the circuit design, Andy designates the specific parts that will be used and then indicates that his work on this section of circuitry is complete. In a few minutes, he knows, orders for the proper devices will be printed out and charges will be entered in the engineering department accounts for his design work. The production department will be informed of the circuit configuration so it can prepare to tool up for its portion of the task. Meanwhile the system design project manager will be notified of all these steps, and will be able to zoom down to the tiny circuit to see that the work meets with his approval.

Andy gets up and stretches, ready for the morning coffee break and satisfied that an hour's work has been well done.



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Laser method slashes cost of custom arrays

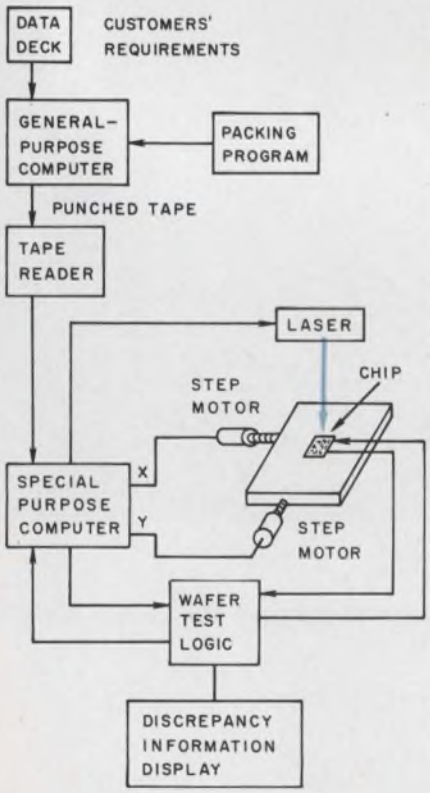
For $10, automatic system removes diode metal connections through the substrate in a few hours

Elizabeth deAtley
West Coast Editor

A computer-controlled laser operation that encodes semiconductor read-only memories automatically promises to reduce drastically the cost of custom units and the time required to get them.

The cost of encoding a single unit can be held to about $10, with completion in a few hours, according to the developer of the new method, compared with a few hundred dollars and a few weeks with conventional methods.

Developed by Autonetics, a division of North American Rockwell Corp., Anaheim, Calif., the operation uses a laser beam to remove selected metal connections in an integrated diode array (Fig. 1). Connected diodes are defined as logic "1," and disconnected diodes as logic "0."



1. **Automatic encoder-tester** can encode and functionally test a 1024-bit array in 5 minutes.

The laser, which is set up on a mobile table, is focused on the metal, but it can do its job through any optically transparent medium. So says Allen D. Sypherd, designer of the system.

In the case of silicon-on-sapphire devices, Sypherd says it is possible to stockpile completely packaged units and encode them on order (see box). Leakage in these devices is negligible, he reports, because of their very small junction area. Thus exposure to light does not cause leakage problems, as it would in a standard MOS or bipolar integrated circuit.

The few-hours interval to complete the custom operation includes access to a central computer and production of a punched tape.

"This approach has the most dramatic application in the area of custom read-only memories where only a few units are required," Sypherd says. "For example, in developmental work where an engineer isn't certain that a read-only memory meets his specification, he doesn't want to pay $400 or $500 and wait several weeks for a custom mask to be made and one or two units run through the line. With this new capability, he doesn't have to.

"This technique makes it possible to consider applications that were never feasible before. For example, projecting into the future, I can imagine in 10 or 15 years from now there may be a laser encoder in the corner grocery store—just like the tube tester of today. The housewife will plug in her blank array, encode her favorite cake or pot-roast recipe and use the memory to control her automated kitchen."

In operation (see block diagram) a deck of cards containing the customer's encoding instructions is fed into a general-purpose computer, such as an IBM 360, together with a packing program that contains instructions for moving the array bit by bit. The computer produces a punched tape, which has instructions for moving the table and firing the laser.

A 12-bit memory in the special-purpose computer stores instructions for selecting one bit position out of a 1024-bit array, as well as for firing or not firing the laser at that position and for testing. In each bit position, a comparison is made with the input requirements. If a diode is not required at that position, the laser is instructed to fire. The array is then retested, to make sure the disconnect is complete.

After one bit has been encoded and tested, the tape reader inserts the data and instructions for the next bit position into the computer memory. The process is repeated, until the entire array has been encoded and functionally tested.

It takes only 30 seconds

The number of cards required to make the tape for a 1024-bit array varies from 15 to 30, Sypherd says, depending on the complexity of the instructions. The total computer time required to produce the tape is about 30 seconds, counting loading time. A 1024-bit array can be encoded in 5 to 10 n inutes. This could be significantly reduced, Sypherd says, with a faster laser. However, this would increase the cost of the equipment.

He estimates that the new laser system, including tape reader, laser, movable table, testing equipment and special-purpose control computer, could be built for $5000 to $25,000, depending primarily on the speed of the laser required.

The laser being used by Autonetics is a neodymium rod type that was custom-built for this function.

Asked why he did not use commercially available lasers, Sypherd said he had investigated a number

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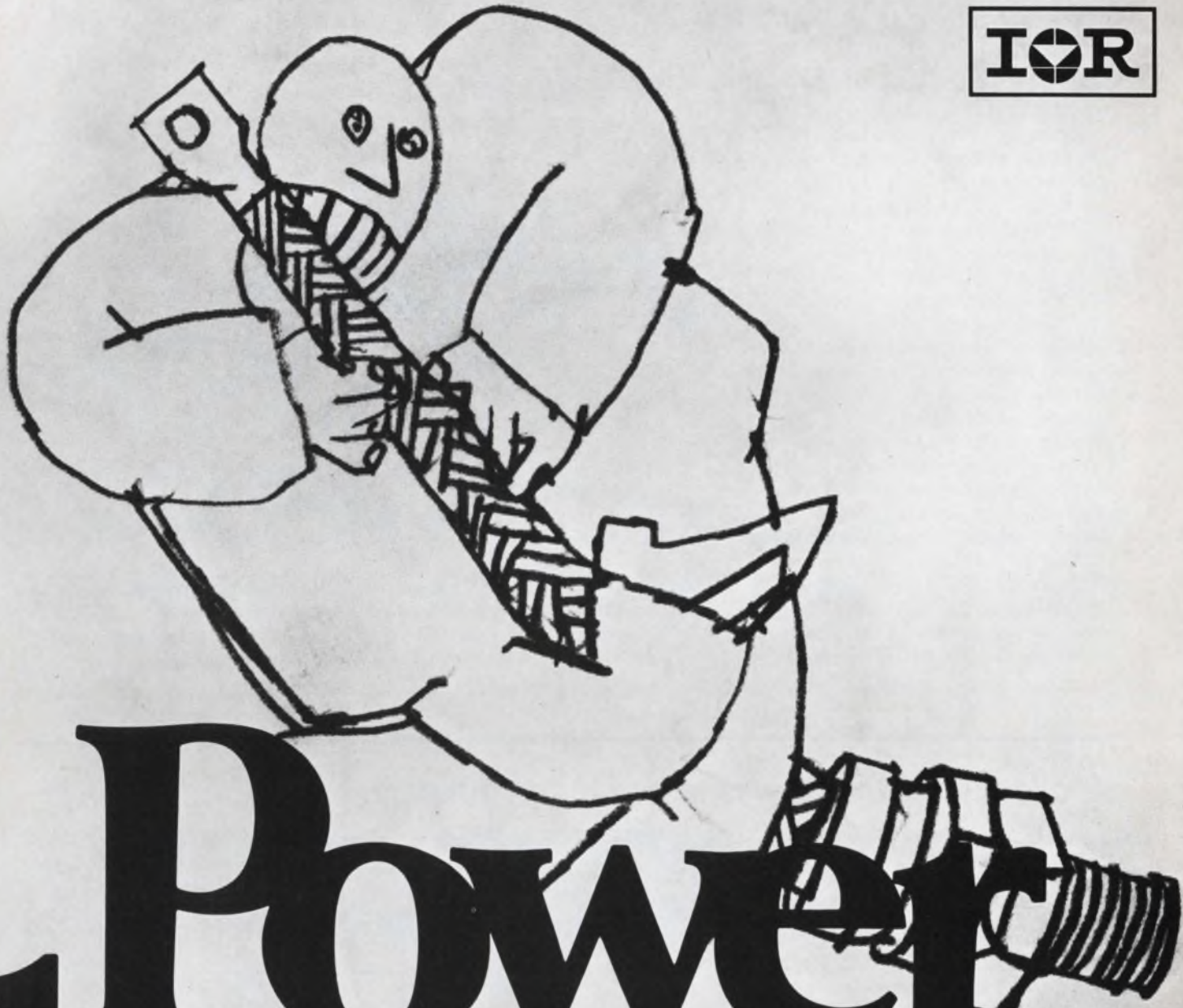


Power hungry.

(**Laser method,** *continued*)
and had found them too powerful for the purpose. They tended to damage the sapphire substrate, he said.

However, a YAG laser manufactured by Korad, a division of Union Carbide, Los Angeles, has been used to remove metal from integrated circuits. Rod Waters, manager of applications engineering at Korad, says the laser was introduced at the Western Electronic Show and Convention in 1968. It sells for $20,000, including special optics that allow the operator to direct the beam to the desired spot on the circuit. Although the equipment is normally used for trimming thick and thin-film resistors from a ceramic substrate, Waters says, it has also been used to remove metal from monolithic integrated circuits.

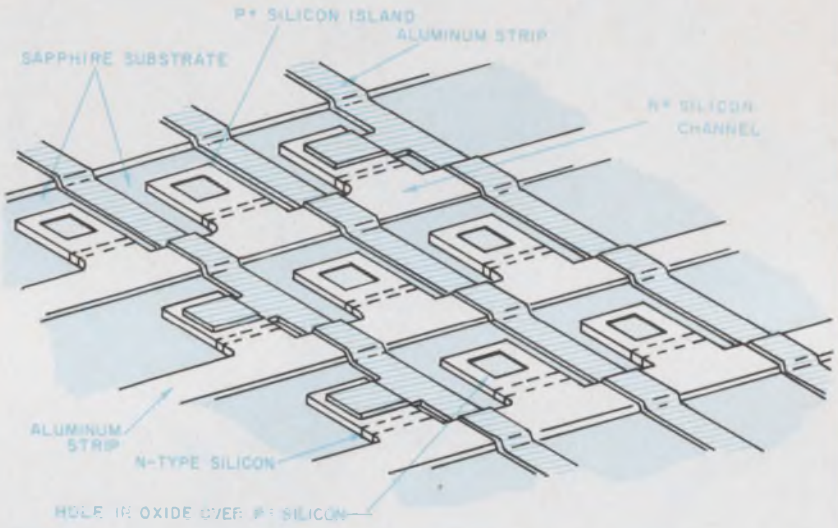
Questioned about the Korad equipment, Sypherd said he had not been aware it could be used for this purpose. ■■

Birth of a silicon-on-sapphire array, step by step

A silicon-on-sapphire array is made by growing a film of n-type silicon 1 micron thick on a sapphire substrate and following with two diffusion steps:

1. A network of p+ islands is diffused into the silicon.
2. An n+ channel is diffused between each row of p+ islands, leaving a narrow strip of n-type silicon at what will become the diode junctions. This n-strip is left to increase the breakdown voltage of the diodes.

The next step is to isolate n+ from p+ everywhere except at the junctions, by selectively etching down to the sapphire substrate. Metal strips are then deposited at right angles to the n+ channels, and small flaps of metal connect with the p+ silicon through holes in the oxide covering the p+ island. An oxide



layer over the silicon lines insulates the two conductors at the crossovers in the matrix.

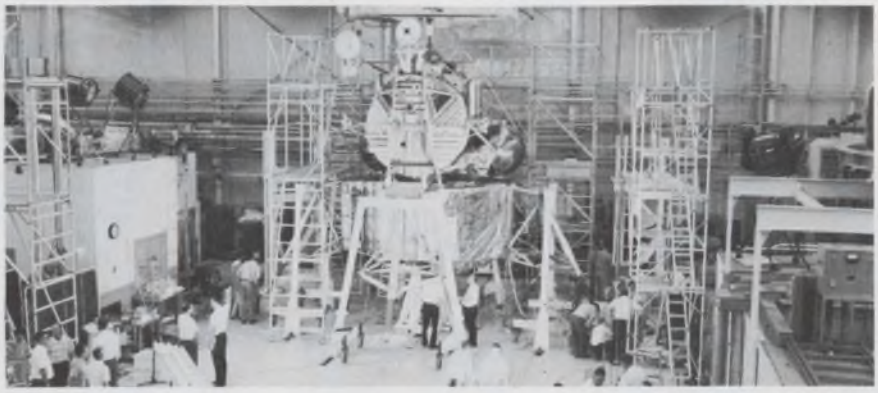
Encoding is done by removing the metal flaps from diodes that are to represent logic "0." The remaining metal-covered diodes represent logic "1."

Apollo lunar module was tested to the nth degree

The lunar module, scheduled to take two astronauts to the surface of the moon and back to the orbiting command service module this summer, is one of the most thoroughly tested items in the whole Apollo program.

During early vibration pad testing (see photo), Grumman engineers mounted transducers on key areas of the lunar module structure. These generated data signals that were processed by a constant-bandwidth frequency-division multiplex system and recorded on magnetic tape. Some 140 channels of data were displayed on an oscillograph for reference and analysis.

A time-code generator, developed by Chrono-log Corp., Broomall, Pa., provided a code that was recorded



Lunar module on isolation platform undergoes vibration testing at Grumman's Environmental Laboratory at Bethpage, N. Y.

on magnetic tape along with the data obtained during the vibration studies. This made it possible for engineers to compare data at any particular instant in time as well as learn the precise moment of resonance or failure of any part of the LM structure. ■■

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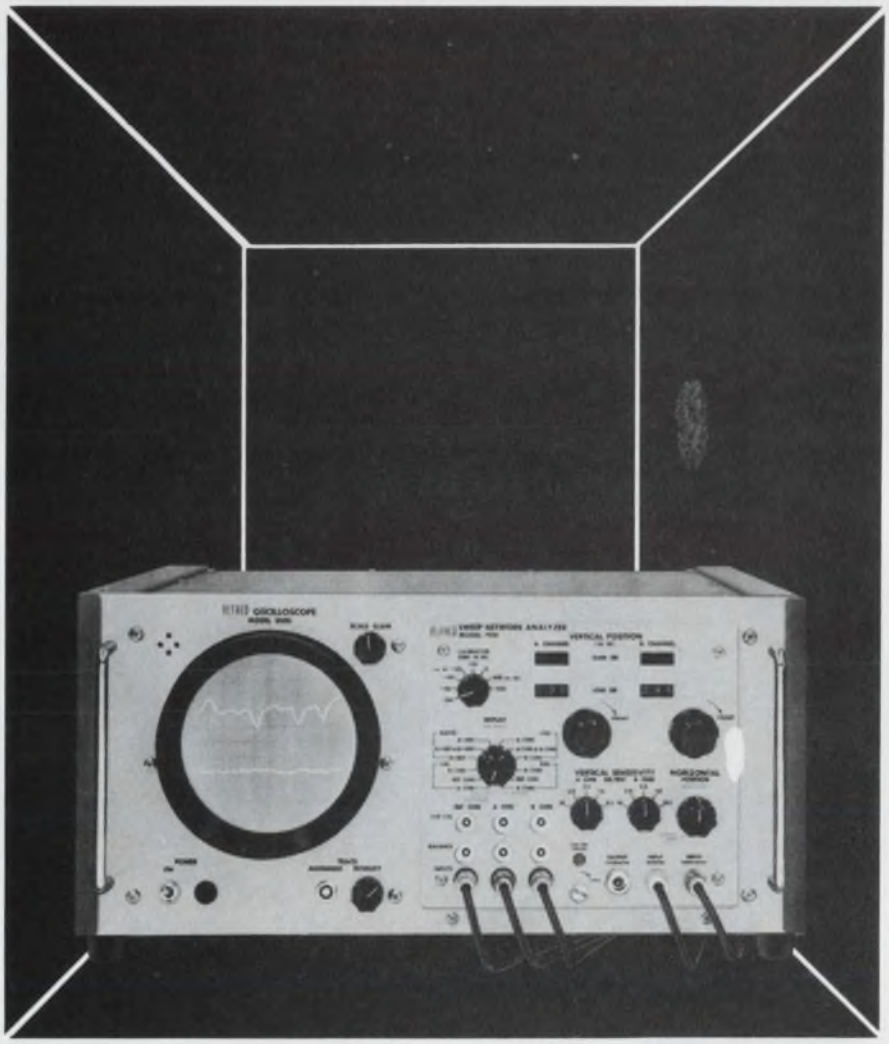

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Applications notes 101 & 105 tell all. For complete information on the Alfred 8000/7051 Sweep Network Analyzer, please write for Applications Notes 101 and/or 105. Note 101 provides detailed applications data for all measurements, including noise. Note 105 offers information on the use of the analyzer to test microwave transmission systems, including coaxial cable and waveguide runs. Please address Alfred Electronics, 3176 Porter Drive, Palo Alto, California 94304. Phone: 415-326-6496. TWX: 910-373-1765.

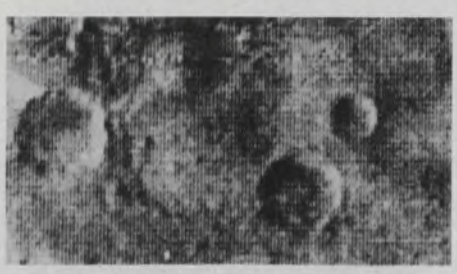
ALFRED ELECTRONICS

INFORMATION RETRIEVAL NUMBER 27

Washington Report

CHARLES D. LAFOND
WASHINGTON BUREAU

Mars: to be part of the Grand Tour



Ten-year space flight contemplated

Although only token funds will be drawn from the NASA budget this year for the so-called "Grand Tour" of neighboring planets, space agency officials are expected to seek funding for the program during fiscal year 1971. Dr. Thomas O. Paine, NASA's acting administrator, has stated that such a program must be initiated by late fiscal 1971 or early fiscal 1972, if we are to take advantage of the launch window that is due to open up in 1977.

The Grand Tour involves launching a highly instrumented, unmanned spacecraft into deep space at a time when the outer planets are in such alignment that a spacecraft can best take advantage of their "grab-and-whip" gravitational effects in its voyage around the solar system. This ideal condition occurs only at roughly 150-year intervals. Thus, if a launch is to be made in our own time, it must be done in either 1977 or 1979.

According to Dr. John E. Naugle, associate administrator for Space Science/Applications, the trip to Mars, Jupiter, Saturn, Uranus and Neptune will require just under 10 years. Cost of such a program, he says, will depend on the type of spacecraft and launch vehicle selected. Naugle estimates a $1 billion cost, if a 1600-lb vehicle is launched atop a Titan IIID/Centaur. A more costly, but much heavier, payload could be sent into space by using the giant Saturn V with a nuclear final stage. The latter could provide continuous propulsion throughout the mission and would permit greater flight flexibility.

Costs aside, many problems remain to be solved associated with the venture. Dr. Paine says that, in advance of the Grand Tour, space probes must further study the meteoroid belt beyond Mars and investigate the intensity of the magnetosphere around Jupiter. While state-of-the-art electronics technology probably can provide onboard systems that are capable of operating for as long as ten years, a more critical problem exists with regard to fuel storage systems: Fuel tanks must be developed that are capable of retaining pressurized fuels throughout this long a time span.

The communications problem, by itself, is not deemed critical.

NASA to continue UFO studies?

Some UFO stalwarts apparently are hard to convince. One of these is Rep. William F. Ryan (D.-N.Y.) who takes issue with the recently released "Scientific Study of Unidentified Flying Objects," prepared under an Air Force contract by the Univ. of Colorado. The findings in that report indicate that ". . . further extensive study of UFOs probably cannot be justified in the expectation that science will be advanced thereby." Rep. Ryan countered on the floor of the House by urging the President to ". . . give this responsibility to NASA."

He urged "that NASA be required to submit a yearly report on the UFO problem to the President, to the Committee on Science and Astronautics of the House of Representatives, and to the Committee on Aeronautical and Space Sciences of the Senate."

Over a year ago the Air Force, apparently fed up with criticism of its research and evaluations of UFO sightings, moved to blunt charges that its investigating teams were

Washington Report CONTINUED

covering up a potential threat to Earth. It gave a $500,000 contract to the Univ. of Colorado, which, in turn, established a team of scientific experts—all civilians—to look into the problem. Their report essentially corroborated previous Air Force conclusions. Before the report was released, it was reviewed by the National Academy of Sciences. That prestigious body added its stamp of approval to the study's conclusions.

Rep. Ryan believes the report errs in recommending that an end be made to UFO studies. Says the Congressman: "At a time when astronauts are exploring outer space and preparing to land on the Moon, it is remarkable that the UFO problem should be discounted." He further declares that the Government ". . . has an obligation to continue to explore every facet of this problem until all the evidence—scientific and otherwise—is in."

Laird against strategic parity

Prior to his confirmation as Defense Secretary, Melvin R. Laird let it be known before the Senate Armed Services Committee that he was opposed to a policy that sought to achieve world armament balance through strategic parity. He expressed concern over the inconsistency shown in the Soviet attitude toward peace and declared that, as Secretary of Defense, his primary responsibility would be to assure maintenance by the U. S. of superior military force. With this approach he asserted, this nation can ". . . always negotiate from a position of strength."

While undergoing committee questioning, Laird was asked by Sen. Margaret Chase Smith (R.-Me.) to state his position on the desirability of maintaining nuclear parity between the U.S. and the U.S.S.R. Laird answered that "I disagree with that theory. It is is absolutely important that the United States maintain a superior position."

Laird also indicated that the Soviet's display of military force in Czechoslovakia had served to set back U.S.-U.S.S.R. missile negotiations by as much as one year.

Apollo 8 support critical

While the Apollo 8 spacecraft and its three-man crew held the world's attention last December, a whole series of unmanned space vehicles that provided critical backup support received much less notice. Among these were 13 spacecraft that provided direct support, and at least eight others that offered indirect support. The satellites provided the highly acclaimed television relay and handled NASA's global tracking communications, provided the meteorological data that cinched the launch date and the splashdown location, and monitored solar radiation. Some of these vital spacecraft were launched and made operational only a few days before the start of Apollo 8.

For communications, the older Intelsat II spacecraft stationed over the Atlantic and Pacific Oceans were joined only three days before launch by the larger Instelsat III. Together with ATS-I and -III satellites, they relayed TV broadcasts to many parts of the world and filled gaps in NASA's communications network.

For weather prediction, a new weather satellite, ESSA VIII, was placed in orbit six days before the Apollo launch. Data from all ESSA satellites, combined with reports from hundreds of surface stations, were processed for NASA's use by the Spaceflight Meteorology Group at Suitland, Md.

The solar-orbiting Pioneer satellites and the HEOS-I, which is in elliptical orbit between the Earth and the Moon, worked to supply continuous reports on cosmic radiation, the strength of the solar wind and the extent of solar storms.

Split personality

This new Hewlett-Packard instrument can't decide if it's a wideband RF sweeper or a versatile signal generator. No wonder—it's both.

Covering 100 kHz to 110 MHz, the HP 8601A Generator/Sweeper combines the high linearity and flatness of a precision sweeper with a signal generator's frequency accuracy and wide range of calibrated power levels. Though it's small and lightweight, it does the work of two instruments easily and conveniently.

As a sweeper, its 0.5% linearity and 1% frequency accuracy give you calibrated displays without having to use markers. Output flatness is ±0.25 dB over the full range. Three sweep functions—full, video and symmetrical—let you shift from broad to narrow sweep with the flick of a switch. You can vary the sweep speed, fast enough for flicker-free display, slow enough for high-resolution recording. And set the trigger for manual, line sync or free run.

As a signal generator, the 8601A output is accurate to ±1 dB from +13 dBm to −110 dBm. The digital frequency dial is accurate to 1% of frequency; higher accuracy is achieved with 0.01% crystal checkpoints at 5 MHz intervals. Internal modulation is 1 kHz, AM or FM, or you can modulate externally.

The HP 8601A offers many more features that satisfy a wide range of lab and production requirements. Price: $1975.

No sense developing a split personality yourself, struggling with several instruments. Let your HP field engineer give you complete details on how the HP 8601A alone can fill your RF sweeper *and* generator needs. Or write to Hewlett-Packard, Palo Alto, Calif. 94304; Europe: 54 Route des Acacias, Geneva.

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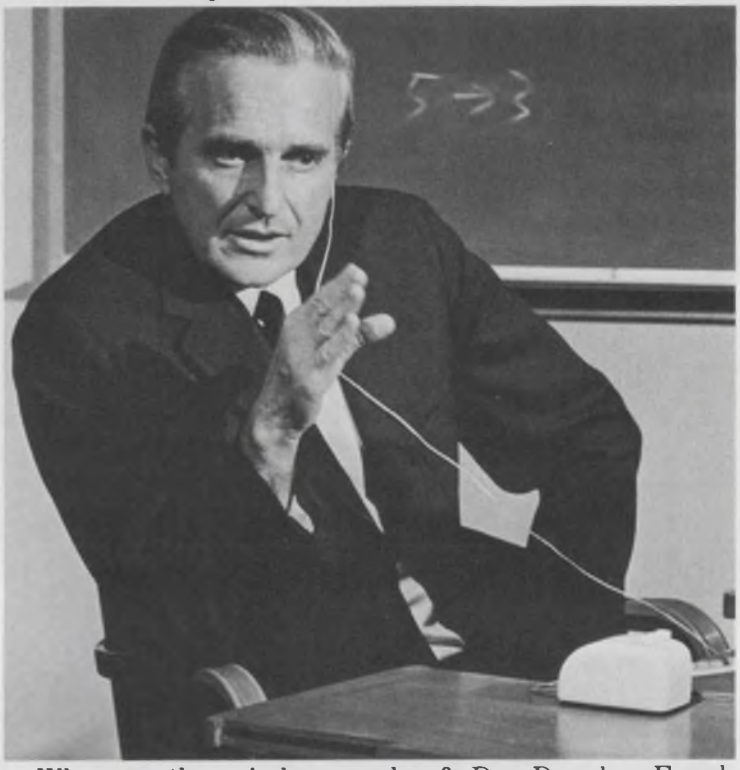
INFORMATION RETRIEVAL NUMBER 28

SIDELIGHTS OF THE ISSUE

Meet the mind expanders



Who are the mind expanders? Dr. Douglas Engelbart (photo above and on the cover) is one. He uses the computer to augment human intelligence. Englebart is principal investigator for the Stanford Research Institute's Augmented Human Intelligence Research Center.

Some years ago at MIT, where he first began his work, Englebart concedes, he was known as "something of a nut." During this period he met someone who perked up at the mention of his name:

"Englebart? Oh, yes, I've heard of you. You're the—" and the man balked self-consciously.

"Nut?" Englebart volunteered.

"Yes," said the new acquaintance, "but a *solid* nut."

For an insight into the solid progress that Englebart and his not-so-nutty group are making at SRI, turn to page 25.

And speaking of the mind . . .

. . . You, too, can be creative

Is it possible to increase your brain power? If you are intelligent, can you be turned into a creative engineer who can solve complex problems in unique ways? Dr. Wilmer C. Anderson, research director of the General Time Corp., Stamford, Conn., says it's possible. But —and it's a big "but"—a company must establish the proper environment, and engineers who would improve must apply themselves seriously.

Starting on page 66, Dr. Anderson, who holds more than 40 patents for ideas he has developed, gives some basic hints on how to put a creative program into practice.

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This model is supplied ready for operation with all the required electronics, integral power supply, attractively-styled cabinet with satin-finish aluminum trim and even a roll of paper. Just plug it in!

The printing mechanism slides forward on full-suspension, ball bearing glide rails for complete inspection and quick, easy paper loading. Series 800 units are uniquely flexible, with great capability in small space. The price is lower than for other printers that are a generation behind!

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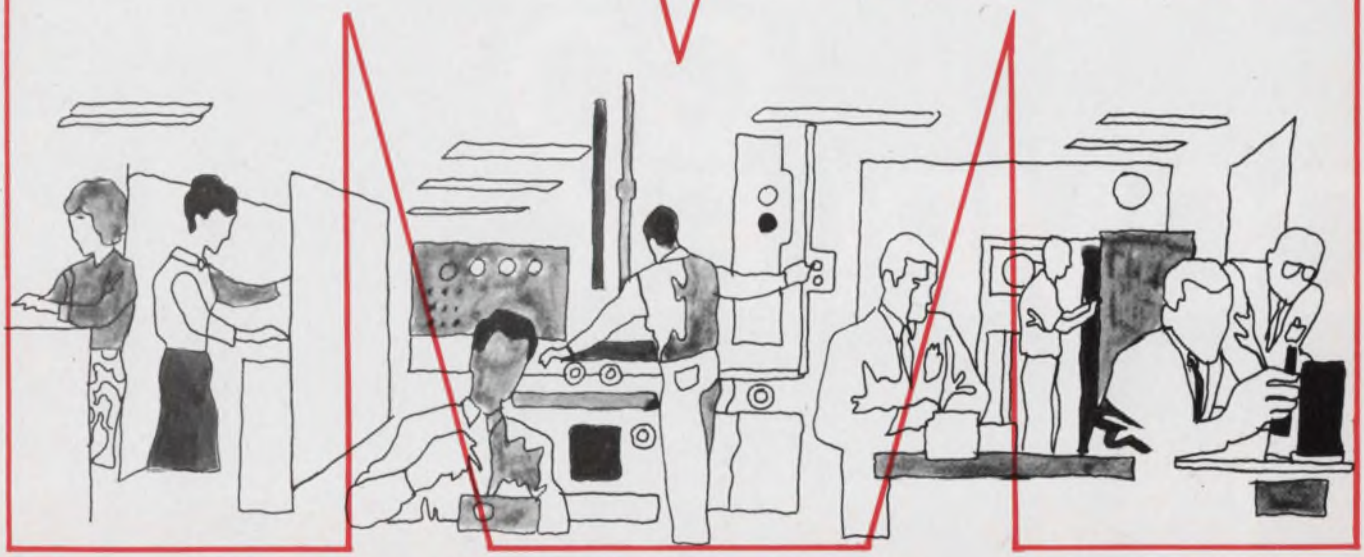

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In real life that LSI measures 0.116″ by 0.082″. A little smaller than a large size fleck of pepper.

In real life it's a Tomorrow MOSFET. With all the earmarks of Tomorrow.

Like a two-volt threshold for compatibility with existing bipolar logic—with the ability to operate at higher voltage levels.

With lower channel resistance.

We think all complex arrays will be built that way someday. So you'll have a freer hand in design. So they'll operate faster. Use up less power. And eliminate level translators.

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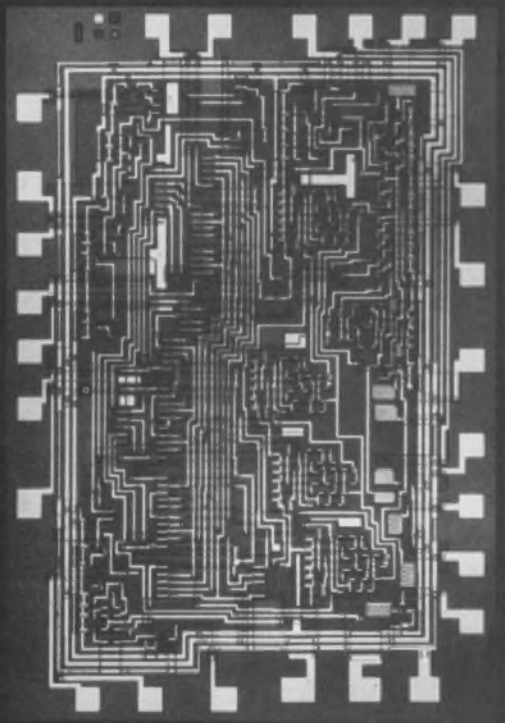

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EDITORIAL

Turnover is a fact of life: It's here to stay

Job hopping among managers and executives has risen fivefold since the Korean war years, according to a recent article in FORTUNE (November 1968). The article—a sixteen-year project of Prof. Eugene E. Jennings of Michigan State University—cited a study of 1500 executives in 500 large corporations in which it was found that job hopping was especially prevalent with managers who were one-to-five years out of college—particularly among those who had been on their first job for 30 to 40 months.

Aerospace firms, for example, reported that their managerial-professional losses were up from 1.5 per cent a year to 18 per cent; for electronics firms, they were up from 2 to 17.9 per cent.

Is this a temporary phenomenon? Or does it represent a completely new development in company-employee relations?

Many psychologists believe that job switching represents more than a passing phase. They predict that, more and more, tomorrow's middle managers and top executives are going to have this itch to move on. Jennings found that "movement is no longer a means to an end but an end in itself. In mobility, the manager finds a challenge incomparably greater than that faced by the previous generation." He says that "the new generation finds that mobility brings competency, whereas the premobile generation (back 20 years or more) believed that competency brought mobility."

How can corporations live with the growing problem?

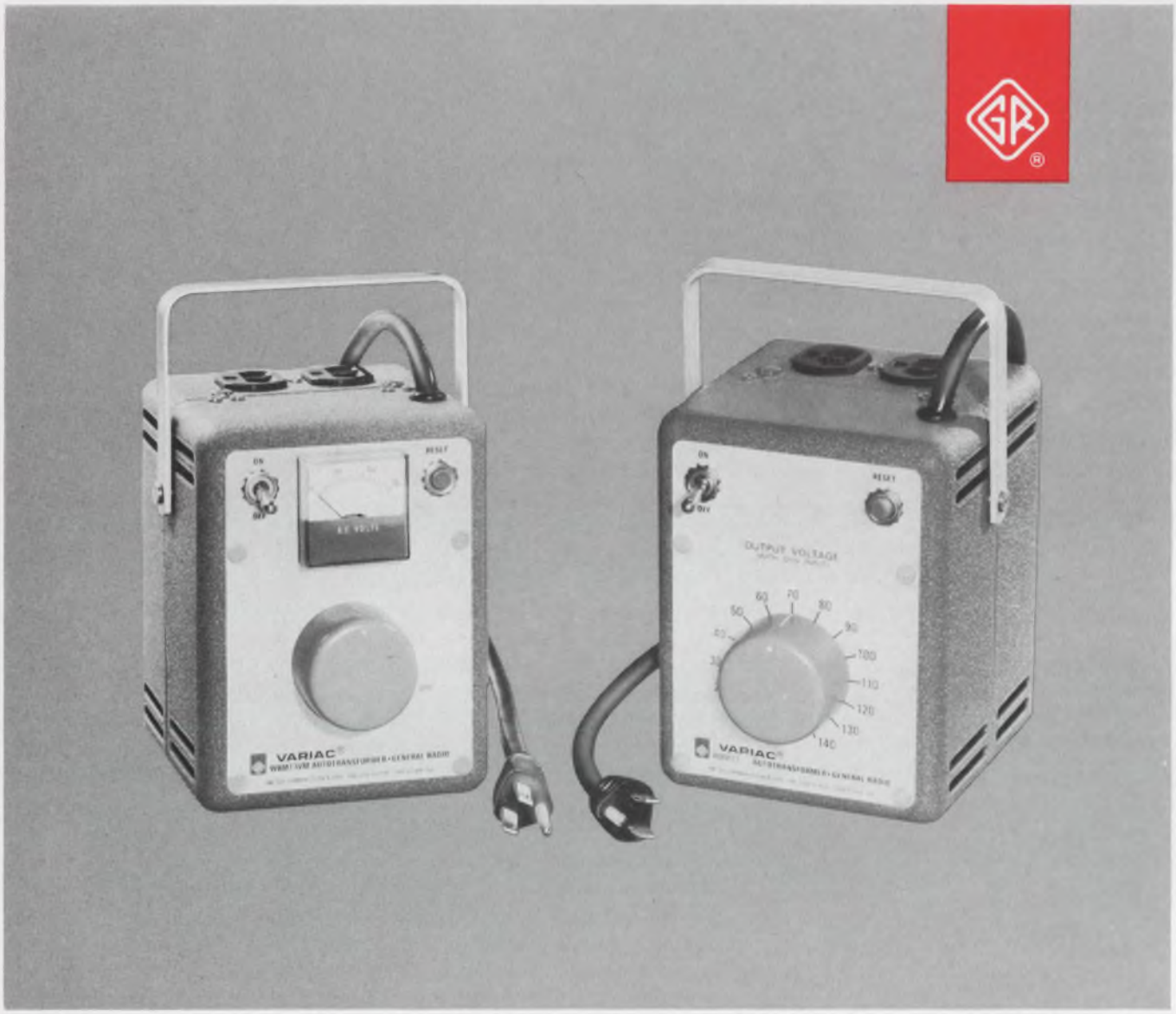
They can, of course, try to hold on to their valued employees by not hiring applicants who exhibit traits similar to those shown by employees who resigned. But, as the FORTUNE article notes, this is a surefire formula for mediocrity. Studies have shown that the men who leave are, often, better than the men who stay on.

Another approach is to provide a bundle of super-rapid promotions, fat salaries with frequent raises and lush stock options to win loyalty. The problem here, as noted, is that with this approach mediocre men tend to be locked in for life. Second-raters soon begin to clog the channels of advancement.

Again, there is no simple way out of this dilemma. Companies must realize that it is better to risk the occasional loss of good men than never to have attracted them in the first place, or, worse yet, to suppress their yen for greener pastures with rewards they do not really seek. The wise company will make the most of its highly talented men, while it can; it will even help them pursue their development elsewhere.

What we think it means is this: cede to the ablest members of the corporation what the corporation rightly insists upon for itself; namely, the right to maximum choice and mobility.

RALPH DOBRINER



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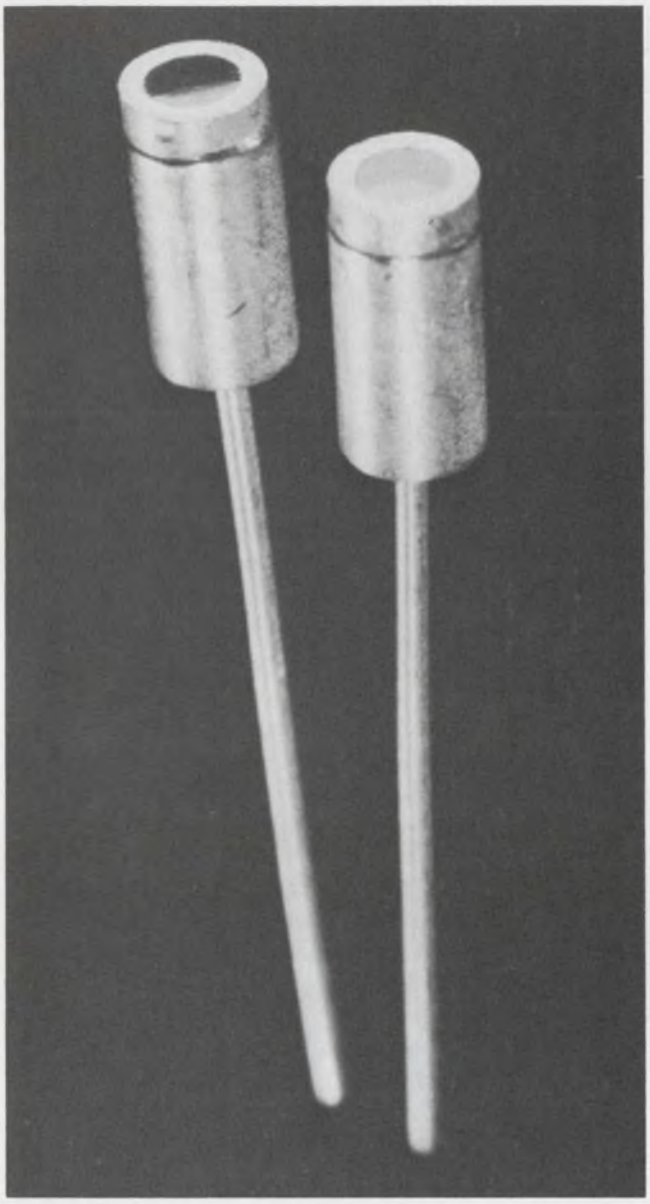
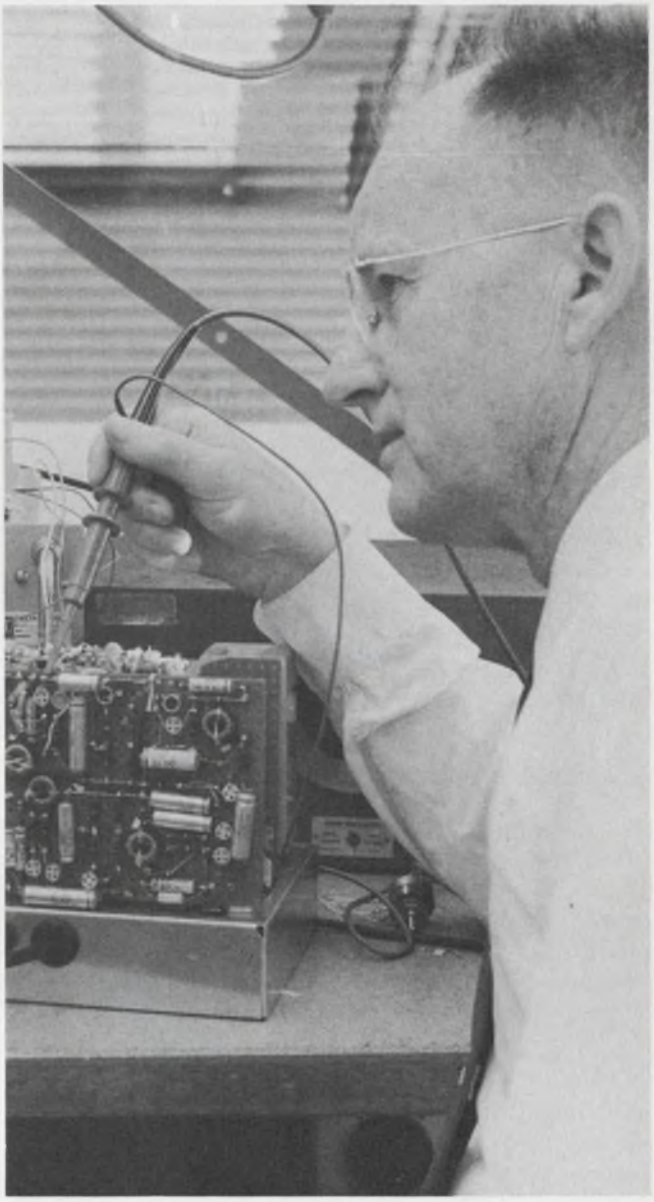
Technology



Shed light on photodevices: their selection and circuit design considerations. Page 60



Creativity can be developed. This R & D chief gives you tips on just how. Page 66

Also in this section:

Sense signal levels with a tunnel diode

A simple threshold detector combines accurate high-speed sensing of current or voltage with low cost.

Threshold sensors—circuits that detect the presence of specified signal levels—are finding wide use as systems grow in complexity.

Among their many uses, threshold detectors can act as hard-limiters—filtering out unwanted information in incoming signals while retaining the frequency components. This function is especially useful in phase-lock loop systems, where amplitude variations are merely undesirable noise. They are key elements in threshold logic circuits.

Both of these functions, and many more, can be performed by a tunnel-diode threshold detector. The circuit is temperature stable, low in cost (on the order of $3); fast (a few nanoseconds), and lends itself to worst-case temperature analysis.

Tunnel diode enables bistable operation

The negative-resistance characteristic of the tunnel-diode (Fig. 1) is the heart of the circuit. This characteristic makes possible a definite change of state in the sensor when the tunnel-diode current exceeds the peak current I_P. The output voltage, taken from the collector of an isolation transistor (Fig. 2), falls abruptly when the diode changes state. Thus the output voltage is near V, the supply voltage, while the input is low; when the input current exceeds the threshold value, the output voltage drops to approximately zero volts.

The operation of the sensor is easily analyzed. Assuming that Q is initially off, we can form the Thevenin equivalent of the circuit external to the diode, and represent the behavior of the combination on the diode characteristic as a load line (Fig. 3). As the input current I_{IN} is increased (corresponding to a change in V_{TH} for the load line), the load line moves from line 1 to line 2, and the operating point moves up along the first positive-resistance region. When the operating point reaches the peak current point, I_P, its voltage-coordinate will jump to a new equilibrium point on the second positive-resistance region. This assumes, of course, that the slope of the load line is small enough so that it intercepts the peak point and the second postive-resistance region simultaneously. When the transition occurs, the transistor turns on and the operating-point voltage-coordinate is determined by the combined circuit characteristics.

The speed at which the transition of the diode takes place is limited by its inherent junction-capacitance, and typically is on the order of a few nanoseconds.[1] The switching speed of the diode-transistor sensor is thus determined by the switching speed of the transistor used.[1]

A useful design approach, which allows for worst-case analysis and takes a minimum of time, is as follows:

(1) *Choose a small-signal switching transistor:* Normally, a silicon transistor will be preferred, for the temperature stability that silicon offers. It should be a switching transistor, because these transistors will operate in this switching mode faster than other types, and because forced-beta (β_F) specifications—needed for proper design—are available for switching transistors.

(2) *Choose a tunnel diode:* Of the three types available—silicon, gallium arsenide, and germanium (see Table)—the high price of the silicon diode will probably rule out its use.

A gallium-arsenide diode characteristic nicely complements the silicon transistor: The peak voltage V_P (Fig. 1) is less than $V_{BE(on)}$ of the transistor, so that the transistor remains off for diode voltage V_P; and the forward voltage V_{FP} is greater than $V_{BE(on)}$, so that the transistor can be firmly turned on when the circuit changes state. However, the GaAs diode is almost five times as expensive as the germanium device.

In view of its low cost, the germanium diode is usually used; the slight incompatibility in characteristics can be compensated for by the addition of a resistor in series with the diode. The voltage drop due to the peak current, I_P, flowing through this resistor plus the forward drop of the diode, V_{FP}, is sufficient to turn on the silicon transistor. The series resistor, R_D, must be chosen small enough, of course, so that when the

Donald B. Heckman, Electronic Design Engineer, American Machine and Foundry, Alexandria, Va.

Table. Tunnel-Diode Parameters

	Germanium	Gallium Arsenide	Silicon
Price*	$1.10	$5.00	$15.00
I_p/I_v	8	15	3.5
V_p	0.06 V	0.15 V	0.07 V
V_v	0.35 V	0.50 V	0.42 V
V_F	0.50 V	1.10 V	0.70 V

*approximate, 1-10 units

diode is in its low state the voltage across the resistor is not sufficient to turn on the transistor.

The diode should have a peak current I_P that is not more than twice the value of I_{IN} at the threshold point. This will ensure that the value of the bias current I_{bias} will not be close to I_P. (If I_{bias} is very nearly equal to I_P, the circuit will be susceptible to instability, due to temperature drift and production tolerances in the component values).

(3) *Determine the value of R_D:*

(a) Draw the transistor base-emitter characteristics on a semi-log paper, with V_{BE} on the linear scale and I_B on the logarithmic scale, for the required temperature extremes (Fig. 4).

(b) Draw the diode characteristic curve on linear graph paper (Fig. 5); then determine from the manufacturer's data the minimum V_{FP} at the low-temperature extreme, and plot this on the characteristics. Draw a second positive-resistance region—parallel to that obtained from the characteristic curve—thru this minimum.

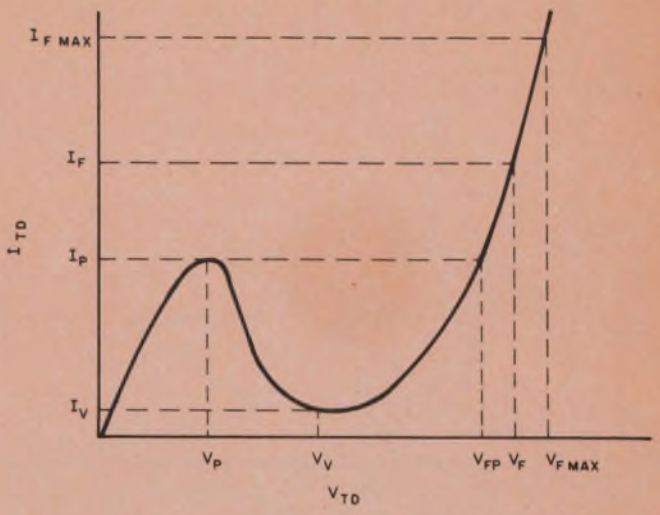
(c) The total current flowing in the diode, just prior to its change to the high-voltage state, is I_P. We can assume, to a good approximation, the current into the base is zero, and so the total current into node V_B is I_P.

Just after turn-on, this same current, I_P, is flowing into V_B, and dividing between the base branch and the diode branch of the circuit (V_{IN} and R_{IN} are assumed to act as a current source). We must assume an initial base-current after turn-on, and then check that this current does, in fact, flow by comparing V_{BE} against the transistor base-emitter voltage curves (Fig. 4). We assume that the base current, $I_{B(ON)}$, is 0.2 I_P.

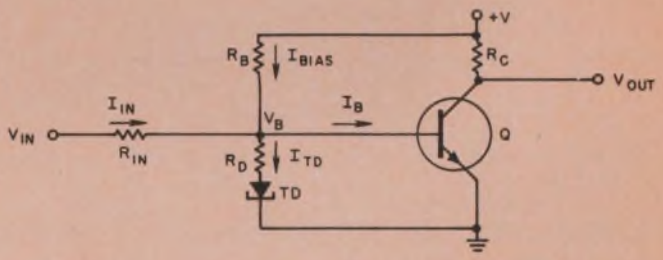
(d) For the worst case assume that the diode switches at $I_{P(min)}$ (obtained from the manufacturer's specifications). Then this is the current that must divide and flow into the base and diode branches.

(e) Determine $V_{B(on)}$ at the assumed value of $I_{B(on)}$, using the low-temperature base-emitter curve (Fig. 4).

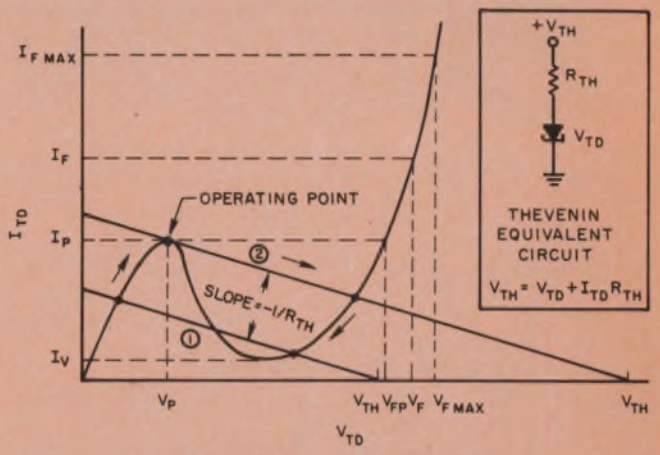
(f) Using the diode curve plotted for $V_{FP(min)}$ at the lower temperature extreme (Fig. 5) determine the tunnel-diode voltage, V_{TD}, at



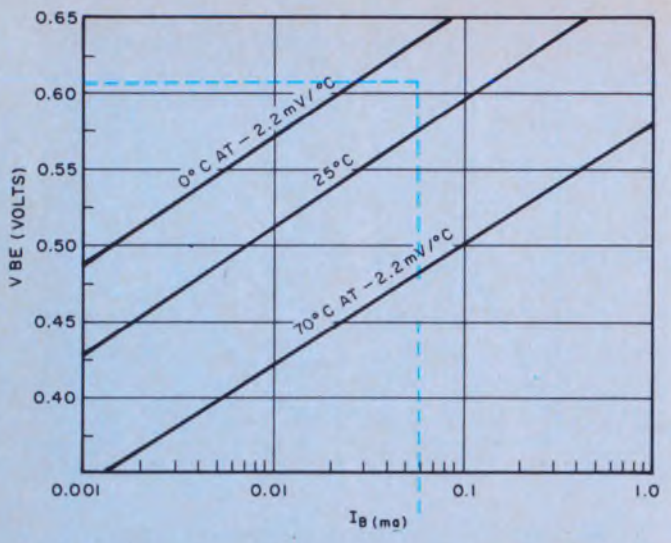
1. **The negative-resistance characteristic** of the tunnel diode is the heart of the threshold sensor. The circuit changes state when the input current to the diode exceeds the peak current I_P.



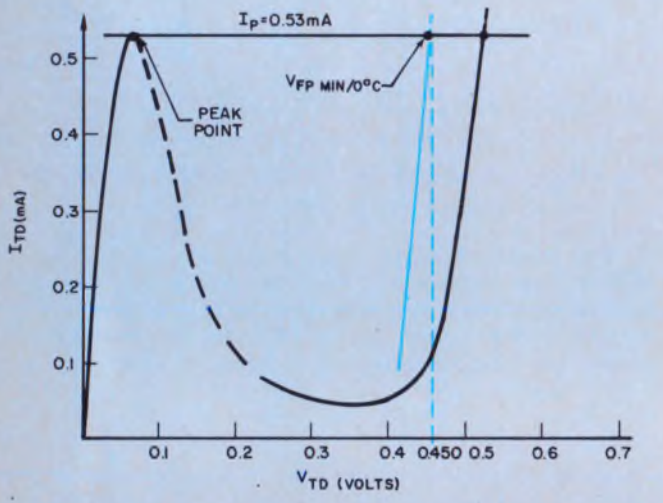
2. **The threshold sensor** uses a tunnel-diode transistor combination to provide output drive capability. The current through the diode is a measure of the voltage V_{IN}. When V_{IN} rises enough to cause I_P to flow through the diode, the output voltage V_{OUT} suddenly drops to the "low" state.



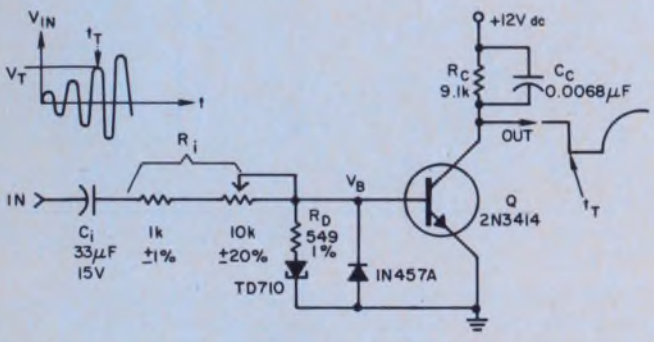
3. **An equivalent voltage source and series resistor** feed current to the tunnel diode. This combination yields load lines as shown, with slope depending on the series resistance and position depending on the input current I_{IN}. The operating point moves up with the load line as I_{IN} is increased until it reaches I_P, then it jumps to the second positive resistance region. The output voltage V_{OUT} drops suddenly as the circuit changes state.



4. **The base-emitter characteristic** of the transistor used must be drawn for the temperature extremes at which the circuit must operate. These curves are used in the iterative design procedure to ensure that the transistor remains off when the input current is below the threshold.



5. **The lowest V_{FP} expected over the operating temperature range** of the sensor is plotted on the diode curve. This voltage, added to the voltage drop across the resistor R_D, must be sufficient to turn on the transistor.



6. **An ac coupled threshold detector** senses the peak values of a 10 kHz sine wave, if they exceed a preset level. The diode connected from base to emitter discharges the coupling capacitor during the negative half-cycles of the input waveform.

a diode current of $I_{TD} = (I_{P(min)} - I_{B(on)})$ (The voltage is on the second positive-resistance region of the curve.)

(g) Using the value of $V_{B(on)}$ found in (e), and the value of V_{TD} found in (f) calculate

$$R_D = (V_{B(on)} - V_{TD})/I_{TD}.$$

(h) Now, determine that this value of R_D will not allow the transistor to turn on prior to diode turn-on, under worst-case conditions. Just prior to diode turn-on, the base voltage will be the sum of the maximum peak voltage of the diode and the maximum current times the series resistor. These maximum values are obtained from the manufacturer's diode specification sheet, for the temperature range that we require. Thus:

$$V_{B(off)} = V_{P(max)} + I_{P(max)} R_D$$

(i) From the base-emitter curves at the upper temperature extreme (Fig. 4), determine the maximum value of $I_{B(off)}$ corresponding to $V_{B(off)}$ in (h). This is the base current which could flow just prior to diode turn-on. It should be small enough so that the transistor is essentially off, or just entering its active region (see the manufacturer's data to determine whether the transistor is off with this base current). If the transistor is on, the value of R_D must be made smaller.

(j) The diode will turn off again, and the circuit will change to its original state, when

$$I_{TD} \leq I_V.$$

(4) *Assume that* $I_{B(on)}$ *is 0.2* I_P *as in 3c, and calculate* $I_{c\ sat}$*:*

$$I_{csat} = \beta_F I_{B(on)} = \beta_F\ (0.2\ I_P)$$

Then $R_c \geq V/I_{c\ sat}$.

(5) *If the diode is chosen with* $I_P \leq I_{IN}$*, then a bias resistor must be provided* to supply the bias current $(I_P - I_{IN_t}) = I_{bias}$, where I_{IN_t} is the input current for which the sensor turns on. This resistor is given by:

$$R_B = [V - (V_P + I_P R_D)]/I_{bias}.$$

(6) *If the sensor is to be used as a voltage sensor,* R_{IN} must be chosen such that

$$R_{IN} = (V_T - (V_P + T_P R_D))/(I_P - I_{bias}),$$

where V_T is the input voltage for which the sensor turns on. The design is now complete.

Design a sensor to your specifications

Suppose now that we want to design a voltage-level sensor, to be adjustable from a 1.5 to a 3 V threshold at room temperature, to derive power from a 12 V dc supply, and to operate over a temperature range of 0° to 70°C.

(1) First, we choose a transistor that is compatible with our speed requirements and power supply voltage. In this case a GE 2N3415 was initially chosen.

(2) We select a tunnel diode, usually a germanium diode, for its low cost, as discussed earlier. A GE TD710 was chosen for this design.

(3) (a) We then draw the base-emitter charac-

teristics of the transistor at 0°C and 70°C, as shown in Fig. 4.

(b) We obtain the diode curve (Fig. 5) from a curve-tracer plot. From manufacturer's data we find that $V_{FP(min)}$ at 0°C is 450 mV. We plot this and draw the corresponding second positive-resistance region.

(c) We assume $I_{B(on)} = 0.1$ mA.

(d) Neglecting the small temperature effects we know, from the manufacturer's data;

$$I_{P(min)} = 0.45 \text{ mA}.$$

(e) From the 0°C curve of V_{BE} for our transistor (Fig. 4), we observe

$$V_{BE(on)} = V_{B(on)} = 0.655 \text{ V}$$

(f) $$I_{TD} = (I_{P(min)} - I_B)$$
$$= (0.45 - 0.1)$$
$$= 0.35 \text{ mA}.$$

Using the $V_{FP(min)}$ at 0°C curve (Fig. 5) for $I_{TD} = 0.35$ mA, we find that $V_{TD} \approx 0.43$ V

(g) $$R_D = (V_B - V_{TD})/I_{TD}$$
$$= (0.655 - 0.43)/0.35 = 643\ \Omega.$$

(h) From manufacturer's data, for 70°C,

$$I_{P(max)} \approx 0.588 \text{ mA}, V_{P(max)} \approx 80 \text{ mV}$$

and thus

$$V_{B(off)max} = V_{P(max)} + I_{P(max)} R_D$$
$$= 80 \text{ mV} + (0.588 \text{ mA})(643\ \Omega)$$
$$= 458 \text{ mV}.$$

(i) From the 70°C base-emitter characteristic curve,

$$I_{B(off)max} \approx 0.027 \text{ mA (at } V_{B(off)max} = 458 \text{ mV}).$$

Now $I_{B(on)}/I_{B(off)} = (0.1)/(0.0.27) = 3.7$.

Obviously, $I_{B(off)max}$ is not small enough, since $I_{B(on)}$ is related to the saturated collector current by a forced beta (β_F) of 20.

For the next trial, we choose $I_{B(on)}$ less than 0.1 mA. We start with step c in the design procedure and skip the repeated steps.

(c) $I_{B(on)} = 0.07$ mA

(e) $V_{BE(on)} = V_{B(on)} \approx 0.643$ V

(f) $I_{TD} = (0.45 - 0.07) = 0.380$ mA

and $V_{TD} \approx 0.435$ V.

(g) $$R_D = (V_{B(on)} - V_{TD})/I_{TD}$$
$$= (0.643 - 0.435)/0.380 = 548\ \Omega.$$

thus we use a 549-ohm 1% precision resistor, the nearest standard value.

(h) $$V_{B(off)} \approx (V_{P(max)} + I_{P(max)} R_D)$$
$$= 80 \text{ mV} + (0.588 \text{ mA})(549\ \Omega)$$
$$= 402 \text{ mV}.$$

i) $I_{B(off)} \approx 0.0052$ mA, which is less than one-tenth of $I_{B(on)}$. Further, if $\beta_F = 20$ and $I_{B(on)} = 0.07$ mA, then $I_{c(sat)} = (20)(0.07) = 1.4$ mA. For the 2N3415 at 70°C, $h_{FE} \approx 550$, and thus for an $I_{B(off)max}$ of 0.0052 mA, an I_c of (550) (0.0052) or 2.86-mA could exist if not limited by the load resistor. If a 2N3414 is used, which has essentially the same V_{BE} characteristics as the 2N3415 but a maximum h_{FE} of 250, then under worst-case conditions, with base current $I_{B(off)max}$, the collector current I_c will be 250 (0.0052) = 1.3 mA. The 2N3414 would still be in its active region when the diode switched under worst-case conditions.

(4) $$I_{csat} = \beta_F I_{B(on)} = (20)(0.07)$$
$$= 1.4 \text{ mA}.$$
$$R_c = V_{cc}/I_{csat} \geq 12 \text{ V}/1.4 \text{ mA}$$
$$\geq 8.56 \text{ k}\Omega.$$

We use the nearest standard value: a 9.1 kΩ.

(5) The use of a bias resistor is not necessary since high input-impedance is not required.

(6) $$R_{IN} = [V_T - (V_P + I_P R_D)]/I_P$$

so $$R_{INmax} = [V_{Tmax} - (V_{Pmin} + I_{Pmin} R_D)]/I_{Pmin}$$
$$\approx [3 - (0.05 + (0.45)(0.549))]/0.45$$
$$= 6.0 \text{ k},$$

and $$R_{INmin} = [V_{Tmin} - (V_{Pmax} + I_{Pmax} R_D)]/I_{Pmax}$$
$$\approx [1.5 - 0.08 + (0.55)(0.549)]/0.55$$
$$= 2.04 \text{ k}.$$

Thus we use a 10-kΩ potentiometer in series with a 1-kΩ fixed resistor.

This circuit was built by the author and used in an ac-coupled configuration (Fig. 6) at a frequency of 10 kHz. In this application, it was desired to sense when the peak voltage of the 10-kHz sine wave was greater than the threshold voltage. The conventional diode from base to emitter provides for discharge of the coupling capacitor during the negative half-cycle of the input. The capacitor in the collector circuit is used to filter the pulses, so that as long as the peak voltage of the input is above V_T, the output is in a low voltage state. ■■

Reference:

1. Millman and Taub, *Pulse, Digital and Switching Waveforms*, Chaps. 12 and 13. McGraw-Hill, New York, 1965.

Bibliography:

1. Lynch, T. H., "Cross zero with a tunnel-diode switch," ELECTRONIC DESIGN 14, July 4, 1968.
2. General Electric Semiconductor Data Sheet 70.27, Nov. 1966.

Test your retention

Here are questions based on the main points of this article. Their purpose is to help you make sure you have not overlooked any important ideas. You'll find the answers in the article.

1. What limits the speed at which the sensing circuit changes state?

2. What are three reasons for using a silicon switching transistor?

3. Why is the gallium arsenide tunnel diode especially suitable for use with a silicon transistor? Why is a germanium diode normally used?

4. Why must the current I_{IN} be at least one-half the I_P of the diode?

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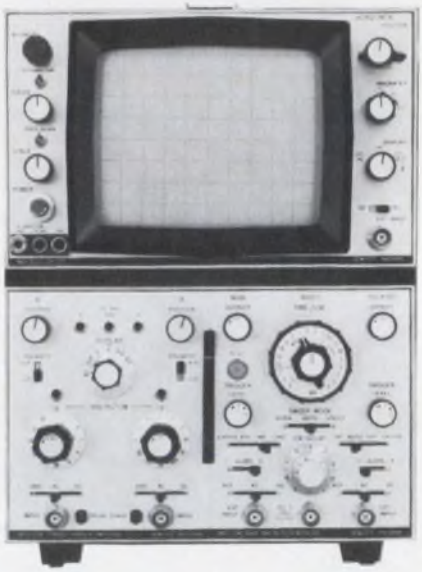

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Build a better frequency comparator

by using state flow techniques and Karnaugh maps. This digital dual-mode unit works well in phaselock loops.

A basic problem encountered in phaselock loop systems is the restricted capture bandwidth of the analog phase detector, where capture bandwidth is defined as the extreme value of frequency offset that can be brought into lock. One method of overcoming this problem is to use a dual-mode comparator.

When the signal frequency is far removed from the reference frequency (that is, out of the capture range of the phase detector), such a comparator will, within a few cycles, unambiguously indicate whether the signal frequency is higher or lower than that of the reference. The output of the comparator can then be used to adjust the variable oscillator until it's close enough to the signal frequency for the loop to lock. At this point, the comparator will automatically switch from the frequency-comparison mode into the phasing mode, in which the output indicates the relative phase between the signal and reference frequencies.

To construct a dual-mode comparator, a sequential digital system may be employed. A previous digital system described by Ebenhoech[1] required that the adjustable signal be brought up or down to the reference frequency and then slightly overshoot it before the comparator would switch into the phasing mode. This overshoot is not required in the present system.

The first step in any sequential circuit design is to relate the required outputs to an exhaustive typical input sequence, as in Fig. 1. Note that the sequence must be exhaustive, if the system is to function properly. In the dual comparator there are two input pulse trains, representing the zero crossings of the reference, X_R, and signal, X_S, frequencies. The outputs are two digital signals, Z and Φ, which are combined to yield relative frequency and phase information as follows: When the Φ output is in the ZERO state, the system is in the frequency-comparison mode; when Φ is a ONE, the system is in the phasing mode. Once the mode has been defined, the Z output provides us with the rest of the information that we need.

In the frequency comparison mode, if Z is a ZERO, the signal frequency is lower than the reference frequency; if Z is a ONE, the reverse is true. In the phasing mode, Z alternates between ZERO and ONE, depending on whether the last input pulse was from the reference input or from the signal input. Thus, the phase relation between reference and signal is indicated by the relative length of time the Z output spends in each state.

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1. **A train of reference pulses,** X_R, and a typical received signal, X_S, which are to be phase locked, are shown. The system states are identified on the third line. The outputs are ONEs when at the upper level and ZEROs when at the lower level. When the Φ output is in the ONE state, the system is in the phase-comparison mode.

When the comparator is used in a phaselock loop, the loop filter will smooth the Z output and use it to control the variable oscillator. Since the closed loop will try to drive the control signal towards zero, the system will tend to a condition where the Z output spends equal time in both the ONE and ZERO states. As is obvious from examining the first few pulses in Fig. 1, this corresponds to a phase difference of 90 degrees.

Define the system states

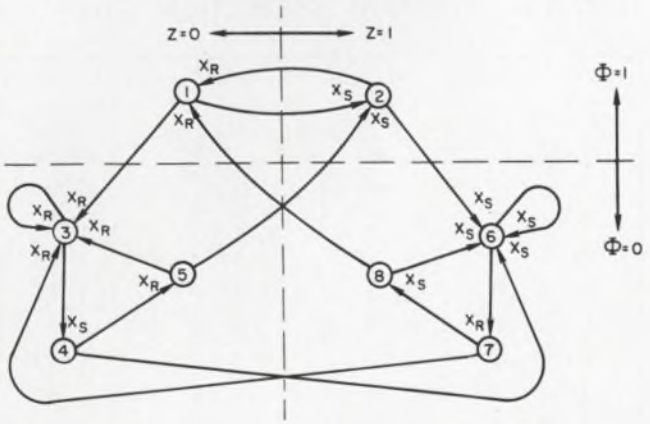
To relate the system outputs to the inputs, we note that the frequency-comparison situation occurs whenever the two frequencies are unequal. Thus, if a reference pulse is followed by two or more signal pulses (or vice versa) then the system is to recognize that it must operate as a frequency comparator. Similarly, if reference and signal pulses alternate, the system must operate as a phase comparator.

In the third line of Fig. 1 we have listed the system's sequential states, S. These states delineate the memory capability of the system, and are defined as follows:

State 1. The circuit is in the phasing mode, and the last pulse received was a reference pulse.

State 2. The circuit is in the phasing mode, but the last pulse received was a signal pulse.

State 3. The circuit is in the frequency-comparison mode, the reference frequency is higher than the signal frequency, and the last pulse received was a reference pulse. If more reference pulses are received, the circuit will remain in state 3. The only way the system can return to the phasing mode is by receiving two alternate signal and reference pulses, thus defining the intermediate states 4 and 5.



2. **The state flow diagram** shows the relations between the eight possible system states and the input signals. Each quadrant represents a different output state.

State 4. The circuit is in the frequency-comparison mode, the reference frequency is higher than the signal frequency, and the last pulse received was a signal pulse.

State 5. The circuit is in the frequency-comparison mode, the reference frequency is higher than the signal frequency, and the last two pulses were a signal and a reference pulse, in that order. If the next pulse is a signal pulse, the system will recognize an alternating condition and will change to state 2.

State 6. The circuit is in the frequency-comparison mode, the signal frequency is higher than the reference frequency, and the last pulse received was a signal pulse.

State 7. The circuit is in the frequency-comparison mode, the signal frequency is higher than the reference frequency, and the last pulse received was a reference pulse.

State 8. The circuit is in the frequency-comparison mode, the signal frequency is higher than the reference frequency, and the last two pulses were a reference and a signal pulse, in that order. If the next pulse is a reference pulse, the system will recognize an alternating condition and will change to state 1.

In the case of extreme frequency jitter—two or more reference pulses followed by two or more signal pulses—it can be seen that state 3 flows through the intermediate states to state 6, and vice versa, without going through the phasing states.

A state flow diagram is used

All of the information of Fig. 1 is summarized in the state flow diagram of Fig. 2. The eight states are shown; the links between them are the input signals. To see how the diagram works

Table 1. State flow chart

S_n	S_{n+1}		Outputs	
	X_R	X_S	Z	Φ
1	3	2	0	1
2	1	6	1	1
3	3	4	0	0
4	5	6	0	0
5	3	2	0	0
6	7	6	1	0
7	3	8	1	0
8	1	6	1	0

Table 2. State memory assignment

Flip-flop 1	Flip-flop 2	Flip-flop 3	S_n
0	0	0	1
0	0	1	5
0	1	0	3
0	1	1	7
1	0	0	4
1	0	1	8
1	1	0	2
1	1	1	6

assume the circuit is in state 5. There are two alternatives: either a signal or a reference pulse will be received next. If a reference pulse is received, the circuit goes to state 3 and remains in the frequency-comparison mode, $\Phi = 0$. If a signal pulse is received, the circuit goes into state 2.

Decomposition simplifies logic functions

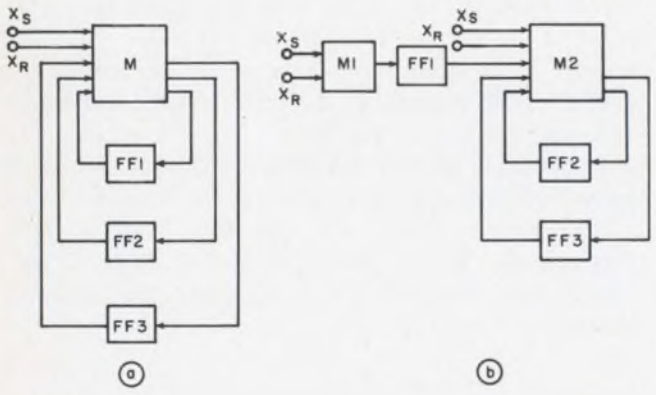
An array of memory elements must now be designed to define the eight states. If flip-flops are used, at least three will be required for eight unique states. The design could be done completely arbitrarily, and a system would be obtained in which each flip-flop would require complicated combinatorial logic. However, the design can usually be optimized by decomposing the system into a number of simpler subsystems, thus simplifying the over-all combinatorial logic[2,3].

To accomplish this, the state flow diagram of Fig. 2 is translated into tabular form as shown in Table 1. The first column (S_n) represents the present state; columns 2 and 3 (S_{n+1}) tell what the next state will be if the next input is a reference or signal pulse, respectively. The outputs, Z and Φ, in the last column correspond to the present state, S_n.

Referring to Table 1, consider the two state groups, A and B, where $A = [1, 3, 5, 7]$ and $B = [2, 4, 6, 8]$. Note that when a signal pulse is applied to the system, only group B states can result. Similarly, applying a reference pulse results in states of group A. Regardless of the state of the system, the two groups remain mutually exclusive with respect to the two inputs.

If one of the flip-flops, FF1, is assigned to differentiate between groups A and B, then the next state of FF1 is dependent only upon the two input signals. The system has effectively been decomposed into two smaller systems, as shown in Fig. 3. The ideal would be to obtain equal-sized orthogonal group sets so that the flip-flops would all be mutually independent. Detailed examination of the system, however, shows that the group set defined above is the only convenient one to use.

There are a number of methods of finding group sets, given the state flow table. The method of Hartmanis and Stearns[3] is automatic and requires that all possible combinations of groups be examined. It is time consuming, but is par-



3. **Decomposition can simplify a design.** Before decomposition (a) three flip-flops had to be considered in designing logic network M. After decomposing the system into two subsystems (b), by having flip-flop FF1 differentiate between state groups, the logic is reduced to two simpler networks.

Table 3. Flip-flop state flow chart

S_n			S_{n+1}						S_n
Flip-flop no.			X_R			X_S			State
1	2	3	1	2	3	1	2	3	no.
0	0	0	0	1	0	1	1	0	1
0	0	1	0	1	0	1	1	0	5
0	1	0	0	1	0	1	0	0	3
0	1	1	0	1	0	1	0	1	7
1	0	0	0	0	1	1	1	1	4
1	0	1	0	0	0	1	1	1	8
1	1	0	0	0	0	1	1	1	2
1	1	1	0	1	1	1	1	1	6

ticularly well suited to computer evaluation. The method that we used is that proposed by Yoeli[2]. It is a convenient semi-graphical technique and is based on the reduction of the complexity of the system flow graphs.

How to represent the memory states

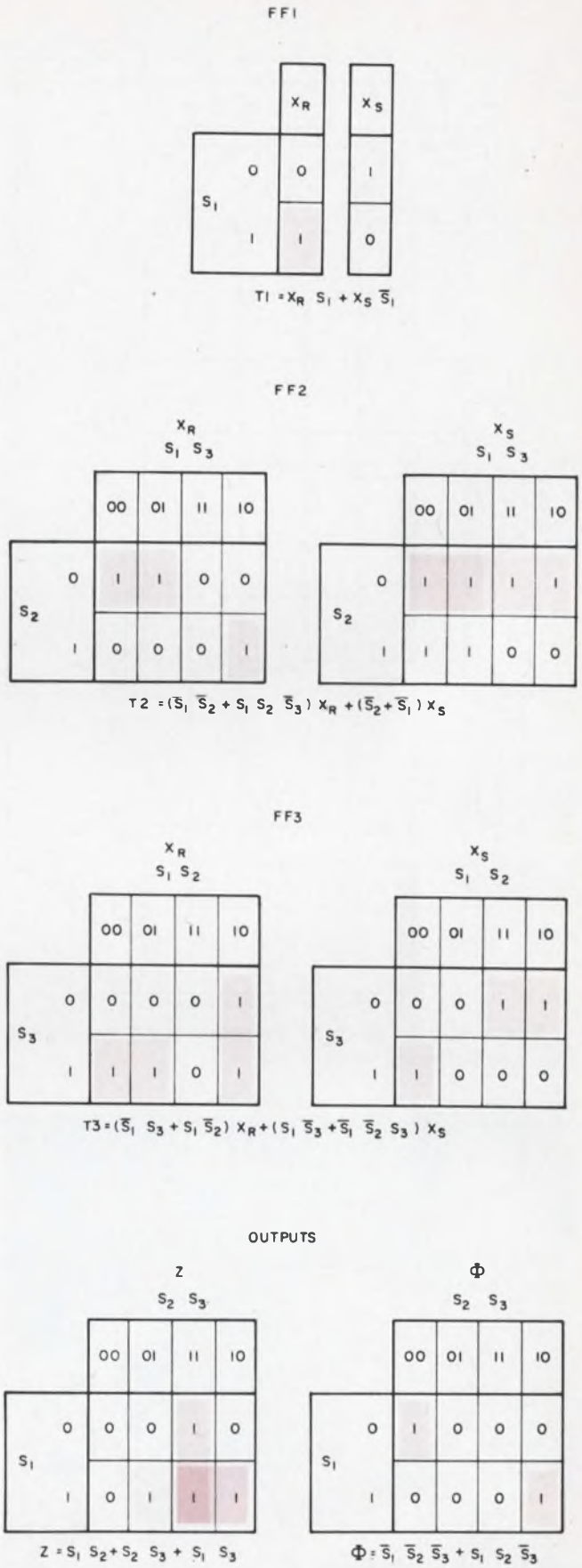
Once the required group sets and flip-flop assignments have been decided upon, the state memory assignment table (Table 2) is drawn. It is seen that flip-flop FF1 is used to differentiate between groups *A* and *B*. The assignment of flip-flops FF2 and FF3, however, is completely arbitrary, as long as they are all different. The state flow table (Table 1) is now redrawn, and each state is represented by its flip-flop equivalent, as shown in Table 3. The first column, S_n, represents the present state of the three flip-flops. The second column, S_{n+1}, is broken into two subcolumns, which tell what the next state will be if the next input is a reference, X_R, or a signal, X_S, pulse.

At this stage, it is necessary to decide whether to use *R-S* or clocked *J-K* type flip-flops. A system composed of *R-S* flip-flops suffers from this disadvantage: if the input pulses are not narrow enough, then each pulse may cause the system to go through several sequential states. The clocked flip-flop, however, changes state only during the fall time of the input pulse. Thus, independent of input pulse width, the system will only change through a single state. It was decided to employ *J-K* flip-flops in building the system.

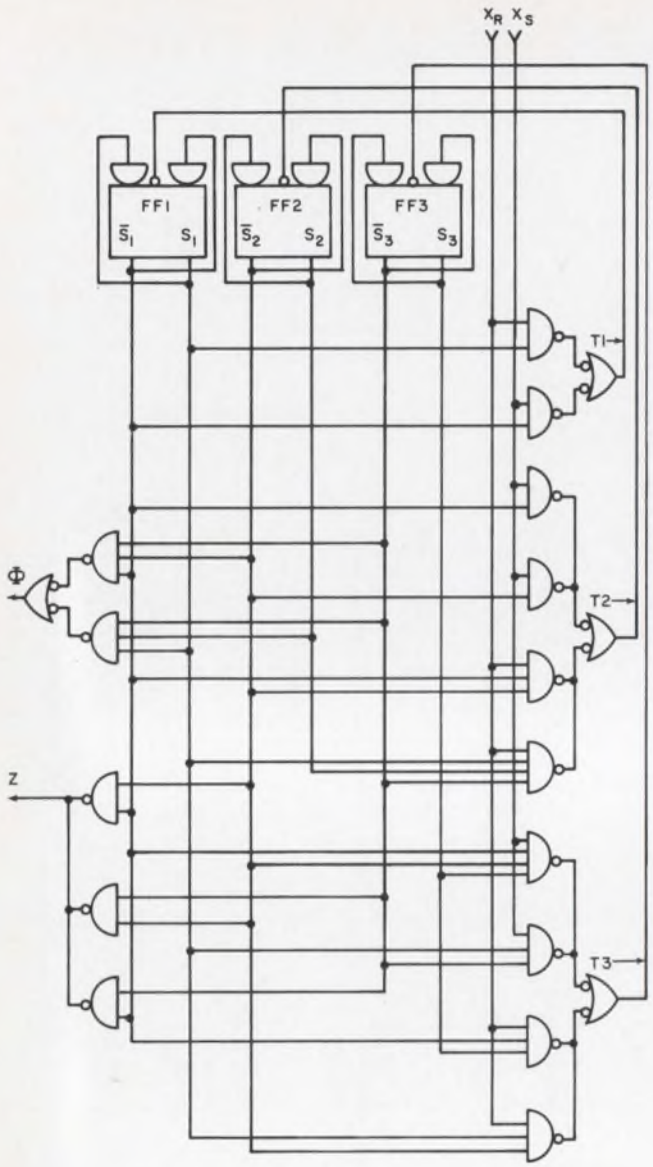
The use of clocked flip-flop logic made it necessary to redraw Table 3 in terms of a toggle function, *T*, (Table 4). Instead of representing the state of a flip-flop directly, the toggle function indicates whether or not the flip-flop must change its state when it receives its next input pulse. *T1* has a value of ONE if FF1 is to change

Table 4. Toggle state flow chart

S_n			Toggle values						Outputs	
Flip-flop no.			X_R			X_S			Z	Φ
1	2	3	T1	T2	T3	T1	T2	T3		
0	0	0	0	1	0	1	1	0	0	1
0	0	1	0	1	1	1	1	1	0	0
0	1	0	0	0	0	1	1	0	0	0
0	1	1	0	0	1	1	1	0	1	0
1	0	0	1	0	1	0	1	1	0	0
1	0	1	1	0	1	0	1	0	1	0
1	1	0	1	1	0	0	0	1	1	1
1	1	1	1	0	0	0	0	0	1	0



4. **Karnaugh maps** are used to simplify the circuitry and to relate the toggle signals to the flip-flop states and the inputs. The state of each flip-flop is given by the corresponding S number. Thus, S_2 gives the state of FF2.



5. **The circuit is designed** from the equations derived from the Karnaugh maps of Fig. 4.

6. **The author, Israel Urieli,** is testing the 1-MHz comparator diagrammed in Fig. 5.

state and a value of ZERO if FF1 is not to change state, when the next input pulse is received.

Map methods can minimize logic

A combinatorial network is required to interconnect the input, output and memory elements. It is designed by using normal Karnaugh map methods[4] to minimize the logic functions. To do this, Table 4 is decomposed into separate maps, for each of the toggle functions T_i and output functions Z and Φ, as shown in Fig. 4.

From the toggle and output functions of Fig. 4, the actual circuit of Fig. 5 was realized.

The Fairchild DTμL series of integrated circuitry was used. The basic logic element of the series is the positive NAND gate, with a typical propagation delay of 25 ns. The system that was built operates with a reference frequency of 1 MHz. Nine IC modules were required for the complete comparator, a photograph of which is shown in Fig. 6. ■■

References:

1. H. Ebenhoech, "Make IC Digital Frequency Comparators," ELECTRONIC DESIGN, ED 14, July 5, 1967, pp. 62-64.
2. M. Yoeli, "The Cascade Decomposition of Sequential Machines," *IRE Transactions on Electronic Computers*, EC-10, No. 4, Dec., 1961, pp. 587-592.
3. J. Hartmanis and R. E. Stearns, *Algebraic Structure Theory of Sequential Machines*, Englewood Cliffs, N.J.: Prentice-Hall, 1966.
4. S. H. Caldwell, *Switching Circuits and Logical Design*, New York: John Wiley & Sons, 1958, pp. 132-143.

Acknowledgment:

The author wishes to acknowledge the aid given him by Prof. Yoeli in introducing him to the state flow techniques, and the helpful comments made on the manuscript by Messrs. Eichenbaum and Shmueli.

Test your retention

Here are questions based on the main points of this article. They are to help you make sure you have not overlooked any important ideas. You'll find the answers in the article.

1. What is a dual-mode comparator? How can it improve the performance of a phase-lock loop?

2. How should you begin any problem in sequential circuit design?

3. What is a state flow diagram?

4. Why did the author break up the eight sequential states into two sub-groups?

5. Why were J-K flip-flops chosen for the hardware design rather than R-S flip-flops?

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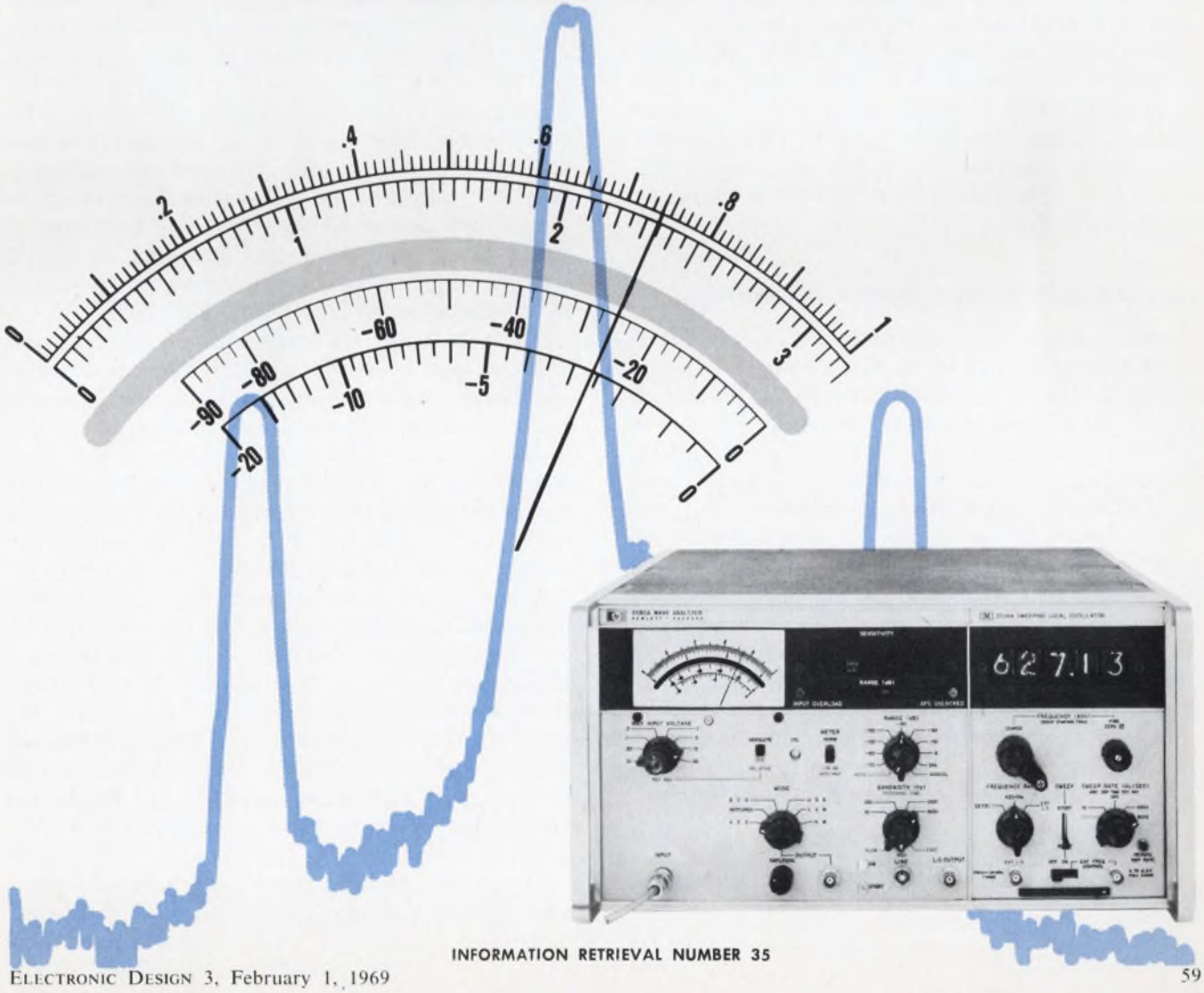


INFORMATION RETRIEVAL NUMBER 35

Photodevices have you in the dark?

They won't, if you understand their basic radiometric properties and how these affect circuit design.

Photodevices are being used to an increasing extent today in many electronic applications. And for the designers who use them, these semiconductor devices provide a versatile component —provided that they are selected wisely and applied correctly. Too often, though, in these areas of selection and application, the designer gets bogged down in the unfamiliar world of radiometry. It is the purpose of this article to cut through the fog and to show just what considerations are important to the designer who is working with photodevices.

The photodevice family consists essentially of photodiodes and phototransistors. The photodiode is a pn junction diode, which develops a voltage and/or current across its terminals when it is irradiated by electromagnetic radiation of an appropriate wavelength. The phototransistor can be considered as a combination of a photodiode and an ordinary transistor and, as such, can provide signal amplification. Basic photodevice theory and a comparison of photodetector types are given in the box.

Light source determines detector characteristics

In any photodetector application, the designer faces three tasks prior to actual circuit design: He must (1) determine the spectral characteristics of the light input to the detector, (2) choose a photodevice that has a suitable spectral response, and (3) determine the electrical characteristics of the selected photodevice.

Sometimes, the light input is controlled by the designer, as in those cases where the light source forms part of his system. Other times, however, he has no control over the light source or its characteristics. (The term "light" here refers to electromagnetic radiation in the visible and infrared wavelength region).

Determination of the spectral characteristics of the light source is usually relatively simple. Either the source is considered monochromatic, as when a gallium-arsenide light-emitting diode is used or it is assumed to be a black body, which is the case for sunlight and other incandescent sources. If it is a black body, the spectral distribution depends only on the color temperature of the source (Fig. 1).

Choosing a type of photodevice is then a matter of selecting one that has a spectral response that coincides with the spectral characteristic of the source. As shown in Fig. 2, typical silicon photodevices have responses that lie approximately between 0.4 and 1.2 microns. The spectral characteristics of the source and detector then form a combined characteristic, as shown in Fig. 3.

Once the necessary photodevice spectral characteristics have been determined, the relationship of light input to current and voltage output must be determined. This requires a knowledge of the quantity of incident irradiation the photodevice will receive. The specification of light requires that the relative amount of energy at each wavelength be specified, as well as the amount of incident light power (irradiation) per unit area at the distance from the source at which the device will operate. Irradiation is inversely proportional to the distance squared from the source.

The relationship of light input to current and voltage output can be found empirically, using an optical pyrometer and a thermopile for measuring the color temperature of the source and the radiation at the anticipated working distance of the photodevice. With the source thus defined, the manufacturer of the selected photodevice can be asked to furnish output data on his device for such a source at the determined radiation level.

A simpler method, however, is to use a photodiode that has been calibrated by the manufacturer. The usefulness of such a unit is that it has a linear response to varying levels of irradiation. If the spectral distribution of the source is completely known—such as for a gallium arsenide source, a diode calibrated for that source can be obtained, and direct input-output measurements taken for the level of irradiation at the working distance.

More often, though, the source is incandescent and of unknown color temperature. In this case,

D. Douglas Snyder, Applications Engineer, Fairchild Semiconductor, Mountain View, Calif.

Photosensitive semiconductors

All semiconductors have the property that when irradiated by electromagnetic radiation of certain wavelengths, they generate hole-electron pairs. For silicon semiconductors, these wavelengths fall within the range of human vision and out to the near infrared—or from about 0.4 to 1.2 microns. A description of various photosensitive devices is essentially a description of how each different device uses the property of carrier-pair generation to produce some electrical property that is useful in circuits.

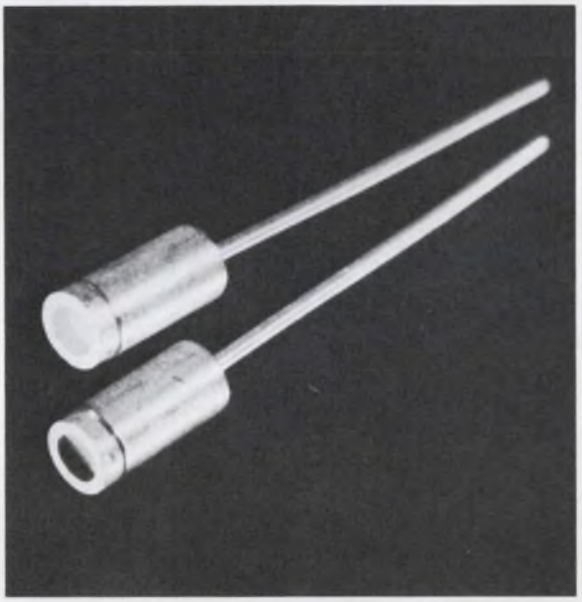
The most elementary photo device is the photoconductor, or photoresistor, which is usually of cadmium sulphide or cadmium selenide composition. The conductance of this device is related to the intensity with which it is irradiated, but is not related linearly. In a photoconductor, one member of the carrier-pairs generated has a long lifetime in a trapped state, thus allowing a higher density of the other member to flow. This effectively reduces the resistance between the photoconductor terminals.

The dark resistance of photoconductors is on the order of megohms; dark-to-light resistance ratios of several orders of magnitude are relatively common. Response times of many milliseconds and long memory, or hysteresis, are the major drawbacks of these devices. Nevertheless, photoconductors are often useful where the voltage offsets inherent in junction devices cannot be tolerated, such as holds true for photo choppers in chopper-stabilized amplifiers.

The photodiode is essentially a normal pn junction diode optimized for photo behavior. The photo response of a pn junction is due to the stimulation of minority carriers that are close enough to the space-charge region to diffuse into that region and thus be swept across the junction. This phenomenon leads to large increases in leakage current, or, in the case of an open-circuited device, to a change in the space-charge field, thus creating a voltage at the terminals of the device when it is irradiated. The photo response characteristics of a photodiode are optimized by increasing the diffusion length of minority carriers.

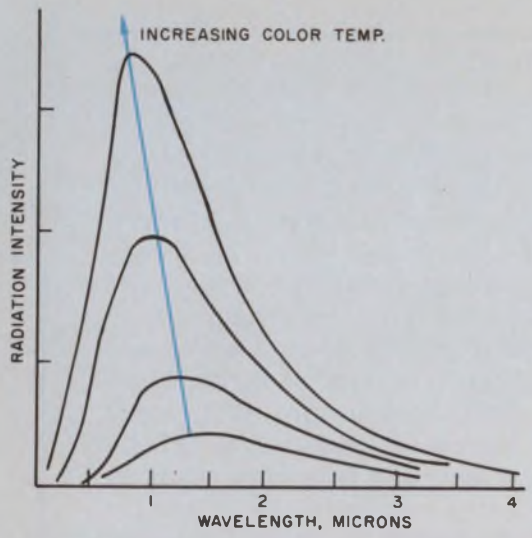
The phototransistor is a marriage of the photodiode and an ordinary transistor in order to provide gain. The marriage is accomplished by using the collector-base junction as a photodiode. Current generated at this junction acts as base drive to the transistor. The phototransistor thus looks like a photodiode driving a common collector transistor.

The phototransistor may or may not have the base lead available externally. Two-terminal devices having coaxial leads (see photo), offer the advantage of higher packing density. Three-lead devices, on the other hand, offer increased flexibility to the designer. This is especially true when optimum gain or speed is necessary, or when the device is used at very low light intensities and it is necessary to bias the transistor at a more favorable operating point.

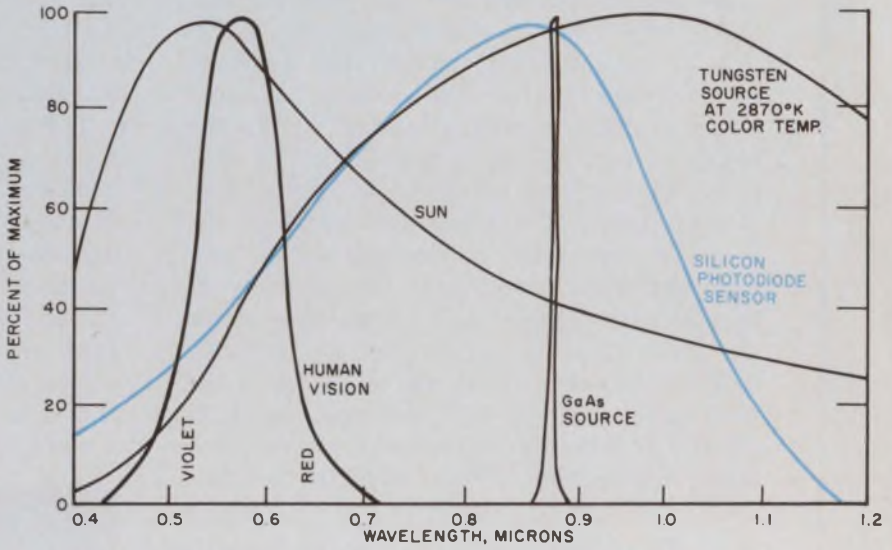


The light-activated silicon controlled rectifier is exactly analogous to the normal SCR, except that light provides the gate triggering. The gate-cathode junction acts as a photodiode to generate the triggering current. Optimizing the light-sensitive properties of the SCR, however, causes it to be more sensitive to heat. This problem limits the device to a restricted range of operating temperature.

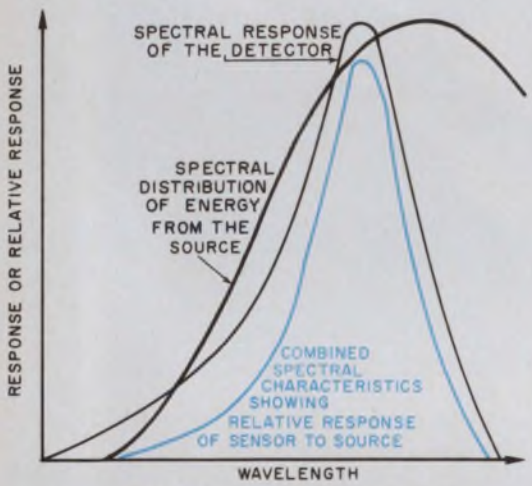
The photo field-effect transistor is a junction field-effect device that uses the gate-to-channel junction as a photodiode. The device has the characteristics of high gain and low offset; the latter characteristic is especially useful for photo-chopper applications. The photo-FET is a normally ON device, as opposed to bipolar transistors which are normally OFF. This characteristic is generally not desirable.



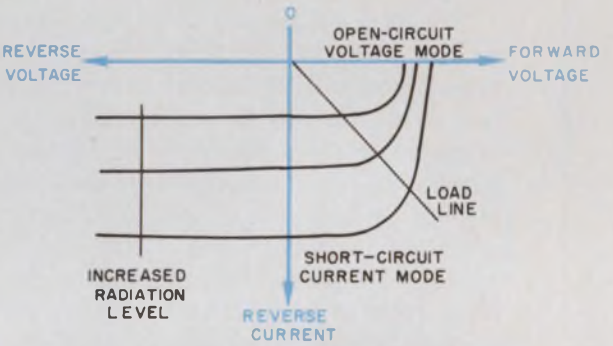
1. **Spectral distribution of a black-body source** depends only on its color temperature.



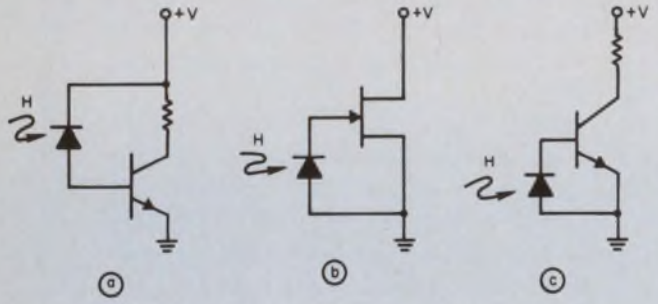
2. **Spectral characteristics** form the basis for matching a photodetector to a light source. Some common characteristics are shown here.



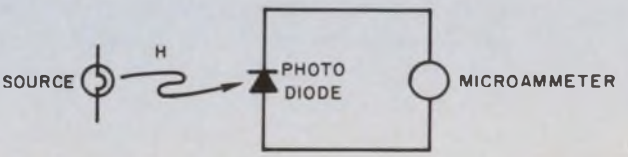
3. **Combined characteristic** shows the coincidence between spectral response of a detector and the spectral distribution of the source.



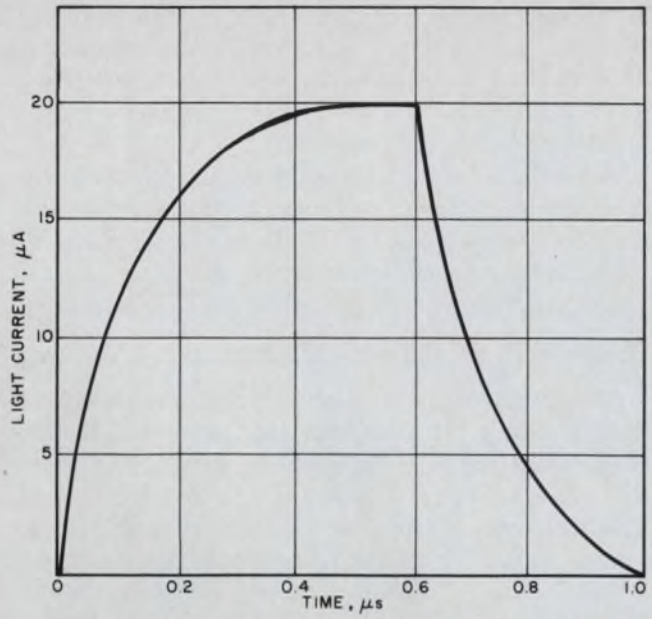
4. **Photodiode operation** can take place in either the third- or fourth-quadrant of the current-voltage characteristic.



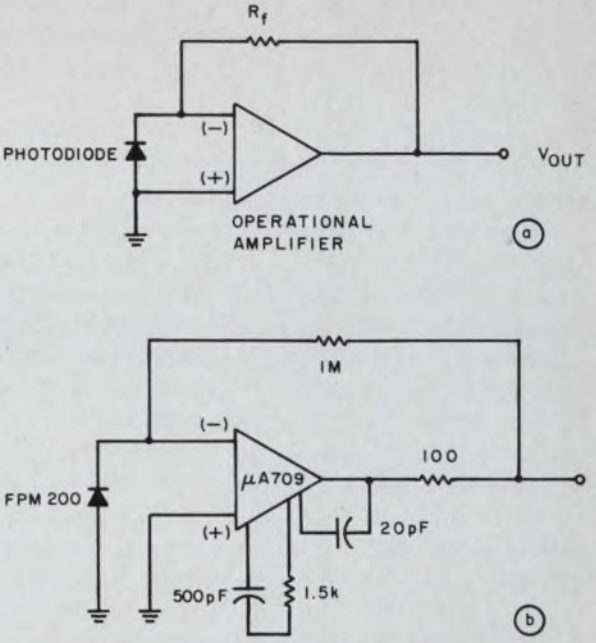
5. **Short-circuit current mode** of photodiode operation provides a simple linear light-intensity transducer.



6. **Three modes of photodiode operation** are reverse-bias mode (a), open-circuit voltage mode (b), and low-voltage reverse-bias mode (c).



7. **Rapid response is a characteristic** of the photodiode. This response curve is for a light input from a pulsed gallium-arsenide source and a photodiode load resistance of 100 ohms.



8. **Basic light-sensing system** (a) provides an output voltage that is linearly related to the input light intensity. An actual circuit of this type is shown in (b).

a diode which the manufacturer has calibrated to his own standard color temperature can be obtained. The short-circuit output current of such a diode is directly related to the incident irradiation. So, by measuring the output current and using the calibration figures, the equivalent characteristics of the source with respect to the manufacturer's standard can be determined. For example, assume that a calibrated photodiode was calibrated at a color temperature, T_c, of 2870°K for a short-circuit output current of $I = 1\ \mu A/mW/cm^2$. Also assume that when the diode was irradiated by the unknown source at the designed working distance, its short-circuit output current was 5.8 μA. The unknown source therefore has the effect of a source at $T_c =$ 2870°K and at an irradiation, H, of 5.8 mW/cm^2.

This information then allows the designer to go directly to the manufacturer's data sheet for the electrical characteristics needed for design.

Designing with photodevices is simple

Designing photodevices into circuits is not at all difficult. If the characteristics of the particular device are known and understood, the photodevice will become just another component for the designer. The first member of the photodevice family to be covered from a design standpoint will be the photodiode.

The photodiode can be operated in two regions of the current-voltage characteristic, as shown in Fig. 4. Operation in the third quadrant is called reverse-bias operation, since the diode has a reverse bias that is externally applied. Fourth-quadrant operation is called photovoltaic operation. In this region, the diode actually generates a voltage across its terminals with no externally supplied power.

The two operating regions are divided by the zero-voltage axis. Operation on this axis indicates that the terminals of the diode should be shorted together, a condition which can be approximated by connecting a low-resistance microammeter between the terminals. This configuration is called the short-circuit current mode of operation, and is one of the simplest and most useful operating modes. It approximates a constant-current source at a given light intensity and has excellent linearity over several decades of variation of light intensity. This is the mode of operation referred to earlier for determining irradiation levels with a calibrated photodiode.

In this configuration (Fig. 5), the diode short-circuit current, I_{sc}, is

$$I_{sc} = KH,$$

where K is a constant of proportionality and H is light intensity. The value of K for any given device depends on its sensitivity and spectral response, as well as on the source's spectral characteristics. K has the units $\mu A/mW/cm^2$; its value can be obtained from the diode manufacturer. Operation of the photodiode in the reverse bias region gives the same linearity and constant-current properties as short-circuit operation, but requires a voltage source for bias.

This technique of using a photodiode to measure light intensity is valid over several decades of light level, from approximately $H = 10$ $\mu W/cm^2$ to $H = 100$ mW/cm^2. The method covers four decades of light intensity and spans the entire range of useful light levels.

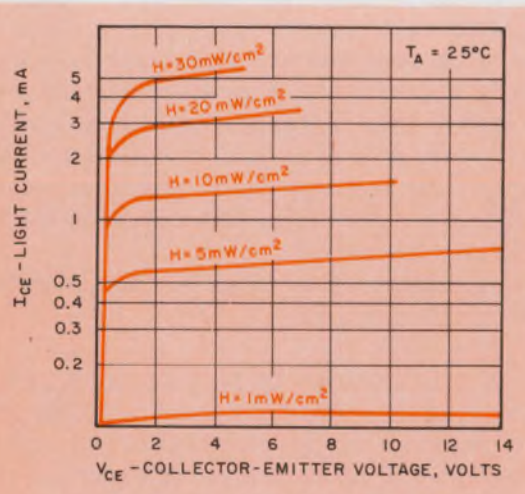
Operation on the zero-current axis is termed the open-circuit voltage mode. Between the two limiting modes of operation, an irradiated photodiode will generate a current and voltage that are dependent on the resistance connected between the terminals. The slope of the load line is equal to the reciprocal of this resistance.

Circuit configurations for other modes of operation are shown in Fig. 6.

An important feature of the photodiode, for many applications, is its response speed. Rise and fall times are typically less than 0.5 μs, as shown in Fig. 7 for the case of a pulsed gallium-arsenide light source. If speed is of utmost importance, use of a pin-photodiode will decrease the rise and fall times to the nanosecond range.

For the most part, photodiode applications are analog, where some linearity between the input light intensity and the electrical output is desired. A linear light-sensing system can thus take the form shown in Fig. 8a. Since the input of an operational amplifier is a virtual ground, the photodiode in Fig. 8 can be considered as operating in the short-circuit mode. Since the photodiode is very nearly a constant-current generator, the short-circuit current must be supplied from the circuit through the feedback resistor. Therefore, since the input is at virtual ground, the output of the amplifier is:

$$E_o = I_{sc} R_f.$$



9. **Manufacturers' data-sheet curves** can be used for converting radiometric quantities into the electrical parameters required for design. Typical collector characteristic curves for a phototransistor are shown here.

An actual example of this circuit is shown in Fig. 8b. The circuit can provide gain bandwidth products of one megahertz, which can be raised to 10 to 20 MHz by using a pin photodiode and an amplifier, such as the μA702.

Essentially, then, designing with photodiodes is extremely simple, because in the most useful regions of operation the diode can practically always be considered a constant-current generator.

Phototransistors shine at switching

Phototransistors may or may not have the base lead available. If it is not, the device cannot be electrically biased in the active region; therefore, it is not generally useful for linear applications. The phototransistor can, of course, still be optically biased for linear operation; however, this is not generally practical from a design standpoint. The device is thus intended primarily for switching applications. Such applications are generally digital, as in computer-card and paper-tape readers.

In essence, the phototransistor sacrifices linearity and speed for gain. Typically it has 100-to-500 times the current output of the photodiode.

Basically, the design of a phototransistor circuit is similar to normal transistor circuit design, once the radiometric quantities are converted into electrical parameters. This conversion can be accomplished in either of two ways. First, one can look at the typical V_{ec} vs I_c vs H characteristics (Fig. 9) and, from that, determine the device's operating point by normal graphical means, using the value of irradiation determined by use of the calibrated photodiode. Or, second, the specification for collector-base photodiode sensitivity, S_{cb}, of the phototransistor is generally specified on the data sheet. Knowledge of this gives the base current drive, I_B, where

$$I_B = S_{cb} H \text{ (at a given } V_{cb}).$$

Then, knowledge of h_{FE} gives

$$I_c = h_{FE} S_{cb} H.$$

Certain additional factors should also be considered when using phototransistors. In using a two-terminal device, the designer loses some flexibility, part of which is temperature stability. Without the availability of the base lead, temperature stability becomes more difficult. The succeeding stages should therefore be designed with this fact in mind.

Additionally, phototransistors have relatively low gain-bandwidth products. This is due to the long lifetime of photogenerated carriers, as well as to the large C_{cb} (approximately 70 pF) resulting from the large base area needed for photo sensitivity. This large C_{cb} should be considered in design. ■■

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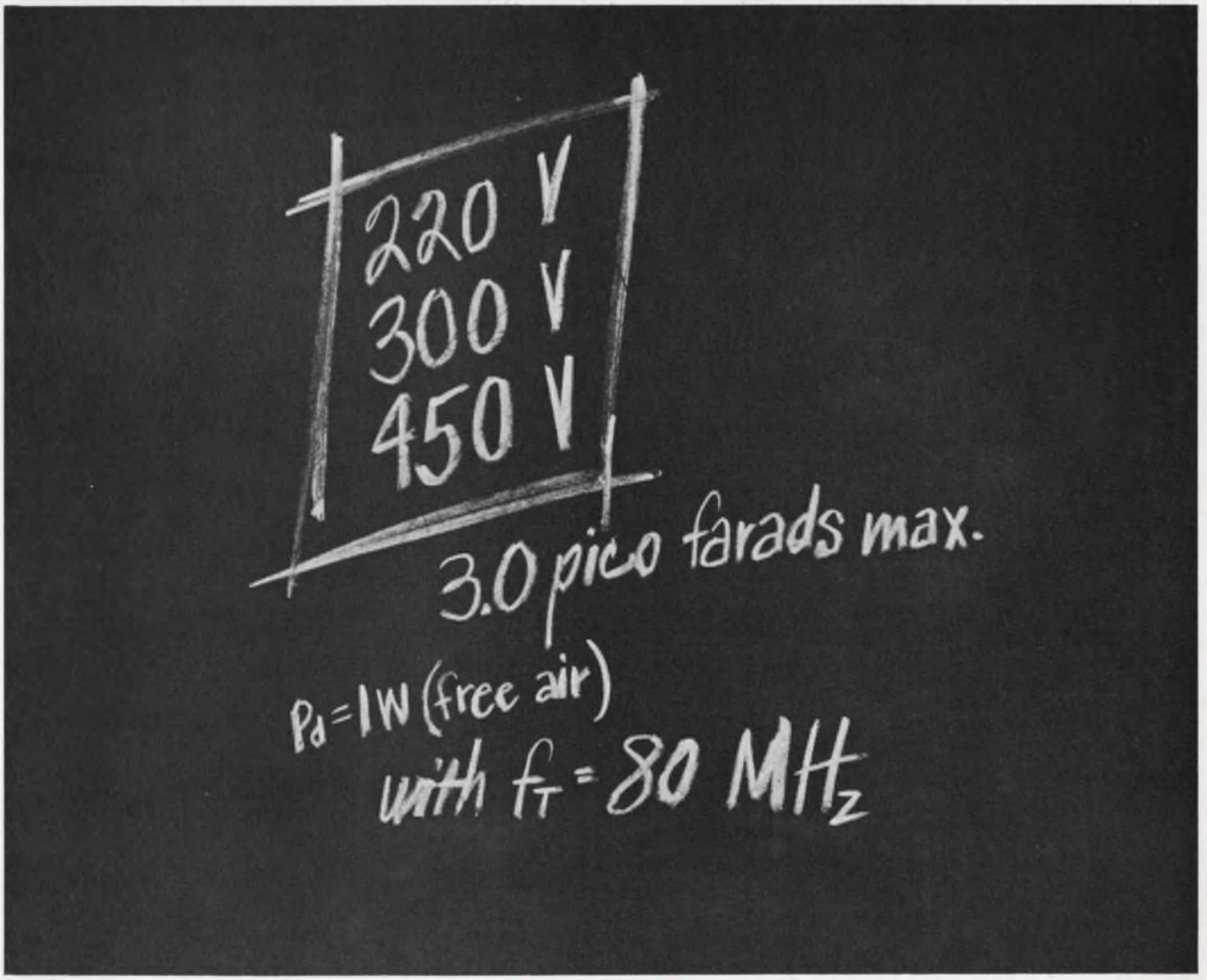

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INFORMATION RETRIEVAL NUMBER 36

Yes, you can develop your creativity.

Engineering staffs can be guided toward more original solutions, if the working climate in the company is right.

First of two articles.

"Life without any problems is not paradise; it is hell."

The quote has been attributed to Confucius, and some engineers may dissent. Life is certainly full of problems in engineering, and elusive solutions can raise hell. The key to paradise in the engineering plant is creativity.

Can creativity be taught? Or is it something innate that a person either has or lacks?

Within limits, enlightened engineering companies are finding that the creativity of their staffs can be improved or developed. But managers must establish the climate for such progress, and the individual must apply himself. You may not develop a team of Einsteins from your present engineering staff, but it is quite possible to improve their creative abilities with suitable training.

Let us see first how the creative process works and then examine how it may be nurtured. In engineering, creativity can be divided into five basic steps:

1. Recognition and analysis of the problem.
2. Saturation with information and suggested solutions.
3. Incubation of ideas.
4. Illumination.
5. Verification of the solution and modifications to it.

An important consideration in creativity is that at the outset the problems to be solved should be stated in functional requirements that are as basic as possible. How many times have we seen good ideas thrown into the wastebasket, only to be retrieved later on when it was found that initial marketing specifications were more restrictive than necessary! Supervisors can be equally guilty if they set the specifications so early in a project that they really reflect a preconceived solution in their own minds. If a solution is left open and purely *functional* specifications are given to the project engineer, he may come up with a better solution than the supervisor had originally envisioned. This is the creative way to *recognition and analysis of the problem.*

Following such functional specification, the engineer should *saturate* his mind with background information on the problem—information tapped from every possible source. As part of this process, he explores many tentative ideas, but not necessarily real solutions in themselves.

Then the engineer should let the problem *incubate.* Some authorities recommend that he actually drop the problem and work on a second project, while the first one is incubating in his subconscious.

One day (or night), hopefully, a solution appears—the so-called *illumination.*

There follow many hours of patient engineering and experimentation to optimize the solution *—verification and modification.*

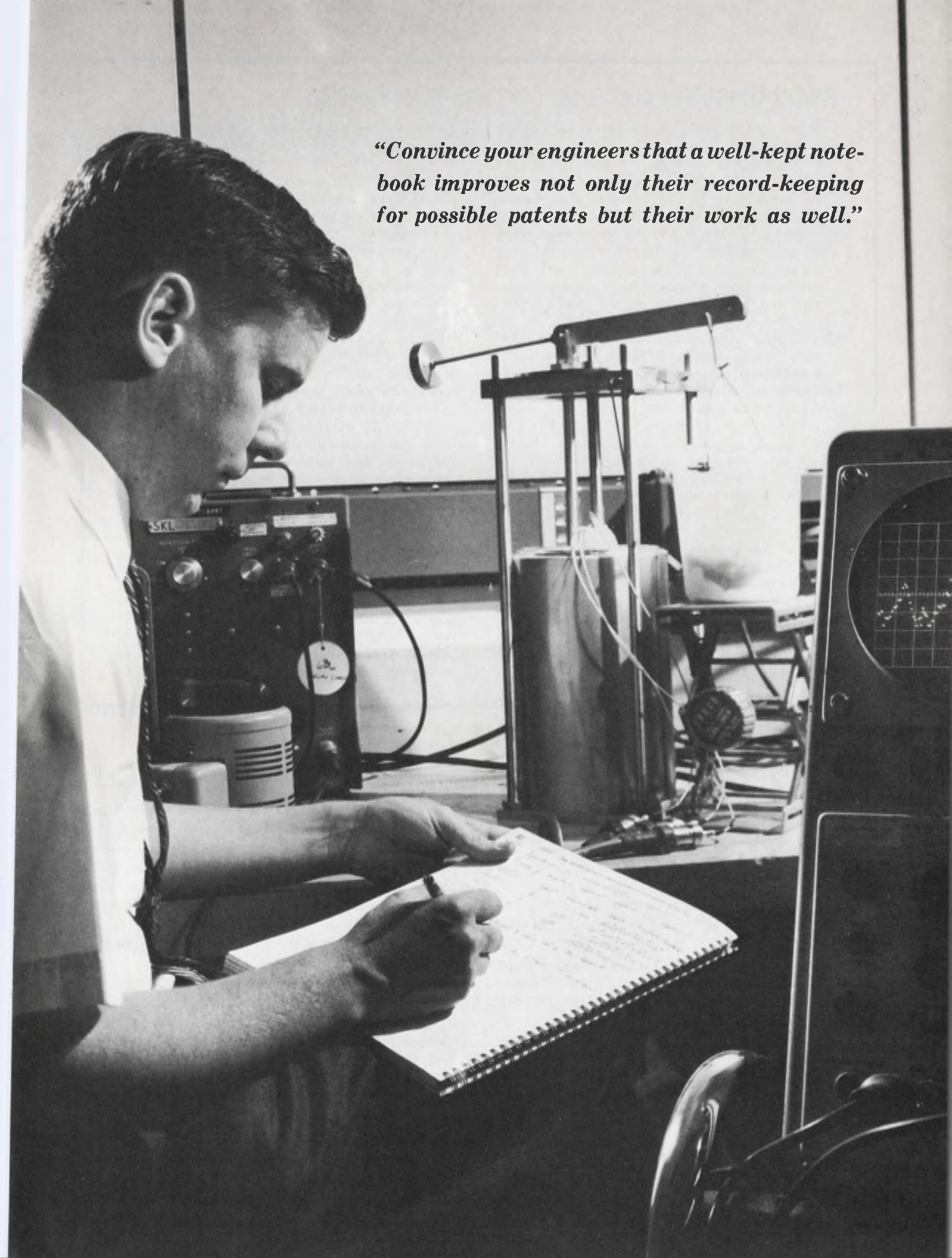
Promoting creative thinking

What can company managers do to help this process? Here are some practical ways to promote creative thinking in your organization:

▪ **Broaden the staff's background of experience.** Creativity is certainly not a universal characteristic. Persons with creative abilities in one field, such as art or music, are not necessarily creative in another—science, say. Yet it is not unusual for a scientist in one discipline to carry over his talents into a second technical field. An engineer can solve problems more easily if he is equipped with basic knowledge in several technical fields. This background will enable him to recognize the merits of a variety of solutions.

Assign engineers to work on projects in teams. One man may be a member of several different teams in any one year, and each team should include men of different technical backgrounds. By close association, each engineer can obtain a working knowledge of other fields and thus broaden his own base for creativity. Obviously a man cannot find an electronic solution to a problem if his whole experience has been solely with mechanical devices. This system is used at the

Dr. Wilmer C. Anderson, Director of Research, General Time Corp., Stamford, Conn.



"Convince your engineers that a well-kept notebook improves not only their record-keeping for possible patents but their work as well."

Avoid these six common barriers to creativity

There are mental blocks to creative engineering. They include:

- **Difficulty in isolating the problem.** A very common trouble with engineers. Frequently what appears to be the problem may not be the real basic problem. It is the old case of not seeing the forest for the trees. How often does an engineer struggle with interfacing two circuits over wide voltage and temperature ranges when, if he examined functional requirements, he would realize that more than likely either one or both of the troublesome stages could be completely eliminated with a slightly different approach.
- **Difficulty in narrowing the problem.** Here the engineer tries to carry too much forward simultaneously, with the result that he is never able to focus on the individual parts of the over-all problem. A good cook is able to focus her attention on critical segments of her dinner—the dessert, say—while still keeping the other elements of her dinner on schedule, so that all will be perfect for eating at the correct time. Contrast this with the inexperienced cook who burns half her food while the other half gets cold because of her inability to keep the different segments of the whole dinner in proper perspective.
- **Closing the door to alternatives too soon.** Another common fault, particularly of development engineers. They are so anxious to get on to the "hardware" stage that they grab the first solution that comes to mind and run with it. One way for the manager to counter this is to take the first solution offered and say: "Fine. Now forget this one and give me a brand new one." Do this several times until four or five solutions are available. Then have the engineer evaluate them himself. He will often discard the first ideas suggested. After a while he will develop the habit of offering alternative solutions before taking them in for evaluation.
- **Difficulty in seeing remote relationships.** This is among the most difficult blocks to overcome. Practice and work with others who have this ability is the only remedy many authorities can suggest.
- **Failure to record "trivia."** Engineers are prone to skip over details that are obvious to them and frequently are guilty of not recording items that may seem inconsequential at first but may later have an important bearing on the solution. Frequently experiments have to be repeated because certain critical circuit details not considered important at the time were omitted.
- **Failure to distinguish between cause and effect.** This is a stumbling block even among the best scientists. Edison discovered electron flow from a heated filament to an anode, but it took deForrest to recognize what Edison had actually discovered and then improve it with a control grid.

General Time Corp. plant in Stamford, Conn., and the proof of its success is the number of electronic patents created by mechanical engineers and of mechanical patents generated by electronics engineers.

- **Insist on good research habits.** Convince your engineers that a well-kept notebook improves not only their record-keeping for possible patents but their work as well. Many engineers have a standard excuse: "Let me put the data down on scratch paper first, then copy everything neatly into a notebook." This is nice in theory; it fails miserably in practice. Such scraps of information are frequently never copied into the research notebook. As a result, earlier discarded approaches, which could prove valuable later, often are thrown into the wastebasket and forgotten.
- **Use simple, but formal, invention disclosures.** Writing up an idea for the patent department makes an engineer think about his solution more thoroughly. Frequently this leads him to alternate solutions. Some of these may even be superior to his first one.
- **Have frequent internal idea sessions.** Let engineers get together to exchange thoughts.
- **Permit "free" time for personal work.** Many companies now grant their research staffs as much as 10 per cent free time to explore ideas on their own. This is time that does not have to be accounted for or rigorously charged to some formal project. The only stipulations are that it be spent on ideas of company interest, and that the results be presented to management in a reasonable period.
- **Encourage the storing of idea materials.** This is like a squirrel storing nuts for winter food. Clippings from papers, trade journals, magazine articles, references and technical journals, advertisements of unusual materials, and samples—all are filed for future use. They become the mental "food" that may supply the missing vital link in a solution; they may spark an idea for a new product.
- **Have periodic give-and-take conferences at which outsiders are guests.** Invite staff members and guest speakers to discuss new developments

in various technical fields. Such talks, followed by informal discussions, can prove extremely stimulating. The talks do not have to be long or formal. A half-hour talk, with equal time for questions and answers, is enough to start several minds thinking in new directions.

▪ **Discuss the creative techniques used by others.** Tailor such sessions as you do an applications forum. Show engineers the methods and techniques used by others, and discuss how these can be applied to their own work.

▪ **Develop practical incentive policies.** Some companies give awards to outstanding men. This is tricky ground from a personnel point of view and must be handled carefully to prevent more damage than gain to the company. Make sure that all team members are properly rewarded; otherwise disgruntled members may quit or refuse to cooperate as a team.

These are basic, universal ways to spark creativity in the engineering plant. Some companies have also found the following to be valuable:

- Input-output schematics.
- The technique of "forced relationships."
- Checklists.
- Morphological analysis.
- Brainstorming.
- Creative thinking exercises.

The *input-output method* is especially useful in systems engineering. A little "black box" is drawn, with input signals and the corresponding output functions desired. It is then up to the engineer to fill in the connecting links that must appear in the black box to produce the results depicted. The mere putting down on paper of such a form helps to clarify the problem.

Forced relationships is a technique that can be helpful in innovating new consumer products and gadgets. Catalogs of existing products are forcefully related to a list of properties or materials from new technologies, so as, hopefully, to arrive at some new and useful product. For example, cooking utensils may be matched with Teflon, baking wear with pyroceram used in satellites or ice jugs with foamed plastics.

A *checklist* for creativity contains key words and a series of questions. It may include:

1. *Modify*: Change color, form, shape, motion?
2. *Magnify:* Additions, more time, greater frequency, larger, stronger, thicker?
3. *Minify:* Smaller, condensed, miniature, lower, shorter, lighter, streamlined?
4. *Adapt:* What other idea does this suggest? What could I copy? Anything similar in in the past?
5. *Substitute:* What else can be used? Other materials, other processes, other power, another approach?
6. *Reverse:* Transpose positive and negative, turn it backwards, turn upside down, reverse roles, opposites?
7. *Rearrange:* Interchange components, new layout, change schedule, pattern, sequence, transpose cause and effect?
8. *Combine:* Blend, alloy, assortment, ensemble, combine units, purposes, ideas?

In other words, take some present product and consider what would happen if you did any one or more of these things to it. Would a new and useful product result?

Morphological analysis is a method developed by Dr. Fritz Zwicky of the California Institute of Technology. It consists of first defining the problem, then listing every conceivable theoretical solution and finally evaluating each of the suggested solutions. Thus a problem having, say, three variables, each with five possibilities, would have a total of $(5)^3$ or 125 theoretical combinations. Of course, perhaps only two or three of these might prove worth pursuing further.

Brainstorming may be summarized as follows: A group of eight to 10 people of varied backgrounds is assembled for a session lasting no less than 15 minutes or more than one hour. Rapid-fire suggestions are made. There is no evaluation of ideas during the session and no criticism. The group suggests ideas as fast as possible, and they are jotted down on a blackboard for visual stimulation and reference.

Brainstorming differs from the *idea session.* For the latter the general rules are: The chairman alone knows the true objective. There is a general discussion at first of the subject matter, without regard to pinpointing a specific area of interest. Gradually the discussion is narrowed toward the goal, and finally the goal is considered in the light of earlier suggestions. ▪▪

The second article in this series will discuss creative thinking and how it can be used to develop new products.

Test your retention

Here are questions based on the main points of this article. They are to help you make sure you have not overlooked any important ideas. You'll find the answers in the article.

1. Name five techniques that help improve creative thinking.

2. What are "idea sessions" and how do they differ from "brainstorming sessions?"

3. Why are well-kept engineering notebooks relevant to creativity?

microtopics

product news from Philco-Ford Microelectronics

Radiation-tolerant IC's now in production

We have developed techniques for producing dielectrically isolated bipolar integrated circuits which can tolerate high levels of transient radiation. Our oxide isolation process has proven reliability. We are now supplying in production quantities.

Prototype quantities of gates, buffers and flip-flops are readily available. Write or call for a consultation on your specific application.

INFORMATION RETRIEVAL NUMBER 161

New packages for LSI

Radial flat packs with 34 and 44 leads are now ready for use with LSI circuits. Leads have .050″ spacing. Precision lapped sealing surface to maximize sealing yields. Supplied with brazed sealing ring and isolated metal base. Prototype quantities can be delivered promptly. For data on production quantities, write or call us.

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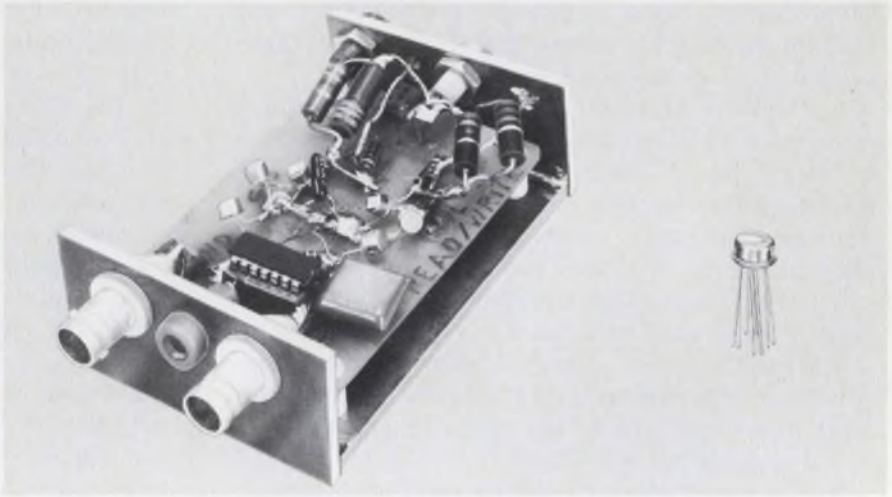

Discrete circuit write amplifier at left was shrunk to hybrid version at right, in TO-5 case.

Microminiaturize your discrete circuits the economical, fast, hybrid way

A write amplifier for magnetic tape, when made of discrete components, used to fill a 2″ x 3″ x 1″ chassis. We converted it to a hybrid microcircuit that fits in a TO-5 case. Four weeks after receiving full circuit data, we had a prototype ready for evaluation. In ten weeks we were producing at a rate of 500 per month.

Performance? The hybrid version is electrically equal, and environmentally superior, to the discrete circuit.

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Hybrid circuits by Philco-Ford are the way to get complex circuits into small packages . . . to provide voltage, current and power output beyond the present abilities of monolithic devices . . . and to do the job quickly, with minimum tooling cost. We've made hundreds of different hybrid circuits. Call a Philco-Ford Hybrid Hunter now, for a consultation on your circuit.

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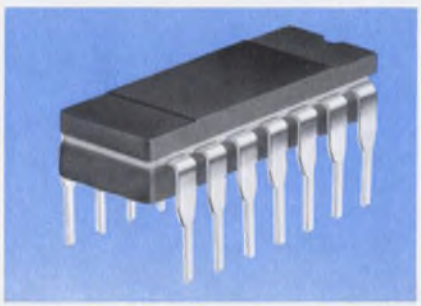
When you go T²L ...go Cerdip



It pays to buy state-of-the-art logic in state-of-the-art packaging. We make a full line of T²L gates, expanders and flip-flops, pin interchangeable with SUHL* II. And we supply them in cerdip packages of proved reliability. Both MIL and industrial temperature ratings are available.

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Oh, yes, we also supply T²L in ceramic flat packs.

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PHILCO Ford

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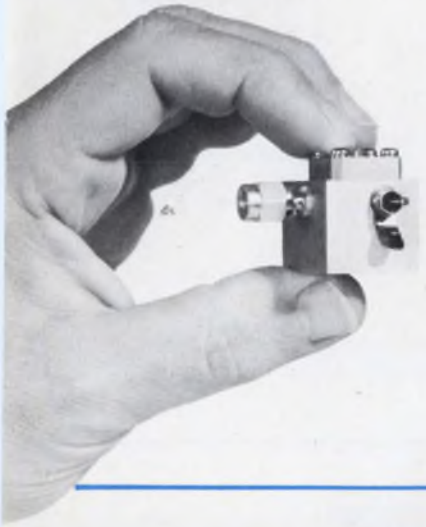
New avalanche oscillator X-band source is available from stock



The Philco-Ford P8510 source is now in full production at our Spring City, Pa., plant. And it has more than instant availability to recommend it.

It's highly efficient at low DC input levels. You get 60 milliwatts of X-band power from only 1.5 watts DC. At higher DC input, you can get up to 200 milliwatts out. The secret of its performance is high efficiency Philco avalanche oscillator diodes. Check the specs. Then write to us for data and prices on our complete line of avalanche oscillators from 6 to 16 GHz.

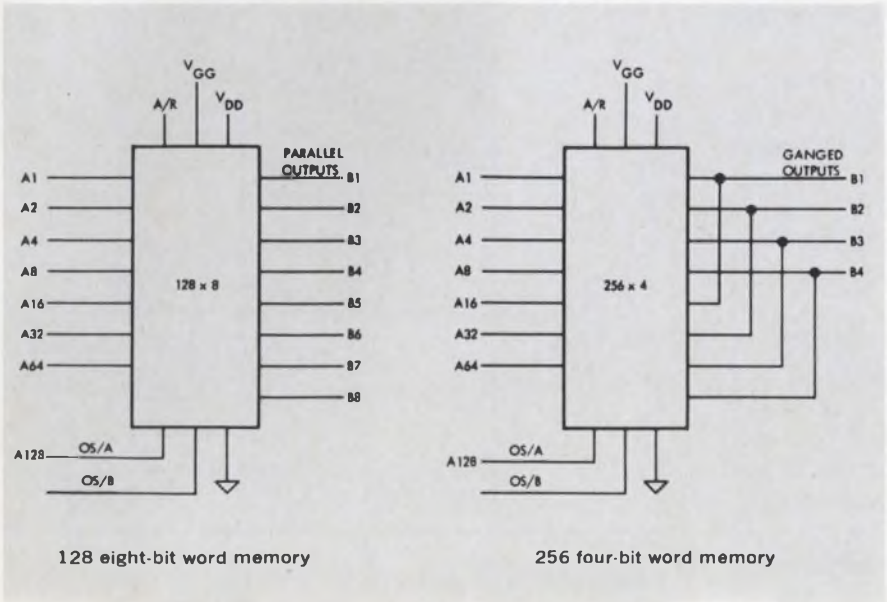
INFORMATION RETRIEVAL NUMBER 165

Specifications of the Philco-Ford P8510.

Frequency range (any 5% bandwidth): 6 GHz to 11 GHz
Mechanical tuning: 5% full power to 20% with reduced power
Power output: 60 mw min (CW)
Power input: 80 to 100 VDC, 15 to 25 ma. from constant current source
Efficiency: 3-5%
Weight: 1.5 oz.
Volume: 0.8 cu. in.
Connector: 3 mm miniature coaxial
Operating temperature: −40°C to +85°C
AM noise: typically 110 db per KHz below carrier from 1 KHz to 100 KHz
FM noise: typically 500 Hz rms per 100 Hz from 1 KHz to 100 KHz

MOS 1024-bit read-only memory costs less than 5c per bit

Systems designers: get acquainted with the Philco-Ford pM1024 MOS read-only memory . . . then let your imagination run wild. The off-the-shelf pM1024 is programmed with a sine look-up table, and is available for immediate delivery. By use of a custom mask, the pM1024 can be programmed as a look-up table for cosine, tangent, log, exponential or any other commonly used function. Or a synched eight signal waveform generator with a period 128 times basic clock frequency. Stack them up, and you can get character generation, provide microprogramming of subroutines, or solve recurrent equations having variables of known interaction. The fast cycle time of the pM1024 . . . short as 1 microsecond . . . makes many new applications practical.



128 eight-bit word memory

256 four-bit word memory

Pattern organization can be 128 eight-bit words, or 256 four-bit words. Built-in chip select lets you parallel chips to build up memory capacity. Address decoding, memory, and output buffers are all contained on the chip. Output buffers can drive DTL and T^2L directly.

Through the use of computerized software, your custom bit pattern is transferred to the pM1024 with complete accuracy, and with fast turnaround.

Cycle times of 1 and 2 microseconds are available. We supply in full temperature rating, −55 to +125°C; or limited temperature rating, 0 to 70°C.

INFORMATION RETRIEVAL NUMBER 166

TV-camera vertical sweep produced by filter ripple

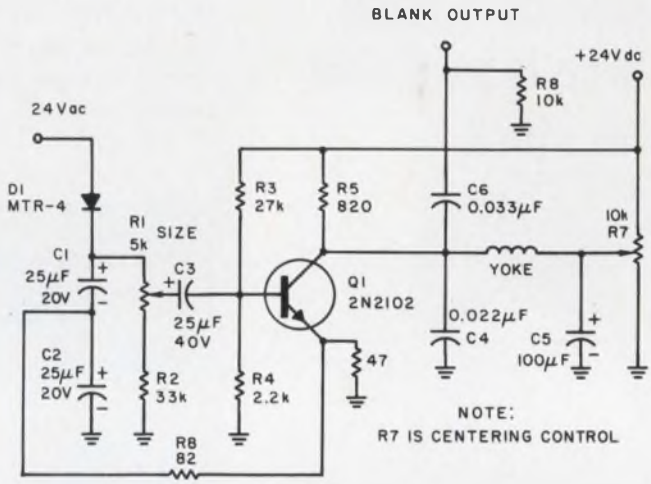
Line-locked vertical sweep for television cameras can easily be obtained with the circuit shown.

The ac input is applied to a standard half-wave rectifier and filter system, whose inherent load discharge ripple is a near-linear, line-locked vertical sawtooth. The sawtooth is amplified by transistor *Q1*, and is used to drive the deflection yoke. Feedback resistor R_8 linearizes the ramp, while R_7 and C_5 set the dc reference for centering control.

The "blank" output may be used to trigger the camera's sync and cathode-blanking functions.

James M. Meacham, Associate Engineer, Westinghouse Aerospace, Baltimore, Md.

VOTE FOR 311



Discharge ripple from the rectifier-filter network appears as a line-locked vertical sawtooth across resistor R_1.

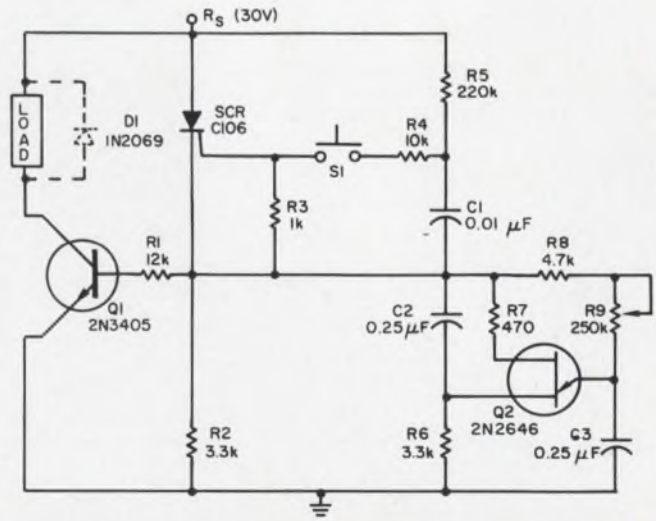
Any switch closure produces a fixed-duration output pulse

A frequently encountered requirement for many applications is that a random-duration switch closure provide a fixed-duration output pulse. In the circuit shown, switch-contact closures from a few microseconds to any maximum value will result in one fixed-duration output pulse per contact closure. Depending on the output pulse and switching durations, the circuit can function as a pulse stretcher, pulse shortener and contact-bounce eliminator.

When power is applied to the circuit, capacitor C_1 charges through resistors R_2 and R_5. Closing switch *S1* then triggers the silicon-controlled rectifier. With the SCR ON, its cathode potential rises to $V_s - V_{FM}$ (approximately 29 V), where V_{FM} is the voltage dropped across the conducting SCR. This causes transistor *Q1* to switch ON, thus applying power to the load.

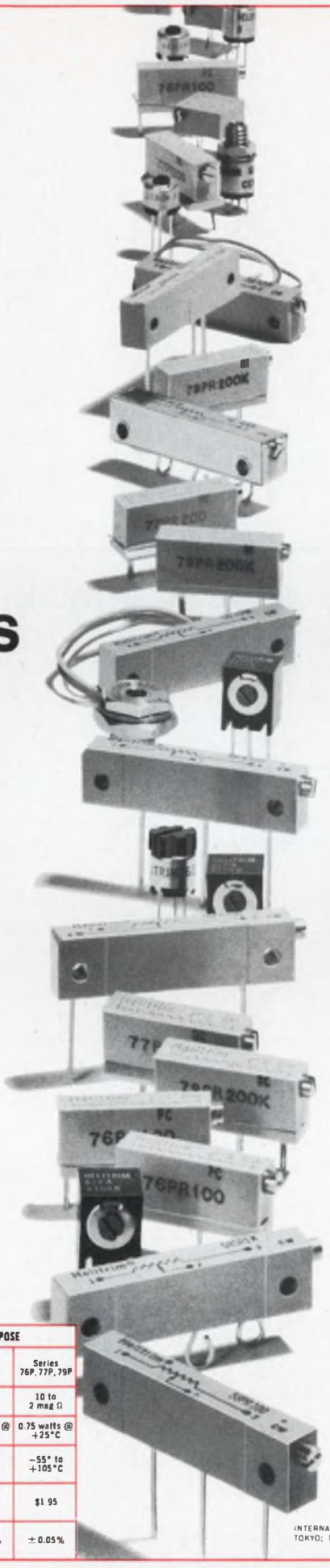
At the same time, capacitor C_2 charges to $(V_S - V_{FM})\ [(R_{BB}+R_7)/(R_{BB}+R_6+R_7)]$ in less time than is required for C_3 to charge to the peak point voltage of the unijunction transistor, *Q2*. Here, R_{BB} is the interbase resistance of *Q2*. When the voltage on C_3 reaches the peak point voltage, the emitter of *Q2* becomes forward biased, and C_3 discharges through R_6 and the unijunction emitter circuit. The voltage thus developed across R_8, plus the voltage on C_2, makes the cathode of the SCR more positive than its anode, turning it OFF. The base of *Q1* then returns to ground potential, switching *Q1* OFF and de-energizing the load.

If switch *S1* is held closed for a period of time



The output pulse duration is controlled by resistor R_9, which determines the charging rate of C_3.

The endless line



It's a complete line – an endless line of Helitrim® cermet trimming potentiometers with a current field failure rate of only 0.08%.

And all have essentially infinite resolution. Plus a wide range of standard resistance values. And excellent setting and total resistance stability under a wide range of environmental extremes.

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For more details on "the endless line" of cermet trimmers, contact your local Helipot sales representative. He'll tell you all about cermet reliability, fill you in with all available test data and personally handle your Helitrim orders.

	MILITARY			HIGH TEMP.	GENERAL PURPOSE		
	Series 55, 56, 58 (RJ11 & RJ12)	Series 61 (RJ50)	Series 63 (RJ24)	Series 50	Series 62	Series 78	Series 76P, 77P, 79P
Resistance Range	10 to 2 meg Ω	10 to 1 meg Ω	10 to 2 meg Ω	10 to 2 meg Ω	10 to 1 meg Ω	10 to 2 meg Ω	10 to 2 meg Ω
Power Rating	1 watt @ +85°C	0.5 watts @ +85°C	0.5 watts @ +85°C	1.5 watts @ +125°C	0.5 watts @ +70°C	0.75 watts @ +70°C	0.75 watts @ +25°C
Operating Temperature Range	−65° to +175°C	−65° to +150°C	−65° to +150°C	−65° to +200°C	−25° to +125°C	−25° to +125°C	−55° to +105°C
Price (List 1 to 8)	$5.50	$5.50 (61P) $6.50 (all others)	$6.50	$8.00 (50) $7.50 (53, 54)	$1.75 (62P) $2.00 (62PF) $2.50 (all others)	$3.00	$1.95
Typical Setting Ability	±0.01%	±0.05%	±0.01%	±0.01%	±0.05%	±0.05%	±0.05%

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INFORMATION RETRIEVAL NUMBER 38

greater than the output pulse duration, the voltage divider action of R_2, R_3, R_4 and R_5 limit the voltage across R_3 to a value less than the minimum gate-trigger voltage. This prevents the SCR from turning ON again after it is commutated.

Transistor *Q1* is used to control the load, rather than placing the load in the cathode circuit of the SCR, for two reasons: First, this makes the component values in the commutation circuit independent of the load impedance, and second, it makes the required capacitance of C_2 and C_3 considerably less (less energy is required to commutate the SCR because of the small current passing through it). This is especially important in applications where space, cost and accurate timing are important.

The value of R_6 is chosen to limit the interbase voltage of *Q2* to a value within its rating. R_7 provides temperature compensation for the unijunction transistor, and R_1 limits the gate-trigger current. If an inductive load is being controlled by the circuit, a free-wheeling diode (*D1*) should be used to suppress the inductive spikes.

With the values specified on the diagram, the output pulse-width of the circuit can be varied by R_9 from 2.5 to 100 ms. Varying the supply voltage, R_8, from 15 to 45 V will result in less than a 0.2-ms change in the duration of the output pulse.

Robert W. Murre, Senior Engineer, Bell & Howell Co., Chicago, Ill.

VOTE FOR 312

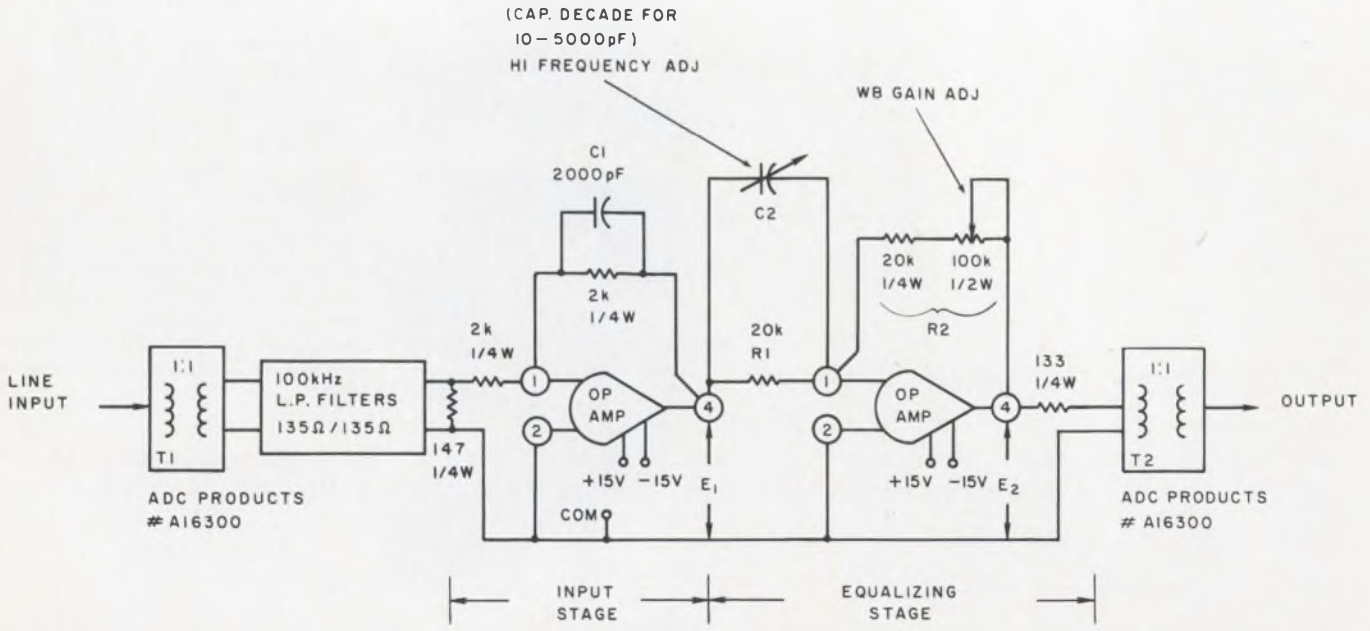
Line equalizer uses active RC network

The upsurge in data transmission over telephone lines has required new techniques in line equalizer design. Such a technique is the use of active RC networks instead of conventional R-L-C amplifier equalizers. This eliminates bulky inductances, thus decreasing package size. Also, active RC networks produce transfer functions not realizable with passive elements. An active RC network line equalizer of this type (Fig. 1) is also very easy to align to the attenuation characteristics of a given line.

The line equalizer of Fig. 1 is for telephone lines that transmit 50 kilo-bit data and for a data waveform that has frequency components from 10 Hz to 70 kHz. The equalizer therefore compensates for the line attenuation over this wide band of frequencies.

An operational-amplifier, active RC network provides the required equalizing characteristics, and a unity-gain input stage provides the required R_{in} of 135 ohms and a 180° phase shift.

Since the equalizing stage functions in the inverting mode, the 180° phase shift of the input stage combined with the equalizer produce the



1. **Active RC network** provides the required equalizing characteristics in this line equalizer.

Philbrick/Nexus DC log amplifier– a slip stick in 2.65 cubic inches

Quicker than you can operate your favorite slide rule, Model 4350 Log Amplifier will calculate the logarithm of a positive voltage or current, or solve the positive antilog of an input voltage. Model 4351 performs the same functions on negative voltage or current.

The combination of two Philbrick/Nexus log amplifiers multiplies and divides. Add scaling resistors and you can compute arbitrarily selected powers and roots. Units are fully temperature compensated for use over wide temperature ranges.

Units are fully encapsulated and measure 1.4" x 2.7" x .7". They feature fast response and a wide 6-decade dynamic range. Priced well below competition at only $95. Contact your Philbrick/Nexus sales representative for complete details and specifications. Or write, Philbrick/Nexus Research, 46 Allied Drive at Route 128, Dedham, Mass.

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INFORMATION RETRIEVAL NUMBER 39

required noninverting amplifier combination needed with data operation. The equalizing stage consists of a differentiating operational-amplifier, active RC network. The equalizer transfer function is

$$E_2/E_1 = -\left[\frac{R_2}{R_1 \quad \frac{1}{C_2 s}}\right] / \left[R_1 + \frac{1}{C_2 s}\right],$$

which reduces to

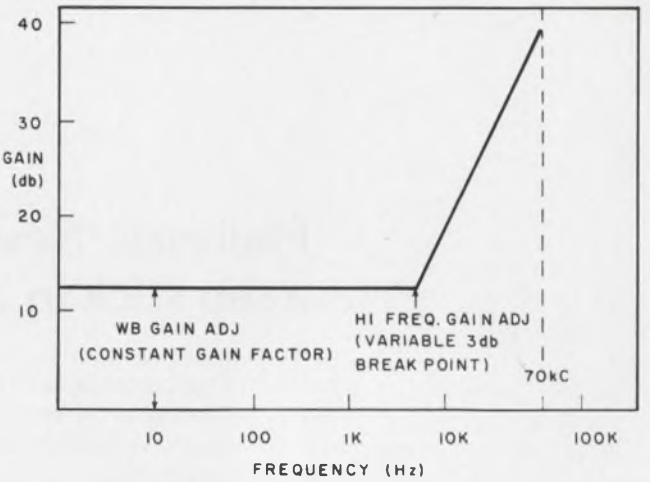
$$E_2/E_1 = -[(R_2/R_1) + R_2 C_2 s].$$

The Bode plot of this transfer function is shown in Fig. 2.

To compensate for various lengths of line, two controls are incorporated. These are R_2 (WB Gain Adjust) and C_2 (Hi Freq Gain Adjust).

Since a differentiating amplifier tends to accentuate high-frequency noise, a small capacitor may be needed across R_2 to roll off this stage at high frequencies. This capacitor would also increase the stability of the stage.

Since the line at low frequencies is essentially an integrating circuit (lagging phase characteristics) and the equalizer is a differentiating device (leading phase characteristics), the equalizer compensates for line phase distortion over a limited low-frequency region. This compensation



2. **Bode plot** shows transfer function of the equalizer stage.

is limited to less than 90° due to the fact that the equalizer phase relation θ is

$$\theta = \tan^{-1}\omega R_1 C_2,$$

which clearly approaches 90° in the limit.

A. R. Campbell, Senior Engineer, Philco-Ford Corp., Philadelphia, Pa.

VOTE FOR 313

Aperture coupling enhances filter selectivity

Aperture couplings in metallic partitions are frequently employed in comb-line bandpass filter structures. Multiresonator filters use apertures as interstage couplings between adjacent resonators, and probes or loops as input/output couplings. Coupling apertures can be located optimally for minimum frequency sensitivity over a wide tuning range. A somewhat different aperture location, however, can be used to provide frequency-sensitive couplings that enhance the selectivity of bandpass filters on their high-frequency skirts.

In comb-line bandpass filters, electric and magnetic couplings are in phase opposition. Consequently, adjacent cavity resonators will decouple when equal and opposite electric and magnetic couplings are present. This condition can be achieved with a properly located circular aperture (see diagram p. 78). For an aperture diameter equal to 0.625 in., located a distance L = 0.963 in. from the plane of the short, measured values of coupling bandwidth are shown in the table (right) for different center frequencies.

Center frenquency (GHz)	Coupling bandwidth (MHz)
1.3	23.0
1.5	24.5
1.7	24.2
1.9	19.0
2.1	11.3
2.2	6.0
2.3	Resonators decoupled
2.4	Resonators decoupled
2.5	8.0
2.7	11.0

For small circular apertures and uniform resonator cross section, decoupling occurs when the aperture centerline is 54.8 electrical degrees from the plane of the short. This corresponds to a frequency of about 18.7 GHz. For the comb-line structure shown here, decoupling occurs at a somewhat higher center frequency. This can be attributed to the use of nonuniform resonator cross section

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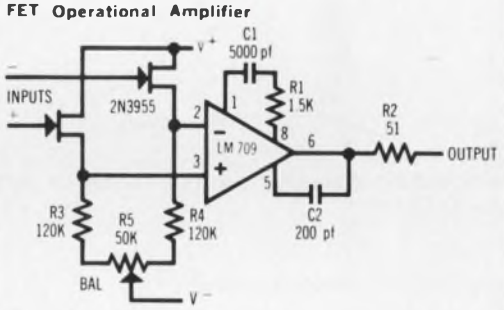

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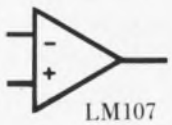
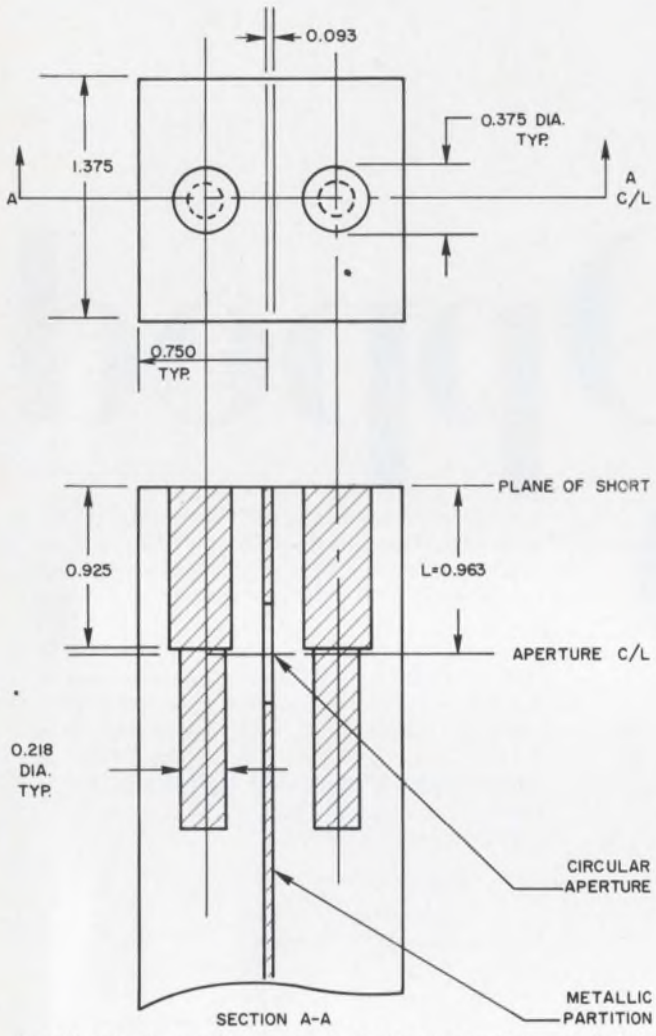


National Linear

INFORMATION RETRIEVAL NUMBER 40



Input/output couplings are not shown on this comb-line filter structure.

(compound center conductors of two different diameters), open-ended fringing, and large aperture affects.

The coupling aperture described here can be used in bandpass filters with center frequencies between 1.3 and 1.9 GHz. Substantial enhancement of high-frequency selectivity will occur between 2.2 and 2.5 GHz.

Richard M. Kurzrok, Consultant, New York City.

VOTE FOR 314

Signal-level envelope detector uses dual operational amplifier

Two operational amplifiers and a dual power gate can be used to form a versatile signal-level envelope detector.

Consider the waveform shown in Fig. 1, where it is desirable to detect when the input signal is above V_2 or below V_1. It is also a requirement that there be some hysteresis about both V_2 and V_1. The circuit shown in Fig. 2 will indicate (by means of a pilot light) whenever the input signal is out of range.

The amount of hysteresis about V_1 and V_2 is a function of R_1 and R_2, as shown in Eqs. 1 and 2.

$$V_t(+) = V_2 + |e_{out_5}^{(-)} - V_2| \frac{R_2}{R_1 + R_2} + V_{os} \quad (1)$$

$$V_t(-) = V_2 - e_{out_5} - V_2 \frac{R_2}{R_1 + R_2} + V_{os} \quad (2)$$

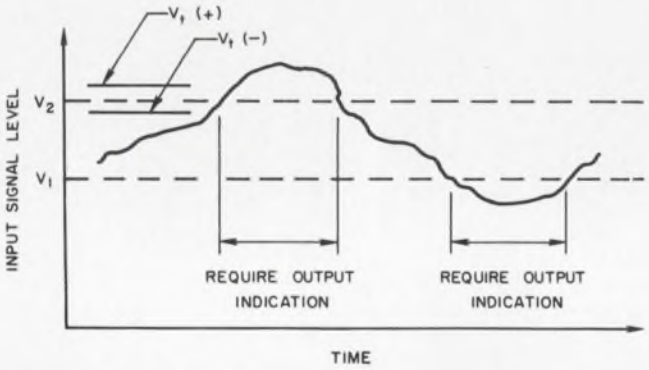
where

V_{os} = input offset voltage

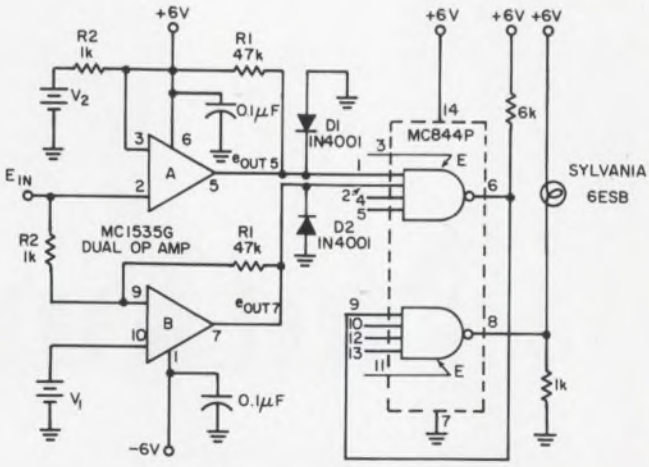
$e_{out_5}^{(-)}$ = output voltage when e_{out_5} is low (typically clamped to —0.7 V because of $D1$).

$e_{out_5}^{(+)}$ = output voltage when e_{out_5} is high (dependent upon load).

The amount of hysteresis resulting is the difference between $V_t(+)$ and $V_t(-)$.



1. **Envelope detector must provide indication** when the input signal level exceeds V_2 or drops below V_1.



2. **When circuit senses out-of-range condition,** the pilot lamp becomes lighted.

With a memory like this, you can forget the logic

Use the logic easily programmed into our ROM (Read Only Memory) elements. With a minimum of time (typically four weeks versus the twelve required for new custom logic elements), we can set up the simple interconnection metalization pattern your needs dictate and start shipments. Costs about a thousand dollars versus the forty thousand new logic elements run to. And there's every probability that your production run elements will cost less too.

ROM elements are far simpler to make than a new, untried logic design. They're highly repeatable and proven reliable. No logic race conditions; no logic circuit debugging. And our new MOS ROM elements are fast, 500 nanoseconds, the fastest available. They operate from +12 and −12 volt supplies. Easily compatible with conventional DTL and TTL.

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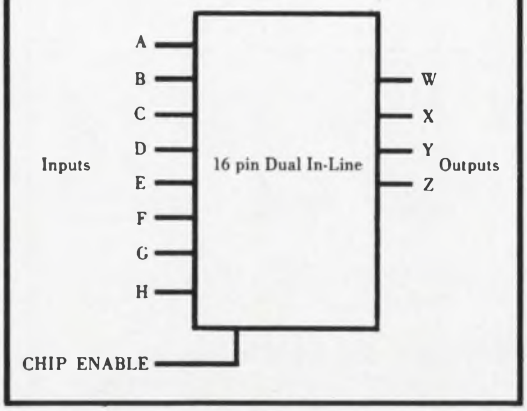
TWX: 910-339-9240. Cables: NATSEMICON.

FROM YOUR TRUTH TABLE

Inputs								Outputs			
A	B	C	D	E	F	G	H	W	X	Y	Z
0	0	0	0	0	0	0	0	0	1	0	1
0	0	0	0	0	0	0	1	0	0	1	1
0	0	0	0	0	0	1	0	0	1	1	0
0	0	0	0	0	0	1	1	1	1	0	0
0	0	0	0	0	1	0	0	0	1	0	0
0	0	0	0	0	1	0	1	0	1	1	1
0	0	0	0	0	1	1	0	0	0	0	0
0	0	0	0	0	1	1	1	1	0	1	0
0	0	0	0	1	0	0	0	1	0	1	1
0	0	0	0	1	0	0	1	1	1	1	1
0	0	0	0	1	0	1	1	1	1	0	1

TO YOUR MM 521



National MOS

INFORMATION RETRIEVAL NUMBER 41

With $V_1 = 2.5$ V, $V_2 = 3.5$ V and the component values shown,

$$V_t(+) - V_t(-) = 69 \text{ mV}.$$

Ken Wolf, Applications Engineer, Motorola Semiconductor Products, Inc., Phoenix, Ariz.

VOTE FOR 315

Complementary 'Schmitt' trigger has zero output-offset voltage

A feature of the conventional two-transistor Schmitt trigger that can sometimes be a problem is the fact that the output does not go to zero when the input signal is removed. As the trigger threshold level of the Schmitt is increased, the output-voltage offset also increases.

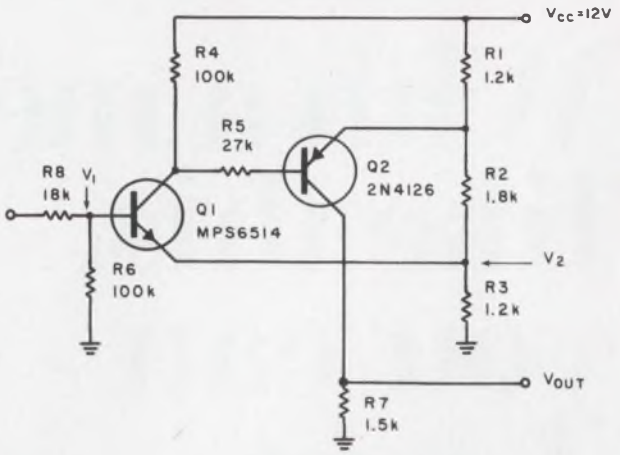
This problem can be avoided with the two-transistor complementary trigger circuit in Fig. 1. It has zero output offset, 5-V turn-on voltage and 1-V hysteresis.

Normally both transistors are OFF. The emitter voltage of both transistors is set by the voltage divider R_1, R_2 and R_3. When voltage V_1 exceeds $V_{2off} + V_{BE1}$, both *Q1* and *Q2* turn ON, providing an output voltage at the collector of *Q2*.

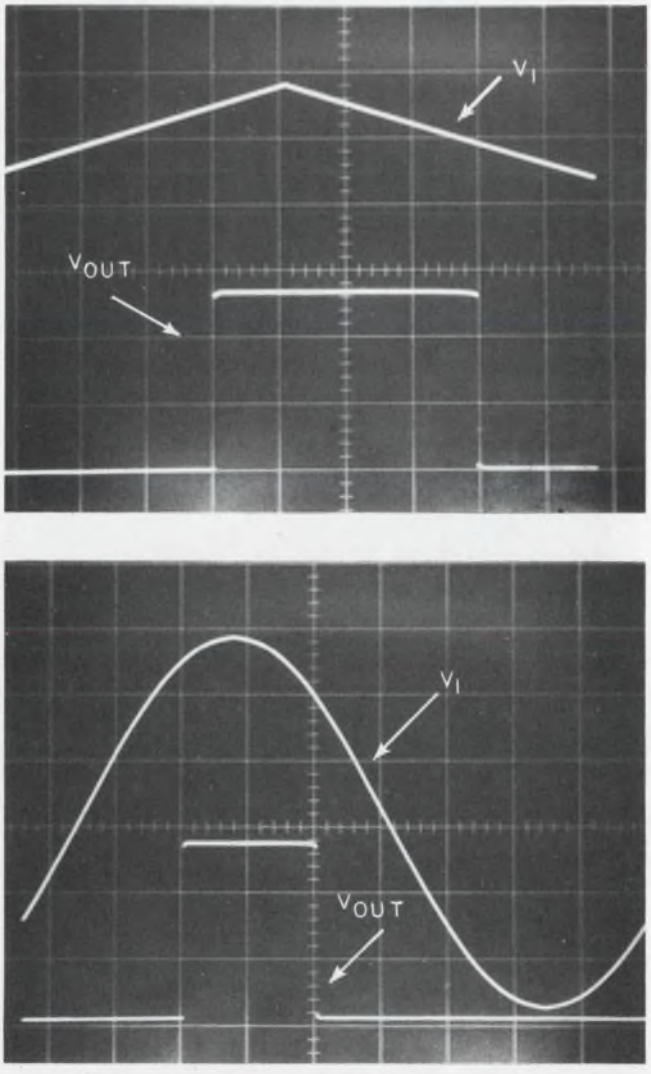
With both transistors ON, resistor R_7 is switched in parallel with R_2 and R_3, thus lowering voltage V_2. To turn *Q1* and *Q2* OFF, V_1 must decrease below $V_{2on} + V_{BE1}$. Thus the hysteresis may be adjusted by suitable choice of the voltage divider (R_1, R_2, R_3) and R_7. Sine-wave squaring with no hysteresis can be accomplished by bypassing the emitter of *Q2*.

Alan M. Hansel, Senior Development Engineer, E. F. Johnson, Waseca, Minn.

VOTE FOR 316



1. **Complementary circuit provides** Schmitt-trigger type operation with a zero output-voltage offset at a savings of one transistor over the conventional three-transistor approach.



2. **Complementary trigger circuit waveforms** are shown for dc operation (top) and ac operation with a 1-kHz sine-wave input (bottom). The two scales in both illustrations are 2 V/cm.

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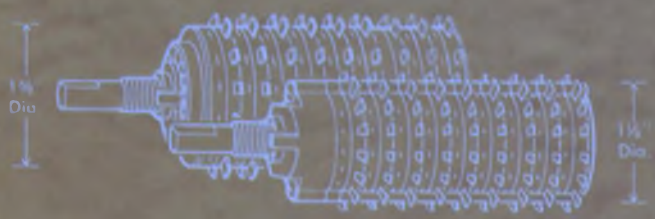

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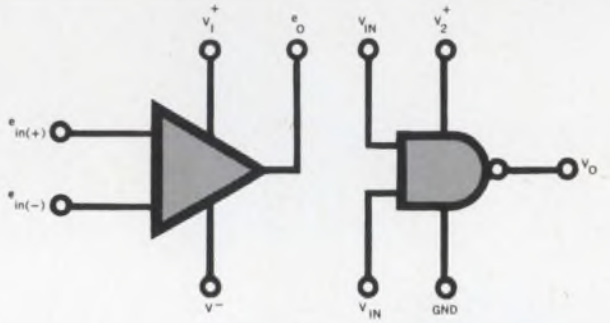

526 High Speed Comparator

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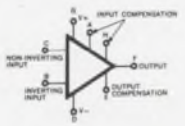
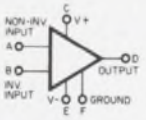
Signetics now has pin-for-pin and spec-for-spec replacements for the 709, 710 and 711 in all established package configurations. They are available in volume at low, low prices starting at $1.86 (100-999) in TO-5 industrial temperature types.

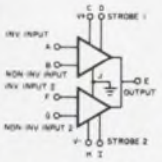
5709 Operational Amplifier



5710 High Speed Voltage Comparator



5711 High Speed Dual Voltage Comparator



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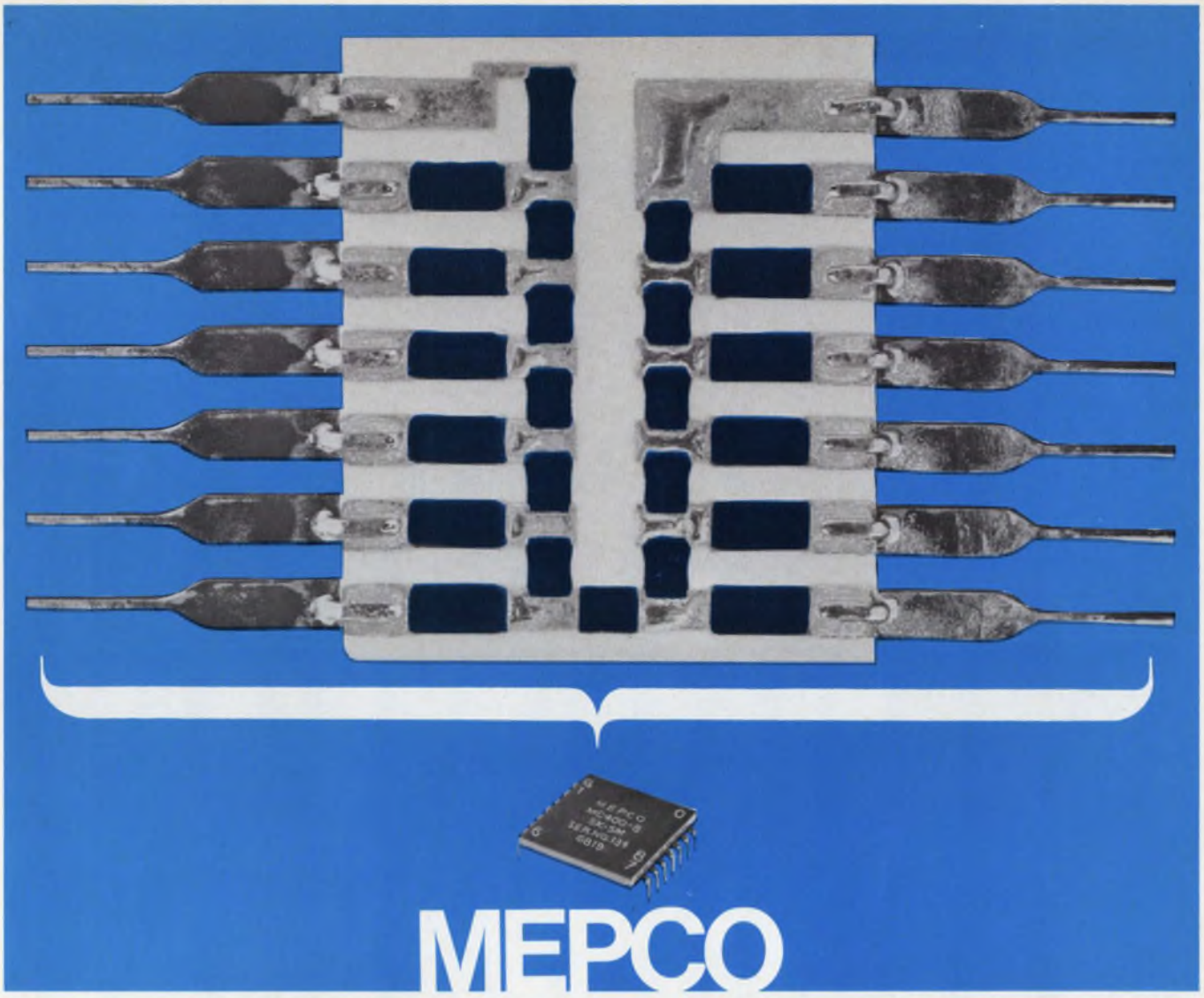

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Desired Salary	**Availability Date**

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Company			
City, State			
Dates	to	to	to
Title			
Specialty			

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Degree			
College			
City, State			
Dates	to	to	to

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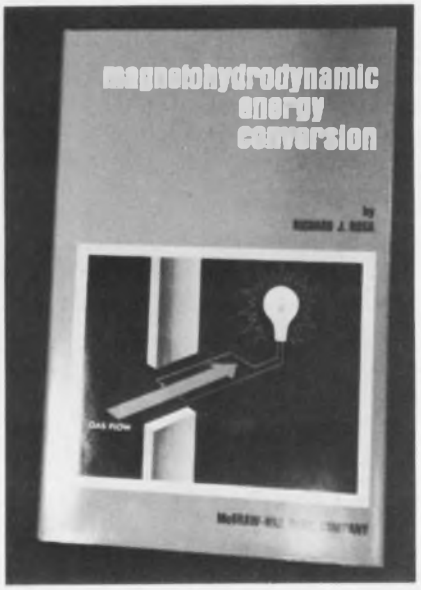
Book Reviews



MHD energy conversion

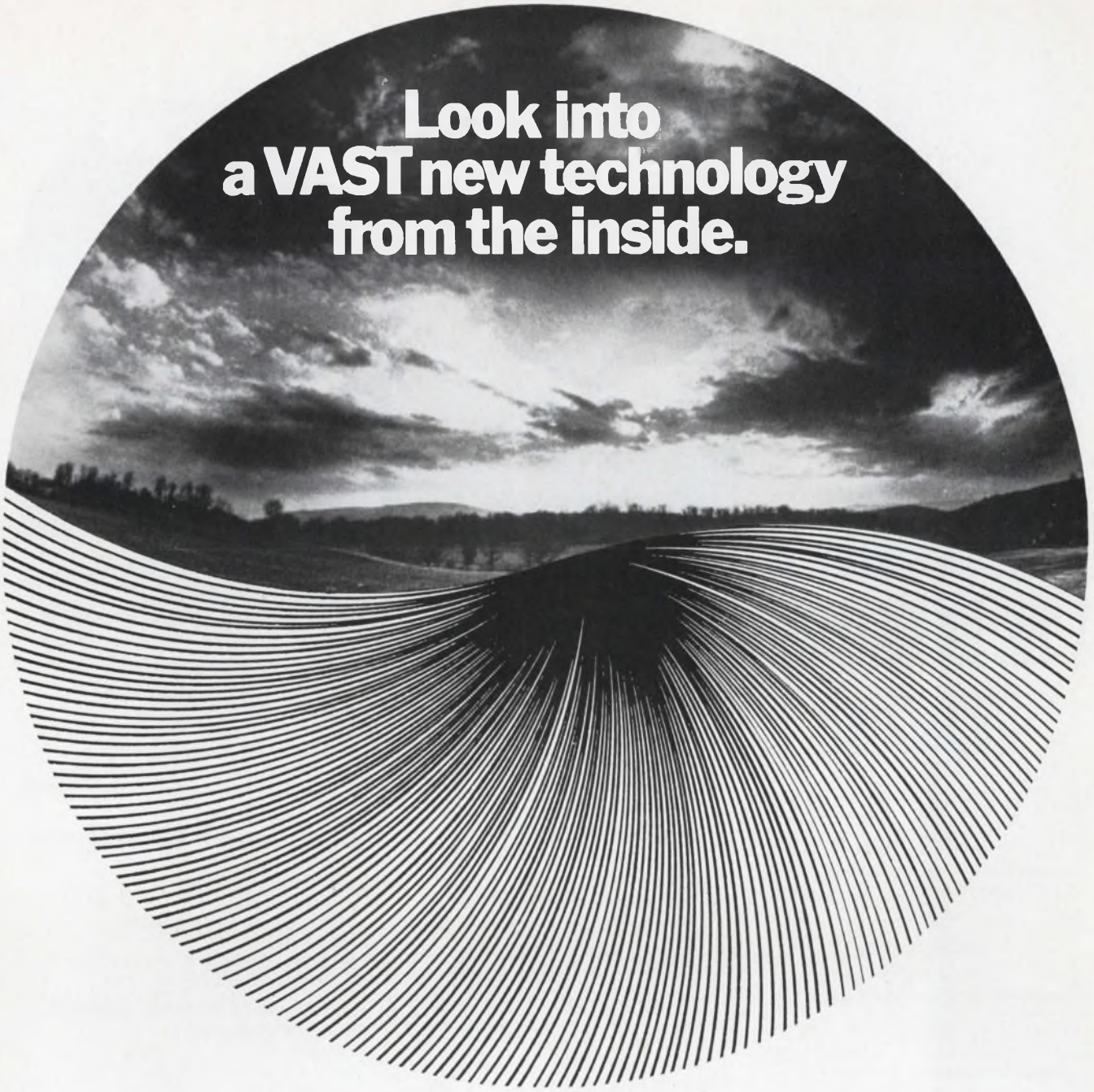
Magnetohydrodynamic Energy Conversion, Richard J. Rosa, (McGraw-Hill Book Co., New York), 230 pp. plus index, $17.50.

This stimulating introduction for the lay engineer—and useful reference for those engaged in the field—reviews the basic principles and practical aspects of MHD energy conversion. Detailed derivations from first principles are absent but pertinent qualitative semi-physical arguments are provided for those unfamiliar with plasma physics.

The book discusses such topics as fluid flow, instabilities and other nonuniformities, magnet designs for MHD generators, and scaling laws. All important advances up to the present are referenced. The possibilities inherent in the unique ability of MHD to handle ultrahigh temperature and power are explored in terms of immediate and future applications.

There are 114 illustrations and the appendices contain graphs of conductivity and Hall parameter for a variety of gases, miscellaneous constants and conversion factors, and expressions for rapid estimations of sound speed, viscosity and Reynolds number.

CIRCLE NO. 250



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*Space Aeronautics, April, 1968, page 76.

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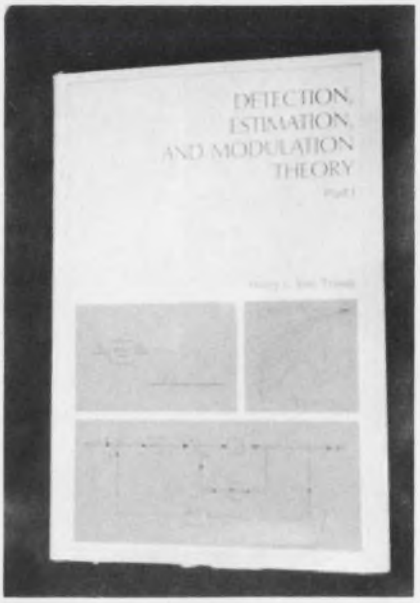

Statistical theory

Detection, Estimation and Modulation Theory, Part I, Harry L. Van Trees (John Wiley & Sons, New York), 697 pp. $20.

The application of statistical techniques to the analysis of all types of systems—and the resulting implications—are the subject of this authoritative book. Building on a sound base of classical detection and estimation theory and random process representation, the author devotes this volume to linear analysis.

The appendix contains a detailed course outline. Comprehensive references, an extensive glossary and a valuable index are also included.

CIRCLE NO. 251

Semiconductors

Semiconductors: From A to Z, Phillip Dahlen, (Tab Books, Blue Ridge Summit, Pa.), 272 pp., $7.95.

In clear, direct language, this text explains the functions and applications of a comprehensive range of transistors and semiconductors used today. With the assistance of over 300 illustrations, such topics as transistor biasing, effects of temperature on operation, factors limiting transistor frequency response, etc. are covered in a highly basic manner. Integrated circuit applications are treated extensively and several chapters are devoted to new developments in the field of optic-electronic circuits.

CIRCLE NO. 252

PHOTOGRAPH OF EARTH FROM AN ALTITUDE OF 22,300 MILES TAKEN BY ATS-3. COURTESY OF NASA.

It doesn't look like much. But it's home.

Earth. While it may not look like much from out here, it's a great atmosphere for hide-and-seek. The kind involving ballistic trajectories, large and small. Super/hypersonic speeds. And other complications.

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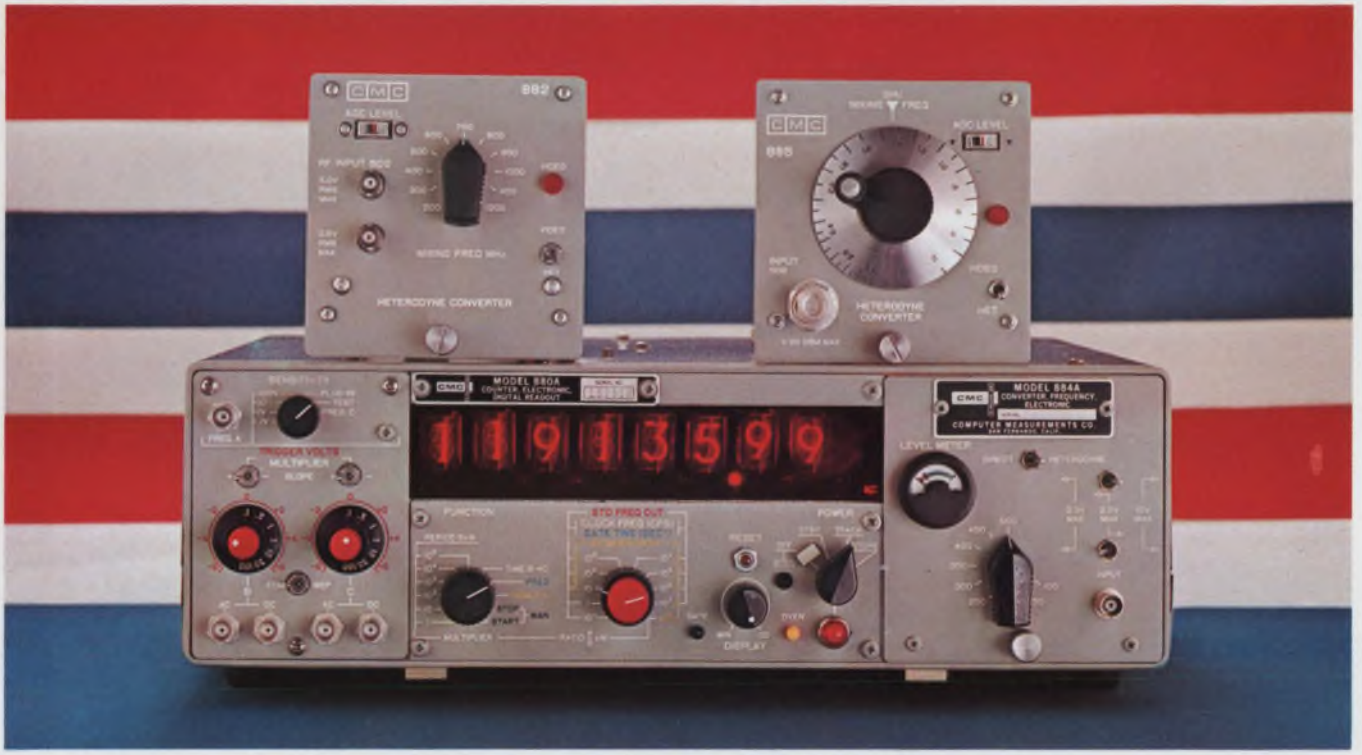
An equal opportunity employer M/F

How many Mil-Spec counter-timers now provide performance to 3.3 GHz?



ONE!

And it's the CMC 880 with two new plug-ins!

The CMC Model 880 is the only high-frequency counter-timer commercially available that has been designed, tested, and field-proven to meet all pertinent military specifications.*

This rugged, completely portable instrument, with its drip-proof clip-on cover and valise handle, has already proven itself in the toughest military and industrial applications. And the CMC 884, a companion heterodyne converter, has been right there when needed to boost the 880's 100-MHz direct-counting range up to 555 MHz. So what else is new? Plenty!

Here are two new plug-ins that further set the 880 apart as the only Mil-Spec counter-timer offering performance in the gigahertz range. The Models 882 and 885 Heterodyne Converters will now boost the 880's frequency range to 1.3 GHz and 3.3 GHz respectively, and both feature built-in video amplifiers providing a sensitivity to 10 mV, the use of all solid-state components, and an accuracy equal to that of the basic counter.

So when you've got a job to do where the going's rough — try the 880. You'll be in good company if you do. And for your copy of CMC's new 12-page Military Counter brochure with complete specifications, circle the reader service card.

**The Model 880 meets all requirements of MIL-E-16400, Shock Spec MIL-S-901, and RFI Spec MIL-I-16910.*

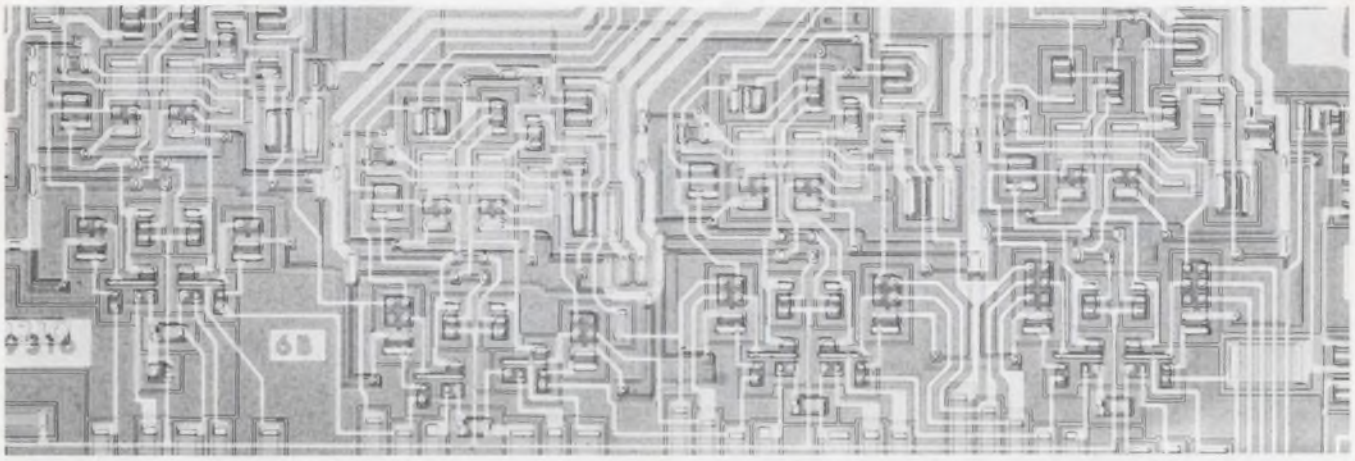
CMC

A Division of Pacific Industries

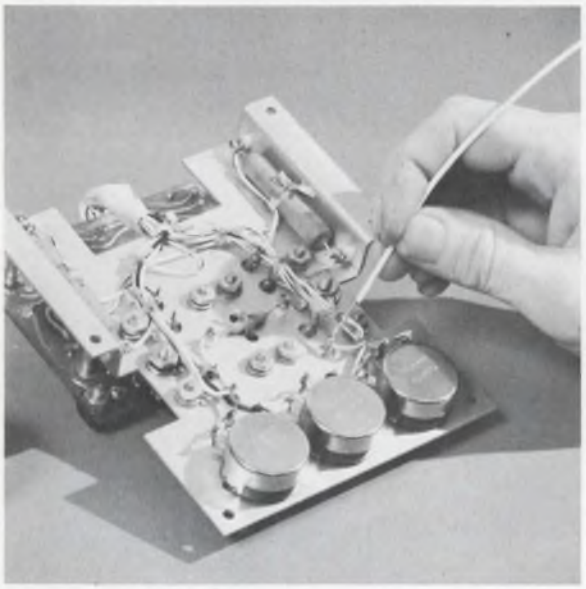
12970 Bradley/San Fernando, Calif. 91342/(213) 367-2161/TWX 910-496-1487

INFORMATION RETRIEVAL NUMBER 47

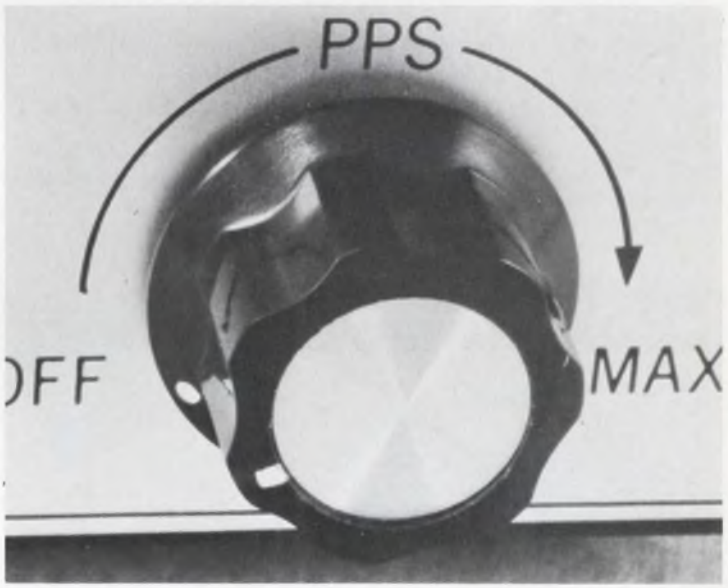
Products



MSI 4-bit counters perform synchronous counting at speeds greater than 15 MHz. The TTL circuits operate in multi-stage systems without external logic. Page 92



Flexible plastic solder, which bonds to aluminum, withstands 500°F. Page 106



Dial fast-rise fast-fall pulses at rates to 1 MHz with pocket-sized pulse generator. Page 103

Also in this section:

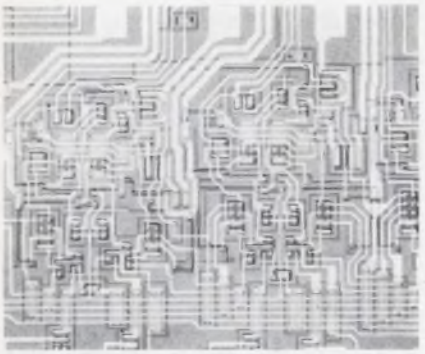
Vhf p-i-n diode predictably changes its rf resistance. Page 100

L-band transistor supplies 20-W output and 5-dB gain at 1 GHz. Page 100

Miniature tapped delay lines feature 14-pin DIP housing. Page 108

Design Aids, Page 114 . . . **Application Notes,** Page 116 . . . **New Literature,** Page 118

MSI 4-bit counters operate at 15 MHz

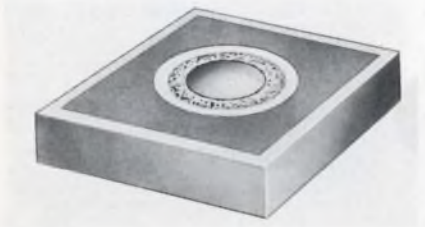


Fairchild Semiconductor, 313 Fairchild Drive, Mountain View, Calif. Phone: (415) 962-2530. Price: $21 to $46.

Designed with MSI complexity for multiple-stage digital systems, two CCSL (compatible current-sinking logic) circuits achieve synchronous counting at speeds greater than 15 MHz. These 4-bit counters are the 9310 BCD decade counter and the 9316 binary hexidecimal counter. Both TTL circuits can be used in multi-stage operations, without external logic or degradation in speed over a single stage. They feature synchronous gated parallel entry.

CIRCLE NO. 253

Silicon chip diodes form compatible family

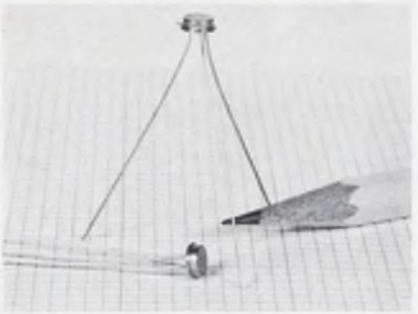


Centralab Semiconductor Div., 5757 N. Green Bay Ave., Milwaukee. Phone: (414) 228-2053.

Developed specifically for hybrid circuits, a compatible line of silicon chip diodes includes planar epitaxial core drivers and regulators; temperature-compensated devices and planar SCRs; rectifiers and tunnel diodes. Their bonding pads are optimized for hybrid microcircuit applications. Gold or silicon backs are available for eutectic bonding; gold-over-nickel is available for solder attachment.

CIRCLE NO. 254

Chopper transistors up breakdown to 60 V



Solitron Devices, Inc. 1177 Blue Heron Blvd., Riviera Beach, Fla. Phone: (305) 848-4311.

Small-signal chopper transistors, types 2N2944, 2N2945 and 2N2946, feature breakdown voltages as high as 60 V, offset voltages as low as 200 μV, and current gains of 50 to 250. These low-level choppers, which are packaged in a TO-46 case, may be ordered as singles or as matched pairs. Applications include modulators, servos, telemetry systems and multiplexing.

CIRCLE NO. 255

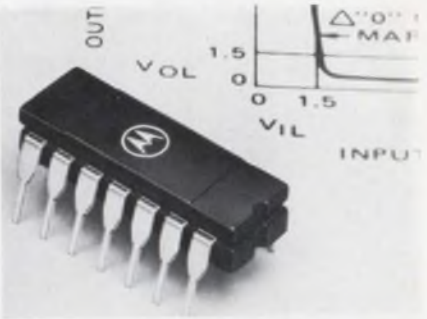
Plastic power triacs carry 10 A at 200 V

General Electric Semiconductor Products Dept., 1 River Rd., Schenectady, N.Y. Phone: (518) 374-2211. Price: 80¢ or $1.04.

Dimensionally comparable with a TO-66 metal can, two 200-V medium-current plastic power triacs, the SC141 and the SC146, handle 6 and 10 A, respectively. Housed in a molded silicone package, the devices feature round leads for easy handling and mounting, a solid copper heat sink for low thermal impedance (2°C/W); simple mounting by fastener and a glass-passivated triac pellet for device hermeticity.

CIRCLE NO. 256

Threshold logic ICs reject noise spikes

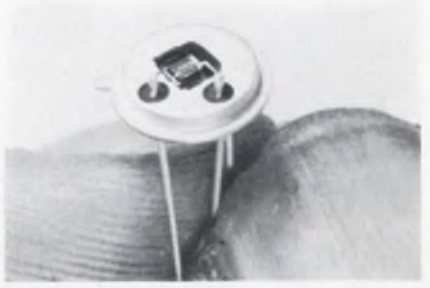


Motorola Semiconductor Products, Inc., P.O. Box 20912, Phoenix. Phone: (602) 273-8466. Price: $2.35 to $6.10.

A digital IC family of threshold logic circuits is able to operate with high noise immunity because of their inhibited response to noise spikes. This characteristic results from the combination of their high threshold (7.5 V) and relatively slow operating speed. Nine functions are available: a line driver (MC662L); two translators (MC665L, MC666L); a dual monostable multivibrator (MC667L); four NAND gates (MC668L, MC670L to -672L), and a dual expander (MC669L).

CIRCLE NO. 257

Power transistors switch 5 A in 100 ns



Solid State Products, One Pingree St., Salem, Mass. Phone: (617) 745-2900.

Able to carry currents as high as 10 A, npn planar passivated transistors turn on in 100 ns and turn off in 700 ns when current is 5 A. Types 2N4150, 2N2811 to 2N2814, and 2N5552 have a minimum sustaining voltage of 80 V at 100 mA and a maximum saturation voltage of 1 V at 10 A. Their minimum current gain ranges from 30 at 10 A to 50 at 5 A.

CIRCLE NO. 253

Si photodetector comes unmounted

United Detector Technology, 1732 21st St., Santa Monica, Calif. Phone: (213) 393-3785.

At full depletion, an unmounted low-capacity silicon photodetector, which has an active-area diameter of 1 cm, provides a minimum capacity of 50 pF. The dark leakage current of model PIN-8LC is 0.2 μA, and its risetime is 4 ns. This unmounted detector can be supplied with leads attached and epoxy coated. A special array is also available that requires no lead attachment and has an element size of 2 by 2 mils.

CIRCLE NO. 259

Power transistors sustain 300 V, 5 A

Solitron Devices, Inc., 1177 Blue Heron Blvd., Riviera Beach, Fla. Phone: (305) 848-4311.

Packaged in a TO-66 case, triple-diffused npn silicon transistors handle power levels of 300 V at 5 A. Types SDT 4901 to SDT 4905 use planar construction to stabilize under reverse-bias condition. Current gains range from 20 to 60 at 1 A; saturation voltages are less than 0.5 V at 1 A with an input voltage of less than 1.5 V.

CIRCLE NO. 260

Avalanche diodes hold down noise

Computer Diode Corp., Pollit Drive, Fair Lawn, N. J. Phone: (201) 797-3900.

A series of low-voltage avalanche diodes feature dynamic impedances as low as 10 Ω and noise densities as small as 4 μV/Hz at 250 μA. The new units, types GLA 28 to GLA 100, have zener voltage ratings from 2.8 to 10 V dc and are rated at 600-mW continuous power dissipation.

CIRCLE NO. 261

Automatic die system probes and attaches

Transistor Automation Corp., 18 Moulton St., Cambridge, Mass. Phone: (617) 868-3600.

Model 1000 production system virtually eliminates all manual handling of semiconductor dice—from probing to die-attach. The system consists of: a wafer prober; a unit that removes the dice from the slice and places them on a tape; and another unit that unloads the die to the attach station.

CIRCLE NO. 262

Accumulator chip performs at 4 MHz

National Semiconductor, Corp., 2950 San Ysidro Way, Santa Clara, Calif. Phone: (408) 245-4320. Price: $30.

Permitting chip recirculation of data into a serial register memory, a dual 64-bit dynamic accumulator/register operates at 4 MHz with a low power consumption of 0.8 mW/bit/MHz. Designed primarily for high-speed drum-type memories and high-speed display systems, model MM510 recirculates data independent of its output drive circuit, thus making it insensitive to external loading.

CIRCLE NO. 263

Solid-state converters replace servo systems

Transmagnetics, Inc., 134-25 Northern Blvd., Flushing, N.Y. Phone: (212) 539-2750. Price: $230.

Replacing mechanical servo systems, a new series of solid-state modules converts three-wire synchro inputs to two dc voltages that are proportional to sine and cosine functions. Ranging in frequency between 45 to 65 Hz and 380 to 420 Hz, series 655 modules operate with an accuracy of five minutes of arc. They are approximately 0.58 by 2 by 2-1/4 in. in size.

CIRCLE NO. 264

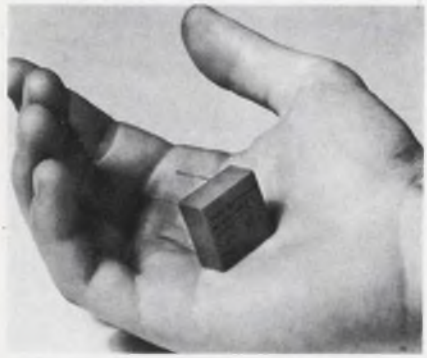
Analog switches have gain of 10^4

Optical Electronics, Inc., P.O. Box 11140, Tucson, Ariz. Phone: (602) 624-3605. Price: from $33.

Representing different basic configurations, three new analog switches feature high isolation at high frequencies and high current gain over wide bandwidth. Models 5349, 5354 and 5430 have a typical isolation of 60 dB at 1 MHz, a current gain of 10,000, and on-resistance of 7 Ω. Applications include video or pulse switching, sample-and-hold circuits, choppers and multipliers.

CIRCLE NO. 265

Miniature oscillator clocks to 50 MHz



Oak Electro/Netics Corp., Crystal Lake, Ill. Phone: (815) 459-5000.

Providing an output between 30 kHz and 50 MHz, a crystal clock oscillator, which is designed for stacked PC-board assemblies, measures only 1 in. square by 0.5 in. high and weighs less than 1 oz. Operationally, model MC109A1 holds ±150 ppm maximum from −55 to +150°C over the frequency range of 30 to 650 kHz; from 180 kHz to 50 MHz, the unit holds ±50 ppm.

CIRCLE NO. 266

Compact circular builder prototypes designs

Advanced Technology & Systems Corp., 199 Sound Beach Ave., Old Greenwich, Conn. Phone: (203) 637-4337. Price: $98.

A portable transistor circuit builder permits circuit observation, design, and redesign without using any components except transistors. Thus, experimental circuitry can be prototyped in minutes. Such circuits as push/pull, differential amplifiers, phase shifters and multivibrators are easily constructed. The compact circuit builder measures 15-1/4 by 9-3/4 by 8 in. and weighs only 11 lbs.

CIRCLE NO. 267

Analog multipliers are self-contained

Optical Electronics, Inc., P.O. Box 11140, Tucson, Ariz. Phone: (602) 624-3605. Price: $75.

Six new analog multipliers can do squares, square roots, division and multiplication without the use of external components. The new units include both four-quadrant multipliers and universal function modules (multipliers with internal utility amplifiers). Models 5323A, 5391, 5474, 5485, 5600, and 5627 offer typical maximum errors of ±0.1% and bandwidths as wide as 10 MHz.

CIRCLE NO. 268

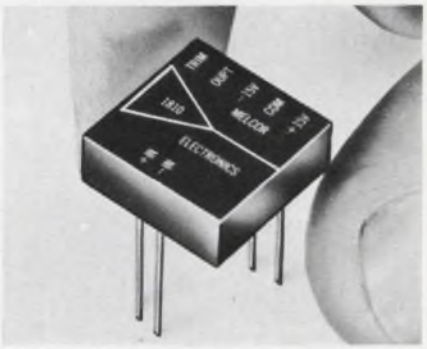
Hybrid regulator supplies 3 A dc

International Circuit Technology, Corp., 18225 Euclid St., Fountain Valley, Calif. Phone: (714) 540-8110. P&A: $49; 4 wks.

Using high-stability thin-film passive substrates and chip semiconductors, a hybrid voltage regulator delivers 3 A dc for 5-V computer logic circuits. The hermetically sealed unit, model LM500, is mounted on an isolated copper heat sink for bolt-down installation. It can handle peak input voltages of 40 V and peak currents of 4 A. With a 12-V input, load regulation from no load to full load is typically better than 0.01%.

CIRCLE NO. 269

FET-input amplifier contains LID devices



Melcor Electronics Corp., 1750 New Highway, Farmingdale, N.Y. Phone: (516) 694-5570. Price: $33.

Constructed on a thin-film substrate with LID-mounted semiconductors, an FET-input operational amplifier combines excellent frequency response, low drift, small size and high over-all performance capability. Model 1810 is an IC-sized amplifier contained in a 0.6-in. square by 0.25-in. high epoxy package.

CIRCLE NO. 270

Dual-output supplies regulate with ICs

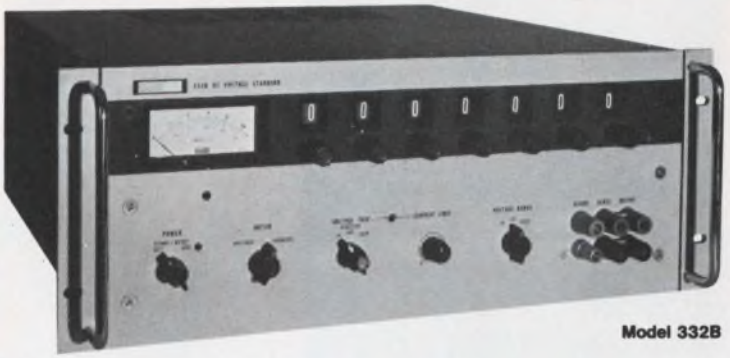
Lambda Electronics Corp., Route 110, Melville, N.Y. Phone: (516) 694-4200. Price: from $155.

Using an integrated circuit for its regulation system, a dual-output power supply cuts in half the number of required discrete components and shrinks its size to only 3-5/32 by 3-9/32 by 3-5/16 in. Series LCD-2 power supplies feature independent operation, independent remote sensing, independent remote programing and series/parallel (master/slave) operation.

CIRCLE NO. 271

18°

20 PPM ACCURACY AT 23°. . . . . AND



Model 332B

22°

23°C

30 PPM ACCURACY OVER A 10°C RANGE!

24°

Model 335A

28°

Ordinary room temperatures are just dandy for Fluke calibrators. For instance, our Models 332B and 335A are specified to an accuracy of 20 ppm at 23° C. And, in typical room environments, accuracy is degraded by only 10 ppm.

How accurate should a calibrator be?

Naturally, every engineer wants the most accurate calibrator he can get for his dollar. At Fluke we believe the best price/performance tradeoff is 20 ppm. This performance provides a 5 to 1 accuracy ratio for calibration of 0.01% instruments. At the same time, it allows our engineers to design instruments whose accuracy can be maintained with a minimum of external equipment. We estimate that 10 ppm calibrators on the market today require about $6,000 worth of extra test equipment to keep them on line.

What calibrator should I buy?

If your requirements are only for a calibrator, compare the Fluke 332B with any other unit on the market. If a multiple purpose instrument is your need, give the hard eye to the Fluke 335A DC Voltage Calibrator, Differential Voltmeter and Null Detector.

Models 332B and 335A measure and supply dc voltages from 0 to 1100 volts with an output of 0 to 50 ma. Accuracy is 20 ppm. Stability is 20 ppm per year. Line variation of ±10% under load from 0 to 50 ma will not significantly degrade the 0.002% accuracy. Overcurrent protection automatically limits output current at any present level between 1 ma and 60 ma. Any voltage within the range of the instrument can be selected as an overvoltage trip point. Ripple and noise are less than 40μv rms on the 1000 volt range. Model 335A offers an accuracy of 20 ppm used as a differential voltmeter. The Model 335A can be used as a null detector and voltage source simultaneously with no interaction. An output meter allows the user to read voltage or current at a glance. Price of the Model 332B is $2295, the Model 335A, $2485.

More information

Your local Fluke sales engineer will be happy to go over his "tell-all" comparison chart with you, provide complete literature and arrange a demonstration of these units. His name and number are listed in EEM and EBG. Or you may contact us directly if it's easier.

FLUKE

Fluke. Box 7428, Seattle, Washington 98133. Phone: (206) 774-2211. TWX: 910-449-2850.
In Europe, address Fluke Nederland (N.V.), P.O. Box 5053, Tilburg, Holland. Telex: 844-50237.
In the U.K., address Fluke Int. Corp., P.O. Box 102, Watford, Herts, England. Telex: 351-934-583.

INFORMATION RETRIEVAL NUMBER 51

Portable tape recorder uses ferrite heads

Video Research Corp., 761 N. Washington St., Rockville, Md. Phone: (301) 762-5999. P&A: $16,350; 30 days.

Using solid ferrite magnetic heads, a portable tape recorder, can record 14 channels on 1-in.-wide tape with performance matching or exceeding that of competitive machines. The recording heads last for 5000 hours—more than five times that of other recorders. Model 8000 has tape speeds that range from 1-7/8 to 60 in./s.

CIRCLE NO. 272

Data acquisition system handles 64 channels

IRA Systems, Inc., 332 Second Ave., Waltham, Mass. Phone: (617) 891-7300. Price: $12,800.

Model 710 data-acquisition system is capable of multiplexing and digitizing 64 channels of low-level analog data onto magnetic tape. This new data logger contains a 16-channel FET multiplexer that is expandable to 64 channels with a switching speed of 1 μs per channel. The accuracy of its integrating digitizer is 0.015% of full scale at a speed of 15 ms per conversion.

CIRCLE NO. 273

Desktop processor transforms at 2 kHz

Computer Signal Processors, Inc., 176 Second Ave., Waltham, Mass. Price: $45,000.

Including teletypewriter, display, control, and software, a computer signal processing system can continuously perform fast Fourier transforms in real time to a 2-kHz bandwidth, or in blocks of real time to a 35-kHz bandwidth. The desktop CompuSignal System-3 also performs zoom transforms, auto-correlations, cross-correlations, convolutions, averaging histograms, and a variety of filter signal-processing routines.

CIRCLE NO. 274

Card reader terminal moves only two parts

Data Computing, Inc., 412 W. Hatcher Road, Phoenix. Phone: (602) 943-6960. Price: from $60/month, rental.

By reducing the number of moving parts to two, a slow-speed card reader terminal achieves new levels of economy, dependability and durability. The Cardliner 10 operates at the speed of 10 characters a second, the same speed as that of the teletypewriter equipment it is designed to complement. The two moving parts are a picker knife, and a rotary feeder.

CIRCLE NO. 275

Magnetic tape recorder has movable keyboard

Vanguard Data Systems, 3835 Birch St., Newport Beach, Calif. Phone: (213) 371-6567.

Called the KB-600 Datascribe, a 7-track IBM-compatible magnetic tape recorder features a 64-character movable keyboard with 16 special keys for control or BCD codes. The unit also incorporates a tape transport that provides automatic tape positioning, recording, verifying and searching at speeds up to 32 inches a second.

CIRCLE NO. 276

TV display system stores 128 pictures

Data Disc, Inc., Display Div., 1275 California Ave., Palo Alto, Calif. Phone: (415) 326-7602.

Incorporating multiple desktop video terminals, a new computer-driven display system can simultaneously store and display up to 128 different TV pictures. Usable for alphanumeric and/or graphic displays, the system basically consists of a disc memory, a time-shared control unit containing addressing logic and a character generator, a control terminal, and display terminals.

CIRCLE NO. 277

Rotary-step attenuator conserves panel space

Daven, Div. of Thomas A. Edison Industries, Grenier Field, Manchester, N.H. Phone: (603) 669-0940.

Model 11300 miniature rotary-step rf attenuator contains two attenuator assemblies operated by concentric shafts. It requires a mounting space of 1-1/8 by 2-1/16-in. and extends 3-5/16-in. behind the panel.

CIRCLE NO. 278

Vhf p-i-n diode is rf resistor

Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000. P&A: $18; stock.

Useful as a current-controlled resistor for vhf or higher frequencies, a new semiconductor component changes rf resistance predictably with variations in its dc or low-frequency bias current. This specially processed p-i-n diode, model 5082-3003, has a resistance/bias characteristic with a slope of 0.9 to 0.86 from 10 μA to 1 mA (about 12 to 900 Ω).

CIRCLE NO. 279

Electron multiplier has gain of 10^7

Bendix Corp., Electro-Optics Div., 1975 Green Road, Ann Arbor, Mich. Phone: (313) 663-3311.

In a small straight-line configuration, a windowless electron multiplier provides gains in excess of 10^7. The Spiraltron consists of a straight-channel preamplifier with a flared input that is joined to a bundle of twisted channel multipliers. This structure results in a high-gain device requiring three active electrical connections.

CIRCLE NO. 280

L-band transistor delivers 20 W

TRW Semiconductors Inc., 14520 Aviation Blvd., Lawndale, Calif. Phone: (213) 679-4561. P&A: $80 or $160; stock.

The PT6821 microwave transistor provides 20-W power output at 1 GHz with 5-dB gain and 55% efficiency. A companion transistor, the PT6820, is rated at 10-W output, 6-dB gain and 60% efficiency. The devices are mounted in low-inductance stripline packages for optimum gain and bandwidth. Their common-emitter configuration provides circuit stability and trimming simplicity. They operate from a 28-V source.

CIRCLE NO. 281

Transistor amplifier covers vhf/uhf bands

Electro-Data, Inc., 3121 Benton St., Garland, Tex. Phone: (214) 276-6167. Price: $300.

A transistor amplifier features a 10-dB gain response from 20 to 1000 MHz and greater than 18-dB gain from 50 to 850 MHz. Model A-10 holds its noise figure to 4 dB typical, 5 dB maximum, in its operating band. It is supplied in a compact, rugged lightweight package, complete with miniature 50-Ω input and output connectors and a shielded dc bias input.

CIRCLE NO. 282

X-band filters attenuate 3 dB

U. S. Capacitor Corp., Filter Dept., 2151 N. Lincoln St., Burbank, Calif. Phone: (213) 843-4222. P&A: $11.43 to $13.35; stock to 2 wks.

Series 2100 low-pass filters use a feedthrough construction to achieve an attenuation of only ± 3 dB at 10 GHz over the temperature range of −55 to +125°C. They are 100-V L-section filters that fit into a miniature package previously associated only with 50-V filters. The non-polar hermetically sealed units accommodate transient surges up to 200 V.

CIRCLE NO. 283

Stripline mixers operate at 18 GHz

G-L Microwave Corp., Sub. of G-L Industries, Inc., 825 Black Oak Ridge Road, Wayne, N. J. Phone: (201) 935-1717. P&A: $150 to $250; 2 to 3 wks.

Covering the frequency range of 200 MHz to 18 GHz, a new line of stripline balanced mixers provide noise figures as low as 6.5 dB maximum and VSWRs of 1.3 maximum. The smallest of these hybrid IC devices is supplied in a package measuring 1/2-in. wide by 3/4-in. long by 1/2-in. deep.

CIRCLE NO. 284

at $1.22*

you have no choice of color...

black

MODEL 3305P

also black

MODEL 3305W

but...

the specs are better than "those other makes" that cost more! The Model 3305 TRIMPOT® potentiometer has been designed from the ground up **as a commercial.**

Here are the facts on the 3305 . . . besides the price, that is!

The unit is sealed to prevent contamination from fluxing, soldering, and cleaning . . . in addition our pins can be used on boards using 0.1" grid spacing. This small 5/16" dia. unit has a resistance range of 50Ω to 25KΩ, with standard resistance tolerance ±5%. Being a wirewound unit, it provides plus features such as low temperature coefficient . . . better resistance tolerance . . . and superior noise characteristics. Operating range is −55°C to +125°C . . . temperature coefficient is only ±70 PPM/°C . . . power rating ½ watt and noise is negligible at 100 ENR.

***500 piece price**

Check into our one color — basic black — Model 3305 for the best . . . at a low-low price. For complete technical data contact your nearest Bourns office, representative or write the factory direct.

FREE Exploded-view drawing and new informative specification comparison chart

BOURNS

BOURNS, INC., TRIMPOT DIVISION • 1200 COLUMBIA AVE., RIVERSIDE, CALIF.
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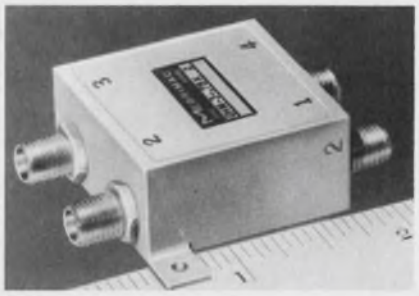
TRIMPOT® and Precision Potentiometers - Miniature Relays - Electronic Modules - Microcomponents.

Miniature hybrids use looped lines

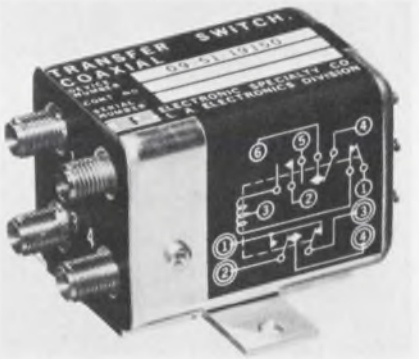


Merrimac Research and Development, Inc., 41 Fairfield, W. Caldwell, N. J. Phone: (201) 228-3890. P&A: $65 to $85; 30 days.

Over the frequency range of 200 MHz to 2 GHz, miniature quadrature hybrids use loop-line networks to achieve small size, less than 2 in. in over-all length. Series QHM-3-K consists of coaxial devices with octave bandwidths and relative output phases of 90° ±2°. Other specifications include 28-dB isolation, 3-dB coupling, 0.3-dB insertion loss, and a VSWR of 1.2.

CIRCLE NO. 285

Transfer switches isolate at 18 GHz

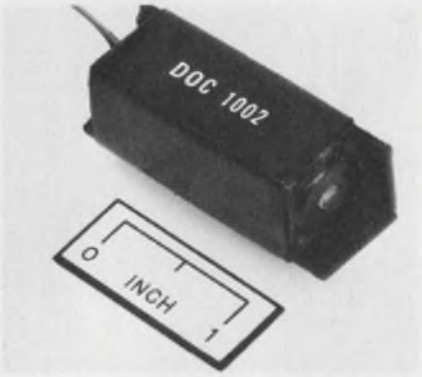


Electronic Specialty Co., 4561 Colorado Blvd., Los Angeles. Phone: (213) 246-6767.

Combining excellent rf performance with broad bandwidth in a miniature package, series 09-51 transfer switches exhibit a VSWR of only 1.25 at 12.4 GHz and provide high interchannel isolation from 0 to 18 GHz. Remote actuation is of the latching type, requiring no holding current. Actuating current is 53 mA at 26.5 V for latching and 177 mA for failsafe operation.

CIRCLE NO. 286

Laser components require only 60 V



Data Optics Corp., div. of Data Technology Corp., 1050 E. Meadow Circle, Palo Alto, Calif. Phone: (415) 321-0551. P&A: From $200; 30 days.

A new line of components for semiconductor laser systems operate with a maximum of 60 V dc applied. Both laser transmitters and photosensitive receivers are available. All components feature short transmitted pulse widths of 20 ns.

CIRCLE NO. 287

Rf transistors handle 22 W

Amperex Electronic Corp., Semiconductor & Microelectronics Div., Slatersville, R. I.

Using a radically new emitter geometry, rf power transistors are able to deliver a maximum gain of 21 dB at powers as large as 22 W with efficiencies as high as 70%. Eight new emitter-grid transistors, types A270 through A277, are available for supply voltages of 12.5 or 28 V. Intended for use in transmitters operated at 175 MHz, the units are packaged in TO-39 cases and low-profile stripline housings.

CIRCLE NO. 288

Pocket pulser reps to 1 MHz

R. H. Dempsey Mfg., P.O. Box 2339, Napa, Calif. Phone: (707) 255-6767. P&A: $39.50; stock to 30 days.

A pocket-sized pulse generator, model PP-55, delivers fast-rise fast-fall pulses at rates from 1 Hz to 1 MHz and with widths from 50 ns to 2 μs. Since it produces isolated ±5-V signals, it can drive TTL breadboarded ICs or trigger pulse-activated equipment (counters, scalers and oscilloscopes). An internal pair of terminals allows a capacitor to be added for stretching pulse width and reducing frequency.

CIRCLE NO. 289

Digital frequency meter covers 220-MHz band

Beckman Instruments, Inc., 2500 Harbor Blvd., Fullerton, Calif. Phone: (714) 871-4848. P&A: $1900, 2 wks.

Intended for communications and other frequency-monitoring applications, a digital frequency meter makes direct and accurate measurements from dc to 220 MHz. Model 6397 incorporates IC circuitry to achieve low power consumption and convenient size. Its gate time varies from 1 ms to 1 s, and input impedance is 50 Ω. Decimal point location is automatic.

CIRCLE NO. 290

Go, no-go checker tests semiconductors

Texscan, Technical Products Div., 7707 Records St., Indianapolis, Ind. Phone: (317) 545-2101. P&A: $14.95; stock.

Model DT-100 diode and transistor checker is a low-current device that can quickly determine whether or not a transistor or diode is good. Diodes are checked by touching the leads to the binding posts on the checker in either direction.

CIRCLE NO. 291

Wideband oscilloscope senses up to 10 mV/cm

Philips Electronic Instruments, 750 South Fulton Ave., Mt. Vernon, N.Y. Phone: (914) 664-4500. Price: $670.

Model PM 3221 5-in. wideband oscilloscope offers two frequency/sensitivity ranges: dc to 100 MHz at 10 mV/cm, and dc to 2 MHz at 1 mV/cm. A time/cm selector provides for triggering on frame and line signals of all present TV systems, as well as for horizontal deflection with an external signal.

CIRCLE NO. 292

Inspection station saves DIP test time

G. D. Patrick Enterprises, P.O. Box 23054, San Diego, Calif. Phone: (714) 279-8856. Price: $69.95.

Designed for quantity testing of dual-in-line ICs, an inspection station can cut by half the time needed for incoming or pre-assembly testing. Able to handle DIPs as received in their shipping magazines, the Inspection Master 5000 works with the user's existing test equipment or manufacturing methods. It consists of three pieces: a board that holds up to 12 DIP magazines, a hand tool for holding single DIP devices and a test block.

CIRCLE NO. 293

Digital stopwatches use IC dividers

Electrodyne Corp., 7315 Greenbush Ave., N. Hollywood, Calif. Phone: (213) 875-1900. Price: from $450.

Series DC-900 electronic stopwatches use IC frequency dividers and cold-cathode discharge tubes to achieve high accuracy and a bright digital readout in any application. Model DC-900F counts up seconds and minutes to 99:59; model DC-900F/10 can log time in tenths. Another model, the EC-900R/P, allows the initial time to be preset, while a fourth, the DC-900R/10P, permits preset timing in tenths.

CIRCLE NO. 294

Pulse generators work on ac or dc

Contronics, Inc., 1061 Terra Bella Ave., Mountain View, Calif. Phone: (415) 969-0793. Price: from $310.

Combination ac/dc pulse generators that supply simultaneous complementary outputs can directly drive most popular RTL, DTL, and TTL families. Series CPG 200 provides pulses with risetimes and falltimes of 6 ns and with duty cycles of 100%. Repetition rates range from 1 Hz to 10 MHz, while pulse widths vary from 50 ns to 20 ms.

CIRCLE NO. 295

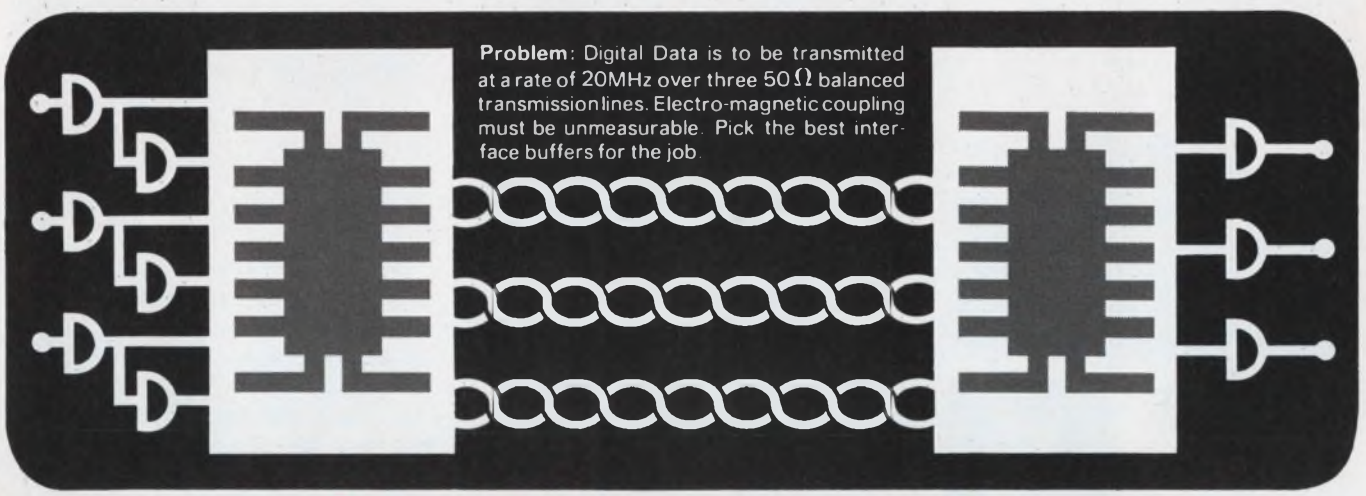
Decade amplifier supplements VOM

Syntelex, 39 Lucille Ave., Dumont, N.J. Price: $34.95.

Used in conjunction with a multimeter, a single low-cost instrument enables the user to measure millivolt signal levels. When used with an oscilloscope, it makes observation of microvolt signals possible. The versatility of this solid-state decade amplifier is limited only by the imagination of the user. Voltage gains of X100, 10, 1, 0.1, and 0.01 are selected by a front-panel switch. Frequency response is 10 Hz to 1 MHz.

CIRCLE NO. 296

Pick the BEST IC for the job



the BEST Solution:

THE NEW RA-245 LINE TRANSMITTER

The best IC to use at the sending end is Radiation's dielectrically isolated RA-245. This line transmitter converts digital voltage pulses to current pulses. The high speed CML circuits assure data transfer rates in excess of 30MHz. Power dissipation is a constant, independent of data rate. The balanced system virtually eliminates the adverse effects of line capacity. Electro-magnetic coupling and susceptibility is greatly reduced. RA-245 is available in both the TO-84 flatpack and the ceramic dual inline package. Three voltage-to-current converters are in each package. Power dissipation is negligible when converters are not being used. So use only one or all three. RA-245 is the Best IC for the job.

THE NEW RA-246 LINE RECEIVER

For best results, use Radiation's dielectrically isolated RA-246 at the receiving end. This 3-element buffer faithfully restores the current pulses to digital voltage pulses. The RA-246 current-to-voltage converter has built-in input terminations for balanced 50Ω lines. Outputs from each element are suitable to drive all standard saturated logic circuits (such as DTL, TTL, etc.).

Like the RA-245, the RA-246 is available in both the TO-84 flatpack and the ceramic dual inline package. And you can use any or all of the converters. The Best IC for the job.

Contact your nearest Radiation sales office for further information. Ask how the RA-245 can be used as a level shifter. And how to use the RA-246 as a threshold detector. We will help you pick the Best IC for the job.

WE MAKE THE BEST IC FOR THE JOB

RADIATION INCORPORATED
SUBSIDIARY OF HARRIS-INTERTYPE CORPORATION
MICROELECTRONICS DIVISION

RADIATION SALES OFFICES: P.O. Box 476, Lexington, Mass. 02173, (617) 862-1055 • 600 Old Country Road, Garden City, N.Y. 11530, (516) 747-3730 • 2600 Virginia Avenue N.W., Washington, D.C. 20037, (202) 337-4914 • 6151 W. Century Boulevard, Los Angeles, California 90045, (213) 670-5432 • P.O. Box 37, Melbourne, Florida 32901, (305) 727-5430 • International Sales: Marketing Department, P.O. Box 37, Melbourne, Florida 32901, (305) 727-5412

INFORMATION RETRIEVAL NUMBER 57

Plastic solder goes to 500°F

Emerson & Cuming Inc., Dielectric Materials Div., Canton, Mass. Phone: (617) 828-3300. P&A: $10/0.2 lb.; stock.

Eccobond 59C is a one-component flexible plastic solder that withstands temperatures as high as 500°F. Without the need for a soldering gun, it can bond to aluminum wire or plate, and can be re-opened and resealed. Its volume resistivity is 0.001 Ω-cm and its thermal conductivity is 80 Btu/h/ft²/°F/in. The silver solder forms bonds with a strength of 300 lb/in.²

CIRCLE NO. 297

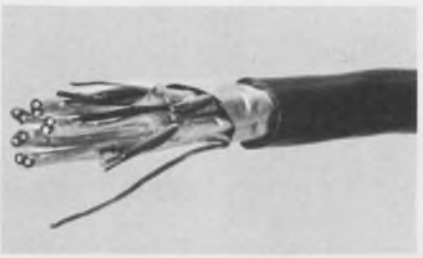
Round-wire flat cables have integral ground

3M Co., 2501 Hudson, St. Paul, Minn. Phone: (612) 733-1110. P&A: 0.0219 or 0.0383¢/ft; stock.

Two new round-conductor flat cables feature a controlled-impedance copper ground plane that is as wide as the cable and laminated along the entire length. Scotchflex 3380 is a 50-conductor cable with AWG #30 wires spaced on 0.05-in. centers; Scotchflex 3386 has 28 AWG #30 conductors on 0.05-in. centers. Both cables feature PVC insulation rated to 80°C.

CIRCLE NO. 298

Shielded thermocouples reject static noise



Thermo Electric, Saddle Brook, N. J. Phone: (201) 843-5800.

Offering increased electrostatic noise rejection, thermocouple extension cables, which consist of individually shielded conductor pairs, are ideal for use in computers or other sophisticated instrumentation systems. Shielding begins with a layer of 2-mil aluminum-backed Mylar tape and a layer of 1-mil clear tape spirally wrapped on each insulated conductor pair. For additional protection, an over-all shield is applied to the cabled shielded pairs.

CIRCLE NO. 299

Epoxy potting compound cures without heating

Epoxy Technology, Inc., 65 Grove St., Watertown, Mass. Phone: (617) 926-1949. Price: $10/2 lb.

Suitable for potting, coating, and encapsulating, an epoxy compound, which cures at room temperature, has a low viscosity of 950 centipoise and a low exotherm to avoid the problems often associated with reaction heat. The two-part Epo-Tek 509 cures to a high-gloss smooth surface that is devoid of all blemishes, even when cured under highly humid conditions. Its dielectric strength is 450 V/mil, dielectric constant is 3.79 at 1 MHz, and loss factor is 0.0362.

CIRCLE NO. 321

Spray adhesive does not burn

3 M Co., Adhesives, Coatings and Sealers Div., 2501 Hudson, St. Paul, Minn. Phone: (612) 733-1110.

Providing either a permanent or temporary bond, a clear non-flammable spray adhesive joins paper, cloth, plastic films, foam rubber, foil, corrugated materials, fibrous glass, and cork to themselves or to metal, wood and glass. Designated Scotch-Grip 77-N, the aerosol adhesive has an adjustable spray tip for a wide or narrow spray pattern. It is a fast-drying rubber-base product that is nearly invisible on most surfaces.

CIRCLE NO. 322

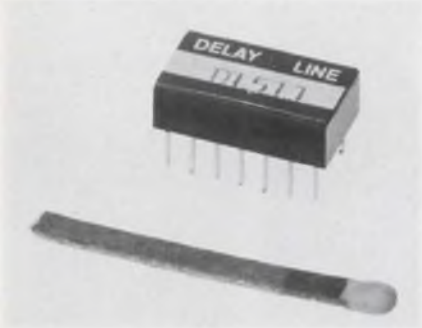
Scaled ink drawing produces custom boards

American Engraving, Inc., 108 S. Pennsylvania St., Magnum, Okla. Phone: (405) 782-3337.

Printed-circuit boards can now be made on an individual basis from an ink drawing. This new technique eliminates the need for elaborate drawings and for making the time-consuming breadboards that are necessary for some experimental work. The drawing can be made to scale or larger. For extremely small boards, the sketch should be drawn so that, when photographically reproduced, it will reduce proportionately. Board sizes can be from 1 to 300 in.^{2}.

CIRCLE NO. 323

Tapped delay lines offer 14-pin DIP

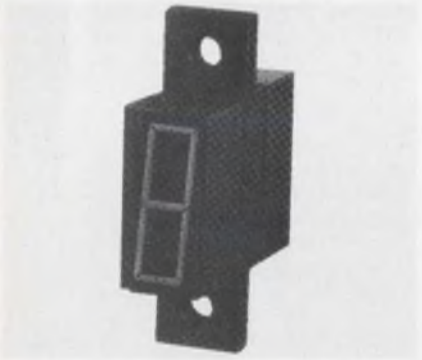


Computer Devices Corp., 63 Austin Blvd., Commack, N.Y. Phone: (516) 543-4220. P&A: $6.45; 1 wk.

Constructed to be compatible with standard dual-in-line microcircuit packaging, miniature tapped delay lines have a pin layout that is the same as standard 14-pin DIP micrologic packages. Measuring 0.39 by 0.7 by 0.21 in., series D1511 provides total delays of 100, 80, 60, 40, 20 and 10 ns. Each unit has 10 tap delay points, spaced at one-tenth of the total delay, with delay accuracies of ±5%.

CIRCLE NO. 324

Tiny readout module operates at 5 V

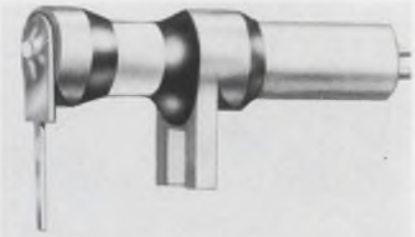


Allen Aircraft Radio, Inc., 2050 Touhy Ave., Elk Grove Village, Ill. Phone: (312) 437-9300.

Designed to meet the environmental requirements of MIL-STD-202, a seven-segment readout module requires only 5 V dc at 20 mA to excite any individual segment. Measuring only 0.3 in. wide by 0.625 in. high by 0.8 in. deep, the numeric display provides a viewing angle of 120° in any plane. Intensities of 20 ft-L are standard; up to 150 ft-L is optional.

CIRCLE NO. 325

Trimmer capacitor has Q of 5000

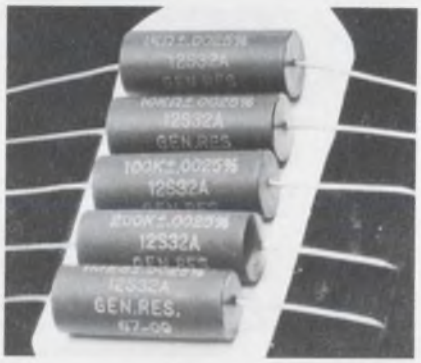


Premier Microwave Corp., 33 New Broad St., Port Chester, N.Y. Phone: (914) WE9-8900.

Rated at 500 Vdcw, a miniature trimmer capacitor exhibits a Q of 5000 at 20 MHz, with correspondingly high Q into the microwave region. Its capacitance ranges from 0.3 to 6 pF, with screwdriver adjustment. The unit, which measures 21/32-in. in length by 5/32-in. in diameter, offers a temperature coefficient of less than 100 ppm/°C. Its insulation resistance is greater than 10^6 MΩ.

CIRCLE NO. 326

Wirewound resistors are 0.0025% accurate



General Resistance, div. of Chronetics, 500 Nuber Ave., Mt. Vernon, N.Y. Phone: (212) 292-1500. Price: $4.95 to $8.75.

In addition to their high accuracy of ±0.0025%, type 12S32AZ wirewound resistors offer cost savings of as much as 50% over previous high-precision units. Resistance values include 1, 10, 100, and 200 kΩ, and 1 MΩ. Temperature coefficient is ±3 ppm/°C from −55 to +125°C, and stability is ±25 ppm per year. The axial-lead units are 3/8 in. in diameter and 1 in. long. Maximum power rating is 3/4 W at 125°C.

CIRCLE NO. 327

Fiber-optic CRT writes 10^6 in./s

Westinghouse Electronic Tube Div., P.O. Box 284, Elmira, N.Y. Phone: (607) 739-7951.

A new electrostatic cathode-ray tube records oscillographic information on direct-print photographic paper at a writing speed greater than one million inches per second. Model WX-30738 overcomes the difficulties normally associated with writing on this less-sensitive paper, by using a high-energy electron gun and a fiber-optic faceplate for more efficient light transmission between the CRT's phosphor and the paper.

CIRCLE NO. 328

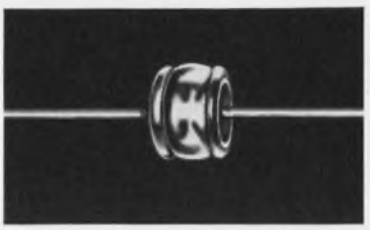
Small ferrite toroids have high permeability

Ferroxcube Corp., Materials Div., Saugerties, N.Y. Phone: (914) 246-2811.

Ferrite toroids, series 3E3, feature a high permeability of 12,500, and a Curie temperature above 125°C. Four toroidal core sizes are available with outside diameters of 155, 190, 230 and 375 mils. All units are coated with a smooth, pinhole-free, non-conductive material. Nominal inductance for 1000 turns ranges from 1800 to 5510 mH.

CIRCLE NO. 329

SIEMENS

Do you have the question to this  answer?

The only limits to the questions answered by the Siemens Gas-filled Surge Voltage Protector are your needs, and your imagination.

Tiny, lightweight, a handful can protect a ton of sensitive electronic equipment, especially supersensitive solid state circuits. They give you tailor-made protection in hundreds of places throughout circuitry. With current carrying capacities up to 5,000 amps. With DC striking voltages from 90V to 1000V. With reaction speeds in the nanosecond range. And with a cost of less than $1 in quantity.

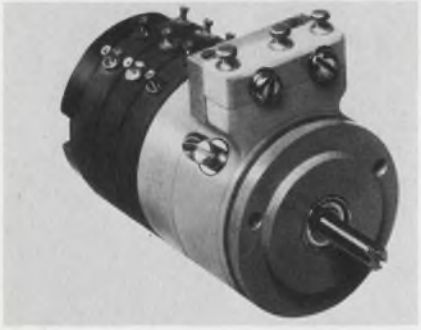
Lightning strokes, static charges, internal switching, short circuits—all these transient dangers are guarded against by these tiny, tireless sentries—Siemens Gas-filled Surge Voltage Protectors. If you've got a protection question, call Siemens America Incorporated for immediate protection delivery.

Send us your questions!

SIEMENS AMERICA INCORPORATED
350 Fifth Ave., New York, N.Y. 10001 • (212) 564-7674

INFORMATION RETRIEVAL NUMBER 60

Cam-switch pots end coupling errors



Markite Corp., 155 Waverly Pl., New York City. Phone: (212) 675-1384.

Mating a rotary control with a precision potentiometer on a single shaft, series CSP-11 integrated cam-switch potentiometers eliminate all coupling errors normally associated with this type of configuration. Their spdt switch is rated at 5 A, 30 V dc, 115 to 230 V ac. It can be adjusted to any desired dwell angle between 3 and 357°.

CIRCLE NO. 330

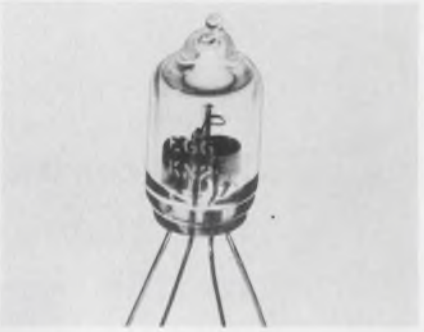
Solid-state timer delivers 2-A output

Artisan Electronics Corp., 5 Eastmans Road, Parsippany, N.J. Phone: (201) 887-7100. Price: $5.75.

Adaptable for either military or industrial applications, a solid-state cylindrical timing device produces a 2-A output. Model 437 assures an accurate, fixed time delay with range settings from 25 ms to 300 s. Operating as a delay-on-pull-in unit, the new timing device may be connected to a load or inserted in series with a relay coil.

CIRCLE NO. 331

Crowbar tube reacts in 40 ns



EG&G Inc., Electronic Products Div., 160 Brookline Ave., Boston. Phone: (617) 267-9700.

Model KN-2 miniature crowbar tube responds with a maximum total delay of 40 ns without warm-up. Although the unit is small and lightweight, it offers reliable protection with a power capacity of up to 160 J. Expected applications for the KN-2 include protection for traveling-wave tubes, electron-beam tubes, transmitting tetrodes, series regulators and modulators.

CIRCLE NO. 332

Semiconductor trimmer cuts all leads at once

Techni-Tool, Inc., 1216 Arch. St., Philadelphia. Phone: (215) 568-4457.

Called Tran-Sem, a multi-purpose tool cuts flush, to any length, all leads of any currently available semiconductor device, from a 2-lead diode to a 10-lead IC. Simultaneous cuts are easily and cleanly made without shock, bending, or breaking individual leads. In addition, the tool has a special head that can firmy grip—without crushing—semiconductors in limited-access areas; it can also be used as a heat sink.

CIRCLE NO. 333

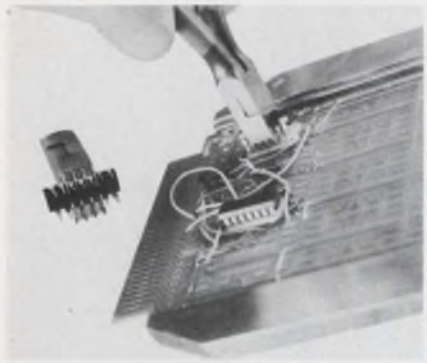
Soldering iron holder stops damage to tips

General Electric Co., 5504 S. Brainard Ave., LaGrange, Ill. Phone: (312) 354-8585.

A convenient soldering iron holder, complete with base and tip-wiping sponge, lets heat escape from a fully powered iron, thus preventing overheating with its resultant damage to tip and heater element. The holder's coil is designed to dissipate heat, to protect the user from burns and to prevent tip damage. The holder is also available without a base.

CIRCLE NO. 334

Teflon DIP extractor works with power on



Techni-Tool, Inc., 1216 Arch Street, Philadelphia. Phone: (215) 568-4457.

Because its jaws are Teflon coated, a new pair of pliers can be used to install or remove 10- and 14-lead DIP devices with power applied. The fulcrum jaws of type 4916 permit quick removal of DIPs during desoldering operations. The unique design of these pliers also serves to guard against bent leads and short circuits.

CIRCLE NO. 335

Beam-lead bonder conserves motion

Kulicke & Soffa Industries, Inc., 135 Commerce, Ft. Washington, Pa. Phone: (215) 646-5800.

In a single motion, a new machine sequentially bonds all leads of any beam-lead device, no matter their number. Model 573 bonds with a thermocompressive wobble-tool action that is not only simple in operation but is readily adaptable to semi-automatic setups. Its reflex optical system gives the operator a clear view of the beam-lead-device pattern, superimposed directly on the workpiece pattern.

CIRCLE NO. 336

Manual PC scriber links sketch to mask

Techne, Inc., 661 Brunswick Pike, Princeton, N.J. Phone: (609) 452-9275. Price: $675.

Able to prepare PC-board masks directly from a designer's sketch, a two-axis manually operated coordinatorgraph completely eliminates drawing office time and expensive photo-reduction work. This master scriber, model TMS-1, yields an over-all accuracy of ±0.005 in. It is available with a variety of tools to make lines of varying thicknesses.

CIRCLE NO. 337

Desoldering tool vacuums work

American Electrical Heater Co., American Beauty Div., 6110 Cass Ave., Detroit. Phone: (313) 875-2505.

Designed for fast, clean component removal, model 495 desoldering tool has a hollow tip that surrounds the connection, melts the solder and then vacuums the work clean. The unit, which complements the company's model 3112 soldering iron, is available with 40-, 50- or 60-W capacity. Tips are interchangeable and come in a choice of apertures: 0.03, 0.04, 0.05 or 0.06 in. All parts are replaceable.

CIRCLE NO 338

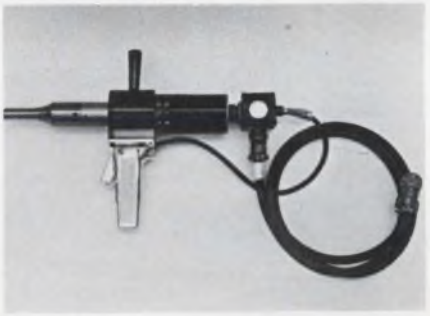
Power stirrer revs to 1000 rpm

Starnetics Co., 10639 Riverside Dr., North Hollywood, Calif. Phone: (213) 769-8437. Price: $152.50.

With a continuously variable speed from 0 to 1000 rpm, a power stirrer mixes thick-film pastes, emulsions, adhesives, resins, and other thixotropic materials used in electronic fabrication. The high-torque, low-speed unit always produces uniform homogeneous mixtures—crucial for obtaining high yields in fabrication of resistors, conductors and insulators.

CIRCLE NO. 339

Ultrasonic hand tool spotwelds plastic



Branson Sonic Power Co., Eagle Rd., Danbury, Conn. Phone: (203) 744-0760.

Dealing out split-second bursts of ultrasonic energy, a pistol-grip hand tool spotwelds plastic to plastic, inserts metal into plastic, and stakes plastic to metal. The new tool broadens the scope of ultrasonic assembly to encompass parts of unlimited size and those whose joint areas are hard-to-reach. It weighs approximately 6 lb and is 18 in. long. Energy output varies from 1200 to 8800 in.-lb/s.

CIRCLE NO. 340

NCR Los Angeles offers you the challenge of the Century

NCR, creator of the sophisticated and fast-selling Century Series computer systems, offers you immediate opportunity to work in new-generation technology. Join the men responsible for the industry's most advanced developments in high-speed thin-film memories, monolithic integrated circuitry, disc memory innovation, and automated production techniques. NCR Electronics Division is the largest commercial computer manufacturing facility in Southern California and one of the most advanced in the world. Benefits include a thoroughly professional environment, an excellent salary, non-defense stability, and fully paid life, hospital and medical plans for you and your dependents. Look into NCR now and accelerate your career.

PRODUCT PLANNING

SYSTEMS ANALYSIS ENGINEERS

Analysis and development of advanced systems specifications; consultation on systems design, hardware configuration, software trade-offs; analysis of competitive systems. Prefer applicants with BS degrees and 3-5 years' experience and ability to write and test functional specifications in such areas as very-high-speed memories, disc files, drum files, central processors employing large-scale integration, communications and time-sharing systems.

SOFTWARE SYSTEMS DESIGN

Develop operating, executive, utility and on-line systems for third- and fourth-generation advanced systems. Positions require a business or science degree and large-scale file computer or software development experience.

DATA PROCESSING

BUSINESS SYSTEMS ANALYSTS

Will investigate areas of data handling such as engineering specifications, inventory control, production planning and quality control. Responsible for designing data processing methods ranging from manual operations to major computer applications. Prefer BS degree and 2-4 years' systems/programming experience.

BUSINESS PROGRAMMERS

Will be responsible for systems analysis and/or the development of programs for business applications such as budgets, cost accounting, engineering, administration and purchasing. Prefer BS degree and prior programming/systems background.

ENGINEERS

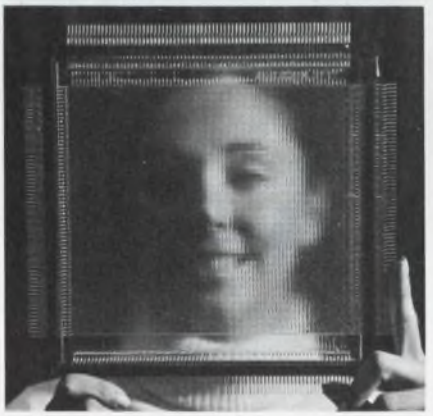
ADVANCED DEVELOPMENT ENGINEERS

Positions available for senior MECHANICAL and ELECTRONIC engineers with strong experience in high-speed mechanisms, and mechanical, hydraulic, and electro-mechanical mechanisms. Will work in area of high-speed precision positioning devices and be responsible for concept, design and fabrication. BSME/BSEE and five years' related experience required.

Plated disc memory with multiple read/write heads

MAGNETIC HEAD DESIGN ENGINEERS

Will design and develop flying magnetic recording heads and the required prototype tooling. Requires BS or MS in EE, ME or physics plus three years' applicable experience. Knowledge of ferrite machining technology and ferrite heads desirable.



Standardized short rod memory plane

ELECTRONIC DEVELOPMENT ENGINEERS

Specification, design, checkout and documentation of digital and digital/analog equipment for use with on-line data processing and data communications systems. Requires BSEE and five years' related experience.

CIRCUIT DESIGN ENGINEERS

Will design and develop digital and analog semiconductor circuits, including discrete, integrated and hybrid types. Requires a BS/MSEE and two years' related experience.

LOGIC DESIGN ENGINEERS

Will participate in logical design of fourth-generation digital computers. Position requires BSEE and minimum of two years' experience in digital logic or circuit design.

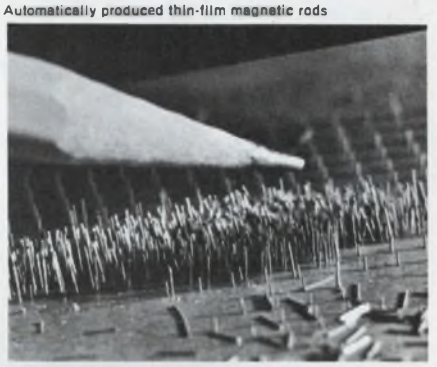
INDUSTRIAL ENGINEERS

Will develop manufacturing machining processes for various projects. Will be responsible for capital equipment analysis, fabrication tooling and initial production. Positions require BSIE and heavy mechanical/industrial engineering experience.

CHEMICAL ENGINEERS

Positions are available for college trained engineers to assume responsibility for film plating, organic finish analysis, and production plating process functions. Successful candidates will possess a BS degree in chemical engineering, a knowledge of organic coatings, the ability to develop and direct a process laboratory, and 3 to 5 years' experience in electro-plating of magnetic thin-film materials for chemical process analysis.

Automatically produced thin-film magnetic rods



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Confidential interviews will be held during the IEEE International Convention at the New York Hilton Hotel, March 24-27. To schedule an appointment, please submit detailed resume, including salary history, to Jerry Hill at the Electronics Division. If you do not plan to attend the convention, an interview will be arranged soon in your area.

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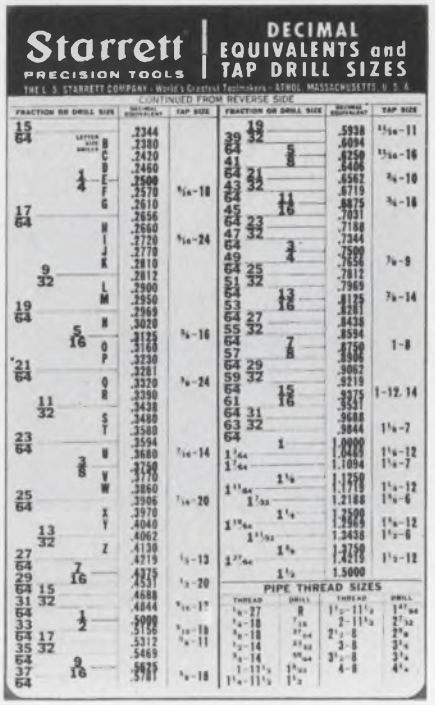
ON CAREER INQUIRY FORM, P. 85, CIRCLE INFORMATION RETRIEVAL NUMBER 906

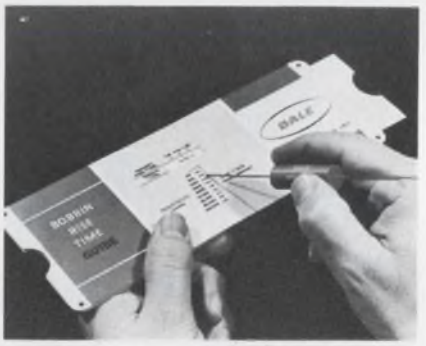
Design Aids



Tap drill card

A pocket-sized plastic chart converts fractions or drill sizes to decimal equivalents and tap sizes. L. S. Starrett Co.

CIRCLE NO. 341



Bobbin resistor rule

A free slide rule quickly gives rise time plus inductance/capacitance for a complete range of wire-wound bobbin resistors from 0.1 to 1 W. Fast, non-ringing rise times as low as 0.003 μs (10% to 90% for 100 kHz pulse) are available. Bobbins are available with the accuracies and/or matching needed for switching in digital to analog converters and other high frequency, low reactance applications. Resistance values are available between 0.1 Ω and 23 MΩ with tolerances of 1%, 0.5%, 0.25%, 0.1% and 0.05%. Dale Electronics, Inc.

CIRCLE NO. 342

Relay selector

Cross-referencing the product lines of two major relay manufacturers, a handy circular slide chart determines interchangeability instantly. The user simply points a black arrow at any relay printed on the outer circumference of the rule and its equivalent appears in a window within the arrow. Cornell Dubilier Electronics.

CIRCLE NO. 343

Power supply nomogram

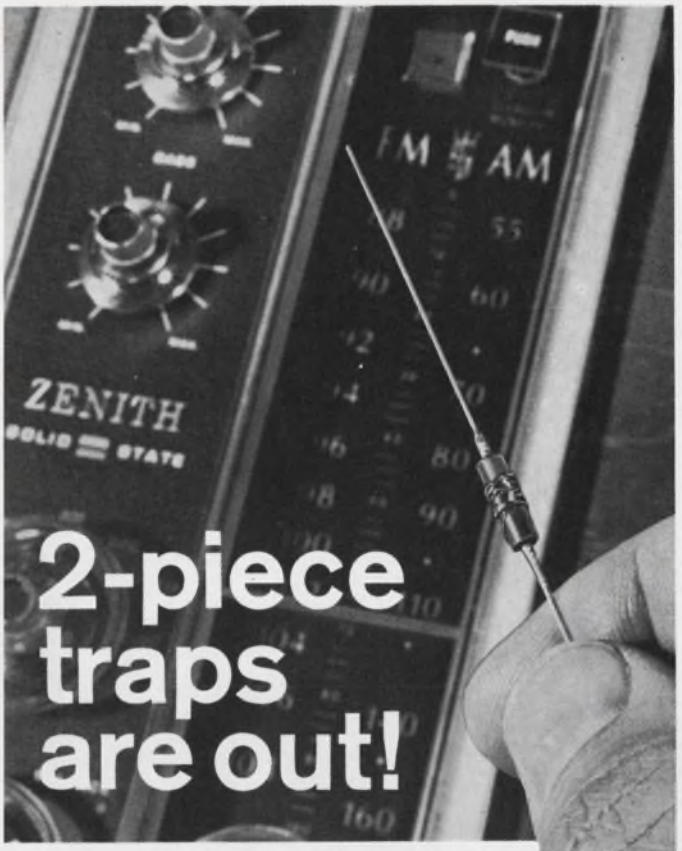
Featured in a 48-page power supply handbook, a nomogram simplifies the calculation of voltage drop across supply leads. The three-scale nomogram gives voltage drop as a function of wire size and load current. Also included are eight pages of application notes, a glossary and 32 pages of power-supply product listings. Kepco, Inc.

CIRCLE NO. 344

Coax calculator

Characteristics of Foamflex coaxial cable can be quickly determined with this handy slide rule. When over-all size and desired impedance are set opposite a pointer, all pertinent mechanical and electrical specifications appear in windows on the rule. Phelps Dodge Electronic Products.

CIRCLE NO. 345

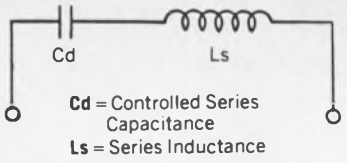


2-piece traps are out!

Zenith uses Dale hybrid Series-Resonant Trap in FM circuitry

Zenith wanted a better way to bypass 10.7 MHz in its FM receivers. To replace the standard 2-component inductor-capacitor trap, Dale provided this unique hybrid.

Dale's Series-Resonant Trap has the electrical characteristics of an inductor and a capacitor in series and provides a method of controlling both functions. The result: Controlled self-resonance in a miniaturized circuit.



Cd = Controlled Series Capacitance
Ls = Series Inductance

After four years of production use, *Zenith says* of the Series-Resonant Trap: *"It saves space, saves time, works satisfactorily."* Here are the basic specs:

- **Resonant Frequency:** 10.7 MHz ± .5 MHz (Other frequencies available)
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INFORMATION RETRIEVAL NUMBER 66

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INFORMATION RETRIEVAL NUMBER 67

Application Notes

Electroluminescence

Describing the theory, types and applications of electroluminescent light sources, a 20-page technical brochure explains how an electric field stimulates light emission from certain layered materials to produce electroluminescence. It includes sections on metal-ceramic panel lamps, other electroluminescent products, and their applications. Sylvania Electric Products Inc., Special Products Div.

CIRCLE NO. 346

Ultrastable thyratrons

A series of hydrogen thyratrons employing an advanced design that significantly reduces power and circuit requirements as well as component replacement in high-energy systems is described in a 16-page booklet. The 4-color booklet gives a systematic description of the new tubes and their advantages. It makes extensive use of charts and diagrams to illustrate the principles and applications. The booklet discusses the effects of drift and jitter, the design of a new thyratron and its theoretical advantages, the empirical verification of these advantages, and specifications of the new tubes. Tung-Sol.

CIRCLE NO. 347

Flat cable connectors

Described in a six-page catalog are removable- and fixed-contact connectors for flexible cable printed-circuit applications. Miniature and microminiature plug and socket, card-edge printed circuit connectors and several terminal blocks are illustrated and described. Continental Connector Corp.

CIRCLE NO. 348

S-parameter techniques

Seven articles on high-frequency (>100 MHz) circuit design with S-parameters are presented in an 86-page application note. Techniques are described for measuring the S-parameters of transistors and networks, and for designing with the parameters. The articles are illustrated with charts and diagrams and include comprehensive bibliographies. Hewlett-Packard Co.

CIRCLE NO. 349

MOS shift registers

MOS shift registers in bipolar logic systems are treated in a 20-page application report. The power requirements of MOS static shift registers are given. Basic clocking requirements and clock drivers are discussed, along with requirements for interfacing with TTL and DTL systems. Basic input and output data on MOS static shift registers is also provided. Texas Instruments, Inc.

CIRCLE NO. 350

Magnetic clutches

A magnetic particle and clutch catalog also features other useful items such as mounting aids and a discussion of working principles. In addition, it includes a nomogram for determining optimum input speed and accelerating torque required for indexing applications. Lear Siegler, Inc.

CIRCLE NO. 351

Discharge lamps

A 28-page publication covers high-intensity discharge lamps, detailing the physical, electrical and performance characteristics of three principal categories of lamps. The booklet discusses the history of light output improvements, bulb shapes and sizes, designations, operating characteristics, lamp life, factors affecting lamp performance and spectral energy distribution data. General Electric Co.

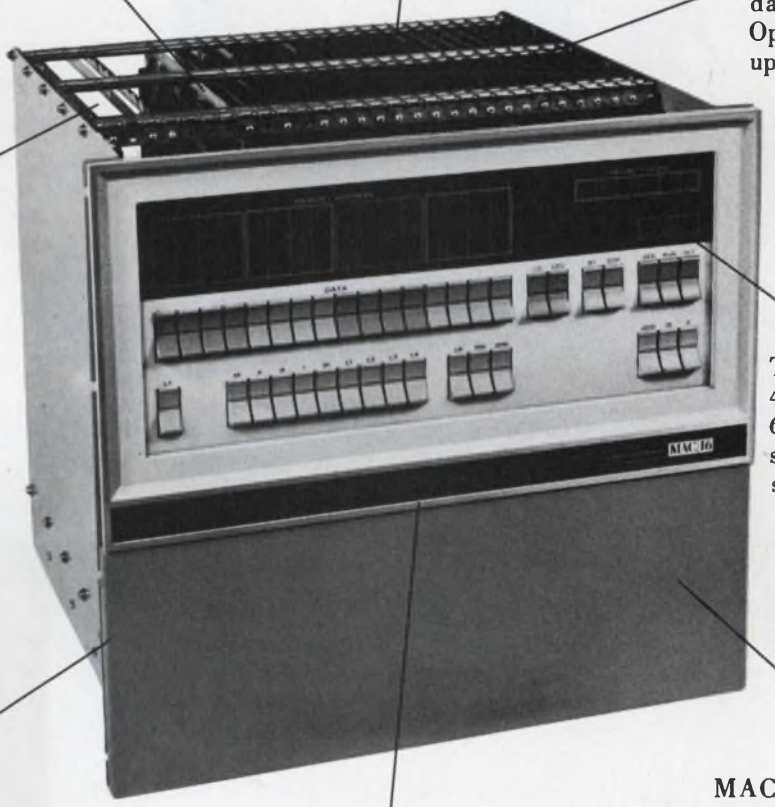
CIRCLE NO. 352

MAC is a good deal of computer.

1-μsec memory cycle time. 16-bit parallel word, 2-μsec add time. 4K words standard.

72 instructions including: byte handling, 3-way nondestruct compare, test and skip up to 15 instructions, fast shifts, and optional multiply/divide.

Three data channels: Programmed data channel, up to 90KHz. Optional multiplexed data channel up to 333KHz. Optional direct-memory-access up to 800 KHz.



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LOCKHEED ELECTRONICS COMPANY LEC A Division of Lockheed Aircraft Corporation

INFORMATION RETRIEVAL NUMBER 69

New Literature

IC regulated supplies

A new 16-page catalog supplement has full product information on six groups of dc regulators that use monolithic IC technology. The use of linear ICs offers improvement in performance. Details are given for voltage regulators, current regulators, operational power amplifiers, computer power supplies and precision voltage standards. Kepco, Inc.

CIRCLE NO. 353

Electromagnetic forming

Bulletin 100, a new 12-page brochure, covers magnetic pulse metal-forming and the operation of electromagnetic forming machines. Illustrations and descriptions of the many joining and assembly applications for which these machines are suited are included in the bulletin. Gulf General Atomic.

CIRCLE NO. 354

Solid-state displays

A 4-color 12-page bulletin discusses the three solid-state-display technologies of magneto-optics electroluminescence, and light-emitting semiconductor devices. These technologies, the state of their development, their prime applications, and some of the advantages of using solid-state displays are presented. General Electric Co.

CIRCLE NO. 355

Rectifiers and zeners

Specifications and performance charts are shown in a 16-page catalog for a complete line of fused-in-glass silicon diodes, rectifiers, zeners and high-voltage assemblies. Covered are rectifiers (up to 9 A) with recovery times from 15 to 500 ns. Other sections describe high-surge 3-, 5- and 10-W zener diodes, MIL-type rectifiers and zeners, and high-voltage stack bridges and rectifier modules. Unitrode Corp.

CIRCLE NO. 356

Induction heating

Induction heating applications are described in a four-page illustrated brochure. Hardening, brazing, and soldering applications using various types of induction heating generators and fixtures are discussed. Special applications and special tooling are also included. Cycle-Dyne Inc.

CIRCLE NO. 357

Electronic components

A 35-page condensed catalog gives complete details on a variety of resistors, potentiometers, transformers, capacitors, solid-state power controls, rf chokes and relays. The relay section includes dimensional drawings and mounting illustrations. The most popular component values are indicated in bold print. Ohmite Mfg. Co.

CIRCLE NO. 358

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DUMONT 766 H/F offers the reliability of silicon solid state circuitry, no-fan low power consumption, greater display area, fully interchangeable X and Y plug-ins, internal graticule and of course, 100 MHz capability and sweep switching. It is also available in a horizontal version for rack mounting, the 767 H/F.

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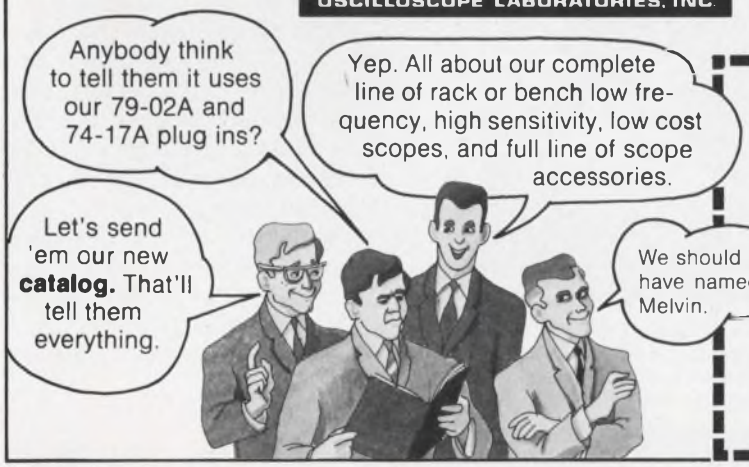
OSCILLOSCOPE LABORATORIES, INC.



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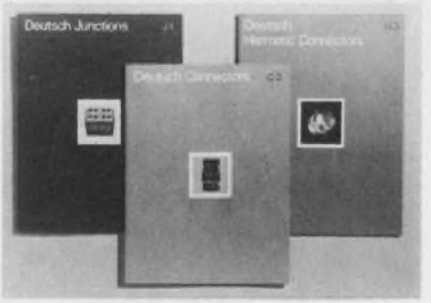
INFORMATION RETRIEVAL NUMBER 72

NEW LITERATURE



Junctions and connectors

Three separate, concise catalogs that visually itemize terminal junctions, miniature and subminiature connectors and hermetic connectors are now available as quick-reference aids. Each catalog illustrates the various product types, describes their advantages and then, in chart form, provides basic data regarding application, sizes, and operating characteristics. In addition to general specifications and background information, each catalog also provides illustrated step-by-step descriptions of crimping and assembly procedures. The Deutsch Company.

CIRCLE NO. 359

Lights and switches

Illuminated pushbutton switches and matching indicator lights, featuring a more versatile range of mounting hardware and improved styling, are described in a new catalog. The 14-page, 2-color catalog gives complete specifications, drawings, circuit details, and ordering information. Also included is a lamp selection guide. Marco-Oak, Div. of Oak Electro/Netics Corp.

CIRCLE NO. 360

Crossbar basics

Crossbar fundamentals are given in a 16-page illustrated bulletin. Capabilities, operational characteristics, and components of this general-purpose, high-performance, signal-switching device are covered. The bulletin provides information on details of actuating assemblies and contact matrix, with data on circuits and bussed-select and independent-select matrix and level selection. Also covered are design considerations, electrical characteristics, and complete specifying data. Cunningham Corp., Sub. of Gleason Works.

CIRCLE NO. 361

Oscilloscopes

Presenting a complete profile of scope data, a 30-page short-form catalog contains information on low-frequency and high-frequency oscilloscopes. Included are general-purpose, dual-trace, high-gain, and large-screen scopes, as well as amplifier and time-base plug-ins. Also described is a line of signal generators and oscilloscope cameras and accessories. Dumont Oscilloscope Laboratories, Inc.

CIRCLE NO. 362

Connector catalog

An expanded series of rectangular pin and socket connectors for rack-and-panel cable applications is fully described in a 42-page catalog. Completely updated specifications, plus application and dimensional data for nearly 900 items are included. Semi-automatic machinery for large-volume production wiring and hand tools for maintenance and production use are also described. AMP, Inc.

CIRCLE NO. 363

DIP packaging

A new concept in high-density packaging of dual-in-line integrated circuit modules is described in a 20-page designer's catalog. Constituting a high-density modular method of mounting IC modules that uses a new type of receptacle, the system offers complete design and flexibility in three dimensions and features maximum component-packing densities. Scanbe Manufacturing Corp.

CIRCLE NO. 364

Accelerometer data

Flutter testing, model studies and similar low-frequency, light weight acceleration measurements can be accomplished with exceptional ease and accuracy using the miniature piezoresistive accelerometer described in a new product data sheet. The instrument weighs only one gram, has a dynamic range from minus 150 g to plus 150 g, and sensitivity at rated excitation of 2.5 mV/g minimum. Endevco, subsidiary of Becton, Dickinson and Co.

CIRCLE NO. 365

NEW LITERATURE

IC hardware

A new catalog describes a complete line of sockets, carriers, contactors and breadboards for integrated circuits, MSI and LSI devices, transistors, relays and operational amplifiers. Profusely illustrated with photographs and dimensional drawings, the catalog covers the full range of components offered for various devices. Barnes Corp.

CIRCLE NO. 366

Production aerosols

Industrial aerosol products are covered in a 12-page catalog featuring anti-rust compounds, cutting oils, industrial points, mold releases, varnish removers, die makers layout inks and a variety of other specialty products. The catalog has been designed to give adequate application data. It is scored, punched and slotted for easy insertion into permanent binders. Percy Harms Corp.

CIRCLE NO. 367

Stainless steel data

Properties of stainless steel machined parts, most frequently used as economical, corrosion resistant materials in high temperature applications, are described in a new technical bulletin. Data are provided on the physical, electrical, mechanical, machining and welding properties as well as heat treatment, heat resistance, drawing and stamping performance. A table gives the corrosion resistance to various gases, acids, alkalis, salts, metals and glass. Design consideration for high temperature applications, as well as finished tolerances and size availability are also listed. Kawecki Berylco Industries Inc.

CIRCLE NO. 368

Small metal parts

Specifiers and users of small, thin metal parts will be interested in a new, six-page folder which describes small metal parts produced by a process similar to that used in manufacturing printed circuit boards. The photoetching process eliminates expensive tooling since only photographic artwork of the desired part is required and costs less than $300 to set up. An etched sample is included with the brochure. Magnetics Inc.

CIRCLE NO. 369

Rack-and-panel connectors

New 28-page guide describes a wide range of low cost rack-and-panel connectors. These rectangular, miniature, modular, and appliance connectors range in size from 2 to 140 contacts, with current ratings of 5 to 20 amperes. An illustrated connector index, shows the basic characteristics of each connector, and expedites their immediate identification. Elco Corp.

CIRCLE NO. 370

Filters and delay lines

Delay lines, L-C filters and passive laboratory instruments are detailed in an eight-page technical bulletin. A wide variety of stock and custom devices are available. Allen Avionics, Inc.

CIRCLE NO. 371

IC catalog

A 1969 IC short-form catalog is now available. The 24-page catalog contains reference data for op amps, voltage regulators, communication circuits, MOS memories, analog switches, logic elements, and TTL circuits. National Semiconductor Corp.

CIRCLE NO. 372

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NEW COAXIAL SWITCHES AND MATRICES

This new colorful 12 page catalog is the most complete and technically helpful of its kind. Cable system noise reduction is covered in detail along with how to establish the best system for your application. Matrices are available with multiple inputs and outputs, with numerous paths through the matrix available simultaneously. Using the same mode of construction, single pole multi-throw, or multi-pole multi-throw coax, twinax and triax relays are available.

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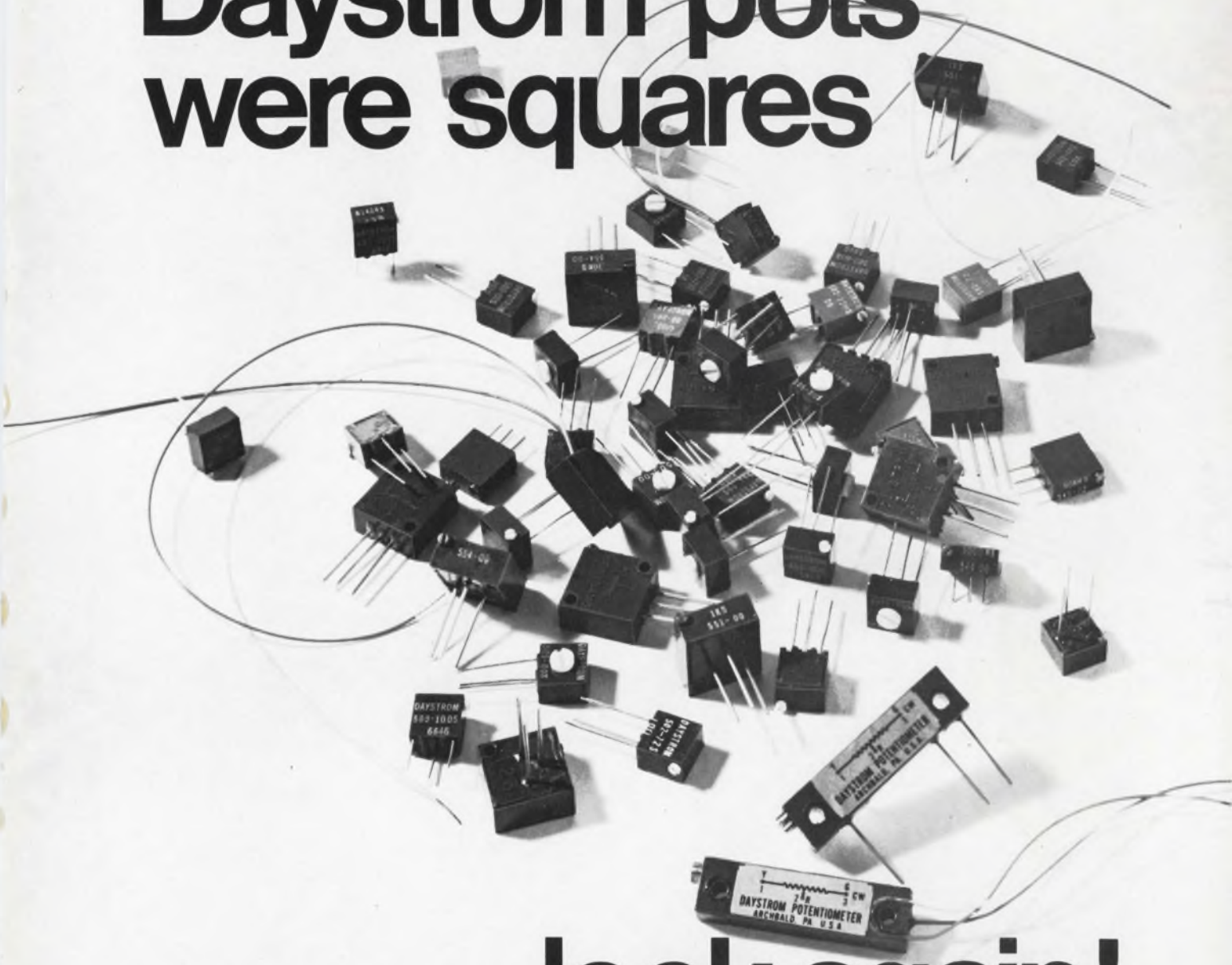
All products, design aids (DA), application notes (AN), new literature (NL), and reprints (R) in this issue are listed here with Page and Information Retrieval numbers. Reader requests will be promptly processed by computer and mailed to the manufacturer within three days.

New Literature

Application Notes

Design Aids

If you thought all Daystrom pots were squares



...look again!

Rectilinear components are still a necessary requirement in many circuit applications. That's why Weston has rounded out its high-performance potentiometer line with two new rectilinear models. RT-12 styles 534 and 535 are designed for both general-purpose and military applications. They feature the same ±5% tolerance, 10 ohm to 50K range, and slip clutch stop protection that are standard with Daystrom Squaretrim® units, plus 24-turn adjustability and humidity proofing. Also new this year . . . models 553 half-inch and 543 three-eighth-inch Squaretrim potentiometers in military and commercial versions. Save board space as well as money with our field proven 501 Series multi-turn and 504 Series single-turn 5/16" Squaretrims offering values to 20K in a 0.02 cubic inch case. All Squaretrim Diallyl-Phthalate cased pots give you Weston's patented "wire in the groove" construction and your choice of flexible leads, pin and screw configurations. Whether your trimmer needs are military, industrial or commercial, you'll find the answer in this complete new low-cost line. Write today for data sheets and evaluation samples. DAYSTROM potentiometers are another product of WESTON COMPONENTS DIV., Archbald, Pennsylvania 18403, Weston Instruments, Inc., a Schlumberger company

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INFORMATION RETRIEVAL NUMBER 233

New! Multi-Color Performance from RCA Single-Gun CRT's

How many colors do you want in CRT read-out? RCA can give you two, and the shades between, from a single-gun CRT. What's more you have a choice of tube size for the display of all types of visual information – waveforms, alphanumeric, pictorial or any combination of these three.

Here's your answer to air-traffic control systems, military IFF systems, stock market quotation displays, airline and other transportation status boards. Utilize RCA's new capability in teaching machines, electronic test instruments, computer read-out equipment—anywhere a multi-color display makes understanding easier.

The RCA multi-color CRT is made with two phosphor layers. The multi-color performance is obtained through the application of different anode voltages.

Whatever your choice of colors and display, the read-out is as sharp and bright as black and white. And the single electron gun means simple back-up circuitry.

For more information on RCA multi-color CRT's and other RCA Display Devices, see your RCA Representative. For technical data, write: RCA Electronic Components, Commercial Engineering, Section No. B-18Q-1, Harrison, N.J. 07029.

RCA