Electronic Design

VOL. 16 NO. 4

FOR ENGINEERS AND ENGINEERING MANAGERS

FEB. 15, 1968

Freedom of speech and action will help aquanauts to extract the riches of the ocean. New electronics makes it possible. Undistorted voice transmission, telemetry for monitoring health and safety, and homing schemes for spatial orientation—all will aid in man's ventures into the wet, dark, hostile deep (p. 25).

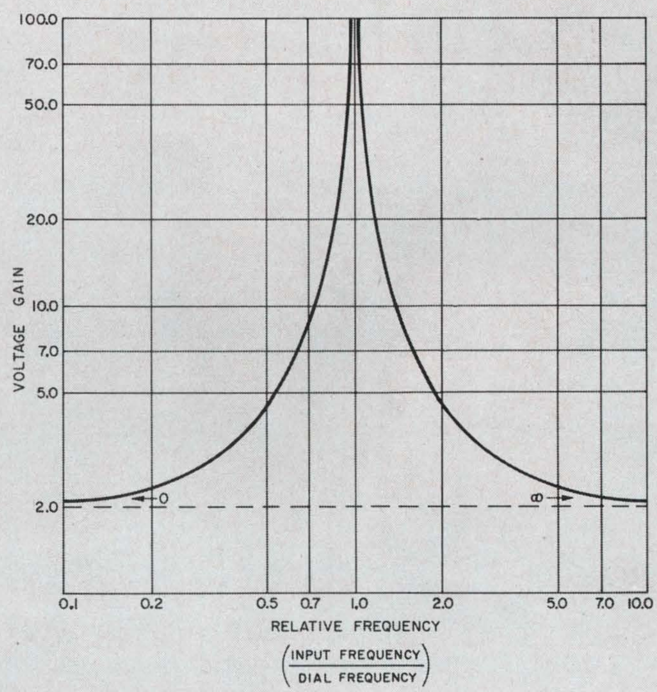
1309-A . . . $325*
• 10 Hz to 100 kHz, sine or square waves
• Distortion < 0.05%
• Output flat ± 2% over entire range; 5-V open-circuit output
• 60-dB attenuator (20 dB/step)

1311-A . . . $260*
• 50 Hz to 10 kHz in 11 fixed steps
• Distortion < 0.5%
• 100-V open-circuit output, 4 A short circuit

1310-A . . . $325*
• 2Hz to 2 MHz
• Distortion < 0.25% (even with output shorted)
• 20-V open-circuit output

1313-A . . . $325*
• 10 Hz to 50 kHz in one range
• sine or square wave
• Distortion < 0.5%
• Output flat to ± 2% over entire range; 5-V open-circuit output.
• 60-dB attenuator (20 dB/step)

*Prices apply only in U.S.A.



These oscillators function as high-Q filters

While oscillating, three of them can function as tunable narrow-band filters . . . hence they can be used at a variety of frequencies to reduce fm and jitter.

They can also serve as frequency-selective amplifiers with a voltage gain of greater than 100 and with effective rejection of noise and harmonics.

They can be locked to a frequency standard for use as high-stability signal sources at test stations. Or, they can be used as frequency multipliers because they can be locked onto a harmonic as easily as they can be locked to a fundamental. They can also furnish sync signals to other instruments.

How can an oscillator do all this? No big secret . . . these RC oscillators are all equipped with a handy "synchronizing jack" . . . another GR first in oscillator design. Put a signal in (1 volt will do) and out comes the same frequency all cleaned up and amplified; or take out the sync signal and use it to trigger a counter or a scope or even another GR RC oscillator.

One other thing — they're great when used as just oscillators.

GENERAL RADIO
W. Concord, Massachusetts 01781

INFORMATION RETRIEVAL NUMBER 2

VOL. 16 NO.

Electronic Design 4

FOR ENGINEERS AND ENGINEERING MANAGERS

FEB. 15, 1968

NEWS

TECHNOLOGY

PRODUCTS

DEPARTMENTS

ELECTRONIC DESIGN is published biweekly by Hayden Publishing Company, Inc., 850 Third Avenue, New York, N.Y. 10022. James S. Mulholland, Jr., President. Printed at Brown Printing Co., Inc., Waseca, Minn. Controlled-circulation postage paid at Waseca, Minn., and New York, N.Y. 70,170 copies this issue.

Good things do come in small packages!

ALL THE FEATURES FOUND IN LARGER SIZE SWITCHES... ***except the larger size***

1/2" ROTARY SWITCHES

INDUSTRY'S MOST COMPLETE SELECTION

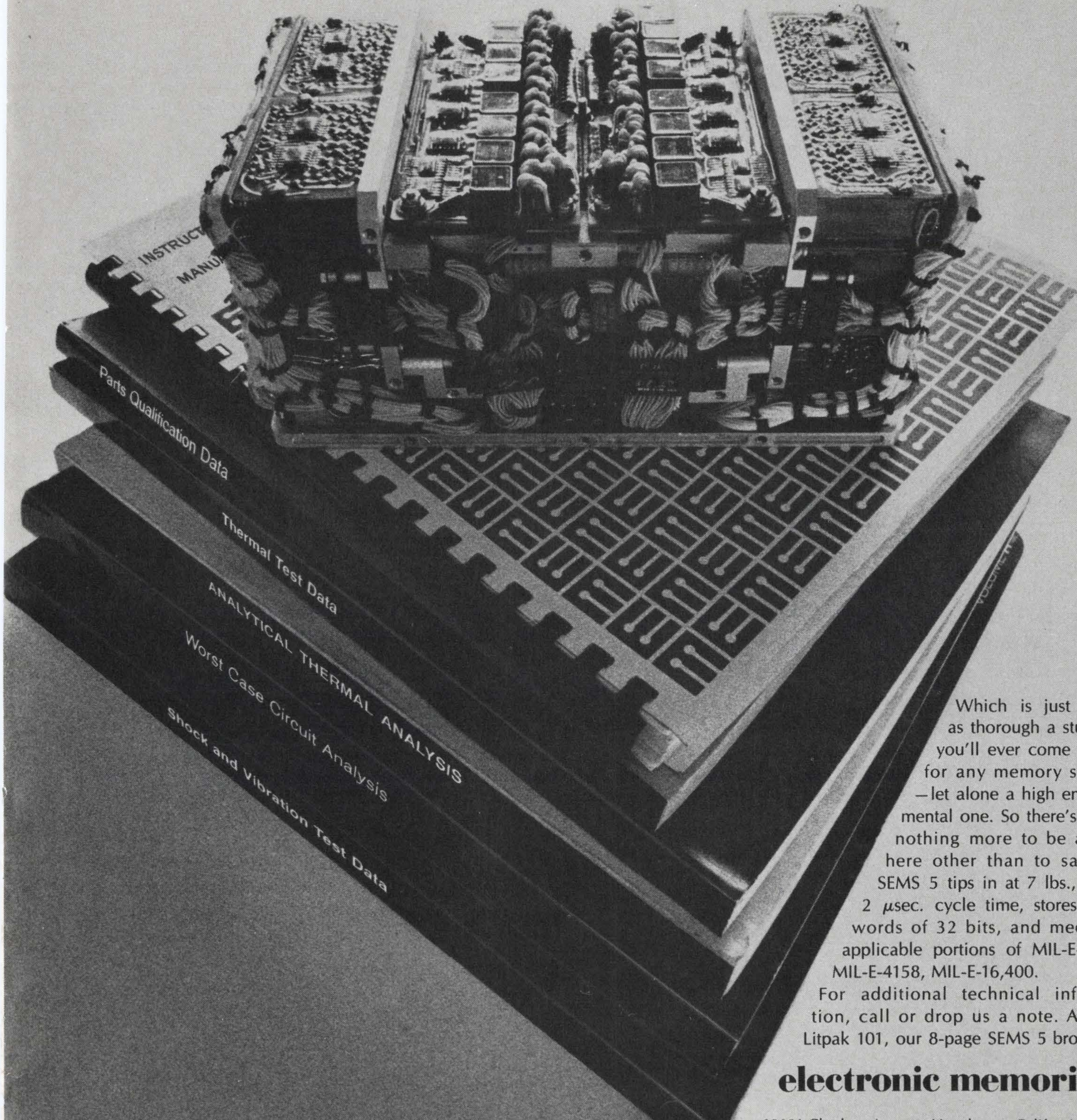
Up to 12 positions per deck SHORTING OR NON-SHORTING / Up to 6 poles per deck / Shorting and NON-SHORTING poles can be grouped in any combination on one deck / Individual deck parts self-contained and permanently molded into place / Extremely low and uniform contact resistance (.004 Ω average) / Life expectancy 200,000 mechanical operations minimum / "Off-The-Shelf" Delivery

RCL.
ELECTRONICS, INC.
General Sales Office
700 So. 21st Street
Irvington, New Jersey 07111

INFORMATION RETRIEVAL NUMBER 4

INFORMATION RETRIEVAL NUMBER 5 ►

Back up data on the smallest, fastest military memory weighs more than the smallest, fastest military memory.



Which is just about as thorough a study as you'll ever come across for any memory system —let alone a high environmental one. So there's really nothing more to be added here other than to say our SEMS 5 tips in at 7 lbs., has a 2 μsec. cycle time, stores 4096 words of 32 bits, and meets all applicable portions of MIL-E-5400, MIL-E-4158, MIL-E-16,400.

For additional technical information, call or drop us a note. Ask for Litpak 101, our 8-page SEMS 5 brochure.

electronic memories

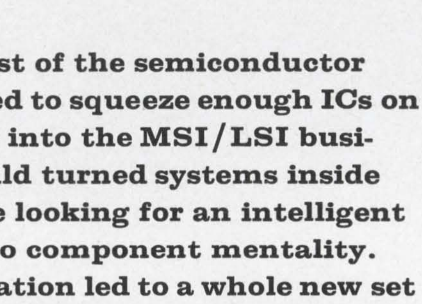
12621 Chadron Avenue, Hawthorne, California 90250
Phone: (213) 772-5201.

The great LSI race.

While the rest of the semiconductor industry tried to squeeze enough ICs on a chip to get into the MSI/LSI business, Fairchild turned systems inside out. We were looking for an intelligent alternative to component mentality. Our investigation led to a whole new set of design criteria for medium and large scale integration devices.

A computer isn't a computer.

It's a digital logic system. It has the same functional needs as any other digital system: control, memory, input/output and arithmetic. There's no logical reason to custom design a complex circuit for each system. That's why Fairchild MSIs and LSIs are designed to function as fundamental building blocks in *any* digital logic system. Even if it's a computer.



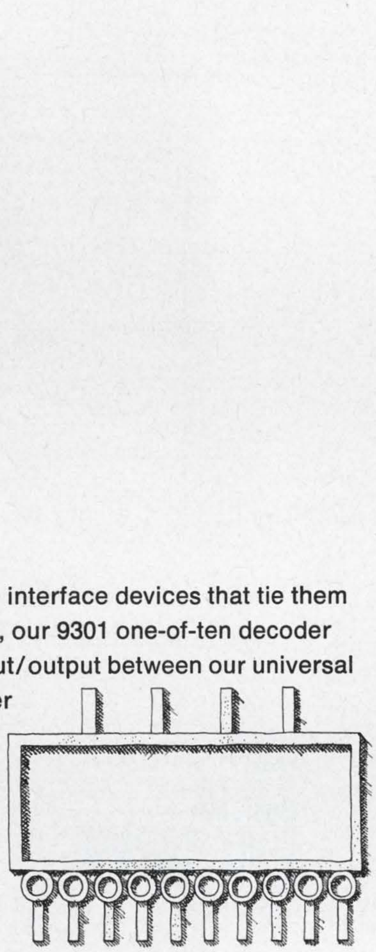
A little complexity goes a long way.

Anybody can package a potpourri of circuitry and call it MSI or LSI. But, that's not the problem. Why multiply components, when you should divide the system? Like we did. We found that sub-systems have a common tendency toward functional overlap. There are too many devices performing similar functions. More stumbling blocks than building blocks. Our remedy is a family of MSIs and LSIs with multiple applications. The Fairchild 9300 universal register, for example, can also function as a modulo counter, shift register, binary to BCD shift converter, up/down counter, serial to parallel (and parallel to serial) converter, and a half-dozen other devices.

Watch out for that first step.

There are all kinds of complex circuits. Some of them have a lot of headache potential. Especially if you want to interface them with next year's MSIs and LSIs. We decided to eliminate the problem before it got into your system. All Fairchild building blocks share the same compatible design characteristics.

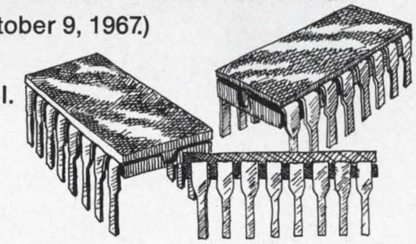
We're also making the interface devices that tie them together. For example, our 9301 one-of-ten decoder can be used as an input/output between our universal register, dual full adder and memory cell. (It could also get a job as an expandable digital demultiplexer, minterm generator or BCD decoder.)



Hurry. Before the price goes down.

Gate for gate, today's complex circuits are about the same price as discrete ICs. But, by the time you're ready to order production quantities, the price should be a lot lower. At least ours will. The reason is simple: Fairchild devices are extremely versatile. There are fewer of them. But, they do more jobs. That means we'll be producing large quantities of each device. That also means low unit cost to you. And you'll have fewer devices to inventory. And fewer to assemble.

If you agree with our approach to medium and large scale integration, we'd like to tell you more about it. There are two ways you can get additional information. One is by mail. Simply write us on your company letterhead. You can also get more data by watching the trade press. Fairchild is introducing a new integrated circuit each week for 52 weeks. (We started on October 9, 1967.) Many of them will be MSI and LSI. If you'd like to see the last few we've introduced, turn the page.



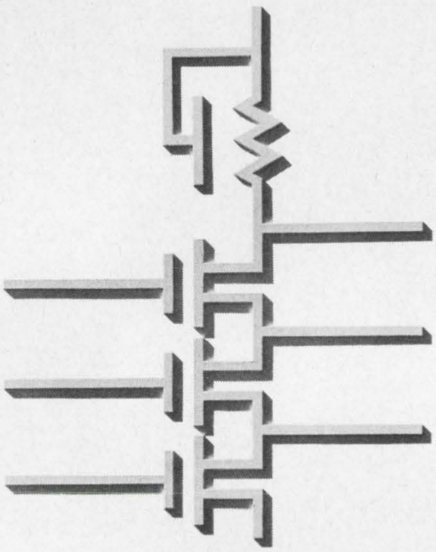
FAIRCHILD SEMICONDUCTOR
A Division of Fairchild Camera and Instrument Corporation
313 Fairchild Drive, Mountain View, California 94040
(415) 962-5011, TWX: 910-379-6435

RECAP:

Starting October 9, 1967, Fairchild promised to introduce a new integrated circuit each week for 52 weeks. This is number **13.**

3102 MOS THREE-INPUT GATE

The 3102 is an extremely versatile three-input breadboard gate which can serve as the fundamental element in any MOS digital logic system. It can also function as an evaluation tool for determining the performance of Fairchild's line of MOS devices; or simply as a vehicle for gaining familiarity with MOS integrated circuitry. The 3102 comes in both TO-5 cans (one 3102 per can) and in 16-pin DIPs (two devices per package). The availability of all source and drain leads for each transistor provides excellent logic versatility. Input protection reduces handling problems. Power consumption is typically as low as 6mW. Operating temperature ranges from −55°C to +85°C. Volume quantities of the 3102 are now available. Your Fairchild distributor has it on his shelf. Write us for complete specs and applications information. While you're at it, ask about our other new products, too.



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CIRCLE READER SERVICE NUMBER 113

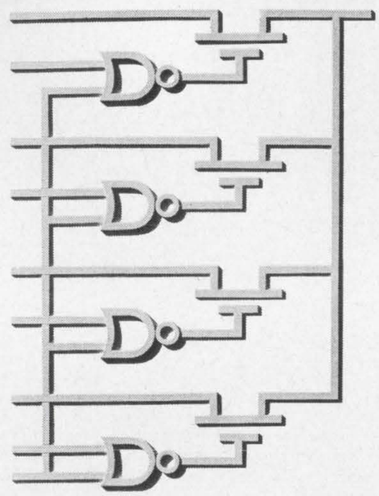
Starting October 9, 1967, Fairchild promised to introduce a new integrated circuit each week for 52 weeks. This is number **14.**

3700 FOUR-CHANNEL MULTIPLEX SWITCH

Fairchild's 3700 is designed for use in A/D and D/A converters; multiplexing, analog or digital data transmission systems; and other airborne or ground instrumentation signal routing applications. It can be used in telemetry systems, computers, remote monitoring equipment and transducer sensing equipment. Control logic has been included to make it NPN bipolar compatible. It utilizes Planar II*, P-channel enhancement mode MOS technology and provides all channel blanking control. It also features zero offset voltage, high ON/OFF ratio and input gate protection. And, our 9112 high level hex inverter (new product number 6) can be used to directly interface the 3700 with CCSL logic levels.

The 3700 is available in two signal ranges: the 3700142 for −5.0 to +5.0 volts, and the 3700143 for ranges of 0 to +5.0 volts. Both of the 3700 devices come in flat pack and will operate over the entire temperature range from −55°C to +85°C. They're available now in volume quantities. Your Fairchild distributor has them in stock. Write for complete specs and applications information. Ask about our other new products, too.

*Planar is a patented Fairchild process.



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CIRCLE READER SERVICE NUMBER 114

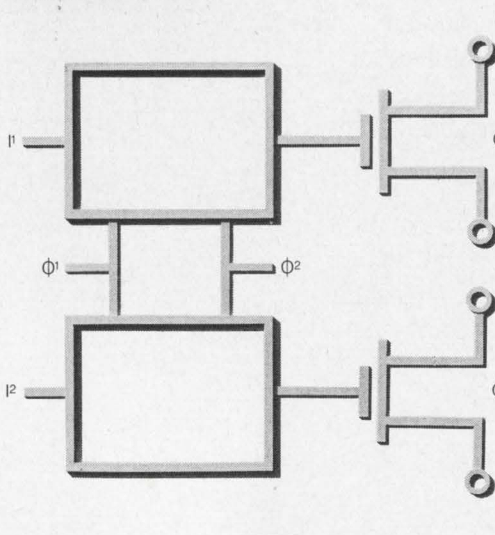
Starting October 9, 1967, Fairchild promised to introduce a new integrated circuit each week for 52 weeks. This is number **15.**

3303 DUAL 25-BIT DYNAMIC SHIFT REGISTER

The 3303 is a product of Planar II*, P-channel enhancement mode MOS technology. It contains two 25-bit shift register strings with two common clock lines. Output stages can be connected as either inverters or as source followers. It is applicable for digital delay lines in computers and radar systems (both ground and airborne). It can also be used as a serial memory in telemetry systems.

The 3303 comes in a TO-5 can and will operate over the entire temperature range from −55°C to +85°C. It operates at 1 MHz (typical). Power dissipation is typically less than 2mW per bit. Volume quantities of the 3303 are now available. Your Fairchild distributor has it in stock. Write for complete specs and applications information. Ask about our other new products, too.

*Planar is a patented Fairchild process.



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CIRCLE READER SERVICE NUMBER 115

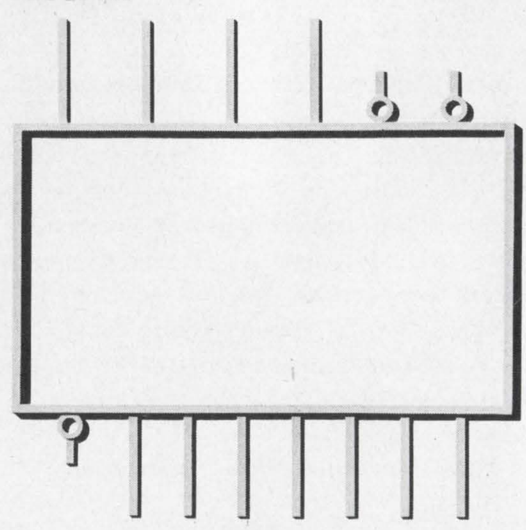
Starting October 9, 1967, Fairchild promised to introduce a new integrated circuit each week for 52 weeks. This is number **16.**

9307 BCD TO SEVEN-SEGMENT DECODER

The Fairchild 9307 is designed to be used in any numeric display system which requires seven-segment information. This includes incandescent, electroluminescent, seven-segment neon, or CRT numeric displays. It is an MSI device. It accepts an input in 8421 BCD code and produces individual outputs to drive the seven-segment display system. It has an active low input lamp test which overrides all other input combinations and verifies overall lamp operation. It also has active high outputs (1.3mA minimum). In addition, it has ripple blanking inputs and outputs to provide leading edge zero suppression. It also has intensity modulation capability.

The 9307 is a CCSL device in a 16-pin hermetic DIP. It operates from a single 5-volt power supply. It comes in both military and industrial temperature ranges (−55°C to +125°C and 0°C to +70°C). The 9307 is available in volume quantities. Your Fairchild distributor has it in stock now.

Write for complete specs and applications information. Ask about our other new products, too.



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CIRCLE READER SERVICE NUMBER 116

INFORMATION RETRIEVAL NUMBER 191 FOR MODEL 4029

INFORMATION RETRIEVAL NUMBER 192 FOR MODEL 4012

Announcing AE's Class H relay. It's compact, versatile, low in cost.

The Class H relay is small in size—just about a 1.3 inch cube. It's a versatile "telephone-type" component that offers better than average quality at a low price.

You can use the Class H to reduce the physical dimensions and decrease the cost of your products. It's well suited for business machines, vending machines, communication equipment, computer peripheral equipment, aircraft and missile simulators. These applications take advantage of its small size, versatility of mounting, and large switching capacity (maximum of 6 form C or 4 C and 2 D contacts).

The Class H can be direct-mounted or socket-mounted to a PC card. Or it can be socketed into a panel. It also has a socket that mounts on a rack.

The Class H is made as a regular quick-acting relay (Series HQA). It's also available as a short or long pulse "latching relay." In this version (Series HRM) it uses remanent magnetism—or controlled residual magnetism of the coil core—as its latching medium.

This little relay's rugged construction protects it from ordinary shock and vibration. Mechanical life expectancy exceeds 100 million operations. Molded pileup insulators provide high dielectric strength and dimensional stability. Contact actuation is by a lift-off card method—which eliminates the problem of contact sticking.

A clear heavy-duty plastic cover provides protection from contamination and abuse. Once this cover is snapped into place, it's not readily removed. This discourages tampering.

Want helpful, detailed specification and application data? Send for Circular No. 1100. Just write to the Director, Relay Control Equipment Sales, Automatic Electric, Northlake, Illinois 60164.

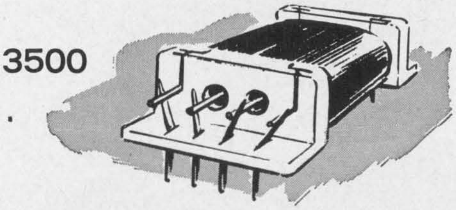
AUTOMATIC ELECTRIC

SUBSIDIARY OF GENERAL TELEPHONE & ELECTRONICS

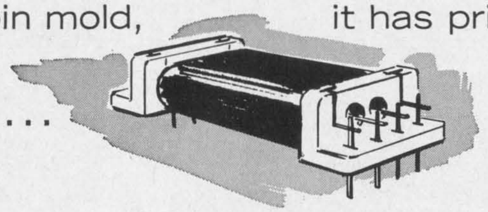
INFORMATION RETRIEVAL NUMBER 6

NEW Hi-G REED RELAY FEATURES SIMPLIFY YOUR DESIGN PROBLEMS

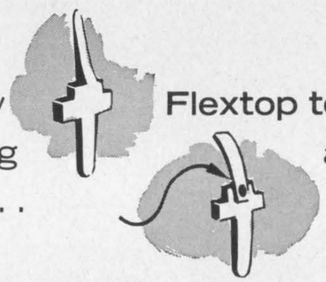
The Series 3500 has printed circuit board mounting terminals . . . on 1 inch x .100 inch centers.



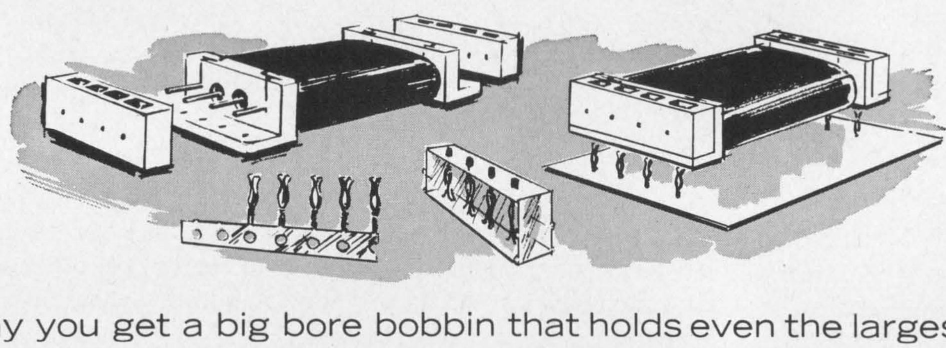
. . . or, when we slide a plate into our bobbin mold, it has printed circuit board mounting pins on 1 inch x .150 inch centers and is called **Series 3600** . . .



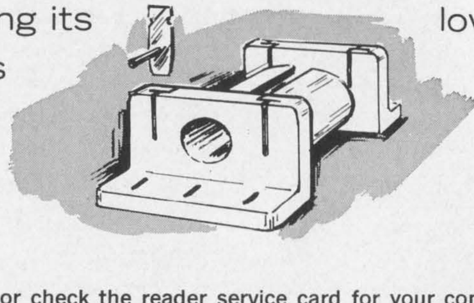
Both versions use our new **Flextop terminal** to give stress-free reed assembly without requiring an intermediate nickel "ribbon" strip and its extra welds . . .



But, when you need a relay that plugs in and out without fuss, or just want an independent source for Berg Pin mounted relays, we add adapter blocks . . . and fill all your needs from stock!



Either way you get a big bore bobbin that holds even the largest "miniature" reeds without sacrificing its low profile, and unique fully recessed coil terminals that eliminate exposed magnet wire and intermediate coil leads.



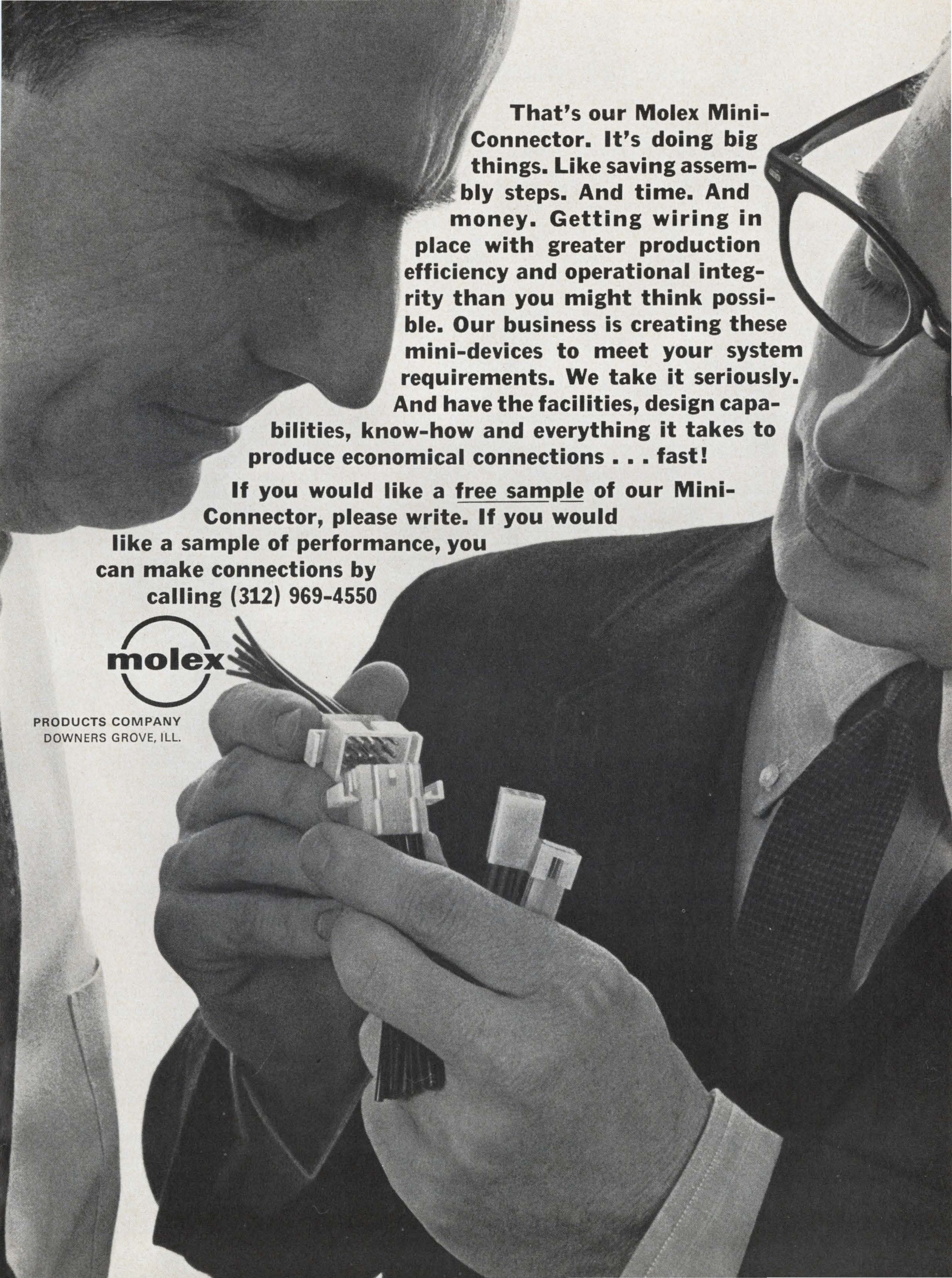
Call, write or check the reader service card for your copy of Hi-G product bulletin #160. If you need application engineering assistance, an experienced Hi-G representative awaits your call. Telephone: 203-623-2481.

Hi G INCORPORATED

SPRING STREET & ROUTE 75 / WINDSOR LOCKS, CONNECTICUT 06096

INFORMATION RETRIEVAL NUMBER 7

INFORMATION RETRIEVAL NUMBER 8 ►


That's our Molex Mini-Connector. It's doing big things. Like saving assembly steps. And time. And money. Getting wiring in place with greater production efficiency and operational integrity than you might think possible. Our business is creating these mini-devices to meet your system requirements. We take it seriously. And have the facilities, design capabilities, know-how and everything it takes to produce economical connections . . . fast!
If you would like a free sample of our Mini-Connector, please write. If you would like a sample of performance, you can make connections by calling (312) 969-4550
molex
PRODUCTS COMPANY
DOWNERS GROVE, ILL.

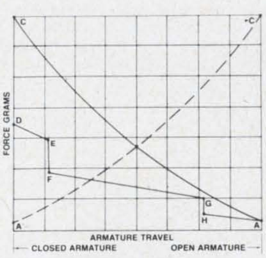
How to keep relay contact forces balanced at 30 G's.

Picking a relay for an extreme shock/vibration environment is a tough problem for many a circuit designer. Few relays are designed to meet the problem head on.
There is now one notable exception —a 4PDT, 10 ampere relay in a one-inch cube.
Using a new design principle—balanced-force—this relay withstands severe shock, vibration or acceleration while maintaining high contact and overload capabilities. It will take more than 30 G's to 3000 Hz vibration, a shock of 100 G's and has a minimum life of 100,000 cycles. This one-inch cube is all welded, weighs 2.5 ounces, and is rated at 2.9 watts coil power.

EFFICIENT MAGNETIC CIRCUIT

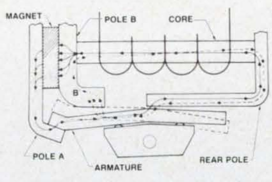
In the conventional relay motor, forces for open and closed contacts are unequal. Energized coil power causes the armature to close the normally open contacts. But, when the coil power is removed and the contacts return to the normally closed position, only the spring forces of the contacts and the return spring provide the force. These combined spring forces are usually low, allowing the contacts to bounce. In addition, the low spring force allows the armature to rebound off the armature stop, again knocking the contacts open—sometimes, for as long as several milliseconds after they have initially closed.

Force-Stroke Curve of Typical Relay and Balanced-Force Relay.



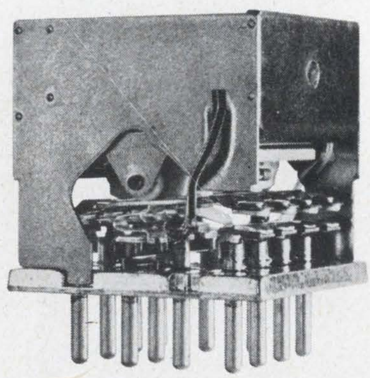
Curve CA—Balanced-Force Relay normally closed contacts.
Curve A C —Balanced-Force Relay normally open contacts.
Curve DEFGH—Typical Relay.

An obvious method of getting rid of a bounce condition is to balance the armature forces exactly. This is achieved in the Leach Balanced Force Relay by use of an extremely efficient magnetic design. It has to be to keep the forces balanced while ignoring 30 G's.
Basically it is a controlled application of magnet and coil flux. In the de-energized position, a permanent magnet flux flows between the armature and the tip of the adjacent pole piece, resulting in a high holding force. The motor is, therefore, relatively immune to shock and vibration. When coil power is applied, the flux from the permanent magnet is nullified by the coil flux flowing in an opposite direction. The armature closes with a rapid build-up of magnetic force driving it against the contact overtravel forces and into a sealed position.



Balanced-Force Motor De-Energized

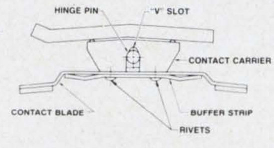
When coil power is removed and the armature returns, the restoring force of the permanent magnet builds up quickly. The armature is then driven against the overtravel forces of the normally closed contacts and into its de-energized sealed position. With this type of force-displacement, the armature isn't about to rebound.



New Leach Model k employs balanced-force concept.

BUFFERED CONTACTS

The moving contacts are mounted to an armature, which is held firmly at the end of each stroke by high magnetic forces. Since the armature can't move during shock or vibration, undesirable contact opening is eliminated.



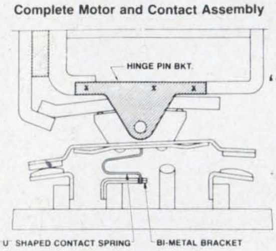
Moving Contact System

Reinforcing the moving contact is a buffer strip which assumes a variety of chores. It has a bow in the center to act as a spring load while serving as a rivet plate. It works as a heat sink. It will break the contact strip free from a weld if one occurs because of excessive overload. It makes contact with the moving blade which results in excellent low contact drop. It serves as an electrical contact between the moving blade system and the header. And, as the name implies, it buffers the contact blade against extreme shocks and vibrations.

WELDED ASSEMBLY

In assembling the relay all detail parts are welded. No part is solder assembled. There is no possibility of contamination from solder flux. The unit is then pressed into a can and electron-beam sealed, leaving only an evacuation hole. After a high temperature bake, the relay is filled with a dried inert gas, and the hole is welded shut. Here, ready for shipment, is a relay with a magnetic circuit designed so the force without coil power applied is equal to the force with coil power applied, but in exactly the opposite direction. And you can rest assured those forces stay balanced no matter how you shake them.

Complete Motor and Contact Assembly



Write for your copy "Tomorrow's Relay Today", a technical paper presented at the National Relay Conference. Leach Corporation, Relay Division, 5915 Avalon Boulevard, Los Angeles, California 90003 (213) 232-8221.

LEACH

INFORMATION RETRIEVAL NUMBER 9

Designer's Datebook

MARCH						
S	M	T	W	T	F	S
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APRIL						
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28	29	30				

For further information on meetings, use Information Retrieval card.

Feb. 28-Mar. 1
Scintillation and Semiconductor Counter Symposium (Washington, D. C.) Sponsor: IEEE, NBS, Atomic Energy Commission; W. A. Higinbotham, Brookhaven National Laboratories, Upton, N.Y. 11973.

CIRCLE NO. 391

Mar. 18-21
IEEE International Convention and Exhibition (New York) Sponsor: IEEE; J. M. Kinn, IEEE, 345 E. 47 St., New York, N.Y. 10017.

CIRCLE NO. 392

Apr. 3-5
International Conference on Magnetics (INTERMAG) (Washington, D.C.) Sponsor: IEEE; Philip Cohen, Magnetics, Inc., Butler, Pa. 16001, or J. M. Lommel, General Electric R&D Center, Schenectady, N.Y. 12301.

CIRCLE NO. 393

Apr. 9-11
National Telemetering Conference (Houston) Sponsor: IEEE; Lewis Winner, 152 W. 42 St., New York, N.Y. 10036.

CIRCLE NO. 394

Apr. 16-18
National Symposium on Law Enforcement Science and Technology (Chicago) Sponsor: U.S. Dept. of Justice; S. A. Yefsky, IITRI, 10 W. 35 St., Chicago, Ill. 60616.

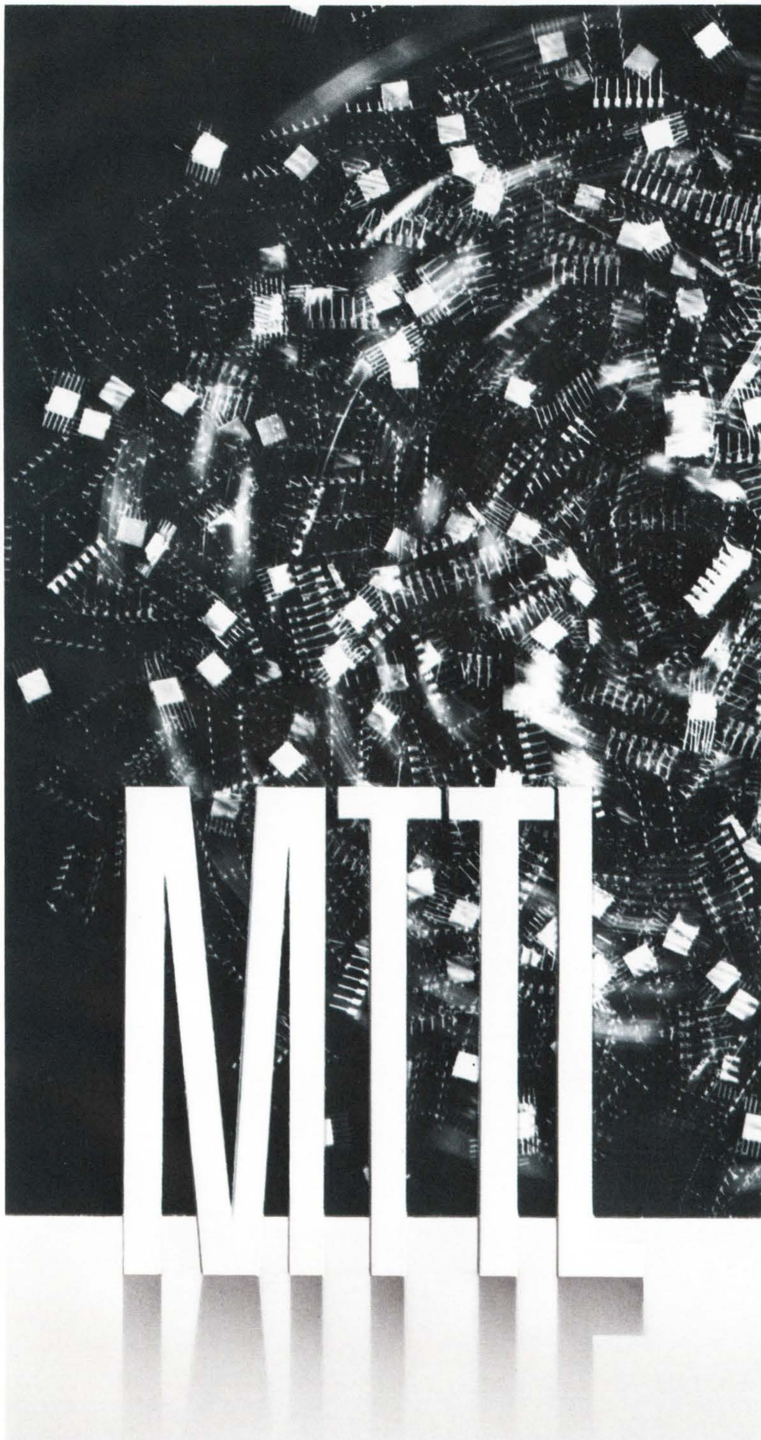
CIRCLE NO. 395

Apr. 22-24
Frequency Control Symposium (Atlantic City, N.J.) Sponsor: Army Electronics Command; M. F. Tim AMSEL-KL-ST, Director Electronic Components Lab., U.S. Army Electronics Command, Fort Monmouth, N.J. 07703.

CIRCLE NO. 396

SEMICONDUCTOR NEWSBRIEFS

PUBLISHED BY MOTOROLA SEMICONDUCTOR PRODUCTS INC.



MTTL I & MTTL II Families Offer Broad Choice Of T²L Functions

Now the system designer can choose from 24 different T²L logic functions with Motorola's MTTL I and MTTL II integrated circuit series (types MC400/500 and MC2000/2100), and can select from both full and limited temperature-range versions, in the 14-lead ceramic flat pack and 14-pin dual in-line plastic package. (Both series are designed to be interchangeable with SUHL I and SUHL II equivalent types and are fully compatible with each other.)

Among the many design advantages for these two series is a selection of speed and fan-out levels, plus excellent noise immunity, high capacitance drive and low power dissipation.

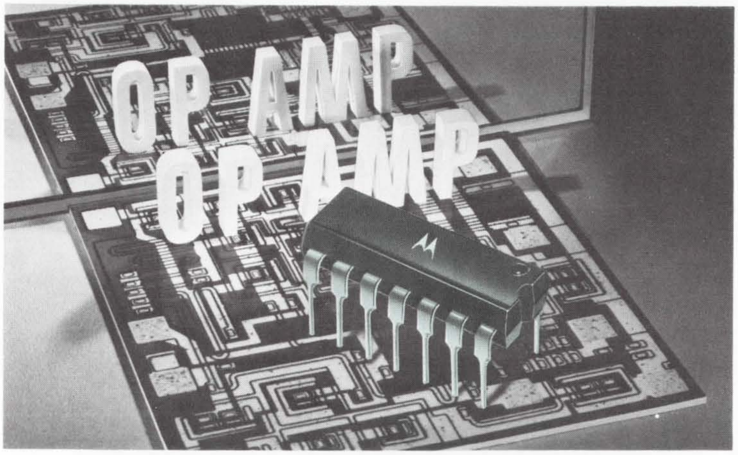
MTTL I offers a moderate speed – up to 20 MHz – for subsystems where speed is not critical. MTTL II will operate up to 30 MHz – in medium-speed applications. Other general specs include:

- Choice of fan-out – up to 15.
- High noise immunity – 1.0 volt (typ).
- High capacitance drive – 600 pF (max).
- Low power dissipation – averages 15 mW per gate (MTTL I) and 22 mW per gate (MTTL II).

Both MTTL I & II are immediately available in production quantities. Even the "hard-to-get" J-K Flip-Flops (SF50 & SF60) are readily available (Motorola type Nos. MC515 and MC516).

For details circle Reader Service No. **211**

Featured In This Issue:



Two closely-matched MC1709C's have been combined, on a single monolithic chip, to yield the dual MC1437P op amp — **and you save almost ⅓ the cost of 2 single units!**

Single-Chip Monolithic 709 Dual Op Amp Provides Matched Parameters!

We've put two of our popular MC-1709C op amps on a **single monolithic chip** and packaged it in the Unibloc plastic case. *We call it the MC1437P.*

The result? A matched set of op amps with characteristics that assure optimum dual amplifier performance (see table).

MATCHING CHARACTERISTICS (Both Amplifiers)	TOLERANCES (typ)
Open Loop Gain (A_{VOL1}/A_{VOL2})	±1.0 dB
Input Bias Current (I_{b1}/I_{b2})	±0.15 μA
Input Offset Current (I_{io1}/I_{io2}) @ Average TC (TC_{Iio1}/TC_{Iio2})	±0.02 μA ±0.2 nA/°C
Input Offset Voltage (V_{io1}/V_{io2}) @ Average TC (TCv_{io1}/TCv_{io2})	±0.2 mV ±0.5 μV/°C
Channel Separation @ 10 kHz ($\frac{e_{out1}}{e_{out2}}$)	−45 dB

Each amplifier has a typical open loop voltage gain of 45,000 with temperature drift of only ±3 μV/°C. It also has the ability to swing almost the entire supply voltage (V_{out} typ. = ±14 V, peak @ 15 V supply), while output impedance is only 30 ohms, typ.

The MC1437P dual op amp is ideal for chopper stabilized applications requiring extremely high, ultra-stable voltage gain. These "twins" function well as summing amplifiers, integrators, or as amplifiers with operating characteristics as a function of external feedback.

While you can't quite get two op amps for the price of one, with the MC1437P it's pretty close — only $8.50 (100-up) -vs- $6.00 for a single MC1709CP.

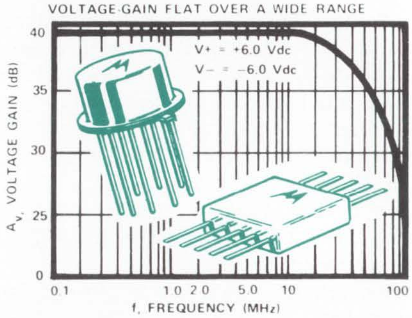
For details circle Reader Service No. **212**

Wideband I/C Diff-Amp Delivers Flat Response From DC to 40 MHz

The MC1510 differential amplifier offers flat response down to dc and does not require ac coupling of the input and output. This reduces "extra" component needs — simplifies design.

In addition to its low-frequency response, the MC1510 also offers a typical bandwidth to 40 MHz (it can be used with gain to above 100 MHz) and, gain is specified typically at A_V = 93.

Its high common-mode rejection ratio of −85 dB (typ), along with a dc power dissipation of 220 mW (max) make the MC1510 highly useful in critical differential-amplifier designs.

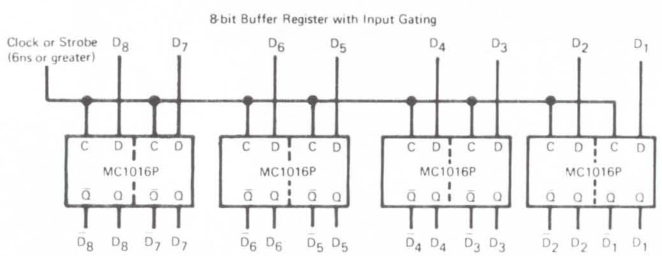


Other typical characteristics include an output voltage swing of 4.5 V (peak-to-peak) at ±6.0 V supply; and low output distortion, where THD = 1.5%.

Available in the 8-pin, TO-99 metal "can" and the 8-pin ceramic flat-pack, the MC1510G and MC1510F are priced at $8.00 and $9.30, respectively (in 100-up quantities).

For details circle Reader Service No. **214**

8-Bit Buffer Register Uses Only 4 MECL II Dual R-S Flip-Flops!



Truth Table

D	C	Q^{n+1}	$\bar{Q}^{n+1}$
Ø	0	Q^n	$\bar{Q}^n$
0	1	0	1
1	1	1	0

Ø = either state may be present

t_{pd}–D_{in} to Q,$\bar{Q}$ ≈ 4ns
t_{pd}–C_{in} to Q,$\bar{Q}$ ≈ 6ns

Here's an easier, less-complex and less-expensive way to construct an 8-Bit Buffer Register *using just four dual-function MC1016P MECL II integrated circuits!* These new dual R-S flip-flops reduce can-count (and system cost) by doubling the number of functions per package.

The versatile MC1016P, monolithic emitter-coupled flip-flop can be used as a temporary storage element (as shown); as a memory data register; or, as a clocked R-S flip-flop with no undefined logic state.

It employs two single-rail input Set-Reset flip-flops with a positive clock input provided for each of the flip-flops. It has a typical propagation delay of 5.0 ns and operates over a 0 to +75°C temperature range. Typical power dissipation for the MC1016P is 125 mW. Operating frequency is 80 MHz. A minimum dc fan-out of 25 for each output is guaranteed.

A wide-temperature-range version is also available in the 14-lead ceramic flat pack, for −55 to +125°C operating requirements (MC1216F).

The MC1016P is available from distributor stock and is priced at only $2.60 (1000-up), in the 14-pin dual in-line plastic package while the MC1216F is $5.75 (100-up).

For details circle Reader Service No. **213**

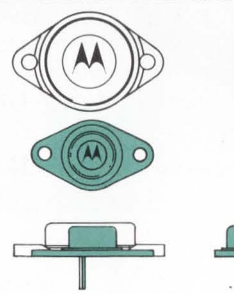
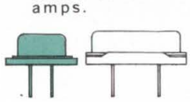
New TO-66 Packaged Silicon Power Transistors Match Current Ratings Of Many TO-3's

If you've been looking for a smaller silicon power transistor that would still provide the current handling capability of a TO-3 packaged device, the new NPN 2N4231-3 5-amp series, encased in the rugged, compact TO-66, will more than "fill the bill."

These little powerhouse metal-can transistors can serve in a broad spectrum of industrial and military servo-amplifier, driver and switching designs to 4.0 MHz, where space is at a premium . . . and economy is a must!

The units have a minimum guaranteed gain of 25 at $I_C = 1.5$ A – with usable gain up to $I_C = 3.0$ A, which lets them handle much greater current loads while still maintaining a more realistic gain level than similar power transistors. And, as to their safe area capability . . . they can handle up to 29 watts at 1.0 Adc – enough for the most stringent medium-current design requirements!

Peak circuit efficiency is ensured by the exceptionally low power losses of the 2N4231-3 series. For example, the maximum saturation voltage of this series is only 0.7 V at $I_C = 1.5$ A (only about one-half that of comparable types at $I_C = 500$ mA). And, if you're comparing

Although only about 60% the volume of the TO-3, the TO-66 packaged 2N4231-3 silicon power transistors can dissipate up to 35-watts and handle current loads to 5.0-amps.

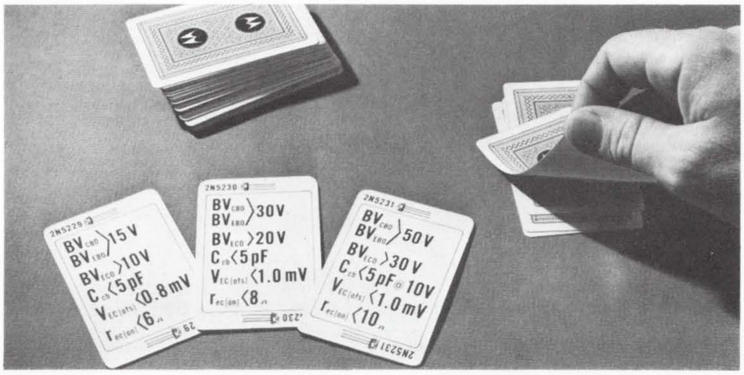
frequency capabilities, note the high 4.0 MHz minimum f_T of the 2N4231-33 series vs. only 800 kHz for other types in the same category.

Here are just a few highlights among many that make the NPN 2N4231-33 silicon power transistor series worth more investigation:

- High $I_{C(cont)}$ – 5.0 A
- Low $V_{CE(sat)}$ – 0.7 V (max) @ 1.5 A
- High h_{FE} – 25-100 @ 1.5 A/2.0 V – 10 (min) @ 3.0 A/2.0 V
- Low Prices (100-up):
  2N4231 (BV_{CEO} = 40 V min) \$1.40
  2N4232 (BV_{CEO} = 60 V min) 1.60
  2N4233 (BV_{CEO} = 80 V min) 2.15
- High P_D – 35 W @ $T_C = 25$°C

. . . and they're all available off-the-shelf from your local Motorola distributor.

For details circle Reader Service No. **215**



Motorola's new 2N5229-31 silicon Annular TO-46 packaged transistors give you a good "run" of efficient low-level chopper characteristics – and there's more coming soon!

NEW BIPOLAR CHOPPERS BID FOR TOP ROLE IN LOW-LEVEL DESIGNS

Did you know that there are now bipolar devices that make it possible to design chopper circuits which can effectively operate at current levels as low as 100 μA?

We're talking about Motorola's new 2N5229-31 silicon Annular PNP transistor series having low capacitance values ($C_{cb} < 5.0$ pF, $C_{eb} < 4.0$ pF @ 10 V_{CB}) coupled with saturation resistances of only 5.0 ohms (typ) and offset voltages down to 0.5 mV @ I_B = 100 μA. With this combination, the designer is assured of both fast and efficient chopper rates.

Take advantage of this price and performance value in applications such as servo-loop circuitry, sensing instrumentation and control amplifiers for motor-drive systems.

Here are the factors that make these bipolar transistors worthy candidates for most any low-level chopper requirement:

CHARACTERISTIC	TYPE	Min	Max
BV_{CBO} @ I_E = 10 μA — (V)	2N5229	15	
	2N5230	30	
	2N5231	50	
BV_{ECO} @ I_E = 10 μA — (V)	2N5229	10	
	2N5230	20	
	2N5231	30	
$V_{EC(ofs)}$ @ I_B = 100 μA — (mV)	2N5229		0.5
	2N5230		0.5
	2N5231		0.8
$V_{EC(ofs)}$ @ I_B = 1 mA-(mV)	2N5229		0.8
	2N5230		1.0
	2N5231		1.0
$r_{ec(ON)}$ @ f = 1 kHz, I_B = 1 mA, I_E = 0, I_e = 100 μA-(ohms)	2N5229	1	6
	2N5230	2	8
	2N5231	2	10
Prices (100-up)	2N5229	\$2.50	
	2N5230	3.00	
	2N5231	3.75	

Prototype quantities are immediately available in the space-saving TO-46 package.

For details circle Reader Service No. **216**

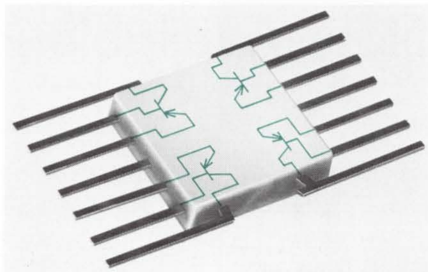
1st EIA Registered Quad Transistor Premieres—2N5146!

A state-of-the-art "quad" device, designed for medium-current, high-speed switching and driver applications where minimum space requirements and low circuit inductance are prime requisites, has been introduced as a "standard" off-the-shelf type.

The Motorola 2N5146 PNP silicon Annular quad transistor is the first ever registered with EIA and is intended for a wide number of applications in both military and industrial designs. Since four chips are mounted in a single, compact, TO-86 ceramic flat pack, this quad device takes up *less space than an individually TO-5 encased transistor.*

Compactness, however, is not its only virtue! The 2N5146 exhibits such superlative performance features as:

- High dc gain at high current levels – h_{FE} = 40 typ. @ 1.0 A.
- Low saturation voltage – $V_{CE(sat)}$ = 0.7 V typ. @ 1.0 A.

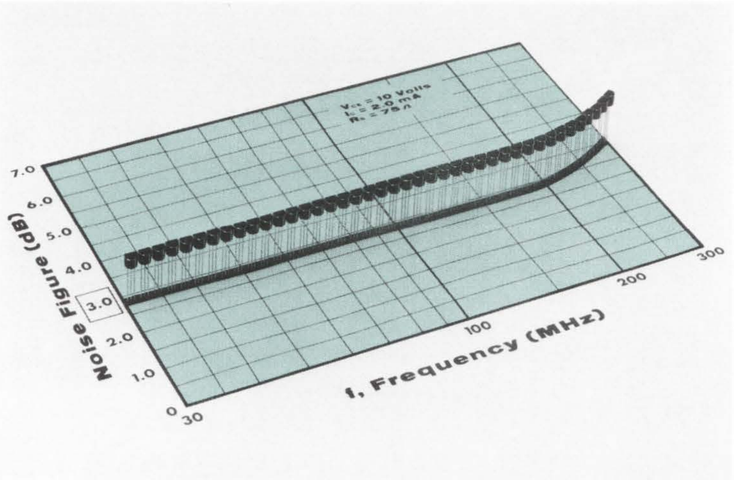


The 2N5146 "Quad," packaged in the 14-pin, TO-86 ceramic flat-pack, makes possible ultra-compact circuitry and reduces wiring requirements, to minimize lead inductance.

- High current-gain-bandwidth product – f_T = 250 MHz typ. @ 50 mA.
- Low capacitance – C_{cb} = 11 pF typ. @ 10 V.
- High power dissipation – P_D = 5.0 W @ T_C = 25°C.

. . . as well as ultra-fast switching speeds (e.g. t_s = 30 ns typ.)!

For details circle Reader Service No. **217**



Although spec'd at 100 MHz, the 2N5208's noise figure remains typically less than 3.5 dB even out to 300 MHz—as indicated by the curve in this photo-diagram.

NOW A PEAK-PERFORMANCE BIPOLAR RF TRANSISTOR FOR LESS THAN $1.00!

You may have doubted that a truly high-performance RF silicon PNP bipolar device, able to fulfill almost any amplifier application up to 300 MHz, would ever be available at a price that made it practical for low-budget designs. And, it has complete "computer-solved" design curves which eliminates tedious calculations!

Even though it is priced at just 90¢, in 1000-up quantities, the 2N5208 gives you top RF performance parameters:

- **High** Gpe >22dB @ 100 MHz
- **Low** N.F. < 3.0 dB @ 100 MHz
- **High** f_T – 300/1200 MHz @ 10 V
- **Low** I_{CBO} < 10 nA @ 10 V
- **High** h_{FE} – 20/120 @ 2 mA
- **Low** C_{cb} < 1.0 pF @ 10 V

. . . and, an $r_b{}'C_c$ < 10 ps @ 10 V/2 mA/ 31.8 MHz.

The 2N5208 operates at breakdown voltages (BV_{CEO}) in excess of 25 volts and is encapsulated in the reliable TO-92 Unibloc plastic package.

All-in-all; its low price, its high power gain, its low noise figure, its high f_T, ad infinitum . . . make it a worthy candidate to fill just about any RF socket to 300 MHz in industrial instrumentation and communications equipment. And, you can get fast delivery in both prototype and high volume quantities.

For details circle Reader Service No. **218**

The VHF/UHF "FET That Fits" Is Now Available in Plastic Package!

Now a wider scope of low-budget applications is possible for VHF/UHF amplifier designs using field-effect transistors. Motorola's new MPF106-07 plastic packaged (TO-92) JFETs, priced as low as 90¢ each (100-up), provide the economy answer for just about 8 out of every 10 high-frequency requirements.

Featuring unusually low-noise figures (even for FETs), these new devices, while ideal for RF "front-end" circuits, will work equally well in any low-noise, high-gain amplifier, from dc to above 500 MHz. Further complementing the state-of-the-art performance of these new, low-cost FETs is their high-power gain of 18 dB @ 100 MHz and 10 dB @ 400 MHz (min).

Here are some other key specifications that make these FETs so universally useful:

Characteristics	Min	Max
Forward Transfer Admittance (μmhos)		
MPF106	2500	6000
MPF107	4000	8000
Input Capacitance (pF)		5.0
Output Capacitance (pF)		2.0
Reverse Transfer Capacitance (pF)		1.0
Small-Signal Power Gain (dB)		
@ f = 100 MHz	18	
@ f = 400 MHz	10	
Noise Figure (dB)		
@ f = 100 MHz		2.0
@ f = 400 MHz		4.0

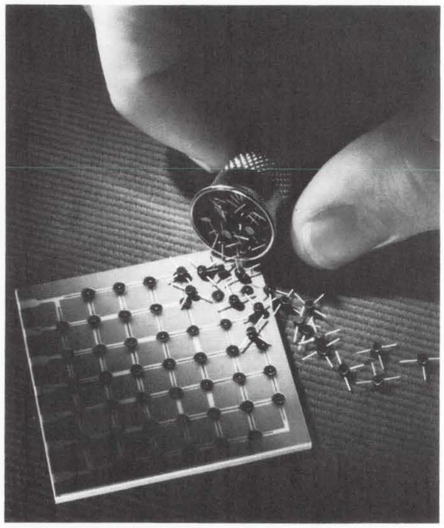
Both the MPF106 and MPF107 are immediately available from distributor stock in the Unibloc TO-92 plastic package. 100-up prices are: MPF106 – 90¢; MPF107 – $1.00.

For details circle Reader Service No. **219**

Ultra-Fast Micro-T MMT2369 Transistor Fits Into Places You'd Never Dream Possible!

If you have an application that requires the miniaturization afforded by integrated circuits, but you can't live with the parasitics – take a good look at the MMT2369 Micro-T NPN silicon Annular transistor.

This new ultra-small transistor opens up a whole new dimension in high-density switching design flexibility. Although only about 1/10 the size of standard TO-18 and TO-92 devices, the MMT2369 retains all the famous high-speed features of its big brothers – the 2N2369 and MPS2369. You can now apply all the performance advantages of these popular switches to miniaturized design concepts, such as thick-film circuitry for computers and instrumentation.



A "thimble-full" of Micro-T Transistors would fill both sides of a 1½" square PC board yet still leave units to spare (we put 100 in the thimble and didn't reach the top)!

The Micro-T Unibloc plastic package also helps you lower your PC board costs. It is ideally suited for drop-in mounting techniques and, significantly reduces circuit board depth – a prime requisite for high-density designs.

Here are some of the MMT2369's high switching performance specs:

- t_{on} < 12 ns; t_{off} < 18 ns
- f_T > 500 MHz
- C_{ob} < 4.0 pF
- I_{CBO} < 100 nA
- h_{FE} – 40/120
- $V_{CE(sat)}$ < 0.25 V

. . . all at I_C = 10 mA

Priced at only 97¢ in 1000-up quantities, it is available in production quantities.

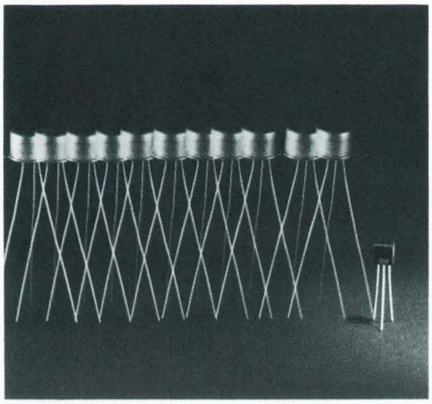
For details circle Reader Service No. **220**

First True Silicon Replacement For The 2N404 Germanium Switch Now Here!

Now, with the introduction of the MPS404/A PNP switching series, you can have all the benefits attributable to silicon devices and still be able to plug them directly into your germanium 2N404 sockets without redesign.

With the MPS404/A, you get **silicon transistors** that operate at temperatures to +135°C and dissipate up to 310 mW at T_A = 25°C. And their high V_{EBOs} (unusual in silicon) of 12 volts for the MPS404 and 25 volts for the MPS404A eliminate the need for external protection against voltage spikes — saving you money on zener diodes as well as giving you greater design freedom. You also get saturation voltages [$V_{CE(sat)}$] as low as 0.15 V max. and a maximum C_{ob} of 20 pF, making them ideal in computer switching and chopper applications where no silicon device has ever been able to perform like the 2N404.

Packaged in the rugged and reliable TO-92 Unibloc plastic case, the units are also inexpensive enough for even the most cost-conscious requirement — only 25¢ for the MPS404 and 35¢ for the MPS404A, in 1,000-up quantities.



MPS404/A Unibloc silicon switching transistors can do everything the germanium 2N404 can do — only better!

Try some! They're available from your local Motorola distributor on an off-the-shelf basis.

For details circle Reader Service No. **221**

New 4-Amp NPN/PNP THERMOPAD Plastic Silicon Power Transistors Solve The Cost Vs. Performance Dilemma!

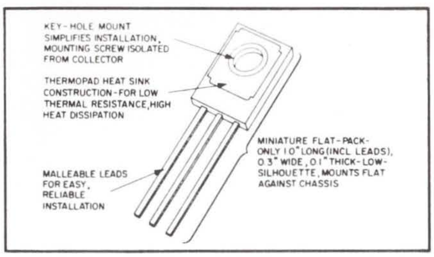
Plastic device performance, cost and reliability have come a long way since first introduced a few years ago . . . and, nowhere is this more dramatically evident than in silicon power transistor advances during the last few months.

The new NPN/PNP 2N5190-95 4-amp Thermopad-packaged transistors, combining high-current, top efficiency and excellent power-handling capabilities (to 30 watts) with economy prices and military-type reliability, are ideal for demanding industrial driver circuits or in switch/amplifier applications where cost/performance is a consideration.

You can use the 2N5190-95 as NPN/PNP pairs to gain all the circuit-simplifying advantages of direct-coupled, complementary symmetry, plus realize a higher degree of frequency stability in both ac and dc driven loads without the addition of expensive, impedance-matching driver transformers.

Exclusive Thermopad construction — with a chip-to-heat sink thermal path of less than 0.030″ — means low thermal resistance and minimum derating in all chassis-mounting applications; and the compact, low-silhouette, malleable-lead package is simple to mount in virtually any place or position.

To date, the Thermopad package has passed 42,000 hours of life-testing under ambient temperature, high humidity and reverse-bias—and 100,000 hours storage life at 150°C, *without a single failure!*



TYPE NPN	TYPE PNP	V_{CEO} (sus)	I_C (max)	P_D @ 25°C	h_{FE} @ I_C = 1.5 A	$V_{CE(sat)}$ @ 1.5 A (max)	f_T (min)	PRICE (100-UP) NPN	PRICE (100-UP) PNP
2N5190	2N5193	40 V	4.0 A	35 W	25/100	0.6 V	4.0 MHz	$1.05	$1.33
2N5191	2N5194	60 V						1.28	1.50
2N5192	2N5195	80 V						1.67	1.95

For details circle Reader Service No. **222**

New BET RF Power Transistors Provide Higher Secondary Breakdown Protection

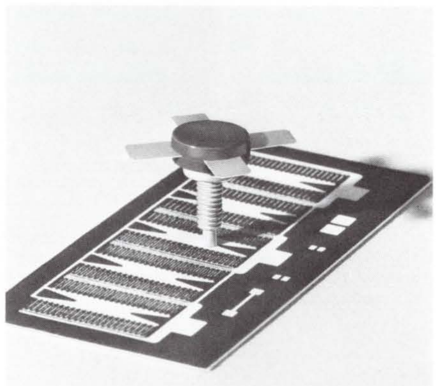
Two new series of 28-volt NPN RF power transistors offer such large safe operating areas that they are almost impossible to damage in high-frequency circuits, even under mismatched loads.

The two series, types MM1549-51 and MM1557-59, are manufactured using a new "balanced emitter" design that permits uniform spreading of current throughout the devices.

They are available in Motorola's new plastic stripline, "opposed-emitter" package which enables simpler circuit design and easier tuning. Also, the low profile of this new package will be helpful where tight mounting space requirements exist.

The MM1557-59 series is designed for large signal, 175 MHz power amplifier output stages, as well as for driver and oscillator applications in FM, SSB and pulse modulation systems up to 200 MHz. The MM1559 is especially suited for use as the output stage in aircraft radio transmitters.

The MM1549-51 series serves the same types of applications in the 200-450 MHz range. Major use of this latter series will be found in government communications equipment.



The Balanced Emitter Technology (BET) protects against the development of "hot spots" by providing nichrome resistors in series with each emitter, to facilitate an even current distribution throughout the entire transistor structure.

TYPE NUMBER	POWER OUT(W)	@ FREQUENCY (MHz)	POWER GAIN (dB)
MM1557	7	175	8.5
MM1558	20	175	8.3
MM1559	40	175	7.5
MM1549	2.5	175	6.2
MM1550	7.5	400	5.7
MM1551	20	400	4.5

All six types are immediately available from distributor stock.

For details circle Reader Service No. **223**

NEW PRODUCT BRIEFS

DUAL-CHIP FORWARD REFERENCE DIODE

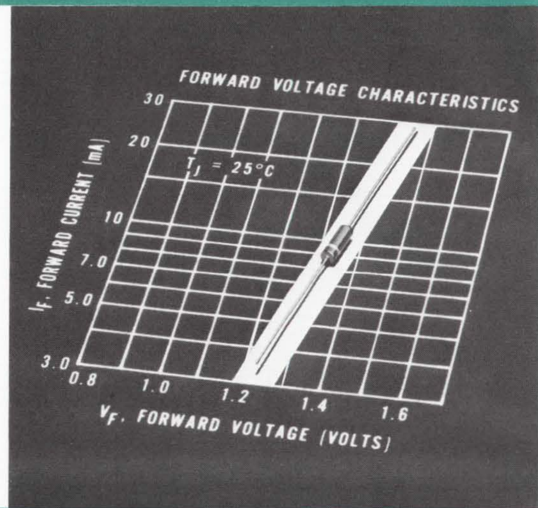
—Provides a Tight-Tolerance, Low-Voltage Reference at an Economy Price!

Two diodes in the convenience of one package! That's the big advantage of this little performer. Nominally spec'd at 1.35 volts @ 10 mA, the MR2361 offers tight ±4% tolerance at 2 points on the forward characteristic to ensure high conductance (low dynamic impedance) in voltage reference and biasing applications; i.e., audio/servo power amplifier complementary symmetry where stable temperature biasing is mandatory.

Its voltage, current, temperature characteristics and low price make it especially suitable for use with silicon plastic transistors. The MR2361 is packaged in a "glass" case (meeting the DO-7 dimensional and hermetic-seal requirements). Triple-chip units are available on request.

Type No.	V_F @ I_F = 10 mA		I_R @ V_R = 5.0 V (max)	Price (1000-up)
	(Min)	(Max)		
MR2361	1.30 V	1.40 V	10 μA	$ .30

For details circle Reader Service No. **224**



LOW-COST, JUNCTION FIELD EFFECT TRANSISTORS

— Offer Exceptionally Low Power-Drain Parameters

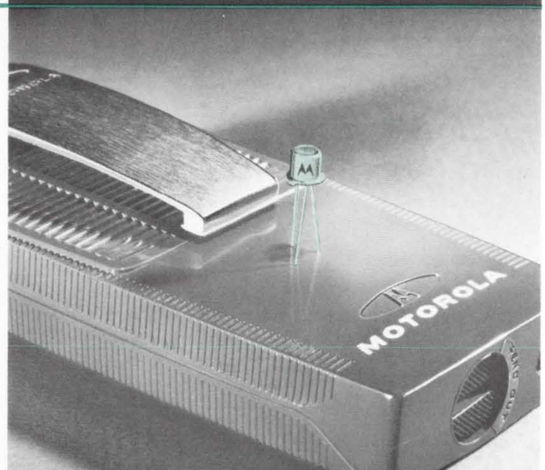
Because Motorola's MFE2093-95 junction FET series offers I_{DSS} specs as low as 0.1 mA, it's a natural for low-current amplifier or switching applications, particularly in compact, battery-operated systems. And, in the TO-72 metal package, they are attractively-priced for most military or industrial users . . . just $1.90 (100-up).

For maximum ease in the use of existing P.C. boards, the series features interchangeable drain and source. In addition, the devices are packaged with the chip isolated and the case is connected to pin 4 for easy grounding. Other features include:

- High dc input resistance (I_{GSS} — 0.1 nA @ 15 V)
- High ac input impedance (C_{iss} — 6 pF @ 15 V)
- Low transfer capacitance (C_{rss} — 2 pF @ 15 V)

Any of the three types are available in production quantities.

For details circle Reader Service No. **225**



CLOSELY-MATCHED PNP DIFFERENTIAL AMPLIFIERS

—Provide h_{FE1}/h_{FE2} Tolerances Within 5% of Each Other!

Another dimension has been added to Motorola's series of 2N3800 PNP dual differential amplifiers with the availability of tightly-matched "A" versions. Not only do these new "A" duals offer all the top-notch specs which have made the rest of their family the first choice of precision diff-amp designers, but their h_{FE1}/h_{FE2} ratio is only 0.95/1.0 (5%), at 25°C, and no more than 0.85/1.0 from −55 to +125°C, both measured at V_{CE} = 5 V, I_C = 100 μA. In addition, they exhibit a V_{BE1}/V_{BE2} differential of less than 1.5 mV at 100 μA.

The 2N3804A/5A are packaged in the TO-72, the 2N3810A/11A in the TO-5 (low-profile) and the 2N3816A/17A in the TO-89 flat-pack — all 6-leaded.

For details circle Reader Service No. **226**

HIGH-VOLTAGE GERMANIUM POWER TRANSISTORS

—Give Peak Performance at Valley Prices!

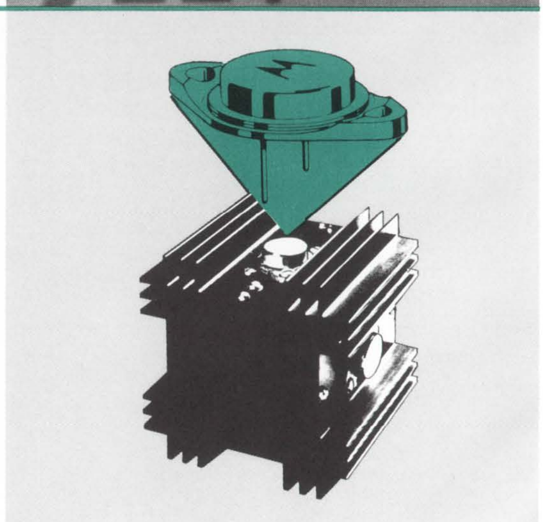
The V_{CES} ratings of 200 V and 320 V, coupled with price-tags in the "just over a dollar" area, combine to make the MP3730/31 germanium power transistors leading candidates for inverter, TV deflection, and power supply designs.

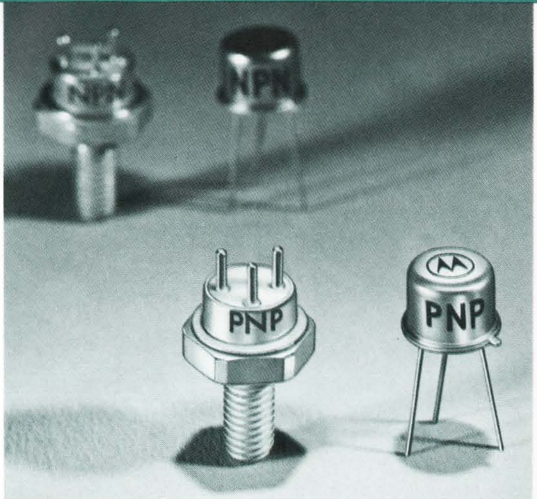
And, top efficiency is assured with excellent thermal dissipation — θ_{JC} = 1.5°C/W — a figure of merit *twice* as good as similar units! Both types handle 56-Watts and operate at temperatures up to +110°C.

Other features include I_{EBO} of 50 mA, V_{BE} = 0.6 V and I_{CES} = 5 mA. The units are packaged in TO-3 cases — and are available in quantity.

TYPE	APPLICATIONS	V_{CES} Volts	I_C Amps	$V_{CE(Sat)}$ Volts	h_{FE} @ I_C	PRICE (100-up)
MP3730	Industrial Power Supplies Inverters TV Vertical Deflection	200	5	0.75 @ I_C = 2.25A	15 @ 2.25 A (min)	$1.05
MP3731	Industrial Power Supplies Inverters TV Horizontal Deflection	320	10	0.5 @ I_C = 6 A	15 @ 6 A (min)	1.40

For details circle Reader Service No. **227**





PNP RF POWER TRANSISTORS

— Provide 1, 7.5 And 30 Watts At VHF/UHF — With Positive "Grounding"

There should be a lot of polarity changes in the near future . . . specifically in the final output stages of both industrial and military communications equipment **The Reason:** A new series of PNP transistors offering a positive "ground" advantage and high power output ratings at 175 and 400 MHz!

Motorola types 2N5161 and 2N5162 are designed for amplifier, frequency multiplier and oscillator applications in mobile communications, air-to-ground tactical communications, and as varactor drivers. The third PNP type, designated 2N5160, is suitable for use as a Class A, B or C output; driver; pre-driver or power oscillator in VHF and UHF applications to 800 MHz.

Device Type	Power Out (W) @	Frequency (MHz)	BV_{CBO} (V)	Min. Power Gain (dB)	Typ f_T (MHz)	Pkg. Type	Price (100-up)
2N5160	1.0	400	60	8.0	800	TO-39	$ 4.50
2N5161	7.5	175	60	8.75	500	TO-60	12.50
2N5162	30.0	175	60	6.0	500	TO-60	18.00

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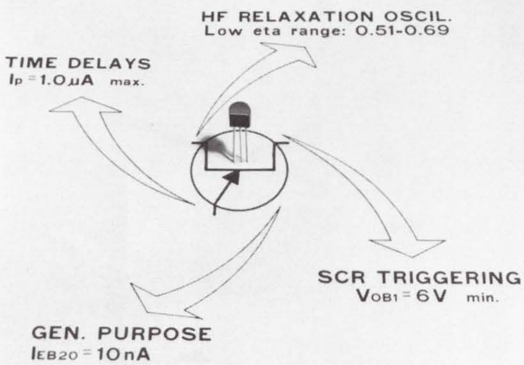

UNIBLOC PLASTIC UNIJUNCTION TRANSISTORS

— Offer A Wide Choice of Specs at Economy Prices

You can now choose the spec that fits your particular application and design criteria (and price requirement) with the new Annular MU4891-94 UJT series . . . from timing-to-triggering-to-general purpose. For example, the MU4893, which exhibits a high V_{OB1} of 6.0 volts min, is ideal for use in SCR triggering circuits while the MU4892 can be zeroed right into high frequency relaxation-oscillator circuits due to its low eta (η) range of 0.51-0.69. And, a low 1.0 μA maximum I_p makes the MU4894 a natural for long time delay applications.

Type	Primary Use	Highlight Parameters	Intrinsic Standoff Ratio (η)	Prices (1,000-up)
MU4891	General Purpose	Low I_{EB2O} = 10 nA (max)	0.55 — 0.82	$ .51
MU4892	HF Relaxation Osc.	Low eta spread = 0.51-0.69	0.51 — 0.69	.70
MU4893	SCR Triggering	High V_{OB1} = 6.0 V (min)	0.55 — 0.82	.54
MU4894	Long Time Delays	Low I_p = 1.0 μA (max)	0.74 — 0.86	.60

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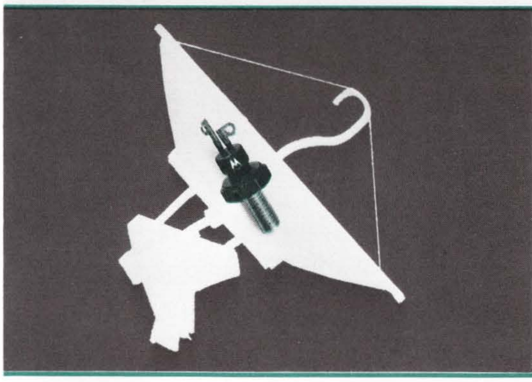

10,000 PULSES-PER-SECOND MODULATOR SCR SERIES

— Provides Voltages from 300 to 600 Volts at 300 Amps (Pulse)

Motorola's rugged 100-amp and 1,000-amp pulse modulator SCR's have now been expanded to include the new MCR1336-5 thru MCR1336-10, 300 amp, 300 to 600-volt units capable of top performance in military/space transponders, beacons, portable aircraft radar and high-pulsing applications.

Typical switching time characteristics include: 75 ns delay and rise (at 100 amps, I_F, capacitive discharge circuit, I_G = 500 mA @ 25°C), and 7 μs t_{off} (PFN discharge, 100 amp and pulse). Its dv/dt is 250 V/μs while di/dt is 1,000 A/μs. The unit has a wide operating temperature range of −65 to +105°C. 100-up prices start at $13.75 for a 300 volt unit (MCR1336-5).

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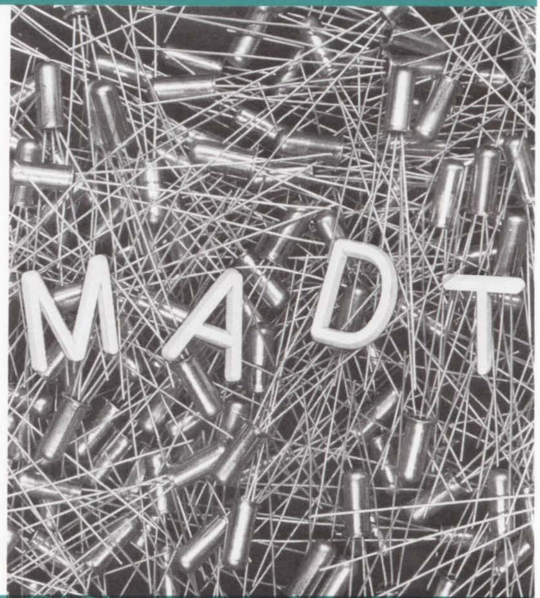

JAN2N499, JAN2N499A, JAN2N501A GERMANIUM TRANSISTORS

– Now Available In Quantity To Fill Mil-Type MADT Sockets

If you say "availability" three times, you've got the big story behind the Motorola JAN2N499, JAN2N499A, and JAN2N501A – newest additions to the growing line of MADT types **immediately** available in production lots for "drop-in" replacement of older, source-limited types. These high-frequency units, fabricated with the Motorola-developed "Selective Metal Etch" process, meet exact parameter-by-parameter specs and achieve nearly identical key MADT characteristic distributions. They can replace MADT types with *no redesign required!*

TYPE	APPLICATION	KEY PARAMETERS			
JAN2N499	VHF Amplifier	h_{fe} @ I_E = 1 mA, V_{CE} = 9 V = 10-250	G_{pe} @ 100 MHz, Y_{cb} = −10 V, I_E = 2 mA = 7.5 dB (min)	C_{ob} @ 10 V = 2.5 pF (max)	BV_{CEO} @ I_C = 1 mA = 18 V (min)
JAN2N499A	VHF Amplifier	h_{fe} @ I_E = 1 mA, V_{CE} = 9 V = 20-80			
JAN2N501A	HF Switch	h_{FE} @ I_c = 10 mA, V_{CE} = .5 V = 30 (min)	f_T = 175 MHz (typ) @ 10 mA/.5 V	$V_{CE(sat)}$ @ I_C = 10 mA, I_B = 1 mA = 0.2 V (max)	

With these three new types, a total of twenty Motorola units are now available for MADT high-frequency amplifier and switching applications.

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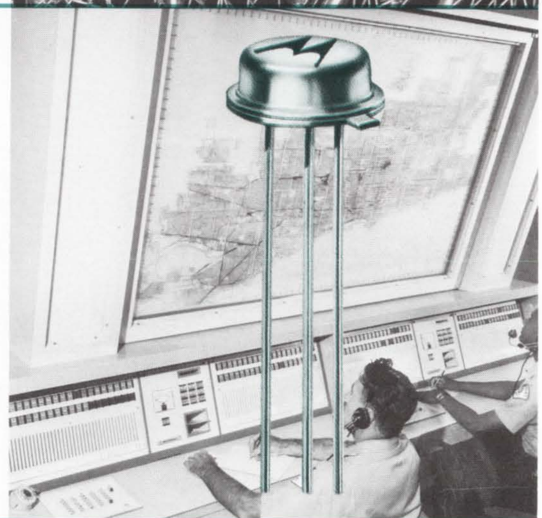

SILICON PNP BILATERAL SWITCHING TRANSISTOR

–For High-Current-Level Chopper Designs.

The bilateral performance capabilities of the Motorola MM4052 transistor frees the designer of sophisticated telephone and communications switching networks from dependence on comparatively slow, cumbersome relays. In addition to all the benefits generally attributable to high-performance transistor switches, this unique device *amplifies high level signals bidirectionally* – e.g., forward h_{FE} = 15 @ 150 mA/1.0 V and inverse h_{FE} >3 @ 150 mA/1.0 V.

Combining a host of peak-efficiency parameters (as indicated by the chart below), the MM4052 is worth looking into whenever you have a requirement for a high-level device that can switch in both directions.

Packaged in the miniature TO-46 case, it is priced at only $3.00 (100-up).

BV_{EBO} (min)	BV_{ECO} (min)	Offset Voltage $V_{EC(ofs)}$ (max)	I_{CBO} (max)	"On" Series Resistance r_s @ 10 mA (max)	Capacitance @ 10 Vdc (max)	
					C_{cb}	C_{eb}
30 V	30 V	1.0 mV	0.5 nA	2.0 ohms	10 pF	5 pF

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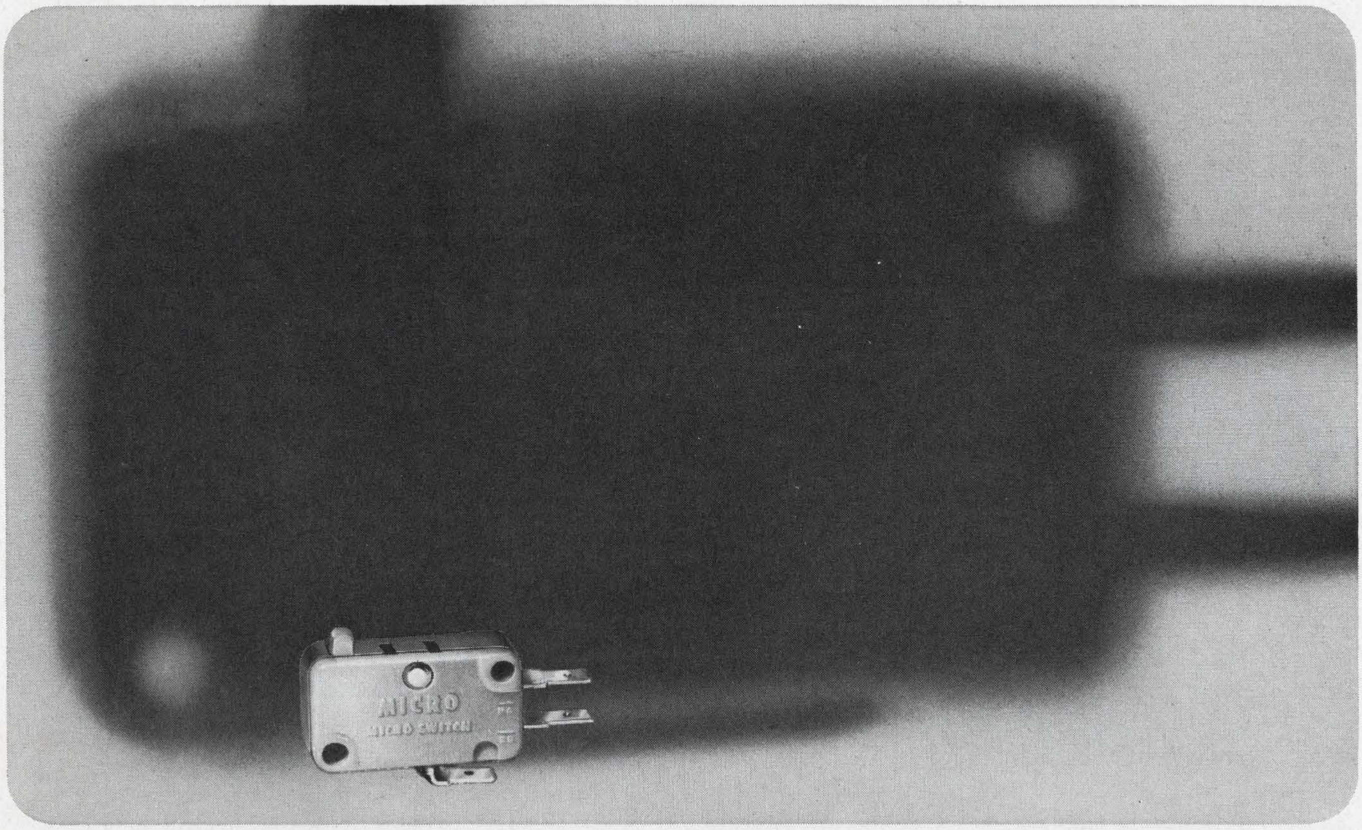
The little switch that works like it's 10 feet tall



Shown above in actual size, it's apparent that the MICRO SWITCH V3 is just a smallfry. But as more engineers than we'd care to count know, there's nothing smallfry about its performance. This miniature switch has contributed to the reliability of nearly every important name in the electrical/electronics industry.

If you're not personally acquainted with what our V3 can do for you, we invite you to put it to the test. Or we'll be happy to supply you with test data compiled in our Test Lab—the industry's largest and best-equipped.

For instance, check it out for repeatability of operating characteristics. Superior design and precision manufacturing result in extremely high repeatability throughout its life.

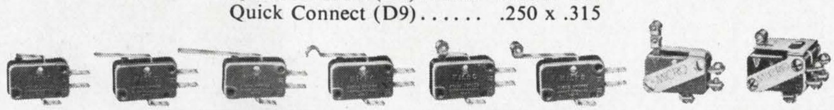
TERMINAL VARIATIONS

Screw	4-40 UNC x .125
Solder	.270 Long
Short Solder	.093 Long
Quick Connect (D8)	.188 x .250
Quick Connect (D9)	.250 x .315

Consider too the exceptional design freedom you get with the V3: over 500 different design combinations including variations in circuitry, electrical capacity, actuators, terminals and resistance to various environments. Furthermore, new designs are constantly being added to the list.

Call a Branch Office or Authorized Distributor (Yellow Pages, "Switches, Electric"). Or write for Catalog 50.

There's practically no limit on the design freedom offered by the V3.



MICRO SWITCH

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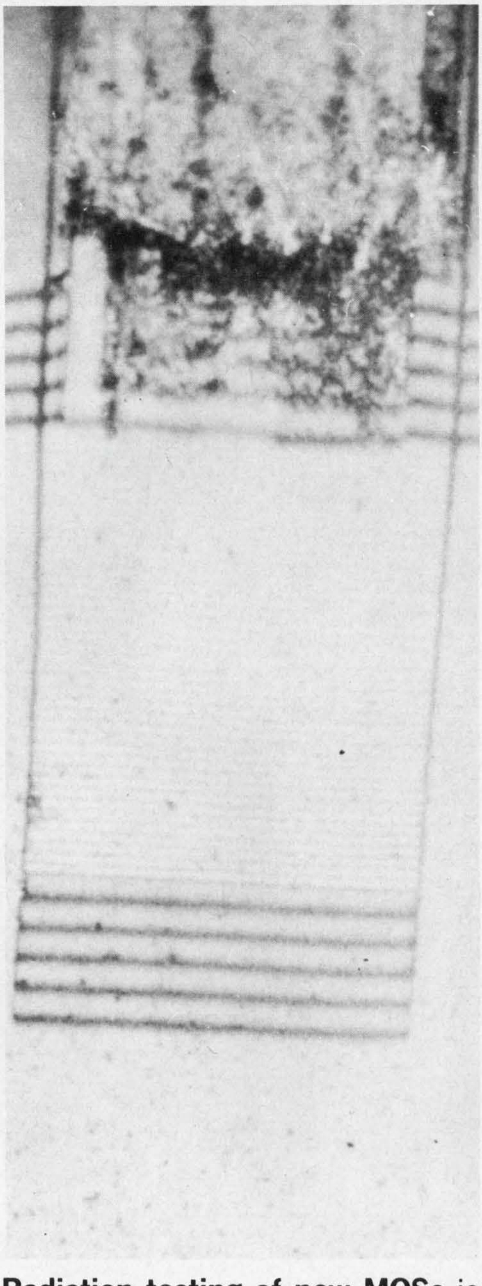
News

Oceanological problems could be solved by electronics. What is wanting is money, and coordinated effort. p. 25



Radiation testing of new MOSs is hindered by nuclear ban. Page 36

Also in this section:

News Scope

It's 'give and take' in new U. S. budget

In general, President Johnson's budget for fiscal 1969 met expectations: total planned expenditures of $186 billion reflected the Administration's attempt to continue a butter-and-guns policy. The defense and space programs, as presented, followed predictions—the military budget was increased by $3 billion, while the space budget dropped from last year's figure by $230 million.

For national defense, expenditures of nearly $80 billion are being sought, of which $76.7 billion is earmarked for the Defense Dept. Roughly one-third of the defense figure is to support the Vietnam War effort and nearly one-third for the procurement of military hardware. One-tenth of the military budget is to be applied to research, development, testing and evaluation. For the electronics industry, major interest will lie with the military procurement of up to $5.5 billion in equipment for electronic subsystems. For communications and electronics hardware alone (items not a part of other major weapons systems), the four military branches are planning expenditures of over $1.5 billion. Other major electronic spending involves continued development of missile and aircraft subsystems, a new airborne warning and control system and a step-up in Sentinel antiballistic missile system outlays.

Post-Apollo manned programs to suffer in NASA budget cuts

NASA is down for $4.57 billion in spending, with cutbacks requested, as expected, in post-Apollo manned activities and some paring in nearly all unmanned programs. On the other hand, increased appropriations are being sought for the Air Force's Manned Orbiting Laboratory program.

(Many political observers in Washington feel that such a change in the direction of the manned space effort, if continued, could permanently shift the responsibility to the Air Force for all advanced manned programs by the mid-1970's.)

A few surprises were tendered by the President, particularly in his request for $223 million for the supersonic transport development program—a rise of about 60 per cent over last year. Also, the Atomic Energy Commission is scheduled for a marked increase in its budget, with emphasis on development of the NERVA nuclear rocket engine and a very large increase for its military applications effort.

Finally, major financing is being requested to begin development by the AEC of the planned 200-billion-electron-volt proton accelerator near Chicago.

2 rocket leaders blast U.S. space budget cuts

Two of the scientists who have directed the comeback of the U.S. space program since the dark days following Sputnik I warn that the program is losing its momentum because of cuts in the budget.

Dr. Wernher von Braun, director of the National Aeronautics and Space Administration's Marshall Space Flight Center, complains that the Government is "dismantling the high competence" of our space team. He says that budget reductions have rendered rocket production rates "too low to sustain the efficiency and interest of organizations in the program."

Dr. von Braun, who made his comments at a luncheon commemorating the anniversary of Explorer I—the nation's first orbiting satellite—was joined in his criticism by Dr. William Pickering, head of the Jet Propulsion Laboratory of the California Institute of Technology. Dr. Pickering voiced concern over waning public interest in space after what he termed "probably the most scientifically productive decade in the history of our culture."

What troubles the two space scientists most is the lack of funds for further space probes after the planned Apollo manned lunar expedition.

Dr. von Braun points out that Jet Propulsion Laboratory has only one project left—a pair of unmanned flights to Mars in 1969—despite its outstanding record.

"If the present trend continues," he says, "we will have one of the most heavily decorated scientific leaders in this country [Dr. Pickering] on the unemployment line."

Manufacturers assail procurement red tape

A fear of rash Government procurement controls in the wake of the Proxmire investigation has been expressed by the Western Electronic Manufacturers Association.

"Each time the General Accounting Office, or a Congressional committee, or the press turns up a 'horror story' of something that has gone wrong," Robert M. Ward, president of the 450-company association, told a Congressional luncheon, "there is a rush to tinker and patch the apparatus by inventing new controls."

Ward was reacting to charges generated by an inquiry led by Sen. William Proxmire (D-Wis.), who has alleged that defense contractors have been making improper use of Government equipment (see "Proxmire investigation may bring new controls," ED 2, Jan. 18, 1968, p. 21).

The most onerous recent action, Ward told a Washington gathering of 60 Representatives and Senators, is a unilateral decision by the Defense Dept. "to initiate a policy of post-award audits of firm, fixed-price contracts."

As a result of this and similar policies, Ward said, "many of our companies have withdrawn from the defense market and confined their government sales to the 'civilian' departments and agencies who look to the electronic industry for instruments and systems to cope with problems in pollution, transportation, medicine and education; yet they find practices and requirements appropriate to wartime defense procurement following them."

Ward strongly endorsed legislation introduced by Rep. Chet Holifield (D-Calif.) and Sen. Henry Jackson (D-Wash.), who seek to establish a "Little Hoover" commission to study the entire Federal procurement process.

In a related development, Hewlett-Packard Co. announced that it would shortly ask the Supreme Court to review an opinion upholding the right of the Controller General to examine H-P cost records in Government contracts. The company and the Government have been arguing the matter for more than five years. At issue is the extent to which Congress intended to authorize the Controller General to audit and make public financial records of companies that supply standard commercial products under negotiated fixed-price contracts.

Honeywell expanding in 2 computer markets

Whether Honeywell, Inc., is second or third in the computer derby is open to dispute, but of late—like that well-known car rental agency—it appears to try harder.

On the heels of last month's announcement that it plans to start manufacturing disk packs, Honeywell's Electronic Data Processing division proclaimed its entry into the small-scaled computer and keytape data input markets.

The company's new Model H-110 central processor is the ninth and smallest in Honeywell's Series 200 line of compatible third-generation computers. It is aimed at first-time computer customers and at users of competitive small computer systems, such as the NCR 615, IBM 360/20 and 1130, and Univac 9300. The processor has a memory capacity of 4,069 to 16,384 characters, access time of 2 μsec and a 4-μsec cycle time. The basic programing language is COBOL B. It will rent for about $2500 a month or sell for about $125,000, Honeywell says.

The new Honeywell line of keytape units is aimed at the huge off-line data preparation market (about $500 million annually) now dominated by one company with one machine: IBM's keypunch. Keytape systems are said to increase data transcription production by an average of 25 to 35 per cent, since data is recorded through a typewriter-like keyboard directly onto magnetic tape for computer use. Mohawk Data Sciences Corp., Herkimer, N.Y., is the only other manufacturer of keytape units.

Vidicon tubes sought to monitor space

An Air Force telescope in the mountains of Cloudcroft, N.M., built to spot and catalogue objects in space but shut down in 1965 because of the lack of sensitivity of photomultiplier tubes, will be reopened if work under two new contracts proves successful.

The telescope—officially the AN/FSR-2 optical surveillance system—was part of the Air Force's worldwide Spacetrack network. Built in 1962 by the Radio Corp. of America's Aerospace Systems Div., Burlington, Mass., it was intended to see objects beyond radar range, as far out as the moon.

The two new contracts, going to RCA's Aerospace Div., are to improve the system's performance. One contract calls for reactivating the instrument, using state-of-the-art tubes. "An image orthicon will probably be used," said an Air Force official at the Spacetrack facility at Hanscom Field, Mass.

The second contract calls for a thorough look at other kinds of tubes to develop more sensitivity in the system. The tube used in the original FSR-2 was an image orthicon developed for televising night baseball games.

"We now have to tailor a tube with a wide dynamic range to fit our particular needs," the Air Force official said. "The vidicon class appears to have the most promise, but we will also look at new image orthicons, secondary electron conduction tubes and tubes beefed up by intensifiers."

2 hearing-aid inventors sue to control company

A court battle is under way for control of the Intelectron Corp., a small New York City electronics company that has developed a hearing aid that bypasses the ears. The device feeds amplitude-modulated rf signals directly to the head of a person and he "hears" through cranial nerves (see "Army tests hearing aids that bypass the ears," ED 26, Dec. 20, 1967, pp. 30-32).

Dr. Henry K. Puharich and Dr. Joseph L. Lawrence, co-inventors of the device, are suing to wrest control of Intelectron from their backer, Borders Electronics Co., Pennsauken, N.J. They charge that Borders has been too slow in its technical support.

Borders, on its part, has dismissed the two men from their positions as president and vice president of Intelectron.

National engineers' week

"Engineering . . . Design for World Health" is the theme of this year's National Engineers' Week, Feb. 18-24. NSPE has made available a series of one-minute films designed for local television use. These and other promotional materials are available from NSPE, 2029 K St. N.W., Washington, D.C. 20006.

Aye, Aye, Sir!

LSI Arrays Win Top Billing In Naval Air Systems Plans

By JACK ROBERTSON

WASHINGTON. — The Naval Air Systems Command is asking all Navy aircraft builders to include LSI arrays in future projects if possible.

It marks the first commitment by a major service to large-scale integration. Some in industry liken it to the Defense Department directive 5 years ago ordering IC use wherever possible.

The Navy Avionics Depart- ... for ... avionics official said. The LSI ... enda- ... is ... ke ... s

steps with IC-cordwood modules may be necessary.

The Navy looks particularly for LSI-multiplexers to allow a radically new approach to interior avionics. Instead of a fantastic maze of wiring throughout the plane, the Navy hopes to use a single coax line, connecting all avionic subsystems by multiplexing onto the single carrier.

"The advantages are obvious, weight and size are reduced, costs are cut, and reliability higher since a mass of interconnection is avoided.

"Changing ...

space, give greater reliability and more flexibility.

The Navy also hopes to take advantage of LSI arrays to do sophisticated jobs not possible today. For instance, self-check controls and fault-finding circuits could be added right at the multiplexer.

LSI Package a Goal.

At first, the multi... well ... to

ELECTRONIC NEWS, MONDAY, DECEMBER 25, 1967

General Instrument's Exclusive MTOS Makes These LSI Multiplexers Available Today!

MEM 5015–Random Access Multiplexer

- 16 Channels of Current or Voltage Mode Multiplexing
- Address Holding Flip-Flops
- "4 in, 16 out" Decoding Matrix
- 16 Single-Throw, Double-Throw Switches
- Extremely High Off-to-On Resistance Ratio
- Low Cross Talk
- Zero Offset
- High Logic Noise Immunity

MEM 5116–16 Channel Random/Sequential Access Multiplexer

- Random/Sequential Modes of Addressing
- 16 Channels of Voltage Mode Multiplexing
- "4 in, 16 out" Decoding Matrix
- 16 Single-Throw Switches
- Extremely High Off-to-On Resistance Ratio
- Low Cross Talk
- Zero Offset
- High Logic Noise Immunity

LSI MULTIPLEXERS		POWER CON-SUMPTION	SUPPLY VOLTAGE (VOLTS)	CLOCK RATE	DESCRIPTION
TYPE	FUNCTION				
MEM 5015	16 CHANNEL RANDOM ACCESS MULTIPLEXER	80 mW	−27V±1V	100 kHz	Sixteen Channel Multiplexer with address storage and decoding.
MEM 5116	16 CHANNEL RANDOM/ SEQUENTIAL ACCESS MULTIPLEXER	100 mW	−27V±1V	500 kHz	Sixteen Channel Multiplexer with parallel access counter and decoding.

Call your authorized General Instrument Distributor for off-the-shelf delivery.
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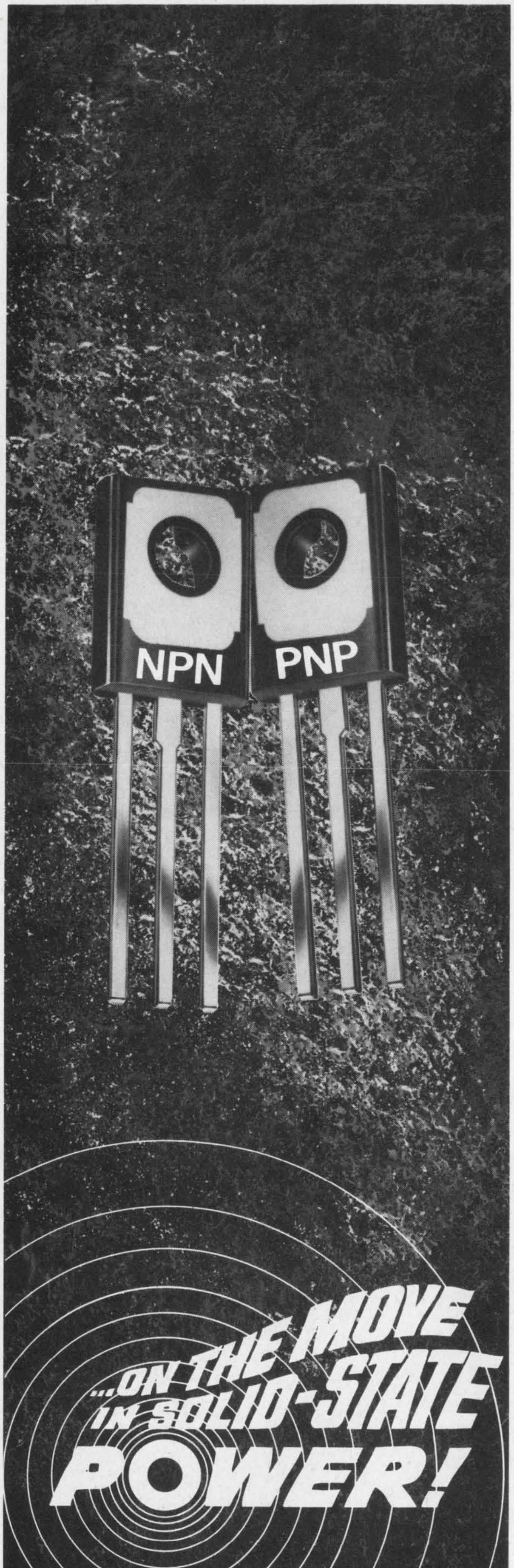
INFORMATION RETRIEVAL NUMBER 15

Complement Your Rugged Designs With 30-Watts of Thermopad Plastic Silicon Power!*



The 2N4918-23 series of NPN/PNP silicon power transistors is designed to put extra performance in — and take the cost out of — industrial switch/amplifier and driver applications that demand premium, military-type capability and reliability.

Besides offering the traditional circuit-simplifying design advantages of eliminating expensive, impedance-matching driver transformers and resistors and offering a high degree of frequency stability, these 3-ampere devices actually handle 30-watts of power . . . 5-watts more than their TO-66 counterparts — yet they cost about 15% less!

Extensive testing has proven Motorola Thermopad units — with the exclusive, ultra-short (less than 0.030″) and efficient chip-to-heat sink thermal path — exhibit optimum reliability in *all* phases of testing from operating life, temperature cycling, humidity and thermal shock. For example, they have passed 42,000 hours of life-testing under ambient temperature, high humidity, reverse bias conditions and 100,000 hours of 150°C storage testing, with no failures.

These unique capabilities plus their low saturation voltages (0.6 V @ 1 A), high beta (20 min @ 500 mA, 1 V) and good frequency response make them ideal for your price-vs.-performance applications . . . particularly where metal-can units prove too costly.

The complementary approach . . . in audio and servo amplifiers plus mounting procedures and thermal aspects of Thermopad devices is discussed thoroughly in 3 application notes we will send you when you circle the reader inquiry number. Or, write Box 955, Phoenix. Do it today and receive them by return mail.

Type								
NPN	PNP	$I_{C(MAX)}$ Amps	V_{CEO} Volts (sus)	h_{FE} @ $I_C = 500$ mA	P_D @ $T_C = 25°C$ Watts	$V_{CE(SAT)}$ @ $I_C =$ 1A (max) Volts	f_t (min) MHz	NPN/PNP Comb. Price (100-up)
2N4921	2N4918	3	40	20/100	30	0.6	3	$2.00
2N4922	2N4919		60					2.26
2N4923	2N4920		80					2.70

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INFORMATION RETRIEVAL NUMBER 16

Aquanauts' goal: 'Cordless' living under sea

Self-contained speech, life-support and navigation gear would permit divers to shed bulky lifelines

Neil Sclater
East Coast Editor

How can electronics best aid manned ventures hundreds of feet down on the sea floor?

"Communications, life support, and navigation. These are the areas where electronics can contribute," according to Cdr. M. Scott Carpenter, the astronaut turned aquanaut who is now preparing for Sealab III, the Navy's most ambitious man-in-the-sea experiment to date.

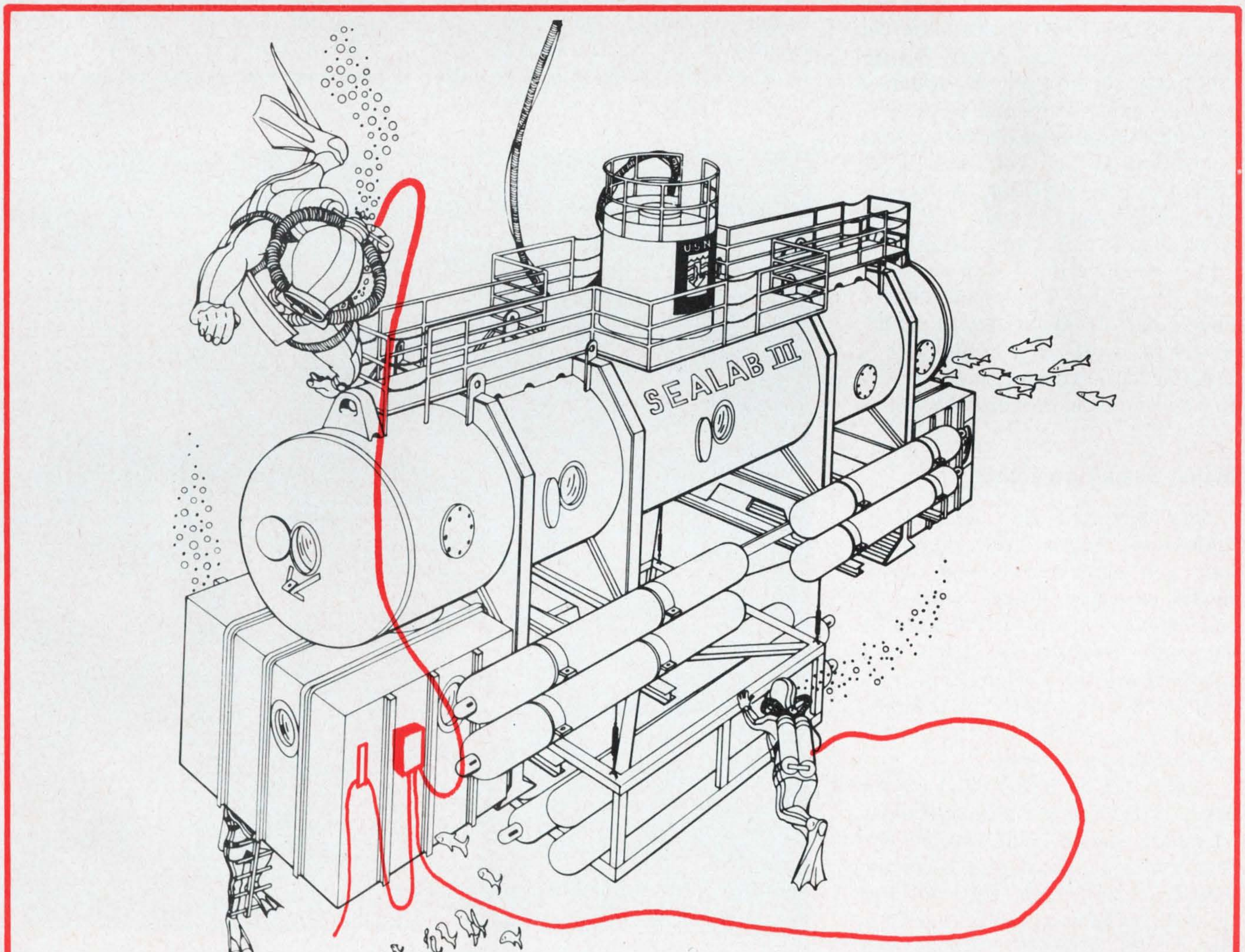
"The aquanauts of Sealab III will use tethers" but would like to get rid of them, continued the slim, ruddy-complexioned naval officer, seated behind his desk at the Navy's Deep Submergence Project Office in Chevy Chase, Md., just outside Washington, D.C.

He went on to explain how during the experiment aquanauts would be connected to life-support cables which double as safety lines. The bulky lines are essential to the aquanauts because of the depth, and the length of time they intend to remain submerged.

"Deep-sea divers will remain tethered until we get the equipment that will permit them to maneuver safely, free of connections, hundreds of feet down," said the commander, who, besides being the second American to orbit the earth has set a record for time spent on the sea floor (30 days at 205 feet off California as a team leader of Sealab II in 1965).

The big problem: Money

The electronics potential exists to solve all of the basic engineering problems that would permit



The Navy Sealab III base will be placed on the sea floor 600 feet down. Aquanauts will be tethered with a cable that supplies heat, light, breathing gas and a phone service. Telemetry will monitor breathing apparatus.

(Aquanaut electronics, ***continued*****)**

human habitation of the sea, most specialists agree. What is needed is money and a coordinated effort. The gains made to date have been the result of piecemeal financing and part-time attention by both the Government and industry.

"We have not moved as fast in undersea technology as we have in space because we have not applied anywhere near the same talent and money to the subject," Carpenter said. "We need the same kind of systems approach that is used on the space program."

The Navy and other organizations with an interest in manned exploration, salvage and research at depths to 1000 feet are already looking at a systems approach.

'Shoestring' gains, so far

The "state-of-the-art" is, as one ocean engineer told ELECTRONIC DESIGN, a "shoestring" affair. Several corporations engaged in undersea salvage, exploration and work projects have already performed diving operations at 600 feet. Both Westinghouse Electric Corp., Annapolis, Md., and Ocean Systems, Inc., New York City, N.Y., an affiliate of Union Carbide Corp. and the General Precision Equipment Corp., have complete apparatus to permit divers to work at 600 feet for a week or more without time-consuming decompression more than once.

Major Sealab objectives

The Navy's Sealab III project, which will begin work this summer, will conduct advanced experiments at these depths with new equipment, similar to that used by the commercial divers. It will be a follow-on of the Sealab II project, conducted at a depth of 205 feet for 45 days off the coast of Southern California in 1965.

Sealab III, to be situated off the coast of Southern California's San Clemente Island, will involve five teams of aquanaut divers, each consisting of eight men. They will live in and around an ocean bottom base for 15-day periods. In the first phase the base will be in about 450 feet of water, and the aquanauts will work at that depth and spend time at 600 feet. In the second phase the base will be moved down to 600 feet.

Sealab III is one of the Man-in-the Sea tasks of the Navy's Deep Submergence Systems Project Office. Among its objectives are the development of better equipment—for example, improved diver-to-diver communications and underwater propulsion devices.

Other objectives include:

- Physiological research and experimentation.
- Development of mobile decompression equipment.
- Surface ship modifications to support diving operations.
- The development of advanced sea bases.

The primary communications between Sealab III divers will be by wire telephone in the umbilical cable. This system will include a helium speech-distortion converter, face-mask amplifiers and high fidelity amplification for all circuits.

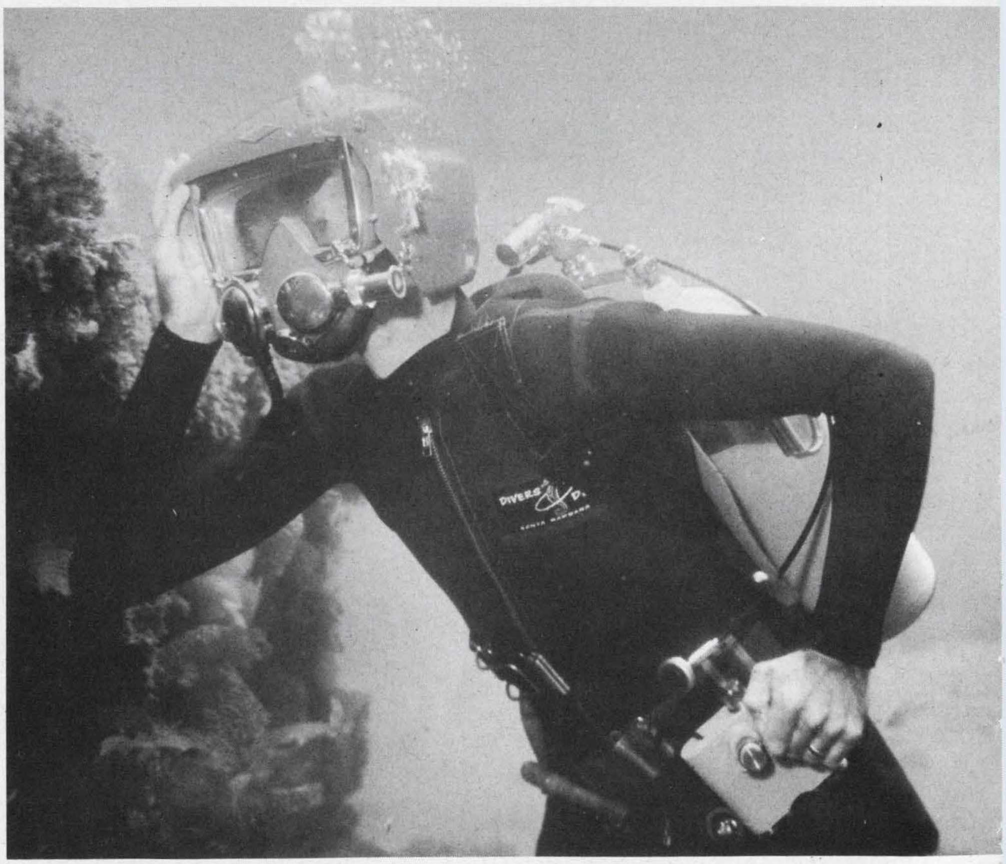
The umbilical cable will, according to D. Martin Harrell, who is a project communication engineer for the Deep Submergence Systems Project, contain wires for body heater and personal lights; wires for the telephone, and wires for oxygen-sensor analog telemetry.

There will also be a hose within the cable for an oxygen-helium gas supply.

Harrell says that the umbilical cable weighs seven pounds per hundred feet underwater; lengths up to 600 feet will be attached to one aquanaut. The wires that will supply up to 750 watts of power to a body heater account for most of the weight.

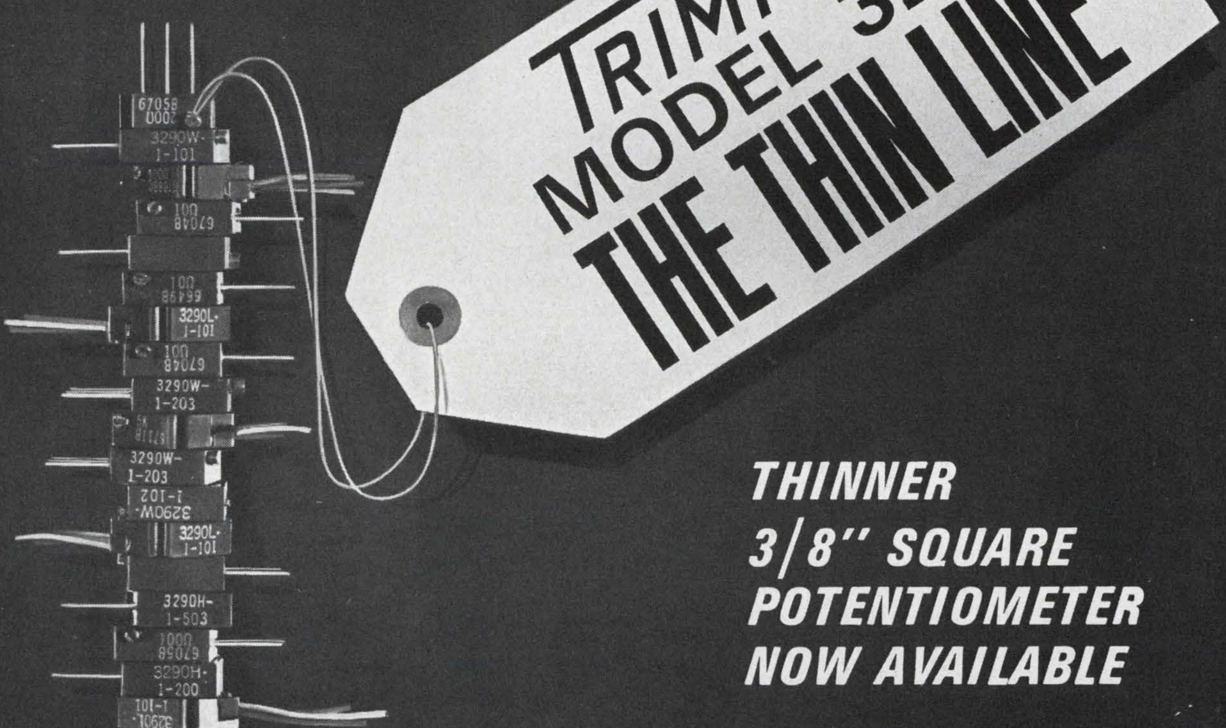
All telephone circuits will be linked to the surface, where the speech converters are. Harrell says the phone system was designed and built by the Navy's Mine Defense Laboratory, Panama City, Fla. Most of it is made of high-quality commercial components. Six separate duplex aquanaut connections will terminate at the undersea base, and a trunk line will carry all messages to the surface.

What are the major equipment problems that designers are wrest-



Bendix AN/PQC-2 acoustic phone for Sealab III can transmit voice, code or homing signals more than 1500 feet. An 8.5-to-11-kHz modulated carrier is sent and received by a piezoelectric ceramic transducer on the underside of his belt-mounted case. Aquanauts will wear similar fiberglass helmets.

GOOD THINGS COME IN SMALL PACKAGES



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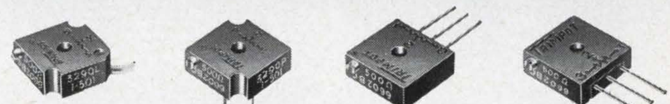

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(Aquanaut electronics, ***continued*****)**

ling with right now? In communications, it's helium speech distortion.

Acoustic links for voice have proved valuable for communications between free divers in shallow water. But their use in the depths is conditioned by the need to correct distorted speech. As long as the diver requires an umbilical cord for survival, it is easier to use a wired telephone as his primary communicator rather than burden him with extra gear. Speech correction can be performed, as needed, in the wired phone circuit.

As divers descend below 200 feet, the quality of the human voice changes when the breathing gas mixture or its pressure changes. The atmospheric air mixture of about 79% nitrogen and 21% oxygen must be changed in deep diving, so the diver will avoid the perils of nitrogen narcosis and oxygen poisoning. Mixtures of about 5% oxygen with the remainder helium, for example, are used at 400 feet.

The velocity of sound in the helium mixture is much higher than in air, and this strongly affects the acoustic resonances and characteristic quality of the voice. The fundamental pitch (about 100 Hz for men) is relatively unaffected, but the amplitudes or volume of the various harmonics change markedly. The normal human voice becomes almost unintelligible and sounds like "Donald Duck."

Speech converters developed

Three different organizations are supplying helium speech unscramblers, or converters, for the Sealab III project: the Navy's Applied Science Laboratory, Brooklyn, N.Y.; HRB-Singer Inc., State College, Pa., and the Westinghouse Underseas Div., Annapolis, Md. They have come up with three different versions to compensate for the upward frequency shift of speech components. Each will be evaluated by Sealab III.

Westinghouse, for example, effectively slows the speed up to one half to reduce voice frequency with an analog chopping and digital integration process. The speech delay depends on the depth and the nature of the mixture. It is introduced by selecting the time values and rate for speech signal chopping and by varying the digital readout speed to compensate for the missing portions of the voice waveform.

After the waveform is chopped, the remaining amplitude "strips" are digitally quantized and fed into memory—a shift register. The shift register is then read out at a slower clock rate than the digitized signal was read in. After digital-to-analog conversion, the restored voice is lowered in frequency in a manner analogous to playing back a record at a slower rate than it was recorded.

"We are only trying to improve the intelligibility of the voice and not restore it completely," says David Houston, a Westinghouse engineering manager. "Complete restoration of the voice would require more sophisticated circuitry that could not easily be miniaturized. We are working with a circuit that we believe can be miniaturized with integrated circuitry, thus making an individual aquanaut converter practical."

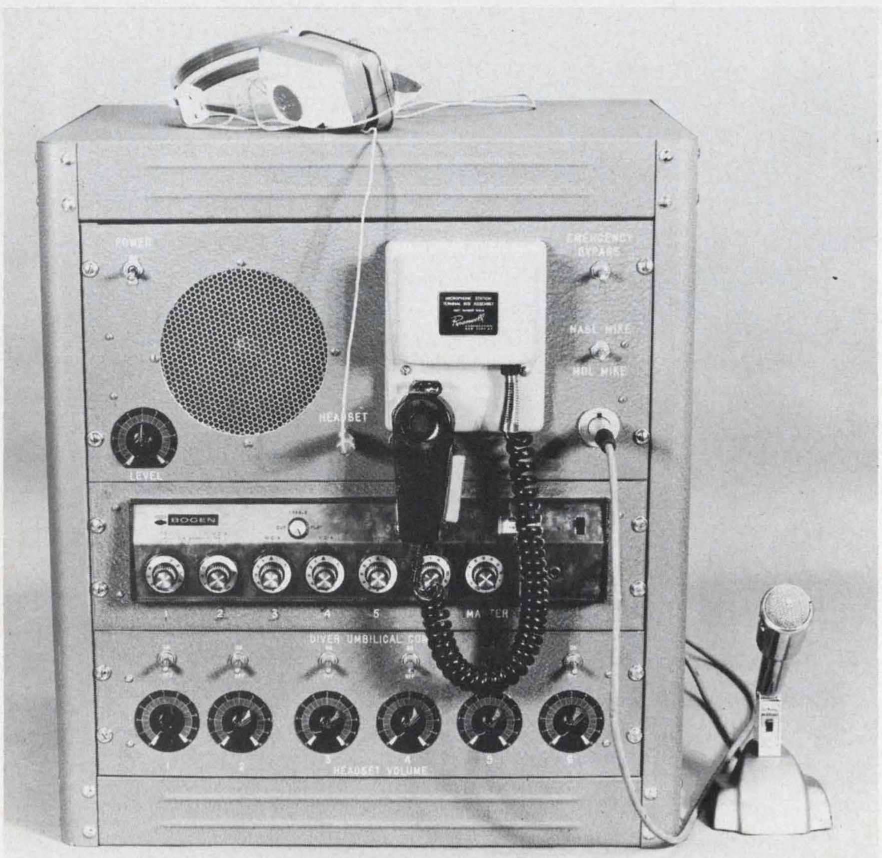
This development, Houston says, would make low-distortion voice transmission practical with sonic links at depths down to 1000 feet: this is not possible because speech conversion must be performed on the surface.

The distorted helium speech can also be separated into harmonic frequencies, and their amplitudes can be measured. Then the envelope of harmonic amplitudes can be shifted back towards the more normal condition. Applied Science Laboratory and HRB Singer follow this approach.

Sonic communications available

Two manufacturers have already developed diver sonic communicators that are said to have ranges of 1500 feet at depths to 600 feet. Based upon sonar techniques, they can transmit and receive voice or code-modulated ultrasonic carrier signals.

Man-pack equipment for these



Navy-built aquanaut phone system accepts calls from six divers and a seabed base. Speech makes round trip to surface, where it can be corrected for helium distortion before it is returned and redistributed.

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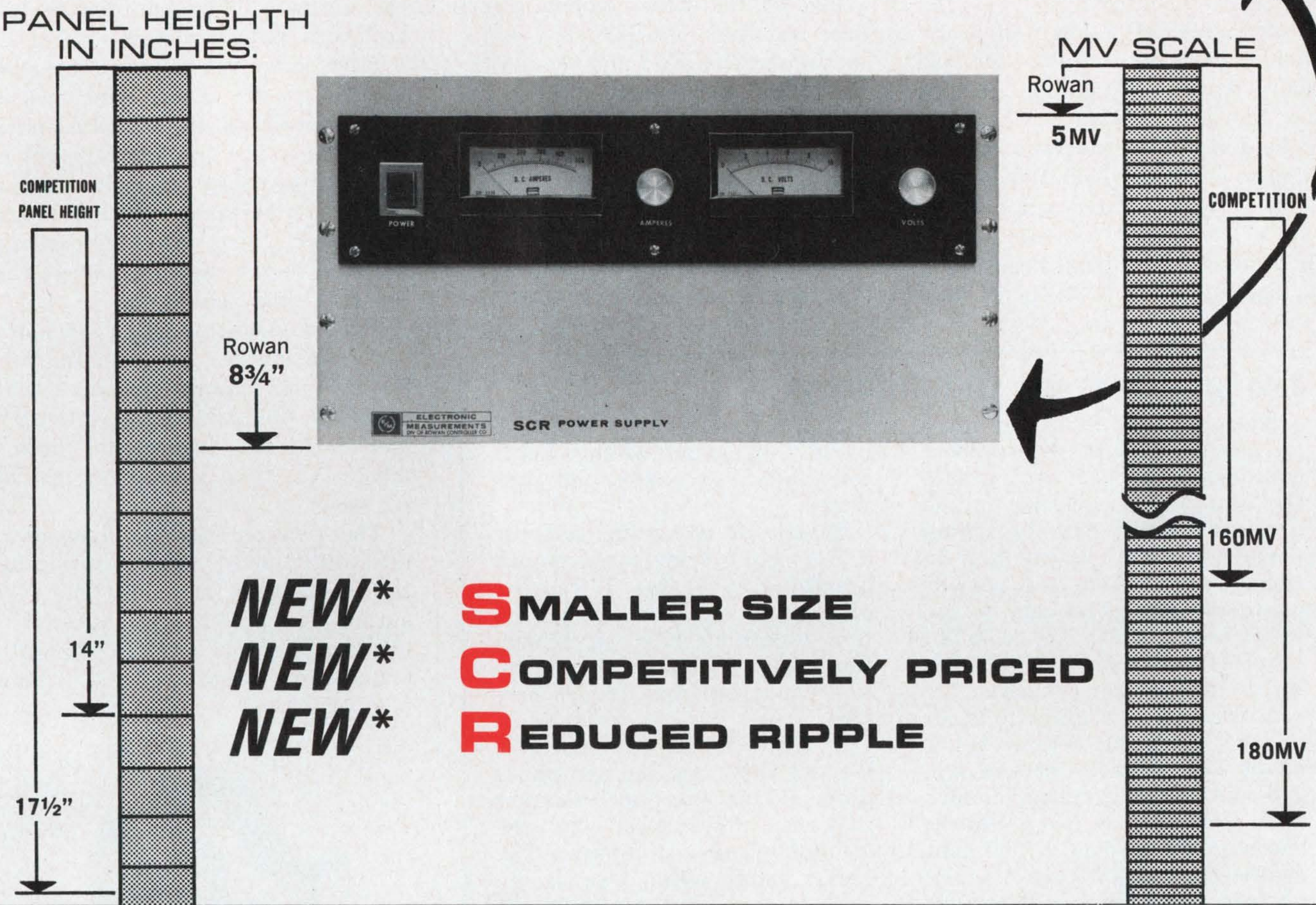

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SCR10-250	0-10	250	0.1	3	0.1	75	5	7	19	20	140#	1300.00
SCR20-250	0-20	250	0.1	6	0.1	75	5	8¾	19	20	190#	1500.00
SCR20-125	0-20	125	0.1	6	0.1	40	5	7	19	20	140#	1150.00
SCR40-125	0-40	125	0.1	12	0.1	40	5	8¾	19	20	185#	1375.00
SCR40-60	0-40	60	0.1	12	0.1	20	5	7	19	20	140#	925.00
SCR80-30	0-80	30	0.1	30	0.1	10	10	7	19	20	140#	900.00
SCR120-20	0-120	20	0.1	40	0.1	8	10	7	19	20	140#	900.00
SCR160-30	0-160	30	0.1	50	0.1	10	10	8¾	19	20	185#	1500.00
SCR160-15	0-160	15	0.1	50	0.1	5	10	7	19	20	140#	900.00
SCR250-20	0-250	20	0.1	75	0.1	8	10	8¾	19	20	185#	1500.00
SCR250-10	0-250	10	0.1	75	0.1	4	10	7	19	20	140#	900.00
SCR500-10	25-500	10	0.1	150	0.1	4	10	8¾	19	20	185#	1700.00
SCR500-5	25-500	5	0.1	150	0.1	2	10	7	19	20	140#	1300.00
SCR120-40	0-120	40	0.1	40	0.1	12	10	8¾	19	20	185#	1500.00

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(Aquanaut electronics, ***continued*****)**

systems includes a microphone or other transducer suitable for use under water. Receiving phones pass the demodulated voice signal to the diver. Both methods call for the use of bone-conduction transducers that are fitted against the diver's skull near his ear. These audio piezoelectric transducers pass the signal directly to the bone, thus avoiding the attenuation caused when the audio signal takes a water path to the ear.

One of the sonic communicators uses separate piezoelectric ceramic transducers to send and receive the modulated ultrasonic carrier, and the other uses a dual-purpose unit. The acoustic underwater link is actually a miniature version of the conventional ship-to-ship underwater telephone.

Aquasonics Engineering Corp. of San Diego, Calif., makes one of the sonic communicators.

The voice amplitude modulates a carrier centered on 42 kHz, and the carrier is transmitted to all receivers within range.

Each diver set includes separate receiver and transmitter packs with connectors, microphone and a headphone. The transmitter pack is attached to the diver's belt, and the receiver is normally attached to his face-mask strap. The microphone is fitted to the mask to permit the diver to talk easily.

The transmitter pack includes the transducer for sending. A water-tight aluminum case that contains the modulation circuitry and a dry-cell transmitter power supply, the pack weighs one pound in water.

The receiver pack is a smaller, mica-filled epoxy case containing the solid-state demodulation circuitry. It receives the modulated ultrasonic signal with a separate transducer, amplifies the audio

Living safely at 100 fathoms

The aquanaut must be specially equipped with life-support equipment for safe entry into the sea, where pressure is the greatest hazard. His breathing apparatus must permit him to remain in the sea for periods up to 6 hours. The cold of the water in the depths (40 to 50°F) requires that heat be supplied to his diving suit for comfort.

Nitrogen has a narcotic effect on the diver at depths below about 150 feet. A helium-oxygen mix has been found to work well. However, at the pressures encountered at 400 to 600 foot depths the oxygen content must be reduced to the 1 to 3 percent range to eliminate the possibility of oxygen poisoning. At these depths the oxygen partial pressure will sustain life. But it must be maintained at these levels and CO_2 and water vapor must be removed.

Three possible life support systems are offered to maintain the required oxygen level:

Open circuit: The compressed helium oxygen mix (usually supplied by bottles to a demand regulator) is breathed by the aquanaut, then exhaled and exhausted into the water. It is the safest but most wasteful method.

Closed circuit: Helium is recirculated in the breathing circuit and oxygen is added by bottle. Automatic regulators control the gas flow and no additional mix is added. It was invented by Alan Krasberg of the Westinghouse Underseas Div. The most economical, it is potentially the most dangerous and requires careful regulation.

Semi-closed: A compromise scheme in which premixed helium and oxygen is constantly metered into the breathing gas circuit from a gas line or bottles at a fixed rate to replenish oxygen. A portion of this gas is constantly exhausted to the water.

Sealab III aquanauts will use a navy-built semi-closed circuit breathing apparatus. It consists of four main parts: An inhalation breathing bag, an exhalation breathing bag, CO_2 absorption cannister, and oxygen sensor.

A Krasberg oxygen sensor is used to supervise the system. It produces an electrical current that is proportional to the amount of oxygen present. The sensor works without regard to pressure or the presence of other gases. The sensor controls the flow of helium-oxygen mix and its voltage level is telemetered to a monitor.

The mix is recirculated from the inhalation bag to the aquanaut. The exhaled gas goes to the exhalation bag and the absorption cannister removes the CO_2 and water vapor.

The aquanaut can switch from the umbilical or hookah line to back pack bottles in an emergency or during brief periods of free swimming. He can also remove his face mask, replace it with a mouthpiece and use the bottles as an open-circuit scuba.

Heat can be supplied to an aquanaut's wet suit by electrical means (an undersuit made like an electric blanket) or by circulating hot water. Westinghouse built an undersuit that is supplied with circulating hot water from a hose line. But the Navy wants to heat the diver with a self-contained system that is part of his equipment. It will supply electric power in the umbilical cable so it can experiment with both circulating water and heating elements.

Navy diver wears semi-closed circuit breathing apparatus. Umbilical cable attaches to fitting on his right side. No communication or telemetry equipment is shown.

signal and sends it to a waterproof encapsulated bone-conduction phone that is fitted under the diver's neoprene helmet.

Weighing only 0.3 pound in water, the battery-powered audio circuitry is said to give a gain of over 80 dB and to furnish 120 mW of audio output to the bone-conduction phone.

Aquasonics also makes a battery-powered station transceiver that is built to work with the diver units. It can be placed on the surface or in an underwater shelter.

Dual-purpose transducer built

The Bendix Electrodynamics Div., North Hollywood, Calif. also is building communicator systems. One model designated the AN/PQC-2, will be used for secondary communications on the Sealab III project.

The Bendix unit, in addition to carrying voice signals, can transmit a continuous tone for homing and Morse Code for emergency situations when the aquanaut is unable to speak. Voice, code and tone all modulate a carrier in the 8.5 to 11 kHz range selected to be compatible with the Navy's standard shipboard and submarine underwater telephones.

Bendix engineers say that they have achieved a 2100-foot range, although the specified range is 1500 feet.

Safety equipment needed

Life-support equipment for the aquanaut requires further development, the experts say, before a truly reliable, self-contained system evolves. Use of the closed-circuit aqualung is limited to four or five hours' use, and it also requires close supervision and automatic control to ensure proper function.

To maintain a diver at depths of greater than 200 feet for as long as six hours, the semi-closed circuit breathing apparatus has been found to be the most satisfactory so far. (See box at left).

For safety and economy of breathing gas, diving experts have found that it is desirable to pipe makeup breathing gas to the aquanaut through the umbilical connection. An umbilical hose attaches to

(Aquanaut electronics, ***continued*****)**

the diver's waist, and the gas is bled into the breathing apparatus.

If the hose is cut or blocked, the diver can revert to his self-contained gas supply.

The umbilical connection also carries wires to telemeter the output of a gaseous oxygen sensor back to an underwater base or the surface, wherever the life-support system is monitored. This record can also be transmitted over acoustic wireless data links.

Improved telemetry due

In the Sealab II project, an experimental acoustic telemetering system transmitted electrocardiographic signals from the aquanaut to an underwater base. The system was assembled at the Philadelphia General Hospital in Pennsylvania.

Electrodes attached to the aquanaut picked up electrical signals from his heart and used them to frequency-modulate a carrier. They were transmitted acoustically 100 feet to the base. An improved version, slated for Sealab III, is expected to have a greater range.

The new system should increase the number of telemetry channels, so that more body parameters can be measured. Channels are being considered for brain-wave transmission, body temperature and for a dual-channel electrocardiogram. Sealab engineers are also investigating the possibility of incorporating a voice channel, so the aquanaut can state what he is doing. His physical activity can then be correlated with the recordings.

Finder points directions

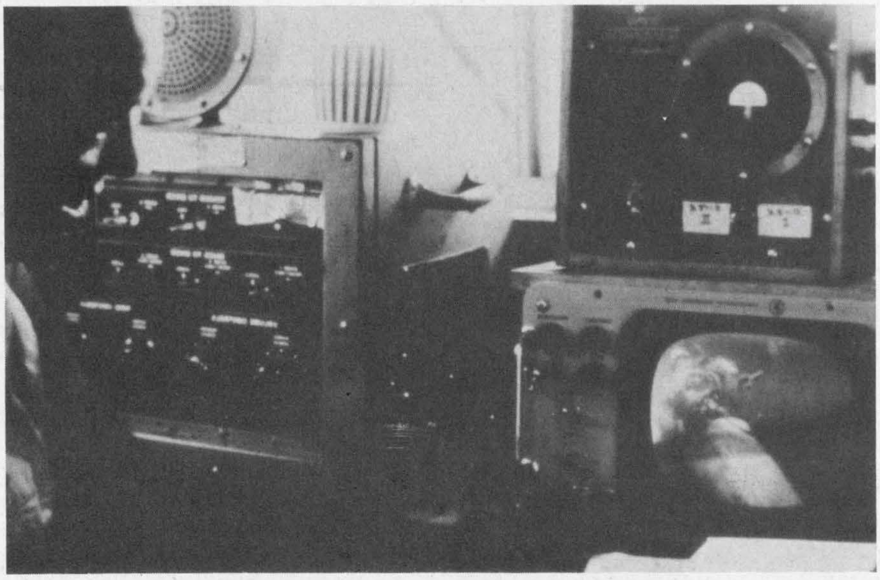
How does the underwater explorer keep from getting lost? Below 200 feet a tether is necessary today. To get rid of the tether, design engineers must come up with a device that the diver can carry or hold that will tell his position unerringly at all times.

The Navy's Undersea Warfare Center, Pasadena, Calif., has built an experimental aquanaut navigation aid, a direction finder that will be tried out by Sealab III.

According to the project engineer, Benjamin Saltzer, it works by determining the bearings of previously placed underwater beacons or transponders. Hydrophones pick up the signal from the beacons and translate them to a relative bearing by continuous phase comparison techniques.

The development model is bulky and suitable for feasibility studies only. However, Saltzer expects that it can be miniaturized.

He says one can be built that will have a multiple needle display. The aquanaut will be able to move around and yet know where each of the beacons is at all times. Each needle on a meter that he will carry will point to a specific beacon.



Westinghouse surface station has an underwater TV monitor, telephone switchboard and a terminal for each diver's oxygen sensor telemeter.

Thus far all of the equipment developments like these have been piecemeal; there has been no coordinated, NASA-like approach to habitation in the sea. Many experts are convinced that until there is, no great strides will be made. Preliminary steps in this direction have been taken by the Navy.

The Navy is using a systems approach called CAVE (for Consolidated Aquanaut's Vital Equipment). CAVE is considering diver life-support, communication and navigation equipment as part of an integrated diving system.

The CAVE program, which looks beyond the impending Sealab III program, is still in its study phase. At least another year will pass before the Navy asks industry to submit proposals for equipment.

Diving systems foreseen

But Navy engineer Harrell ventured some concepts on what the Navy is seeking:

- An underwater communication system that combines voice and code communication with biomedical and life-support telemetry. Acoustic signals using sonar principles would be transmitted through the water. By using different or time-shared frequencies, divers would be able to transmit and receive voice messages while continuous information on their physiological and mental condition was being sent. Coded data would establish the diver's identity and location on displays in sea-floor shelters and at the surface.
- Miniaturized helmet sonars (perhaps combined with headlights) to help the diver maneuver without becoming lost. Elementary displays would help him determine distances to underwater objects or to sea-floor beacons that mark specific locations.
- Automatic life-support controls to supervise and regulate the diver's breathing gas supply to changes in depth and muscular activity. The operating conditions would be telemetered to a control station, but personal alarms (perhaps skin vibrators) would alert the diver to hazardous conditions.
- A unified man pack power supply (perhaps a nuclear isotope source) to power the diver aids and heat his suit in cold water. ■■

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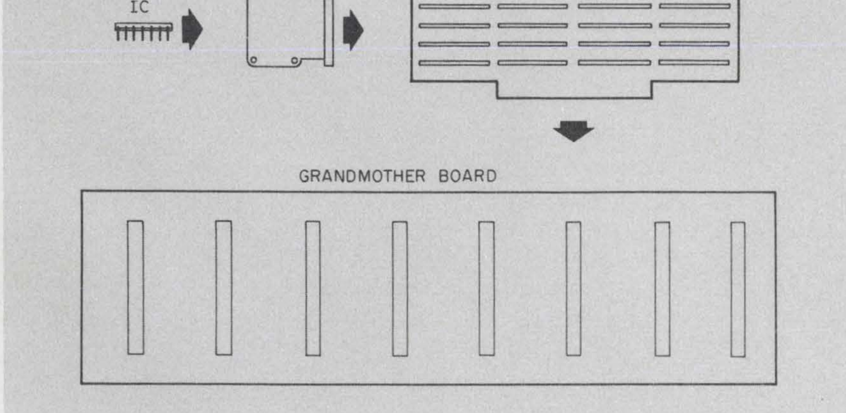


Ten or more integrated-circuit logic cards plug into a mother board. Then a number of "mother" boards are mounted on a single "grandmother" board. Next step: a "great-grandmother" board, if system complexity warrants.

This issue in capsule

Designing parallel adder subsystems with anticipated or ripple carry.

How parallel adder subsystems operate and how Sylvania IC fast adder units enhance their performance. Anticipated-carry subsystems are for high-speed operation; ripple-carry subsystems are not as fast, but are more economical to design and assemble.

Anticipated carry subsystems

Some high speed parallel adder subsystems incorporate the anticipated carry configuration which is designed to perform all summing operations in a given time interval without regard to the number of binary digits being added. In such subsystems, all previous combinations of bits must be monitored simultaneously at each succeeding stage. A "stage" of anticipated carry addition is defined as the summing of one Augend bit and one Addend bit of the same significance, taking into account all previous carry combinations affecting the sum at that stage. Each "stage" must also provide the sum for that stage and the necessary carry-out information to all succeeding stages.

A single anticipated carry adder stage is the overall fast adder logic diagram shown in Figure 1. In the anticipated-carry (SM20, SM30 series) configuration there are three separate outputs, each dependent upon an input logic configuration. The three outputs are the SUM, the Exclusive-OR, and the Carry. The Exclusive-OR output is dependent upon the following combination of the literals A and B being added:

$$\text{Exclusive-OR} = \overline{A}B + A\overline{B} = A \oplus B$$

The symbol "$\oplus$" means "Exclusively ORed"

The Carry output is dependent only on the AND function of the two literals A & B. Hence, the Carry is:

$$\text{Carry-Out} = AB + AC_P + BC_P \text{ (SM20 Series)}$$
$$\text{Carry Out} = A \cdot B \text{ (SM30 Series)}$$

The SUM output is the result of the following expression:

$$\text{SUM} = A_N\, B_N\, C_P + \overline{A}_N\, \overline{B}_N C_P + A_N\, \overline{B}_N\, \overline{C}_P + \overline{A}_N\, B_N\, \overline{C}_P \quad (1)$$

Where A_N and B_N are the Nth digit of the Addend and Augend.

Equation (1) may be factored as follows:

$$\text{SUM} = (A_N\, B_N + \overline{A}_N\, \overline{B}_N) C_P + (A_N\, \overline{B}_N + \overline{A}_N\, B_N) \overline{C}_P$$

Where C_P is a complex Boolean expression and represents the carry-in to the Nth stage from all less significant stages.

C_P is defined as a complex expression since to implement a fast or simultaneous carry adder all possible combinations of previous adder stages must be simultaneously examined to determine if a Carry into the Nth stage will affect the SUM_N.

For a Carry into the Nth stage, the inputs must satisfy the following expression:

$$\begin{aligned} C_P = {} & A_{N-1} \cdot B_{N-1} + (A_{N-1} \oplus B_{N-1}) \\ & (A_{N-2} \cdot B_{N-2}) + (A_{N-1} \oplus B_{N-1}) \qquad (2) \\ & (A_{N-2} \oplus B_{N-2})\ (A_{N-3} \cdot B_{N-3}) + \cdots \\ & [(A_{N-1} \oplus B_{N-1})\ (A_{N-2} \oplus B_{N-2}) \\ & (A_{N-3} \oplus B_{N-3}) \cdots (A_2 \oplus B_2)\ (A_1 \cdot B_1)] \end{aligned}$$

Where $1 \leqq N \leqq 8$ for an eight stage anticipated carry adder subsystem.

This expression is logically demonstrated by the Carry-In structure shown in Figure 1.

In Figure 1, the crux of the anticipated carry adder stage is enclosed by dashed lines. Examination will show that it is a series of two comparators. Truth tables for the two comparators are shown below:

Comparator 1

X	Y	Output W
0	0	1
0	1	0
1	0	0
1	1	1

Comparator 2

W	Z	Output V
0	0	1
0	1	0
1	0	0
1	1	1

For Comparator 1, X and Y are the inputs and W is the output. For Comparator 2, W and Z are the inputs and V is the output. The following expressions are derived from the above truth tables:

$$W = XY + \overline{XY},\ \overline{W} = \overline{X}Y + X\overline{Y} \quad (3)$$

$$V = WZ + \overline{WZ} \quad (4)$$

by substitution:

$$V = (XY + \overline{XY})Z + (\overline{X}Y + X\overline{Y})\overline{Z} \quad (5)$$

Equation (5) is the same as the SUM equation.

Upon examination of the inputs it can be seen that:

$X = \overline{A}_N$, $Y = \overline{B}_N$, where N represents the digit under consideration, and: $\overline{Z = C_{N-1} + C_{N-2}\ (A_{N-1} \oplus B_{N-1}) + (A_{N-2} \oplus B_{N-2})\ (A_{N-1} \oplus B_{N-2})\ (C_{N-3})}$ (6)

Since $C_N = A_N \cdot B_N$, it can be seen that Z is the complement of the complex Carry-In structure previously referred to as C_P (see equation 2).

Therefore, $Z = \overline{C}_P$

By substituting the above values in equation (5) one arrives at the following:

$$V = (\overline{A}_N\, \overline{B}_N + A_N\, B_N)\, \overline{C}_P + (A_N\, \overline{B}_N + \overline{A}_N\, B_N)\, C_P \quad (6)$$

By manipulation, it can be shown that equation (6) is the complement of equation (1) the standard SUM equation. Therefore by a simple inversion of equation (6), the correct SUM at S_N is available.

Maximum addition time

Worst case logic conditions (overflow) for anticipated-carry adder subsystems occur when all respective Augend and Addend bits are different except for each least significant bit which in both cases is a binary ONE. For example:

1	1	0	1	1	1	0	1	AUGEND
0	0	1	0	0	0	1	1	ADDEND
0	0	0	0	0	0	0	0	SUM

Expressions for the propagation delay of the SUM of two 8-bit numbers which are multiples of eight may be derived in the following manner:

For one 8-stage section: (6) $T_{SUM} = t \oplus + t_S$ (7)

where $t \oplus$ = propagation delay of the EXCLUSIVE-OR output with respect to the inputs A & B.

t_S = propagation delay of any SUM output with respect to an EXCLUSIVE-OR input.

It should be noted that only the first 8-stage section is dependent on the propagation delay of the EXCLUSIVE-

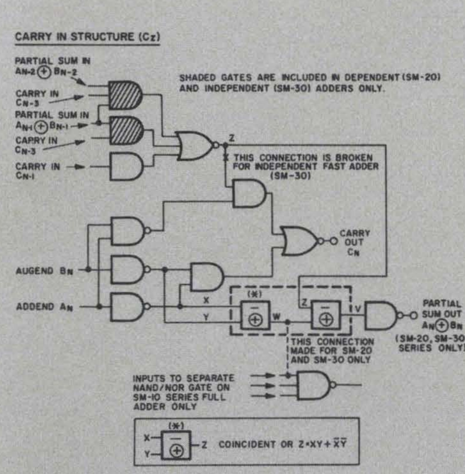


Figure 1. Logic diagram for a single parallel adder stage

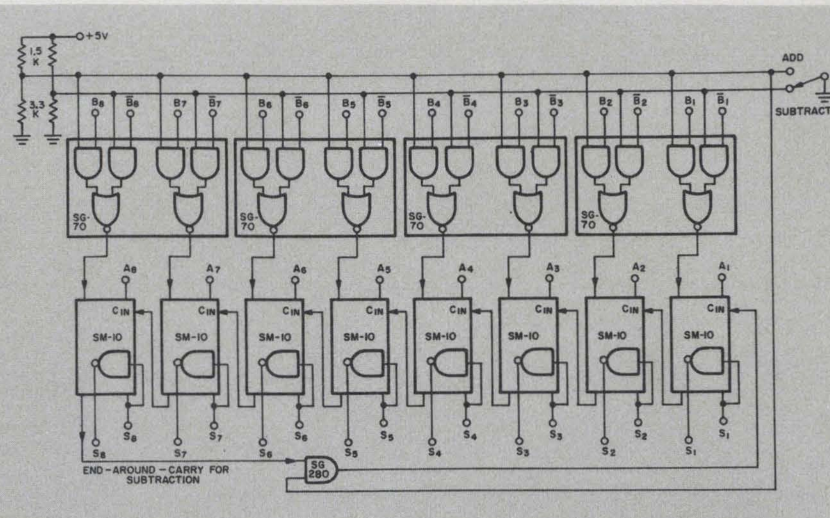


Figure 3. This parallel add/subtract configuration uses ripple carry propagation. This configuration will compute an eight-bit sum in approximately 135 nanosecs, or a difference in approximately 150 nanosecs. The SG280 dual 4-input AND/OR gate is enabled during subtraction to provide end-around-carry. The "B" register is made from only four SG70 Dual 2-Input AND-NOR Gates. Both the SG280 and the SG70 are standard SUHL gates.

Figure 2

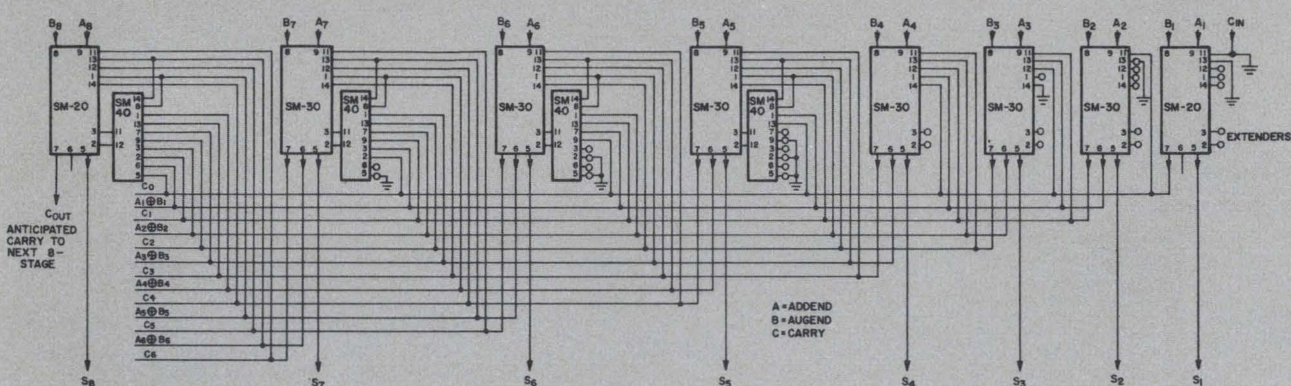


Figure 2. The above diagram shows SM-20, SM-30, and SM-40 series Adder Arrays interconnected to form an eight-stage anticipated-carry parallel adder subsystem.

OR outputs. Succeeding 8-stage sections will be dependent on a function of the Carry-Out signal.

For any number of cascaded 8-stage adder sections, the propagation delay for the SUM with respect to the Augend and Adder may be expressed as follows:

$$T_{SUM} \approx (2N\text{-}1)\, t_{CO} + t_S \qquad (8)$$

where N = number of 8-stage sections

t_S = as defined previously

t_{CO} = propagation delay for the Carry-Out of one stage of an adder, where Carry-Out = $A \cdot B$

A careful examination of the 8-stage adder section shown in Figure 2 will show the derivation of equations (7) and (8).

Ripple adder subsystem

Where package count and interconnection economies are prime factors in the design of an adder subsystem, the parallel ripple-carry adder configuration is usually chosen (Fig. 3). This configuration, though logically much simpler than the anticipated-carry approach, is also slower in terms of total add time.

A stage of ripple-carry addition is similar to a stage of anticipated-carry addition except that carries from previous stages do not simultaneously affect the sum at subsequent stages. Instead the sum at each stage is affected sequentially by the carry from the next less significant stage.

A single stage of ripple-carry addition is shown in Figure 1. In this diagram, the logic structure for this configuration is described by the unshaded gates. The expressions for the sum and carry are as follows:

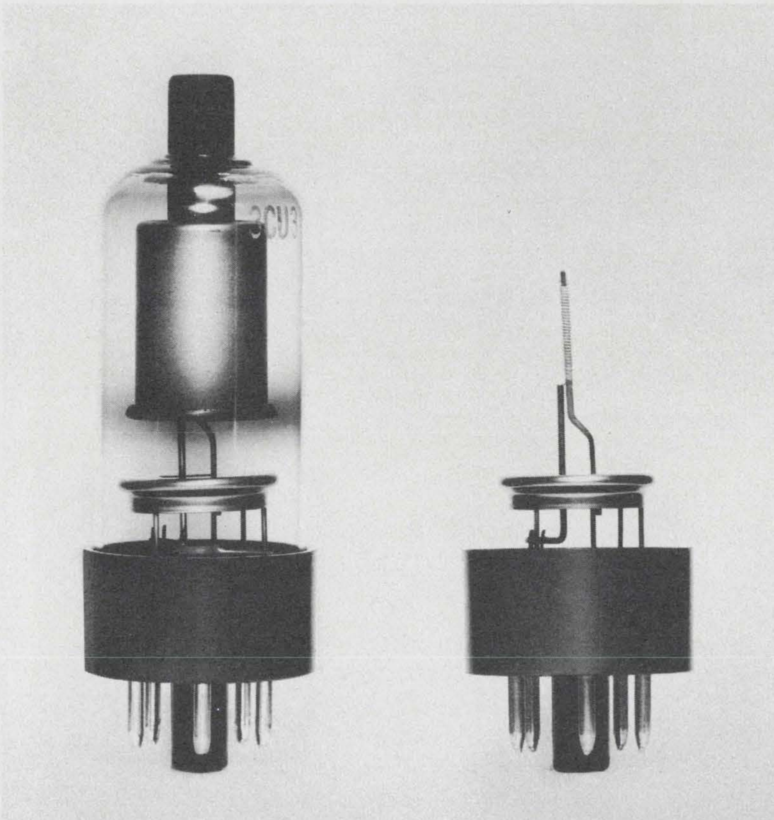
$$\mathrm{SUM} = ABC + \overline{A}\overline{B}C + \overline{A}B\overline{C} + A\overline{B}\overline{C}$$

$$\mathrm{CARRY} = AB + AC + BC \text{ (from previous stage and propagated to the next stage)}$$

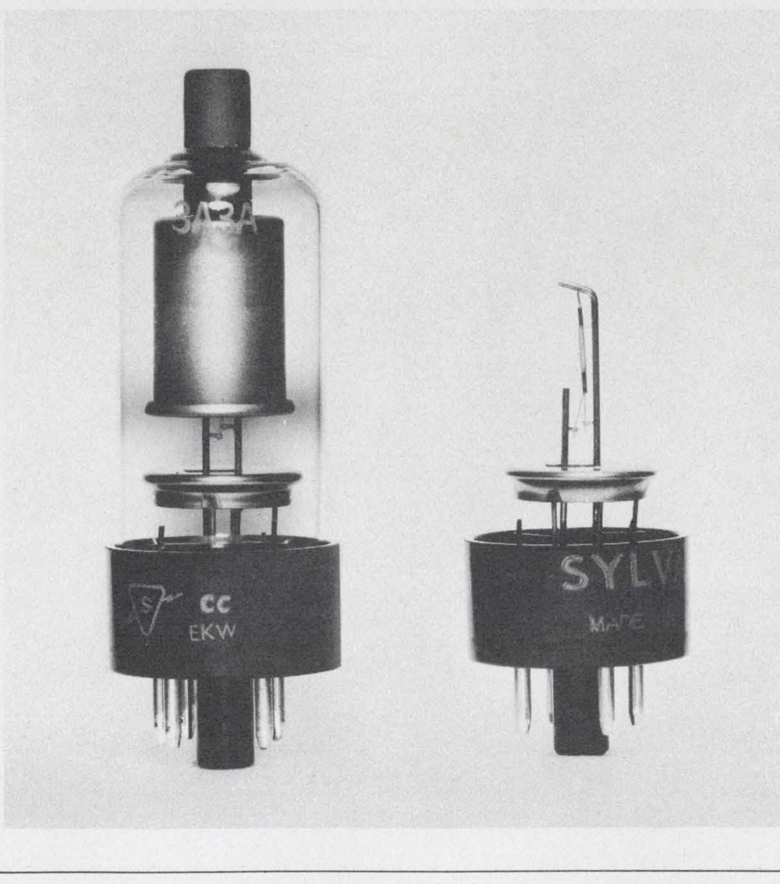
There are three inputs to each stage: the Addend, the Augend, and the Carry-In. The Carry-In, propagated from the previous stage, represents the result of addition at the previous stage and the ORed result of carries from all previous stages. The Carry-Out from a given stage is the Carry-In to the next subsequent stage. The output is the true sum of two binary digits of the same significance at the specific stage, and including the result of all carries up to that stage.

New high-voltage rectifier with posted filament provides "instant-on" and fail-safe operation.

Sylvania has developed a new high-voltage rectifier tube, our 3CU3, with a rugged posted filament that is virtually fail-safe in that it cannot short out and damage other components.



New Sylvania 3CU3, above, contrasted with our 3A3A high-voltage rectifier with cathode-type construction. Note simplicity and ruggedness of posted filament design in 3CU3.



The receiving tube above represents a significant advance in high-voltage rectifier design. The filament is wound onto — but insulated from — a strong central support post. This construction aligns the filament in the exact center of the anode to assure uniform field distribution.

In addition, it makes filament-to-anode shorts virtually impossible *even if the filament should fail*. This affords fail-safe protection for other circuit components that could be damaged by filament-to-anode shorts in the high-voltage rectifier.

The tube was designed to meet the most demanding and critical color-TV circuit requirements, and is particularly useful in sets which are all solid-state except for the CRT and the HVR. The tube takes momentary overloads in stride, where a solid-state HVR may not. And its total warm-up time is less than one second, making it ideal for "instant-on" TV sets.

Posted filament construction assures long life and provides considerable reserve emission capability and excellent emission stability at reduced line or overload voltages. Reliability is increased by the large filament area, by the high filament-power input and the center posted filament suspension. The undesirable shielding effect caused by side mounted supports (see heater cathode type construction of the 3A3A, below) which unavoidably reduces emission capability, is eliminated with the posted filament design.

Electrical Data

Heater Characteristics

Heater Voltage (AC)	3.15±0.5 Volts
Heater Current	280 mA

Direct Interelectrode Capacitances

Plate to Filament and Internal Shield Without Shield	1.5 pF..

Ratings (Design Maximum System)

Pulse Rectifier Service

Peak Inverse Plate Voltage	
Total DC & Peak	33,000 Volts
DC Component	27,500 Volts
Steady State Peak Plate Current	100 mA
DC Output Current	2.0 mA

Characteristics

Tube Drop for Ib=7 mA	50 Volts

CIRCLE NUMBER 302

EL alphanumeric readouts: The modern approach to visual information display.

Sylvania EL readouts are today's most advanced solution to numeric or alphabetical information display problems. Each letter or number appears on the same flat surface, for widest possible viewing angle, and with none of the "bloodshot-eye" look characteristic of multiplane incandescent and gas-glow tubes.

There is virtually no information display problem that cannot be solved *better* with Sylvania electroluminescent panels.

For long-range visibility, characters may be as much as 12″ high. For pictorial or analog displays, any figure may be presented as a combination of dots as small as 1/10″ square on a random-access panel.

All characters are in the same plane; they don't jump back and forth as in incandescent and gas-glow tubes. And there's no "bloodshot-eye" appearance; you don't have to look through nonilluminated characters to see the one that's lit.

If the information can be displayed in numbers or letters, EL panels can do it. Better. Faster. Faster, in fact, than the eye can detect...when you need that kind of speed.

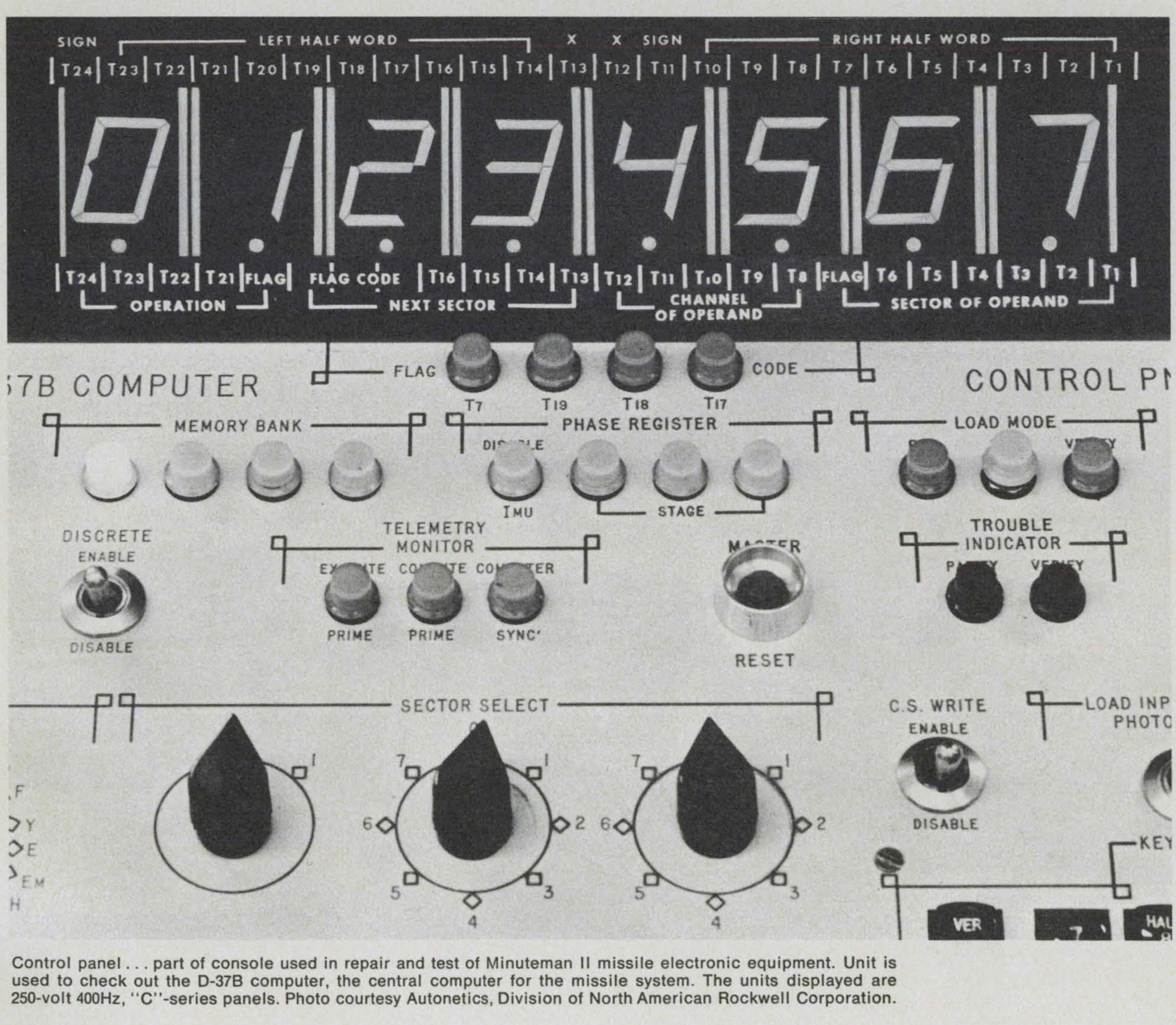
Our "C" Series is designed to operate typically at 250 volts rms, 400 or 800 Hz with a peak voltage rating of 420 volts over the temperature range of −55 to +94°C. This series yields an average initial brightness of 8 footlamberts operating at 250 volts rms, 400 Hz and 12 footlamberts at 250 volts rms, 800 Hz.

Sylvania also has other electroluminescent units, such as our "P"-series, which offer high brightness and all-glass construction. They are available in 115-volt (400 Hz) and 250-volt (400 Hz) versions.

A few possible applications

Hospital paging systems	TV channel indicators
Elevator floor indicators	Nuclear radiation counters
Auto speedometers	Desk calculator readouts
Bar-graph indicators	Airline monitor boards
Random-access panels	Baggage pickup boards
Frequency counters	Stock quotation boards

CIRCLE NUMBER 303



Control panel . . . part of console used in repair and test of Minuteman II missile electronic equipment. Unit is used to check out the D-37B computer, the central computer for the missile system. The units displayed are 250-volt 400Hz, "C"-series panels. Photo courtesy Autonetics, Division of North American Rockwell Corporation.

Now, planar 8-diode arrays for high-speed memory core driving.

Sylvania planar diode arrays combine such benefits as reduced assembly costs, less external wiring and component handling plus high reliability and packaging density—with ultra-fast switching capability in configurations from 2 to 16 diodes.

The combination of high forward conductance, fast recovery, low capacitance and tight performance tolerances makes Sylvania's new diode arrays well suited for high speed core driver applications.

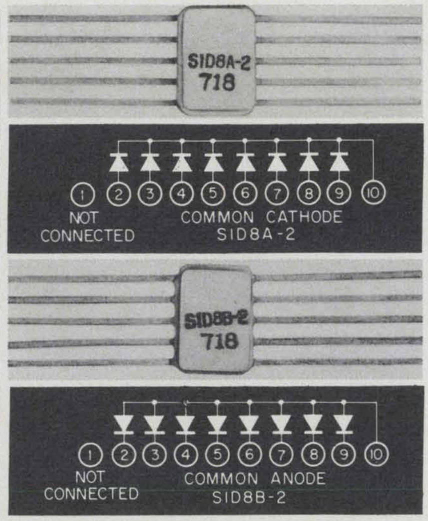
Typical of these units are the SID8A-2 and SID8B-2, eight diode core drivers with forward current ratings of 300 mA and power ratings of 300 mW per diode. Couple this power drive capability with ultra-fast recovery and designers have diode arrays which meet the demanding requirements for memory drivers in military and aerospace computers as well as commercial computers.

Reverse recovery time of these diodes is a maximum of 50 nsec even at such extreme switching conditions of a forward current of 300 mA and an I_R of 30 mA. Typical values for the recovery time of I_F and I_R switching from 300 mA to 30 mA is 35 nsec.

Sylvania's SID8A-2 and SID8B-2 are monolithic silicon diode arrays assembled in hermetically sealed flat packs (0.250″ x 0.175″) or dual-in-line plug-in packages. Available in a common cathode (SID8A-2) or common anode (SID8B-2) configuration, these planar devices feature silicon dioxide passivated construction. They are fabricated on a high resistivity layer which is epitaxially grown on a low resistivity substrate.

The manufacturing process used to produce these arrays results in diodes which have closely matched electrical characteristics over a wide temperature and current range. Passivation insures that performance remains stable over a long operating life. Manufactured to standard MIL quality assurance requirements, these packaged arrays meet MIL-S-19500 standards.

Other core driver arrays available on request from Sylvania include units with two to sixteen diodes connected common cathode or common anode.



Sylvania Type SID8A-2 and -8B-2 8-diode arrays in common cathode and anode configurations. Either type is also available in 10-lead dual-in-line plug-in packages.

CIRCLE NUMBER 304

Maximum Ratings at 25°C (each junction):

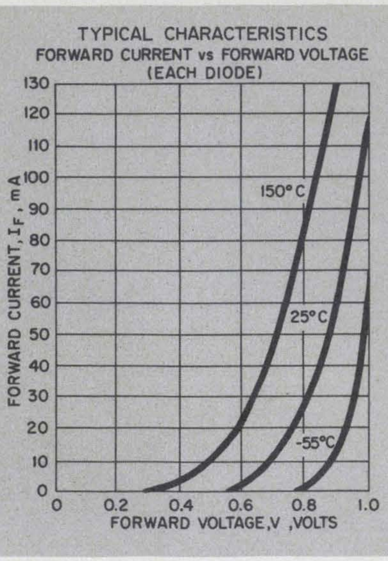
Reverse Voltage, V_R	40 volts
Forward Current, I_F	300 mA
Peak Forward Current, I_{FP}	1.0 amp (0.1 µsec, 25% D.C.)
Average Power Dissipation, P_D	300 mW (500 mW total package)
Junction Temperature, T_J	−65°C to +150°C
Storage Temperature, T_{stg}	−65°C to +300°C

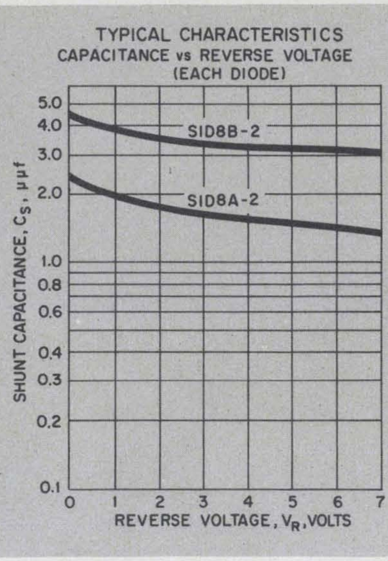
Notes:

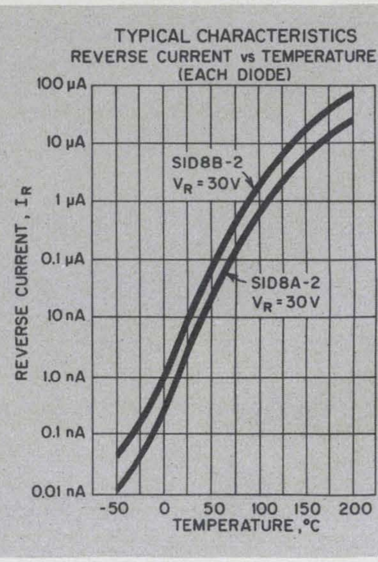
1. Pulse test ≤ 300 µsec, ≤ 2% duty cycle.
2. Forward voltage drop of highest reading diode junction shall be within 200 mV of lowest reading diode.
3. θ_{JC} 0.1°C/mw; θ_{CA} 0.2°C/mw. Linear-derating of +25°C to +150°C.

Electrical Characteristics at 25°C (each junction):

	Conditions	Min	Max	Unit
Forward Voltage Drop, V_F (Note 1.)	I_F = 300 ma	–	1.25	V
Forward Voltage Drop, V_F (Note 1.)	I_F = 500 ma	–	1.40	V
Forward Voltage Drop, V_F (Note 1.)	I_F = 800 ma	–	2.00	V
Reverse Current, I_R	V_R = 30 V	–	0.1	µA
Peak Inverse Voltage, PIV	I_R = 10 µa	40	–	V
Capacitance, C SID8A-2	OV 1 MHz		3.0	pf
SID8B-2			6.0	pf
Reverse Recovery, t_{rr}	I_F = 300 ma, I_R = 30 ma, i_r = 3 ma, R_L = 100 ohm	–	50	nsec
Forward Voltage Match, AV_F (Notes 1. and 2.)	I_F = 500 ma	–	0.2	V







Use this new 2″ monoscope and CRT to print over 30,000 characters per second.

Consider a new system for extremely high-speed printout of computer-generated or computer-retrieved data – alphanumeric, special symbol or foreign language.

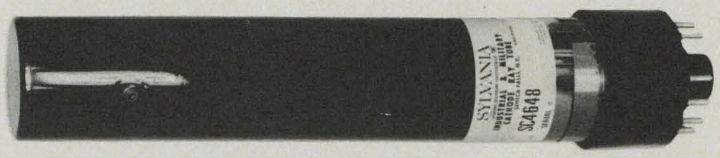


Fig. 1. Sylvania 2″ monoscope Model SC-4648

The new 2″-monoscope (Fig. 1) can generate over 30,000 characters per second from computer tape. And our cathode-ray printing tube (Fig. 2) can print them just that fast by an electrostatic printing technique.

The secret of the monoscope's unique character-generating capability is in the metallic character screen (Fig. 3), electronically opaque except for the open characters. To generate a character, the electron beam scans only one character location, not the entire target. Since a single character occupies less than 1/100 of the full screen, the monoscope generates a character in 1/100 the time required for a full raster scan.

The stencil target screen shown has 64 alphanumeric and mathematical symbols. But it can be made with additional character symbols *to meet your individual specifications* including other languages, in any given character style.

This monoscope is recommended as a character generator for: computer display, airline status boards, stock quotation boards, teaching machines, address-label printing, command control center displays, racetrack tally boards—anywhere a high-resolution electronic information readout system is required.

CIRCLE NUMBER 305

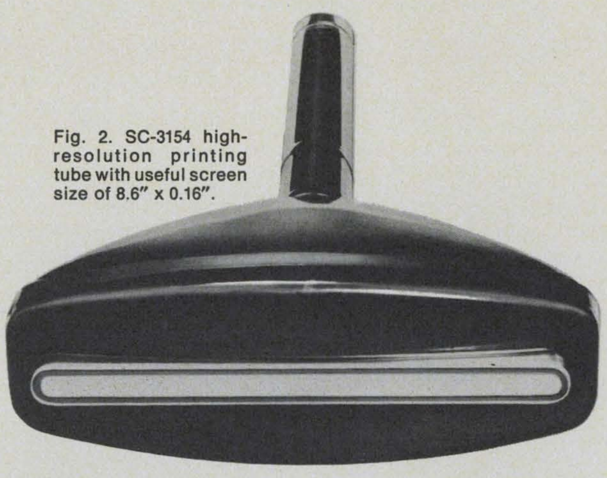


Fig. 2. SC-3154 high-resolution printing tube with useful screen size of 8.6″ x 0.16″.

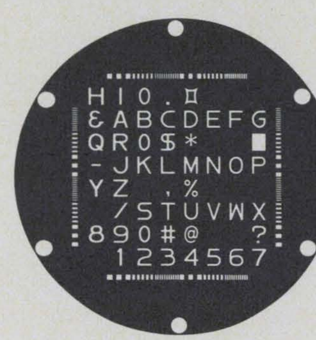


Fig. 3. Stencil character screen from 2″ monoscope can be custom-designed to your requirements.

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Commercial Engineering... where it's our business to mind yours.

Some time ago an irate customer confronted a Sylvania sales engineer with the accusation: "This high-voltage rectifier you sold us doesn't work!"

"What seems to be the problem?" we asked.

"It has problems on life," the customer said. "It runs all right on the production line, but it burns out too early in the field."

Analysis of quality control measurements and life tests showed excellent conformance to ratings and specifications.

Then we examined the customer's circuit and found that the tube was being run at higher than specified filament voltage. We recommended inexpensive circuit changes necessary to bring filament voltage within proper limits . . . and the early life failure problem disappeared.

That's often the cause of component failure: not the component itself, but the circuit in which it's used. Where such failures occur, it's our job to find causes and recommend remedies.

In another case, a customer brought in for evaluation a prototype of a new TV set he planned to market. We checked it through, *predicted* trouble on life with the horizontal output tube, and recommended circuit changes to compensate. But the customer, with thousands of subassemblies in stock, did not feel the changes were essential. The predicted trouble did indeed occur in the field, and he wound up changing the circuit as we had suggested.

What else do we do in the Commercial Engineering Department of our receiving tube operation in Emporium, Pa.?

Well, for example, we make independent laboratory evaluations of customer-designed prototypes, systems, instruments or subassemblies in which our components are used. Run high-line and dynamic life tests simulating worst-case operating conditions. Provide thorough technical descriptions, specifications, application notes and standards for every component we manufacture. Furnish technical answers to customer questions that cannot be answered fully by our engineering field force.

We recommend component substitution when necessary, so that a given circuit will operate properly without redesign. Recommend changes in test, setup or production procedures to eliminate dependent and interdependent failures. Help assure that every component we sell is operated in the most reliable mode. *Anything to help a customer match components to circuits.*

Because we, in our receiving-tube manufacturing operation, are *component* people while our customers, by and large, are *circuit or systems* people who often need the component-oriented engineering backup we provide. Yet unfortunately, some customers occasionally forget that we offer such services.

And the important thing is, our Commercial Engineering factory service is *nearby and immediate;* similar service from foreign manufacturers—if available at all—is far, far away and takes a long, long time. As you probably well know.

HC Pleak

H. C. Pleak
Manager, Commercial Engineering
Receiving Tubes

C2

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NEWS

Photoresist film faster than liquid

An automatic nonliquid photoresist system promises to reduce greatly the number of operations required to etch and plate high-quality printed circuits.

The system developed at Du Pont Co.'s Photo Products Dept. in Wilmington, Del., is undergoing final field evaluation. It is expected to be available by the end of the year, according to a company spokesman.

The new system comprises a photopolymer resist film and integrated equipment to apply and develop the resist. Current techniques involve a considerable number of hand operations.

The Du Pont resist is described as being made of a sandwich of Mylar polyester film and polyethylene film with a predyed, presensitized photopolymer layer in between. Since the resist reaches the user ready for application to the board, the need to mix and filter liquids to ensure proper viscosity and sensitometry is eliminated.

Spraying, dip- or roller-coating and air-drying, also necessary with liquid resists, have been eliminated as well, because the new resist is applied by lamination.

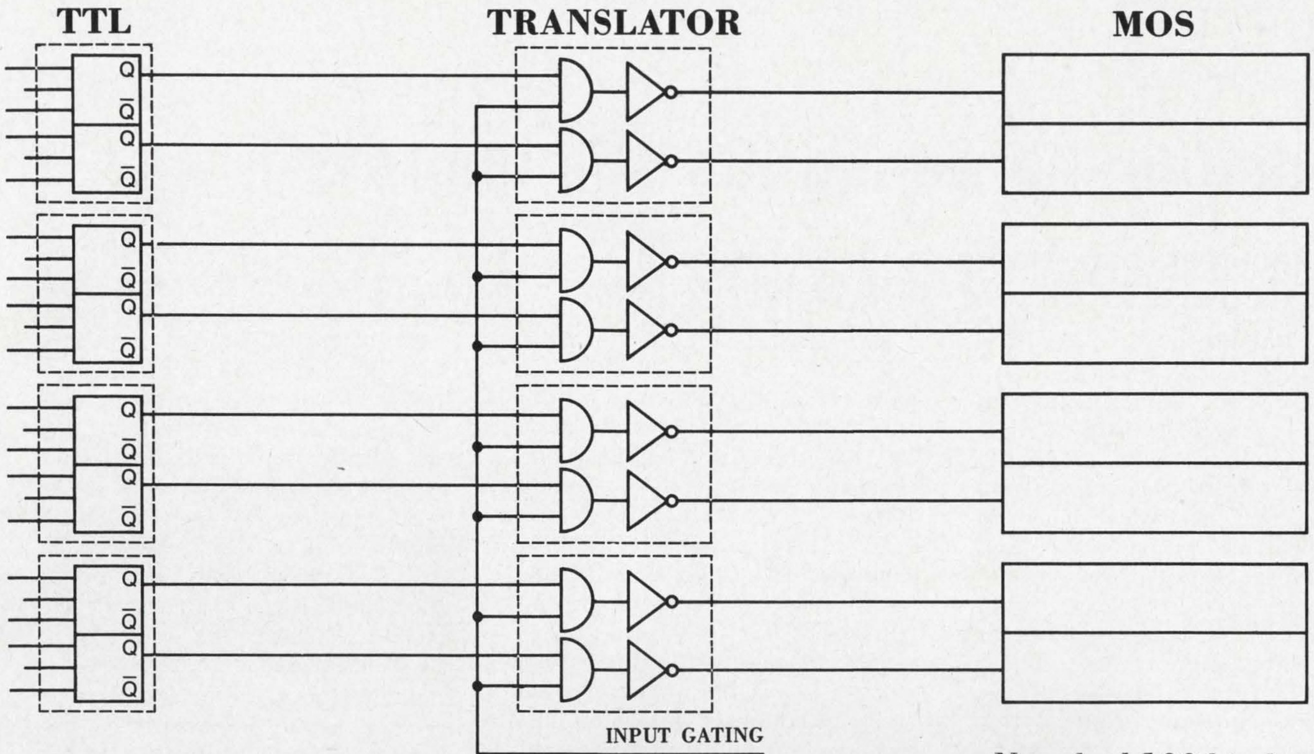
The company noted that the uniform photopolymer layers are from five to 20 times thicker than existing liquid resists and so provide clean, sharp side walls, and greater plating resistance and tolerance to surface defects than liquid types.

The resist is applied in a Du Pont automatic laminator which operates up to 10 linear feet a minute.

The clean copper-clad board is fed into the laminating machine in which the polyethylene film is stripped automatically from the film sandwich and the resist is applied under controlled heat and pressure to one, or both, sides simultaneously. The resulting sensitized surface is fully protected by a Mylar polyester film cover.

The negative-working photopolymer film is exposed through the Mylar cover through a suitable transparency in a vacuum frame. Exposures can be made with any conventional ultraviolet source.

Mating game:



New DM7501 dual JK flip flop used as a TTL shift register for an 8-bit word.
Monolithic.
Hermetically sealed.
SN5473 equivalent.
Price: $8.80 (100-999), $4.00 for commercial DM-8501 (SN7473 equivalent).
Immediate delivery.
Circle Number 105.

New DM7800 dual voltage translator to change bi-polar logic voltage levels to MOS logic voltage levels.
Monolithic.
Gated inputs.
Input voltage levels DTL- and TTL-compatible.
Output levels variable between +25V and −25V.
Price: $15.00 (100-999), $10.00 for commercial DM-8800.
Immediate delivery.
Circle Number 106.

New dual 100-bit dynamic shift register stores one hundred 8-bit words at 15¢ per bit in electronic "drum" memories.
1 MHz operation.
Price (100-999): $60.00; MM406 full temp, $30.00; MM506 commercial.
Immediate delivery.
Circle Number 107.

Data sheets, a list of distributors and a picture postcard of Niagara Falls are yours for the circling.
Or write: National Semiconductor Corporation
2975 San Ysidro Way
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National Semiconductor

Radiation-hardened ICs still unproved

Nuclear test ban treaty hinders research on effectiveness of new MOS microcircuits

Richard N. Einhorn
News Editor

The problem of hardening vulnerable microcircuits in ballistic missiles against radiation has not yet been solved satisfactorily, say the civilian microelectronics experts who are advising the Dept. of Defense. Vigorous efforts are under way to develop new microcircuits and to redesign old ones. The treaty banning atmospheric nuclear testing has made the solution agonizingly elusive, they say, because actual tests are needed to dispel any uncertainty.

The limitations of present microcircuits are, as the experts see it:

- The vulnerability of bipolars both to photocurrents generated by X rays and to neutrons; frequently reverse currents are catastrophic.
- The buildup of space charges under the gate of MOS devices. This buildup shifts the drain current vs gate voltage characteristics.
- Difficulty in fabricating monolithic junction FETs (more radiation-resistant than the other two), as well as their lack of versatility.

Recently the technique of dielectric isolation—separating microcircuits from the substrate with a thin layer of glass—has come to the fore because it limits photocurrents. Such companies as Radiation, Inc., Union Carbide, Texas Instruments and Fairchild Semiconductor Div. have taken an interest in dielectric isolation, although Autonetics has abandoned it.

But the most surprising development of all is the award of a contract by the Air Force to TRW Systems, Redondo Beach, Calif., for a prototype radiation-resistant memory and switching device based on TRW's dielectrically isolated metal-oxide-semiconductor (MOS) integrated circuits.

Why MOS? Why dielectric isolation? And what will dielectric isolation do for MOS?

To begin with, there's the novelty of dielectric isolation.

Experts like Trygve Ivesdal of Radiation, Inc., Melbourne, Fla. contend that it reduces stray capacitance effects in integrated circuits and is particularly important in maintaining the frequency response of bipolar devices.

More important from the standpoint of transient radiation effects, they say, is the elimination of ionization-induced photocurrents from substrate to surface by virtue of the 1000-volt breakdown strength of a glass barrier.

In addition the polycrystalline silicon used as the passive substrate conducts heat far better than single-crystal silicon, an important consideration in view of the thermal effects of X rays.

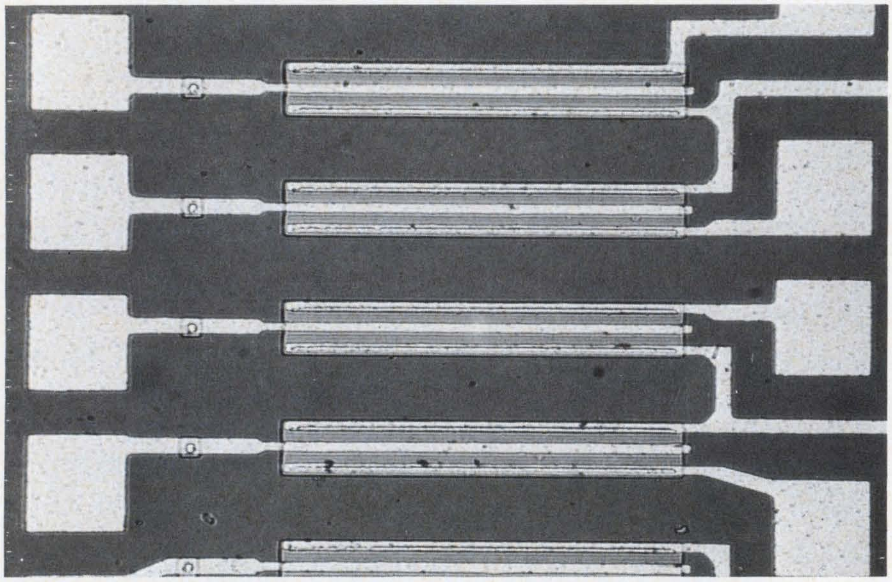
But many of these same experts say that MOS is inherently susceptible to damage because of the vulnerability of the oxide layer under the gate. At high radiation levels, ions are generated, and this can shift the conduction threshold through the creation of space charges at the silicon-oxide interface.

Dielectric isolation of MOS would be futile, these experts argue, since radiation would degrade the gate oxide long before capacitive coupling could be felt. They imply it would be like armor-plating the boots of a gladiator whose chest and abdomen were protected only by a cotton tunic.

Alan G. Stanley, a staff scientist at the MIT Lincoln Laboratory, has been studying insulated-gate field-effect transistors that have been irradiated. He doesn't think MOS transistors could withstand the steady-state ionizing radiation encountered in space.

"The gate turn-on voltage is enormously displaced—as much as 80 volts," he told ELECTRONIC DESIGN. "There are large leakage currents, and a positive charge builds up on the insulator." He did, however, concede that the dielectrically isolated MOS was protected against stray capacitance, which he has calculated to be "ruinous for transient radiation on the order of 10^{11} electrons."

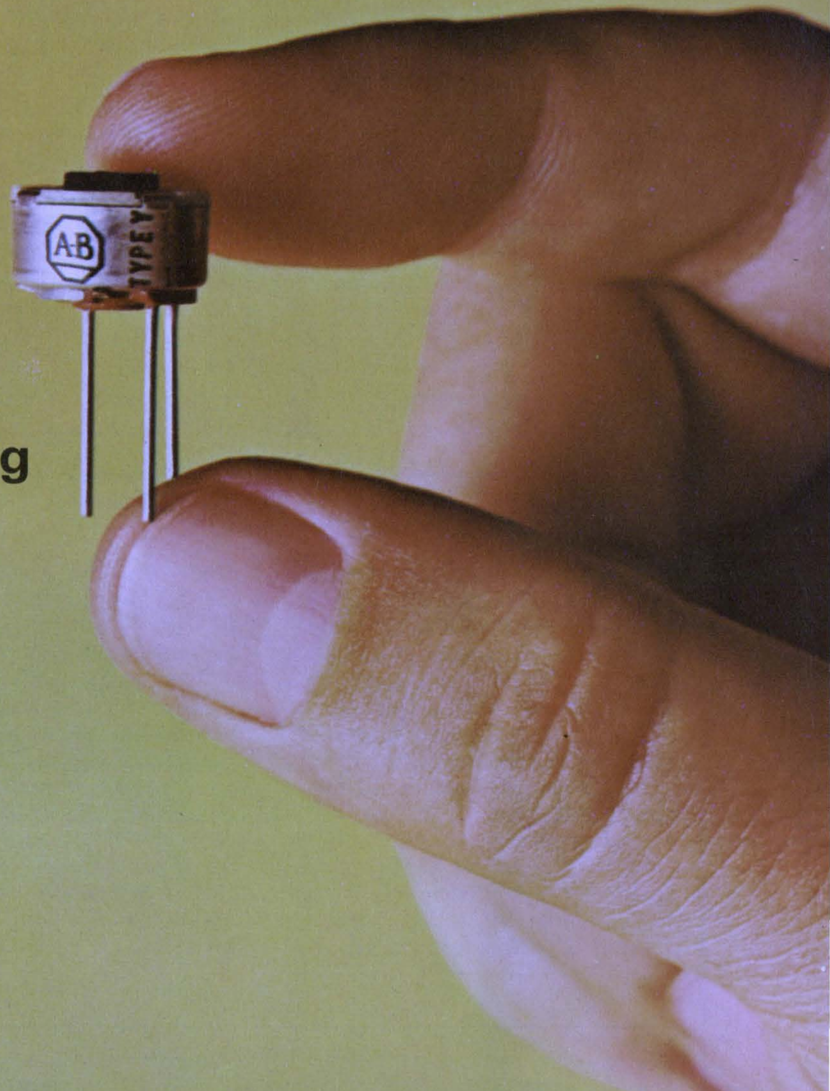
E. H. Snow, A. S. Grove and D. J. Fitzgerald[1] of the Fairchild Semiconductor Div. have studied



Dielectrically isolated MOS devices are used in five-channel multiplex switches fabricated on a polycrystalline silicon passive substrate by TRW Systems.

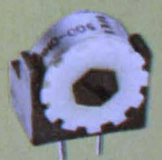
LOW PROFILE

hot-molded trimmer for close circuit board stacking



Basic Type Y unit shown actual size

With wheel for side adjustment



With attachment for horizontal mounting and wheel for side adjustment

With attachment for horizontal mounting

New Type Y single turn trimmer is especially designed for use on printed circuit boards. It has pin-type terminals for use on boards with a 1/10″ pattern. And the new low profile easily fits within the commonly used 3/8″ space between stacked printed circuit boards.

For greater operating convenience, the Type Y can be supplied with an optional thumb wheel for side adjustment, or an optional base for horizontal mounting, or both. The Type Y enclosure is splash-proof as well as dust-tight, and the metal case is isolated to prevent accidental grounding.

While featuring a new low profile, this new Type Y trimmer retains the popular Allen-Bradley solid resistance element, which is produced by A-B's exclusive hot-molding technique. With virtually infinite resolution, adjustment is smooth at all times. Being essentially noninductive, the Type Y can be used at frequencies where wirewound units are inadequate. The Type Y is rated 1/4 watt at 70°C and is available in resistance values from 100 ohms to 5.0 megohms. Standard and special tapers are available.

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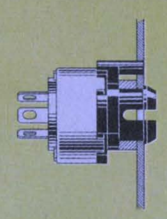


New Type Y with handy snap-in panel mount, supplied with spacers for use on panels up to ⅛″ in thickness

ALLEN-BRADLEY
QUALITY ELECTRONIC COMPONENTS

1067E-3

(**radiation,** *continued*)

the buildup of positive charge in SiO_2 layers in MOS devices. They have found that when the gate voltage is negative with respect to the silicon, there is litle change in the charge stored in the oxide. But with the reverse condition, positive charge builds up rapidly.

They surmise that the SiO_2 layer contains neutral traps that, upon irradiation, become positively ionized. Excited electrons drift to the positively charged gate under the action of the field in the oxide and are discharged. Since the silicon cannot supply electrons to the oxide, a positive space charge builds up at the SiO_2-Si interface. The charge falls off exponentially in the oxide with distance from the interface.

The proponents of MOS devices agree with this cataloging of the disadvantages, but they feel that bipolars are even more vulnerable to radiation and that steps can be taken that will improve MOS performance.

- Sprague Electric Co., North Adams, Mass., reports that radiation resistance varies with gate oxidation and the particular metals employed; by optimizing both, it is possible to create an MOS structure that survives radiation doses greater than 10^7 rads.
- The Westinghouse Molecular Electronics Div. claims that metal-nitride-oxide-semiconductors resist radiation better than MOS because silicon nitride (Si_3N_4) is denser than silicon dioxide.
- TRW Systems claims that MOS integrated circuits can withstand the transient radiation of weapons environments far better than bipolars. Furthermore, substituting nitrides for oxides and introducing impurities that permit rapid healing may reduce long-term damage, the company says.

The basic arguments for using MOSFETs in critical microcircuits have been summarized by Donald McWilliams and Lawrence Scott of TRW Systems:

- In a nuclear environment that does not cause catastrophic failure, most of the radiation passes completely through the device, but there is also secondary emission of prompt gamma rays. The photocurrent generated by the prompt gamma rays can easily destroy bipolar integrated circuits, because a current-gain mechanism is at work: beta times the primary current. With MOSFETs, on the other hand, only the primary current is involved. Junction FETs enjoy the same advantage but, because of their junction geometries, they do not lend themselves to integration into monolithic devices.
- Neutrons have less effect on MOSFETs than on bipolars because the former are majority-carrier devices.

Richard Weggener of Sperry Research Laboratories, Sudbury, Mass., amplifies upon this second argument as follows:

Neutrons displace atoms from their sites in the lattice. With minority-carrier devices, the result is the recombination of holes and electrons. This degrades beta dramatically and produces failure. With majority-carrier devices, the effect is to increase the resistivity. But since this is high anyway, it does not lead to immediate failure.

Weggener estimates that the lifetime of bulk-silicon minority-

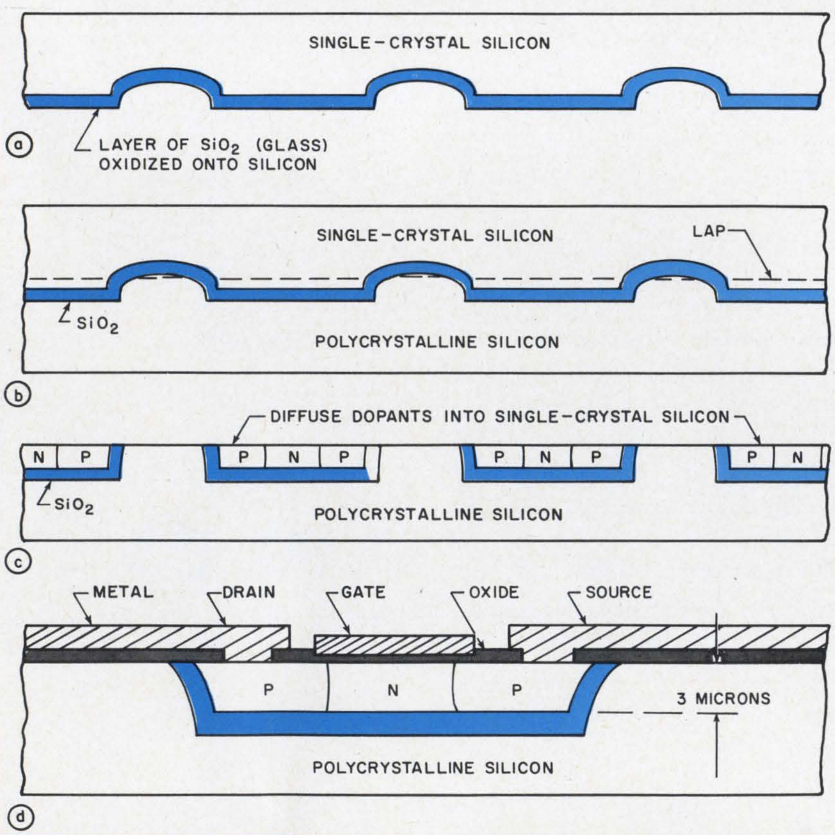
Glass isolates MOS devices

Dielectric isolation of MOS integrated circuits involves accurate lapping. First, a single-crystal silicon wafer is channel-etched, stripped and permitted to oxidize (a) until a thin film of silicon dioxide (glass) coats the surfaces of the channels.

Next, polycrystalline silicon is vapor-phase-deposited on the etched surface of the single-crystal silicon (b). Then the single-crystal silicon is lapped to just under the glass layer.

At this point, dopants are diffused into the pockets of single-crystal silicon that are isolated by the glass from the polycrystalline silicon (c).

The last stage (d) shows the p region of the drain and source with their associated metal contacts, as well as the insulated gate used to modulate the enhancement channel through the center, or substrate, n region. This substrate is distinct from the polycrystalline silicon substrate, from which it is isolated by glass.



(**radiation,** *continued*)
carrier devices degrades 1000 times faster than the resistivity of surface majority-carrier devices.

There is another advantage to MOS devices—their tiny size. Not only do they present a target an order of magnitude smaller than bipolars, but they are also more rugged mechanically and thermally.

Controlling resistivity helps

Weggener comments on the chief radiation problem confronting MOS devices—namely, the buildup of a considerable charge under the gate. He says that the amount of bias under radiation conditions depends on the rate at which the accumulated charge can leak off. Therefore radiation hardening of these devices would have to include the creation of a leakage path by the conductivity of the dielectric.

"So long as the RC constant is on the order of the frequency of the device, the charge can leak off," Weggener contends.

Harold Nigh of Bell Telephone Laboratories, Allentown, Pa., says that if a gate dielectric consisted only of silicon nitride it would serve better for radiation hardening than a double layer of oxide-nitride, since the oxide portion would still be more vulnerable. Stanley and Weggener concur.

According to Snow, Grove and Fitzgerald of Fairchild, not only is Si_3N_4 less sensitive to ionizing radiation than thermally grown SiO_2, but so, too, is silicon monoxide (SiO). The nitride shows less space charge buildup than SiO_2, and the SiO still less.

Wendell Noble of the technical staff of Sprague Electric Co., suggests several ways in which MOS devices can be augmented.

For one thing, he says, different metalizations as well as different oxides can be tried. For example, Sprague has protoype devices employing p-enhancement chromium.

"We have found chromium to be superior to aluminum," Noble says.

He adds that cleanliness is essential. Even dirty tweezers can contaminate an oxide.

"We test for shifts in the threshold voltage," he explains. "If there is no shift, then the oxide must be clean."

He cites experiments in which, at 250°C, there was a shift of only 0.1 volt in a 25-volt bias.

"What in the oxide really contributes to the damage?" Noble asks. He points out that X rays impinging on OS structures (without the metal) don't change the oxide structure. But with gamma emission of 2×10^7 rads, there is a 2-volt increase in threshold for negatively biased MOS.

Noble says that when MOS is irradiated, there is an increase in threshold that in most cases can be annealed out. The SiO_2 is not altered, and only the impurities that have intentionally been put into the oxide are affected.

"Most radiation passes through," he says. "Once in a while molecules of oxide ionize. Electrically it is equivalent to an applied signal. But if you introduce impurities into the oxides, there can be rapid healing of the damage—in microseconds."

Noble says that in the past, MOS devices with negative and zero bias have survived 10^7 rads but that those with positive bias have failed. He hints that Sprague may have a solution, but that he is not permitted to reveal it.

"We claim that oxides are hard enough to withstand the radiation environments associated with weapons," he says. "But to withstand neutron bombardment or long-range gamma rays, silicon nitride would have to be used rather than silicon dioxide."

Richard Cornelissen, a staff scientist in the Solid-State Sciences Laboratory of the Air Force Cambridge Research Laboratories says of the contract with TRW:

"We feel that this is a definite step forward."

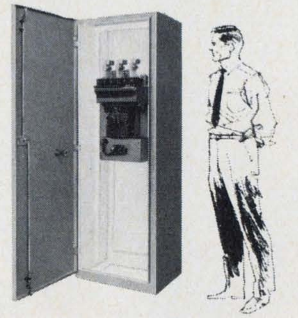
Cornelissen doubts that back-biased pn junctions can protect semiconductor devices. Dielectrically isolated MOS, he says, affords smaller junction area and reduced photojunction radiation. The TRW structures are only 34 μM deep.

The contract award doesn't prove anything, but neither can the TRW concept be dismissed lightly. ■■

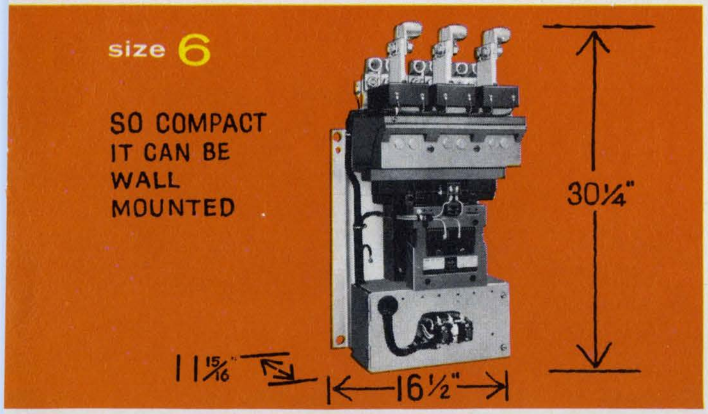
Reference:

E. H. Snow, A. S. Grove and D. J. Fitzgerald. "Effects of Ionizing Radiation on Oxidized Silicon Surfaces and Planar Devices," *Proc. IEEE*, LV, No. 7 (July 1967), 1168-1185.

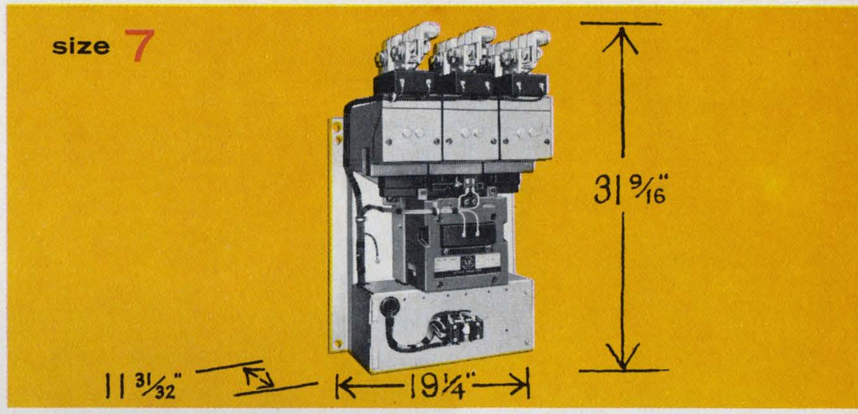
much higher ratings but the same simple starter design



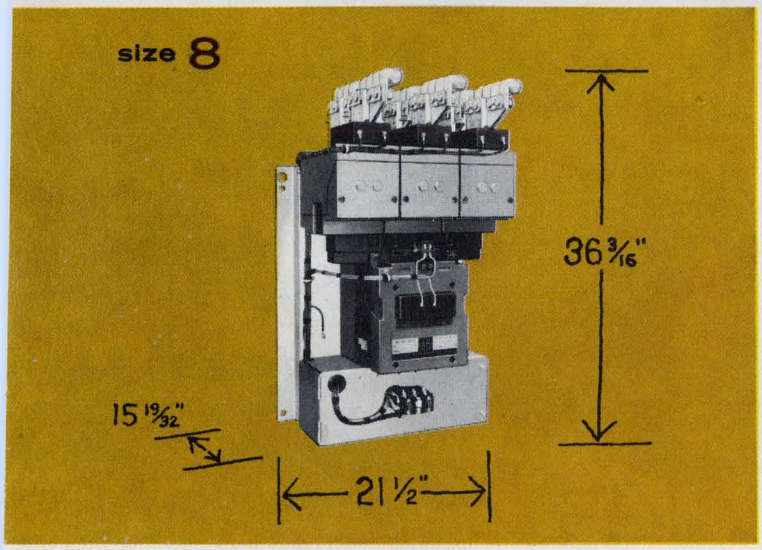
Allen-Bradley starters are now available up to Size 9!



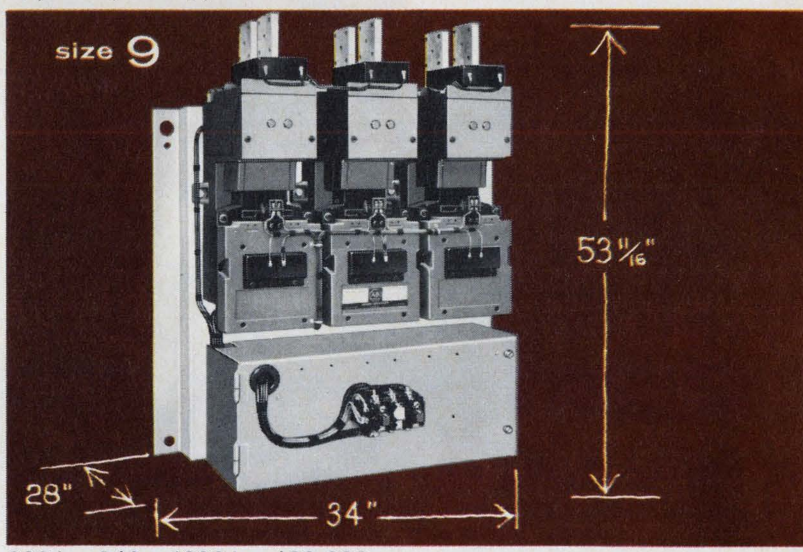
200 hp, 240 v; 400 hp, 480-600 v



300 hp, 240 v; 600 hp, 480-600 v



450 hp, 240 v; 900 hp, 480-600 v



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■ The addition of these four husky controls—completes the Allen-Bradley low voltage starter line—with a maximum rating of 800 hp, 240 v; and 1600 hp, 480-600 v. These larger starters are based on the famous A-B solenoid structure which guarantees unheard of life in starters of this size.

■ There is still only one moving part (one per pole in the Size 9)—the movable contact support that carries the heavy double break contacts and holds the contacts in precise alignment. The contacts are of weld-resistant cadmium oxide silver—no matter what the duty cycle may be, they never need service attention.

■ As with the smaller sizes, the magnets of these larger starters are cushioned to reduce impact and wear. A built-in air-gap remains permanent for the life of the starter—magnetic sticking can never occur. The pressure molded coils carry the same lifetime guarantee as applies for the lower Bulletin 709 starter ratings—and these large coils are not inexpensive.

■ In these larger starters a self-contained control circuit supplies rectified d.c. current for operation of the coil. An "economizer" reduces the sealed power input to the coil to less than 3 watts—it runs virtually cold in continuous operation.

■ As is so true with the smaller starters, you can depend on trouble free operation and long life from these higher ratings also. For complete details, please write: Allen-Bradley Co., 1344 S. Second St., Milwaukee, Wis. 53204. In Canada: Allen-Bradley Canada Ltd. Export Office: 630 Third Ave., N.Y., N.Y., U.S.A. 10017.

166M-7

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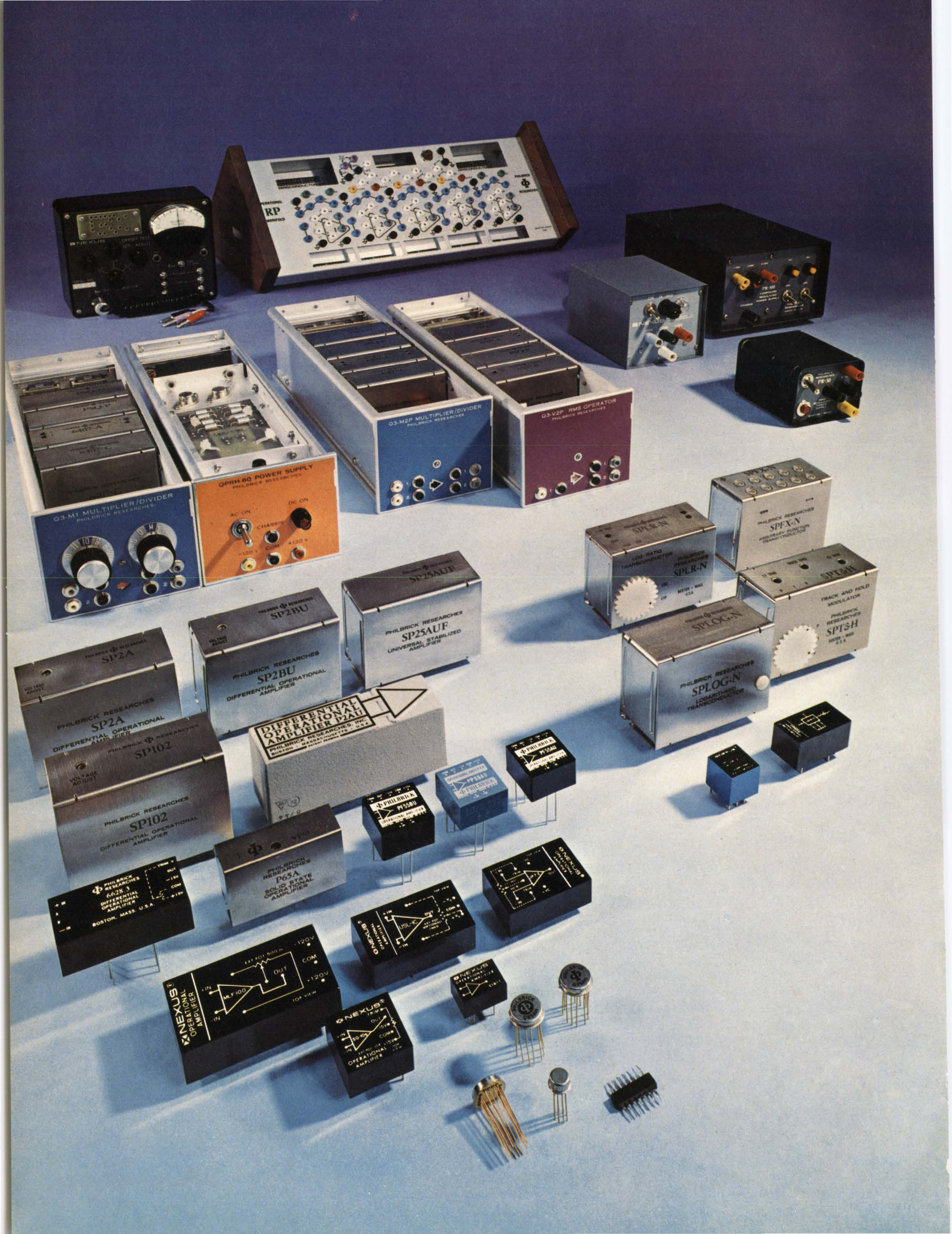
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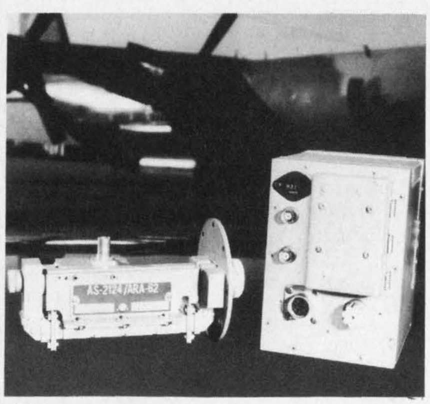
L band to help X band through rain

For years, rain has frustrated operators of ground-controlled-approach (GCA) radars, trying to get radar returns from an approaching aircraft with enough accuracy to talk the pilot down to a safe landing. To get the fine resolution needed to determine a plane's position within feet, the frequencies allocated to this radar lie between 9100 and 9200 MHz in the X band.

Unfortunately, transmission in X band is attenuated by heavy precipitation—often the very ingredient that has caused the pilot to need radar (see "Radar specs come with built-in headache," ED 1, Jan. 4, 1968, p. 22).

To obtain good resolution as well as penetration through rain, a technique has been developed by the U.S. Air Force Systems Engineering Group at Wright-Patterson Air Force Base, Ohio, and turned into hardware by the Airborne Instruments Laboratory Div. of Cutler-Hammer, Inc., at Deer Park, N.Y.

A receiver in the aircraft acts as a cross-link between the ground-based X-band radar and an L-band air-traffic-control transponder in the plane. Although weakened by having to pass through rain, enough of the ground-based X-band radar transmission gets through to trigger the transponder in the aircraft. The response is at 1090 MHz—an L-band frequency that doesn't provide the range accuracy that X band does but is not impeded by rain. The GCA operator on the ground receives the signal strong and clear.



Airborne transponder responds to X-band signals from ground-controlled-approach radar with L-band signals, in order to penetrate precipitation.

Later, when the aircraft gets closer, the X-band signals become strong enough to receive echoes from the aircraft itself and monitor it with the precision needed to put in on the runway.

Designated AN/ARA-62, and known as a beacon reinforcement adapter, the transponder consists of an antenna, which weighs less than one pound, and an amplifier-trigger pulse generator, which weighs less than five pounds.

The adapter is a big improvement over its predecessor, the AN/ARA-44, according to Airborne Instruments Laboratory. The new version is all solid-state, with extensive use of linear and digital microcircuitry, it has a packaging density 10 times that of the ARA-44, and it houses more than twice the circuitry of the older equipment in one-quarter the volume.

The system's video amplifier has a 75-dB dynamic range with a maximum input of 1.5 volts and a constant amplitude output of 2 volts. Since no existing microcircuit video agc amplifier was available that had both the required dynamic range and voltage swing, fixed-gain amplifiers were used with a MOSFET connector as a voltage-variable attenuator at the input of each video stage. The MOSFET gate-to-source voltage is controlled by a sample-and-hold agc circuit, which eliminates received beam-shape distortion by changing the agc voltage only after beam passage.

To aid maintenance, modular construction was used. A pass-band skirt frequency stability of better than ±0.01 per cent over full MIL temperature range is ensured by a highly stable Invar preselector with positive-lock tuning slugs.

Mean time between failures is expected to be 1000 hours. The first two of the seven units ordered will be delivered to the Air Force for testing early this year. ■■

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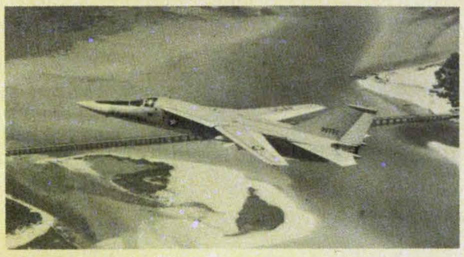
F-111 cuts could hurt industry



Washington Report

CHARLES D. LAFOND
WASHINGTON BUREAU

F-111 cancellation hurts both sides

The British have canceled their order for fifty F-111 jet fighters and with as much pain as honesty have assumed the posture of less than a second-class military power. As a result of its decision, Britain will ultimately pay contract cancellation fees of between $200 and $300 million, but will save nearly $1 billion. Since about 40% of the nearly $7 million that each aircraft costs is for electronics, a broad segment of the U.S. electronics industry is directly affected.

The long-term effect on General Dynamics will be attenuated by the fact that the order for F-111A fighters and FB-111A fighter-bombers anticipated from the Pentagon is expected to amount to about 1300 aircraft. At present the Air Force has been authorized to spend $972.3 million on the F-111A during fiscal year 1968. That includes $10.9 million left over from last year's authorization. Another $501.9 million has been authorized for procurement of FB-111A bombers including $1.2 million carried over from fiscal 1967 funds. The Navy has been authorized in fiscal 1968 to buy only eight F-111B aircraft for evaluation purposes.

Loss of the 3000-mile-range aircraft from Britain's planned inventory leaves that country with a strategic strike capability of four Polaris-type nuclear submarines and some old Canberra and Vulcan bombers. One question unresolved is whether Britain will buy its planned 200 F-4 Phantom jets from McDonnell-Douglas. It is reported to be so far committed on this procurement however, that cancellation penalties would negate any significant dollar savings.

Contractor guidelines due from Pentagon

Within the next three months, the Dept. of Defense will issue guidelines on the accounting information required from military contractors. Under a proposal released last June, contractors could have been required to redesign their military-contract accounting completely in order to meet highly detailed government requirements. In the meantime, however, the Council of Defense and Space Industries Association (CODSIA) has intervened and prevailed on the Pentagon to tone that proposal down. The result, according to Pentagon officials, is that the Pentagon will accept any adequate existing system as long as it provides all the information required.

The new system, developed largely by CODSIA over the last two years, will be contained in DOD instruction 7000.2. It governs all contracts of $100 million or more for production and $25 million or more for research, development, tests and evaluation. Fixed-price contracts are specifically excluded. Subcontracts will be subject to the new provisions when there is agreement to this effect ahead of time between the prime contractor and the responsible military service, or when the Pentagon classifies the program as critical.

New landing system to be developed

A new concept for a precision approach-and-landing guidance system, together with its associated electronic signal structure, is to be developed for the aircraft industry, according to Alexander W. Wuerker, Chairman of the Radio Technical Commission of Aeronautics (RTCA). A special committee of RTCA, a nonprofit organization of government and industry aircraft-electronics users and manufacturers, has been set up to investigate a possible successor to the aircraft instrument landing system now used by the military, the airlines, and other instrumented aircraft. A cross section of U.S. commercial and general aviation experts will be polled for suggestions for such a system. Contributions will also be sought from the U.S. military and from foreign organizations, Wuerker said.

The committee will first seek to develop on paper the "operational needs against which any new, precision approach-and-landing guidance systems must be judged," said Wuerker. Following this, it will study all proposed techniques and try to develop common agreement on a universal signal structure. The system sought, according to Wuerker, is one that can be scaled down for a low-cost facility at small airports or temporary fields but with an over-all configuration that would still satisfy the exacting civil and military requirement of the Seventies. Some industry experts say that if agreement can be reached on a satisfactory system within the next two years, the first hardware would probably be built for the military in the mid-Seventies. Large U.S. airports would presumably follow shortly thereafter.

U.S. electronics for the Concorde

Seven U.S. firms are subcontractors contributing to the Anglo-French Concorde supersonic-transport development. At the present time, they include: Bendix Corp.—automatic direction finder marker receivers and vertical speed indicators; Collins Radio Co.—high-frequency communication subsystems; Hamilton Standard Div., United Aircraft Corp.—air-conditioning heat exchangers; International Wilcox Electric Inc.—air-traffic control transponders and vhf communication subsystems; Sperry-Rand Corp.—loran-C navigation subsystems; TRW Inc.—design, development and continued engineering services for the magnetic flight-test recorder system. Other U.S. firms, such as Litton, may be associated with the program through foreign licensing arrangements.

NASA studies northern lights

NASA scientists last month began an extended study of the aurora borealis, the arctic air glow, using instrumented aircraft from the Churchill Research Range, Churchill, Man. About 12 missions will be flown in coordination with a series of high-altitude sounding-rocket launchings from Churchill and with the orbiting geophysical observatory satellite, OGO-IV. From a Convair-990 jet, measurements will be made above the Churchill area and cross-country to Fairbanks, Alas. and Thule, Greenland. The aircraft will carry a variety of experimental equipment, including spectrometers, photometers, wide-angle cameras and radio receivers. An on-board magnetometer will measure magnetic-field activity in the polar region.

The object of the study is to better understand the causes of the auroras. It will be the most comprehensive scrutiny ever made of the phenomenon, NASA scientists declared. The influences of solar-produced cosmic rays entering the Earth's atmosphere at the poles and the natural dumping of electrons and protons from space into that region will be examined. A better understanding of the causes of northern lights may elucidate the radio communications blackouts that occur not only in the arctic region but also sometimes thousands of miles below the poles in association with the auroras.

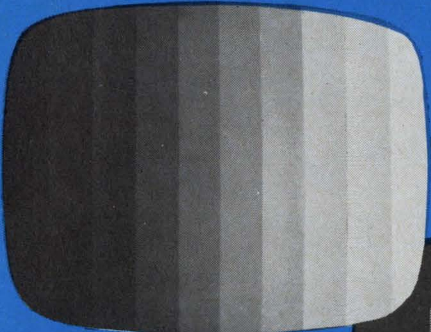
RCA to build moon laser locator

A gallium-arsenide injection-laser transmitter is to be developed for NASA by the RCA's Astro-Electronics Div., Princeton, N.J., for possible use by Apollo astronauts on the Moon. Under the recently awarded $125,000 contract, RCA will build an experimental 30-lb laser transmitter measuring 18 × 14 × 10 inches plus a smaller associated electronic subsystem. The range of the device, which will be tested in the U.S. western desert region, will be about 700 meters.

The laser transmitter is intended for use in tracking exploring astronauts and in surveying the lunar surface, NASA said. Essentially a ranging device in which a beam is reflected back to the source from the astronaut or lunar exploration vehicle, the transmitter is to have an accuracy of less than 1 meter for ranges up to 5 miles.

Integrated-circuit sales soar

Semiconductor integrated-circuit sales continue to spiral upward with a 59% dollar increase and a whopping 134% unit increase during the first ten months of 1967 compared with the same period in 1966. In its latest tabulation of U.S. sales, the Electronic Industries Association reports January-October, 1967 IC sales of $183 million ($116 million in 1966)—a total of nearly 52-1/2 million units (nearly 22-1/2 million in 1966). The dollar increase occurred despite a 32% decline in average unit values, EIA said.



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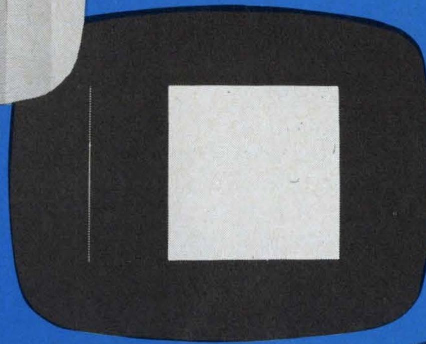
New Patterns of Performance



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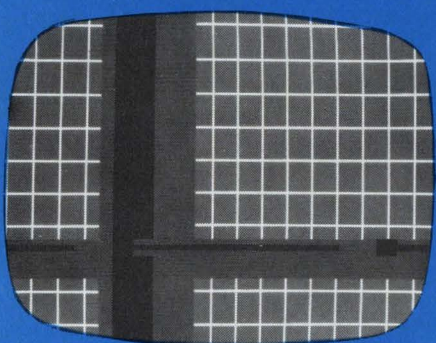

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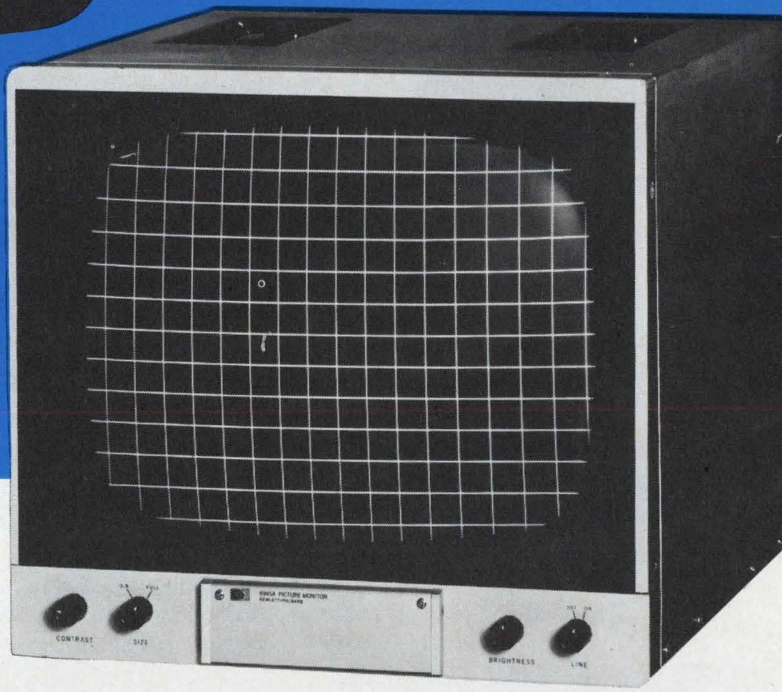

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COMMUNICATION INSTRUMENTS

Letters

Designers tend to reinvent the wheel

Sir:

I'm afraid neither the idea for design of R. S. Hughes ["Idea for Design is not original," ED 1, Jan. 4, 1968, p. 48] nor that of T. M. Jarvis ["Get sharp edges from an astable multivibrator waveform," ED 19, Sept. 13, 1967, p. 128] is original. Most of the pulse-circuit ideas shown in your Ideas for Design section are not original. They are generally an adaptation of the vacuum-tube version that was invented many years before.

It would be well if the budding young circuit designers would read *Waveforms* by Chance, Hughes, MacNichol, Sayre and Williams in the "MIT Radiation Laboratory Series" (Lexington, Mass.: Boston Technical Publishers, Inc.). The speed-up by using an active device in the feedback circuit or a disconnect device, they will see in that monumental volume, is now 20 years old. It has been published many times since as original, and no doubt such "new ideas" will continue to be reinvented.

K. E. Wood
Severna Park, Md.

Government should tell more about its projects

Sir:

Mr. Germann's letter in your January 4, 1968, issue remarks about overstaffing and deadwood in Government agencies [see "Government agencies should fire deadwood," ED 1, p. 50].

After spending 14 years at the Naval Ordnance Laboratory and the National Bureau of Standards, plus 11 years in private industry—all as an electronic engineer or supervisor—I have had to conclude that there is no real difference between the quality of the engineers in government and in industry. There are geniuses in government and bums in industry, and vice versa.

When we talk about government deadwood, we have to ask, "What are the government engineers assigned to do?" If they really don't have to get anything done, then they should all be fired. But if they have a lot to do, then there should be enough engineers to get it done.

The point of this is: none of us knows enough about what the real tasks of the government agencies are, what they have to get done.

I vote for better disclosure by the Government of what its projects are, and how they are staffed. Some projects, in my experience, were of real importance, others were obsolete and others were plain boondoggles. But without knowing the job, we can't talk about the manpower.

Lawrence Fleming
President
Innes Instruments
Pasadena, Calif.

Government control cannot solve problems

Sir:

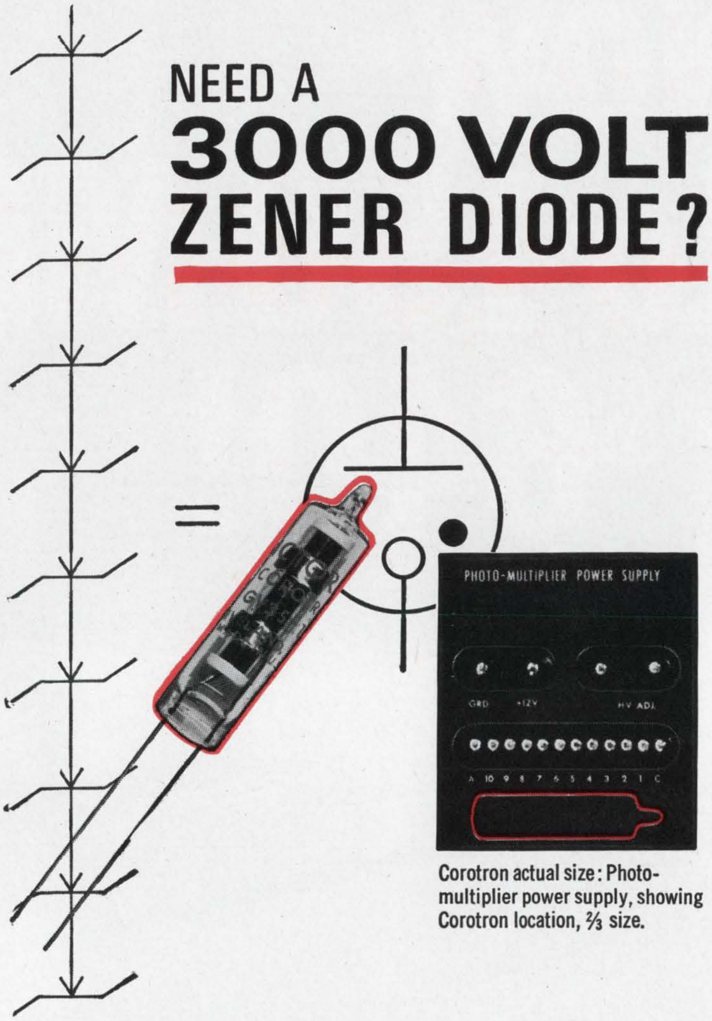
I would like to comment on your editorial "The great American brain drain: It's time to stop," ED 22, Oct. 25, 1967, [p. 61].

The basic premise of the editorial is that all problems should and could be solved by means of government-administered public projects and the only questions left for discussion are which public projects should be given priority, and how can these projects be run without waste, inefficiency and graft.

However, it is not axiomatic that it is the proper function of government to take over control of the efforts, earnings and lives of the citizens and distribute them as it thinks fit. It has been demonstrated both in theory and aeons of historical and present practice that this can lead in the long run only to economic chaos, poverty and social demoralization.

Problems can only be solved by the application of free minds to their solution—and to be free means to possess the right to act according to the independent judgement of one's mind. The proper function of the government in a

NEED A 3000 VOLT ZENER DIODE?



Corotron actual size: Photomultiplier power supply, showing Corotron location, ⅔ size.

You *could* string together several hundred zeners. Or you could specify *one* Victoreen Corotron. It is the gaseous equivalent of the zener with all the advantages of an *ideal* HV zener diode.

For space research and other rugged applications requiring absolute power supply stability, GV3S Series, shown, provide the ideal reference voltage anywhere in the range of 400 to 3000 volts. They enable circuitry to maintain constant high voltage regardless of battery source voltage or load current variations. Cubage and weight (GV3S Corotron weighs only 4 gm.) are important considerations. So is temperature variation (Corotrons operate from 200°C down to -65°C). Ruggedized versions withstand shock to 2000 G, vibration 10 to 2000 cps.

If you're trying to simplify circuits . . . to cut cost, size and weight . . . to upgrade performance—you need Corotron high voltage regulators. Models are available now from 400 to 30,000 volts. A consultation with our Applications Engineering Dept. will speed up the countdown.

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INFORMATION RETRIEVAL NUMBER 32

free society is to make this possible by protection of the individual's inalienable rights to life, liberty and the pursuit of happiness. It does this by means of the law courts, the police force and the armed forces. The rest is up to individual initiative and voluntary cooperation. There is no way to have the benefits of freedom, which in the political context means freedom from coercion and violence, without having freedom itself.

Bernard S. Super
Elmhurst, N.Y.

Corrected reprint on gateless counting

Author Peter Duryee, who informed us that he had made errors in his article "Counter designs swing without gates," ED 25, Dec. 6, 1967, pp. 82-88, after it had been published, has now revised it. His revisions are based on new research that aimed to set right the inaccuracies noted in this column in ED 2, Jan. 18, 1968, pp. 65-66. A reprint of the complete article, incorporating all his corrections and Table 2 omitted from the original published version, is available to readers who circle Information Retrieval Number 250.

Accuracy is our policy

In "Gated amplifier uses FET in feedback loop," in the Ideas for Design section of ED 1, Jan. 4, 1968, p. 140, make the last three lines of the second paragraph read: ". . . highest R_{on} is 500 Ω. The new voltage gain is then 500 Ω/10 kΩ or 1/20. Thus a voltage gain reduction of 300 to 1 has been effected." This corrects the value of R_{on} from 5 kΩ to 500 Ω, and the corresponding mathematics. In Fig. a the value of R_{on} should be 500, not 5k as printed.

In " 'Fence' in sky keeps an eye on space objects," ED 1, Jan. 4, 1968, pp. 33-35, the name of the prime contractor for the AN/FPS-85 was omitted. It was the Bendix Communications Div. of the Bendix Corp., Baltimore.

INFORMATION RETRIEVAL NUMBER 33 ►

Plumbing the ocean depths

Man is pushing deeper into the sea and staying there for longer periods. But, so far as the national effort is concerned, oceanography is still a stepchild when the spending money for research is doled out. To find out why this is so and what the needs of oceanography really are today, ELECTRONIC DESIGN assigned two editors at opposite ends of the country to dig for facts.

Ron Gechman hoisted editorial antennas and swept the West Coast; Neil Sclater did the same in the East. After zeroing in on targets in person, they have come up, between them, with a most interesting report, starting on page 25. It includes a face-to-face talk with Cmdr. M. Scott Carpenter, the astronaut turned aquanaut.

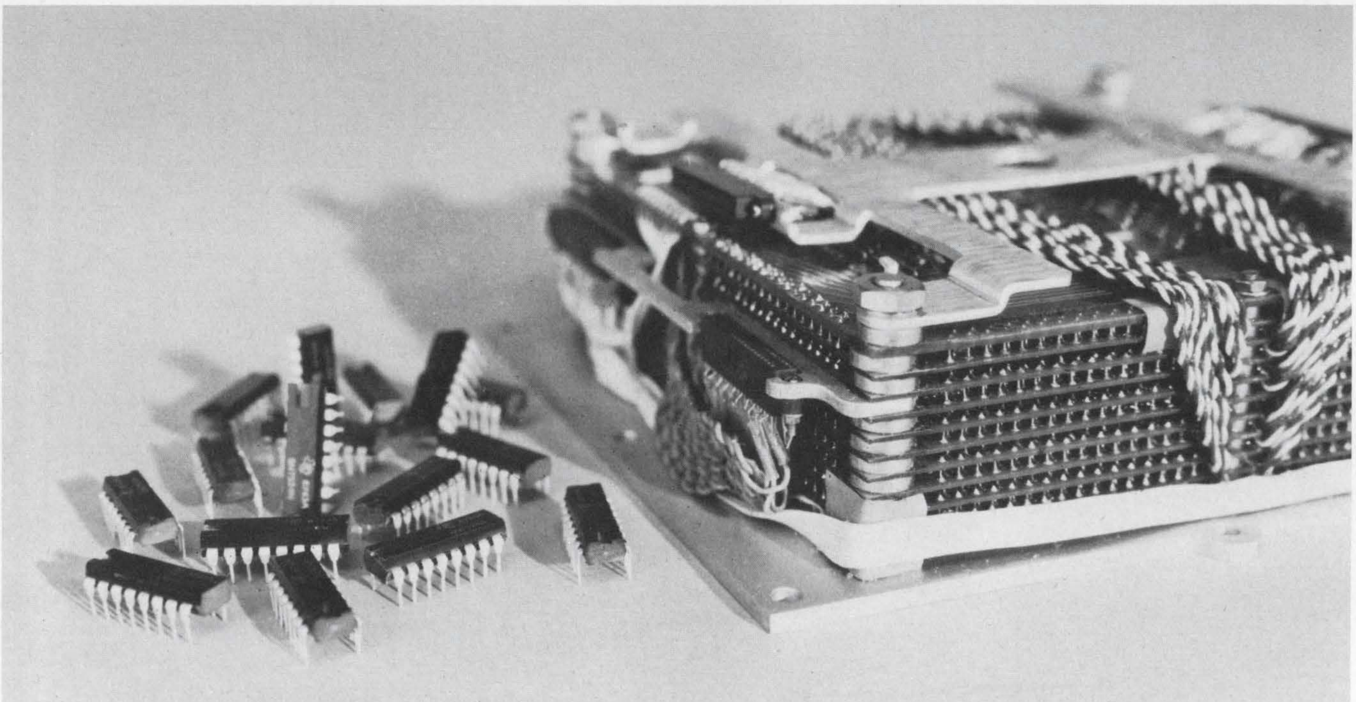
He counted three areas where electronics designers can do a vital job: in undersea communications, life support and navigation. Sealab III is collecting data to help the designers but the biggest obstacle remains money.

Comdr. M. Scott Carpenter talks about undersea research.

Don't miss issues of the magazine

Have you just changed jobs, or are you about to move? If so, here's a tip on how to get your subscription to ELECTRONIC DESIGN changed with the least delay. Include your old address label with your address-change form. The address-change form, on which there is space for you to paste your old mailing label, is attached to the Information Retrieval Service cards inside the back cover of most issues. Without your old address label, your previous subscription data cannot be located, and your address-change form has to be treated as a new application. Then, since our subscription-renewal requests are presently running at about 98.2 per cent, you might have to wait some weeks to get back on the subscription list.

Half as many do a better job



Sixteen new TI sense amplifiers do the job of 32...with higher speed, faster overload recovery, better noise margin

Dual preamps make it happen! These 16 new SN7524N circuits from Texas Instruments will interface this 4096-word, 32-bit memory with TTL or DTL logic sections. This means a reduction of more than one third in component and assembly costs.

But that's not all. This advanced family of *six* new Series 7520N sense amplifiers offers you superior performance through a unique "matched amplifier" design. Propagation delay is only 25 nsec, overload recovery time is only 20 nsec, and noise margin is one volt.

The d-c coupled circuitry is based on matched resistor ratios rather than absolute values to give virtually drift-free performance. And unlike reactive-coupled circuits, problems of overload-recovery time and threshold shift are all but eliminated.

Want to know more? Just circle 165 on Reader Service card for data sheets and this new 82-page bulletin which details operation and use of Series 7520 sense amplifiers. If you prefer, just phone your TI sales engineer or authorized TI distributor.

TEXAS INSTRUMENTS
INCORPORATED

EDITORIAL

Who knows how important the electronics engineer is?

Few human events have captured the public's interest as keenly as the recent heart transplants. Yet how many people know of the vital role that the electronics engineer has played in making possible the transplant of hearts and other human organs?

The newspapers have published much about the operations, the doctors, the patients, the donors. Little has been written about the role of the engineer.

Much of the equipment used in the transplants involves electronics. One such piece of equipment is the intraarterial cardiac-assistance device, an electronically controlled balloon pump that provides temporary assistance for a patient's old, failing heart and assists the new organ. Without this and other electronic equipment, the heart transplant in all probability would not have been possible.

Does the public know this?

You may ask: "What's the difference whether or not the public knows?"

If you ask the question contemptuously, you are not entitled to complain that the engineer lacks professional standing in American society (many engineers feel that he does and unjustly so).

To its credit, the National Society of Professional Engineers is attempting to alter the situation. Among its activities is National Engineers Week, an annual, major public-relations program to promote the engineering profession. The society readily acknowledges the cooperation of industries and other engineering societies in promoting observance. From Feb. 18 to 24, this year's theme will be "Engineering . . . Design for World Health." The participants will focus on the contributions of engineers in finding solutions to world problems of health, pollution and hunger.

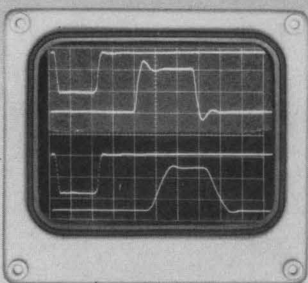
While NSPE deserves praise for sponsoring this public-relations program, the question remains: Why should the engineering profession wait for only one week a year to put its best public-relations foot forward?

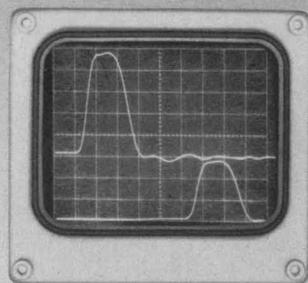
If the engineer is truly concerned with enhancing his profession, such efforts should be conducted year-round. Let's use the society's theme as a case in point. The world of engineering has done much to benefit world health. Yet where was the medical electronics field when it came to publicizing its role and the role of the engineer in the recent heart operations?

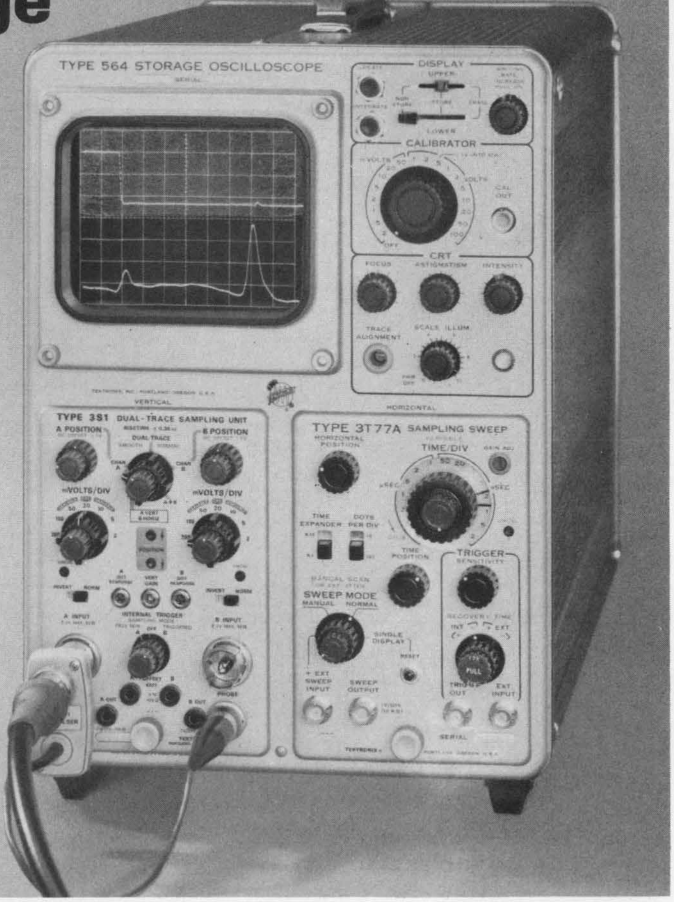
Is your company doing something to solve the problems of air and water pollution? Or is it working on any other engineering projects of great value to society? If so, ask why it hasn't been more vocal in publicizing its accomplishments. If your engineering society has not spread the word effectively, ask its leaders why they have not been more aggressive.

HOWARD S. RAVIS

Tektronix sampling oscilloscope features split-screen storage







Before-after

With sampling and split-screen storage, you can compare your fast risetime input and output signals, before and after circuit modifications. Store the original waveforms on the upper half of the display and compare the new waveforms with the original.

Low repetition rate

Analyze low repetition rate, fast risetime pulses with split-screen storage and dual-trace, 350-ps risetime sampling plug-ins. The display is two, 2-ns wide pulses from a 60-Hz generator. Signals can be stored for up to one hour.

TDR

Using the Type 281 Time-Domain Reflectometer Pulser, the total length of the transmission line is stored on the upper half of the display. The lower display is a magnification of the transmission line discontinuity. (Waveform shown on oscilloscope.)

Type 281 Pulser (order 015-0060-00) . . . . $ 95
($T_{rise} \leq$ 750 ps, $\approx$460 mV into 50Ω)

The Tektronix Type 564 split-screen storage oscilloscope with the Type 3T77A sampling time-base and the new Type 3S1 dual-trace sampling vertical is a DC-to-1 GHz measurement system with the unique capabilities of split-screen storage.

The Type 564 storage oscilloscope is virtually two instruments in one, offering all the advantages of a split-screen storage oscilloscope, plus those of a conventional plug-in oscilloscope. The contrast ratio and brightness of stored displays are constant and independent of viewing time, writing and sweep speeds, or signal repetition rates. The entire screen or either half can be used for storage and/or conventional displays. In the stored mode, either half of the screen can be erased independently of the other half.

The new Type 3S1 is a dual-trace sampling plug-in that has two identical amplifiers with 350-ps risetime and DC-to-1 GHz bandwidth. The 50-Ω verticals feature a 2-mV/div to 200-mV/div calibrated deflection range and built-in delay lines that provide internal triggering. A complete selection of probes is available, providing minimum high-frequency loading.

The Type 3T77A sampling time-base has a calibrated sweep range from 10 μs/div to 200 ps/div, extending to 20 ps/div with the X10 magnifier. It features internal or external triggering from 30 Hz to 1 GHz on pulses and from 100 kHz through 1 GHz with sinewaves. Time positioning provides a sweep delay range corresponding to at least one screen diameter. Manual scan and single display modes permit full use of the Type 564 split-screen storage capability.

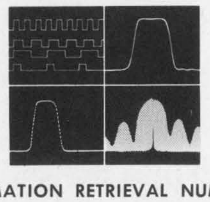
For a demonstration, contact your nearby Tektronix Field Engineer or write: Tektronix, Inc., P. O. Box 500, Beaverton, Oregon 97005.

Type 564 Storage Oscilloscope	$ 925
Type RM564 Rack-Mount Oscilloscope (7" high)	$1025
Type 3T77A Sampling Time-Base Plug-in	$ 690
Type 3S1 Dual-Trace Sampling Plug-in	$1150

U.S. Sales Prices FOB Beaverton, Oregon

TEKTRONIX

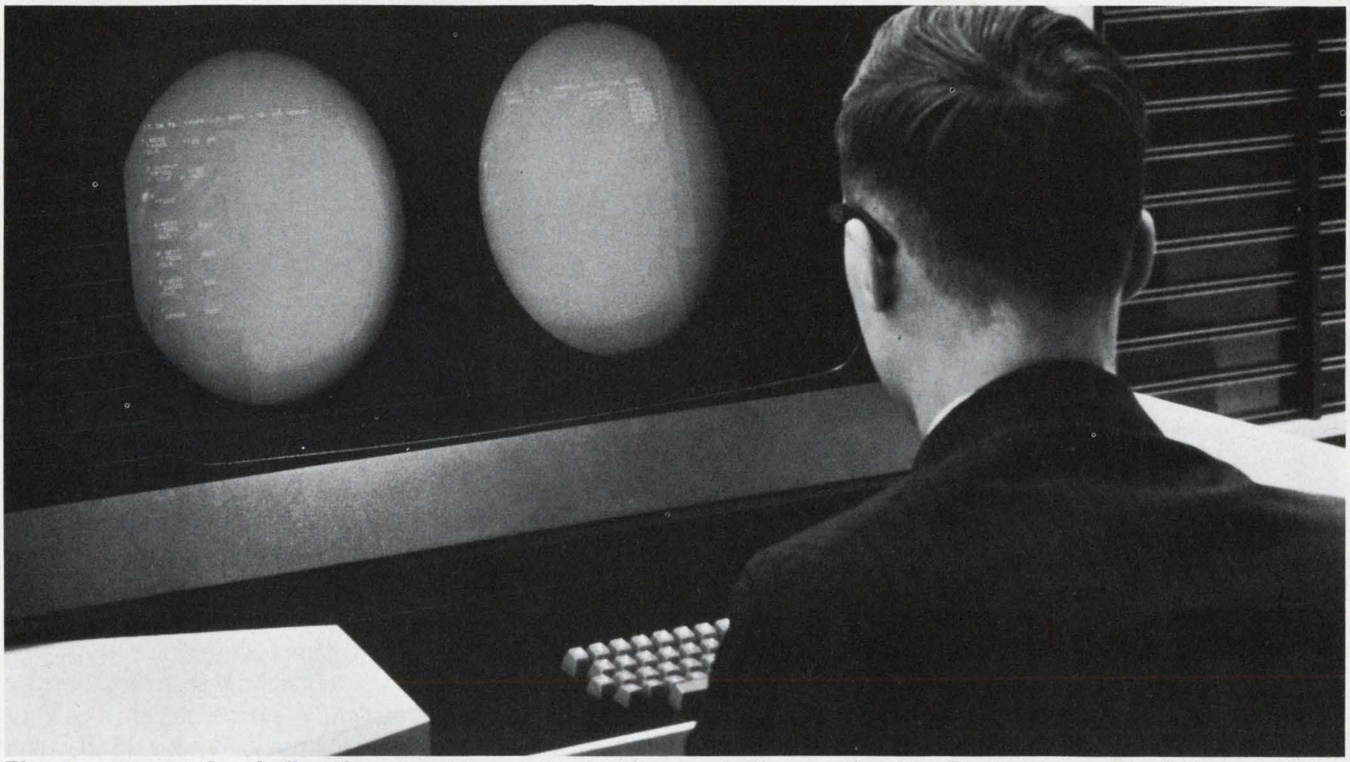
Conventional or storage oscilloscopes



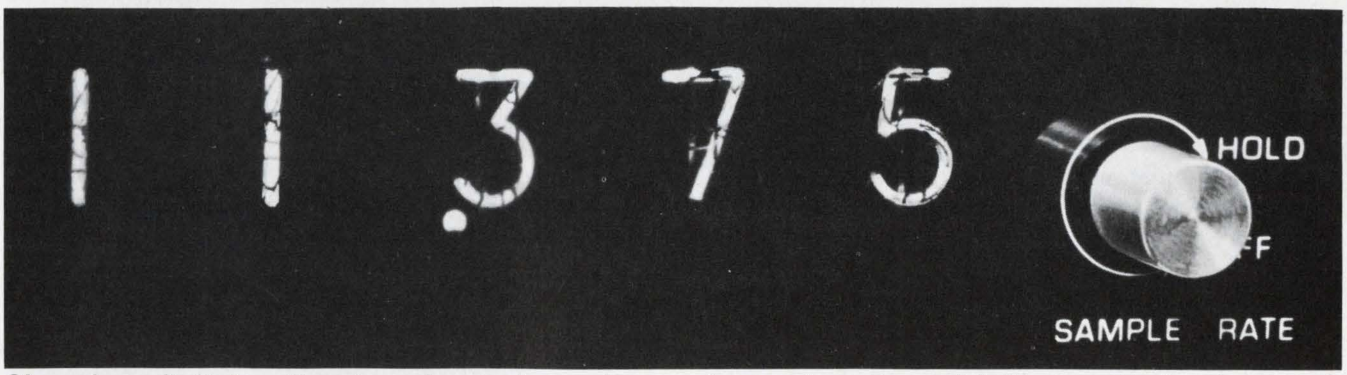
...with multi-trace, differential, sampling and spectrum analyzer plug-ins

INFORMATION RETRIEVAL NUMBER 36

Technology



Electromagnetic deflection systems are better for alphanumeric displays than electrostatic methods. For parameter interrelationships and simple equations, turn to p. 66



Choosing digital voltmeters is made easier if the method of analog-to-digital conversion is used as the guideline, so that selection is made among five broad categories. Page 76

Also in this section:

Try estimating to check out circuit designs

A 'shot in the dark' plus successive approximations can solve circuit problems rapidly and accurately.

Circuit designers now have more tools than ever before. And as new ones become available, it is all too easy to set aside old and tried methods. So, like a sledgehammer to crack nuts, sophisticated computer analysis programs are being used for simple circuits with perhaps no more than a dozen elements.

Do not apply complicated methods to the solution of simple problems. The simple approach may not only turn out to be faster but may also give insights that the computer cannot. The rush to computer-aided design, for instance, has tended to obscure the value of the straightforward method of successive approximation.

This method is not the panacea for all the designer's ills, but it is one of the many tools that he should keep well honed and handy. One of its principal uses is in deciding whether certain simplifying assumptions are justified. Everyone likes to solve problems quickly and easily, but there is always the chance of oversimplifying analysis in the quest for a speedy, uncomplicated answer to a problem. In such cases as this, guessing gives a more exact solution, which can then be used to check the simple method. Properly used, successive approximation can be one of the fastest and most versatile procedures at the designer's disposal.

Use approximations for nonlinear circuits

This procedure is especially valuable in analyzing circuits that contain nonlinear elements. Most engineers are happiest dealing with constant-voltage or constant-current sources, for with these there is little problem in establishing the circuit equations and solving for the currents in all the branches. A constant-voltage source in series with a fixed resistor involves only drawing a straight load line on the characteristic of the nonlinear element.

What is harder is when the source is not purely constant voltage or constant current. If the voltage from a source varies arbitrarily with current, there is no straightforward way to plot its relationship with a known nonlinear element. Guessing, however, is quite easy.

Only the first shot is a guess

As an illustration, consider a battery, a resistor and a diode connected in series (Problem 1). The battery voltage is ordinarily assumed to be fixed and even the forward drop across the diode may at times be ignored. But if both components are in fact nonlinear and their characteristics are available as *EI* curves, guessing is probably the quickest way to an exact solution. Even a wrong guess yields some information, and since the second guess is based on the results of the first, only one shot is taken in the dark.

Another simple example is two or more diodes in series or in parallel. Were the diodes identical, this would be trivial. It becomes meaningful under the realistic circumstances where the diodes' characteristics are known only to fall within the area of two limiting curves (Problem 2).

Try estimating for digital circuits

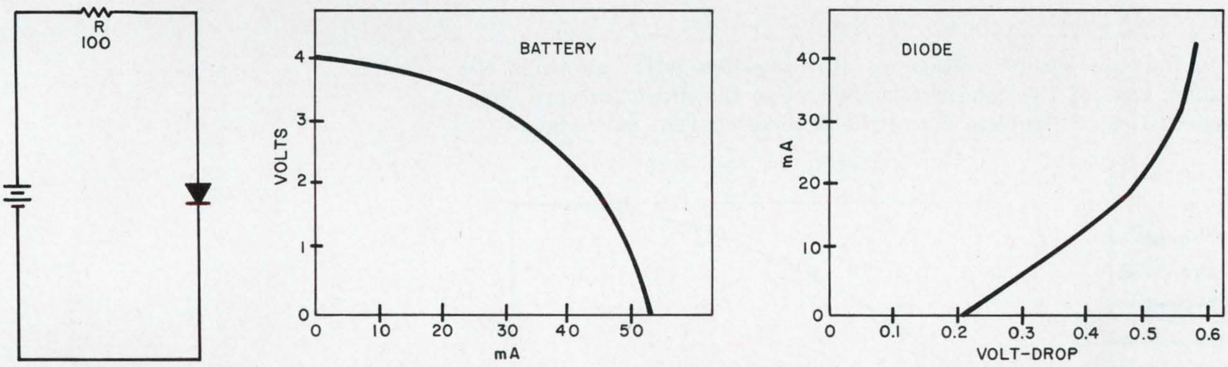
Diode gate circuits are a little harder, but their worst-case conditions are generally easy to determine by inspection. Take, for instance, the six-input, positive AND circuit in Problem 3, where the reverse current is found to be relatively small and constant. This simplification allows the problem to be solved by drawing a load line, but after taking two guesses to find it out, it is probably just as easy to continue guessing.

Multiple-level diode gating is slightly more complex (see Box). Yet it is necessary only to guess the output voltage and then determine whether it differs from the right answer. The truth table shows that it is enough to check just two of the 16 possible input combinations—guessing here is a two-stage process. With an assumed value of output voltage, the voltages at junctions J and K are also determined by trial and error.

Gerald D. Smoliar, Staff Engineer, Radio Corp. of America, Camden, N.J.

PROBLEM 1:

Find the operating point when the *EI* characteristics of the battery and the diode are as shown. Resistor *R* is fixed, but the problem is little more complicated if it varies with current.



SOLUTION 1:

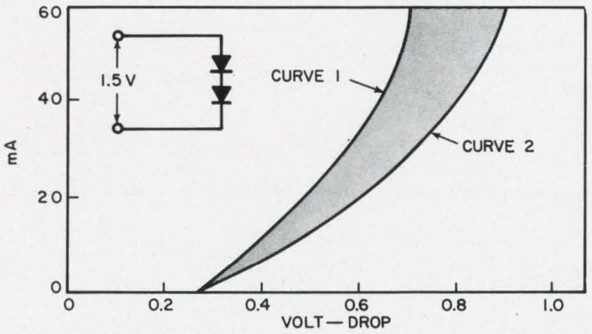
A possible approach is to guess at the current and see whether the battery voltage is equal to the sum of the drops in the resistor and the diode. The table shows the calculations.

Current estimates (mA)	20.0	30.0	25.0	28.0
Battery output (V_B)	3.7	3.2	3.5	3.3
Resistor drop (V_R)	2.0	3.0	3.5	2.8
Difference $(V_B - V_R)$	1.7	0.2	0.0	0.5
Diode drop (V_D)	0.5	0.56	0.54	0.55
Conclusions	too small	too big	too small	within 0.05 volt

Four attempts give an answer with sufficient accuracy. On the first try, the difference between the battery voltage and the resistor volt drop comes out as 1.7 V, whereas the indicated diode drop is only 0.5 V for a current of 20 mA. On the second try, $V_B - V_R$ is only 0.2 V for an actual V_D of 0.56 V. The third try gives a zero voltage difference. The fourth try gives agreement within 0.05 V.

PROBLEM 2:

Two diodes from a group that falls within the shaded area between the curves are connected in series, as shown, across a 1.5-V supply. Determine the conditions for maximum voltage drop across one of the diodes.



SOLUTION 2:

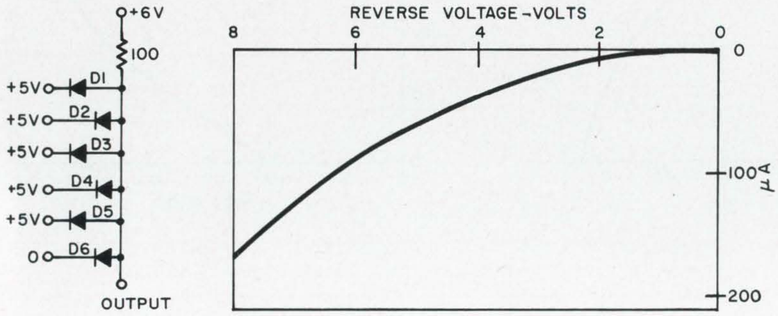
The conditions occur when one of the diodes is at curve 1 and the other at curve 2. Since the same current flows through both of them, it is necessary to find only that current for which the sum of the voltage drops is 1.5 V.

Current (mA)	60	40	50	46
Curve 1 drop (V)	0.71	0.64	0.68	0.67
Curve 2 drop (V)	0.90	0.80	0.87	0.84
Sum (V)	1.61	1.44	1.55	1.51
Conclusions	over	under	over	good

Where characteristics are not known precisely, guessing simplifies the calculations. On the fourth attempt, for an estimated current of 46 mA, the sum of the voltage drops is within 0.01 V of the supply voltage. A similar method could be used for two diodes in parallel.

PROBLEM 3:

Find the output voltage of this positive AND gate for the worst case of the condition shown? Use the diode forward characteristics of Problem 2 and the reverse current curve below.



SOLUTION 3:

Diode *D6* must keep the output low while the inputs to the other five diodes are high. Use curve 2, Problem 2 (high resistance) for *D6*. The output voltage can be evaluated by noting whether the current through the resistor, I_R, plus the reverse currents through *D1* and *D5* add up to the current through *D6*.

Output estimate (V)	0.9	0.5	0.8	0.87	0.88	0.872
Resistor current (mA)	51.0	55.0	52.0	51.3	51.2	51.3
Five reverse currents (mA)	0.3	0.4	0.3	0.3	0.3	0.3
Sum of $I_R + 5I_D$ (mA)	51.3	55.4	52.3	51.6	51.5	51.6
Diode *D6* current (mA)	60.0	12.0	40.0	51.0	53.0	51.6
Conclusions	too high	too low	still too low	quite close	too high	final guess

The worst-case condition of this AND gate occurs when all but one of the inputs are high. A guess at the output voltage for that state enables the resistor current and the five diode reverse currents to be caluclated. These are then compared with the forward diode current of *D6* until reasonable agreement is achieved.

Estimating multiple-level diode gate circuits

Several worst-case conditions exist for this circuit, which implements the function (A OR B) and (C OR D). The worst-case *off* states are cases 3 and .12 (see Truth table). To find the output voltage for case 3, use the diode forward drops and reverse currents of Problem 2, curve 2, and Problem 3. For case 3, A and B will be 0 and C and D will be +5. The output will be low.

If identical diodes are assumed for simplicity, K will be raised by C and D, so $D4$ and $D5$ will be conducting while $D6$ will be back-biased. Most of the current through $R3$ will flow through $D3$. $D1$ and $D2$ will probably not conduct since as a first approximation the voltage at J is determined by the two supply voltages and $R3$ and $R1$.

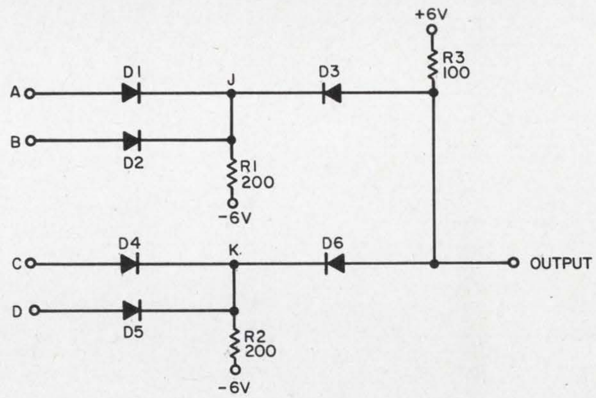
Under these conditions the current through $R3$, $D3$ and $R1$ is approximately $12/0.3 = 40$ mA. At 40 mA the drop across $D3$ is 0.8 volt. When this drop is taken into account, the computed current becomes $(12 - 0.8)/0.3 = 37.3$ mA. The diode drop is then 0.78 volt, making the next current estimate $11.22/0.3 = 37.4$ mA. This is close enough, especially since reverse currents are ignored. The output voltage is then estimated to be $+6 - 3.7 = +2.3$ volts.

The same procedure is now applied to diodes $D4$ and $D5$, which, it should be remembered, are identical. Only $D4$, $D5$ and $R2$ are taken into consideration. K is estimated to be +4.3 volts, so that the reverse current through $D6$ is approximately 100 mA, that is, negligible.

To check junction J the 0.78-volt forward drop through $D3$ is subtracted from the assumed +2.3-volt output to give +1.5 volts. With a reverse voltage of less than 2 volts, reverse currents will be even smaller than through $D6$. However, reverse currents in these circuits remain fairly constant. For greater accuracy repeat the calculations with the reverse currents determined in the first round of approximations.

Truth table investigation

Case	Inputs A B C D	Output	Remarks
0	0 0 0 0	0	Trivial
1	0 0 0 1	0	Not worst case
2	0 0 1 0	0	Not worst case
3	0 0 1 1	0	Worst case (out. low)
4	0 1 0 0	0	Not worst case
5	0 1 0 1	1	Worst case (out. high)
6	0 1 1 0	1	Worst case (out. high)
7	0 1 1 1	1	Not worst case
8	1 0 0 0	0	Not worst case
9	1 0 0 1	1	Worst case (out. high)
10	1 0 1 0	1	Worst case (out. high)
11	1 0 1 1	1	Not worst case
12	1 1 0 0	0	Worst case (out. low)
13	1 1 0 1	1	Not worst case
14	1 1 1 0	1	Not worst case
15	1 1 1 1	1	Trivial



Errors will not invalidate solution

It is often unnecessary to complete calculations to realize that a guess is far of the mark. Furthermore, an error in computation at an early stage (where it is more likely to occur), though it may incur more successive approximation steps than necessary, will not affect the accuracy of the final result.

This type of analysis depends on understanding how the circuit *ought* to work. This is what leads to the sequence of calculations of voltages and currents. If there is an error in design, moreover, it will not remain hidden. A wrong resistor value, for instance, may come to light when the assumption that a particular diode is back-biased proves to be false. In other words, simple checks on the solution will show up certain flaws in the design. ■■

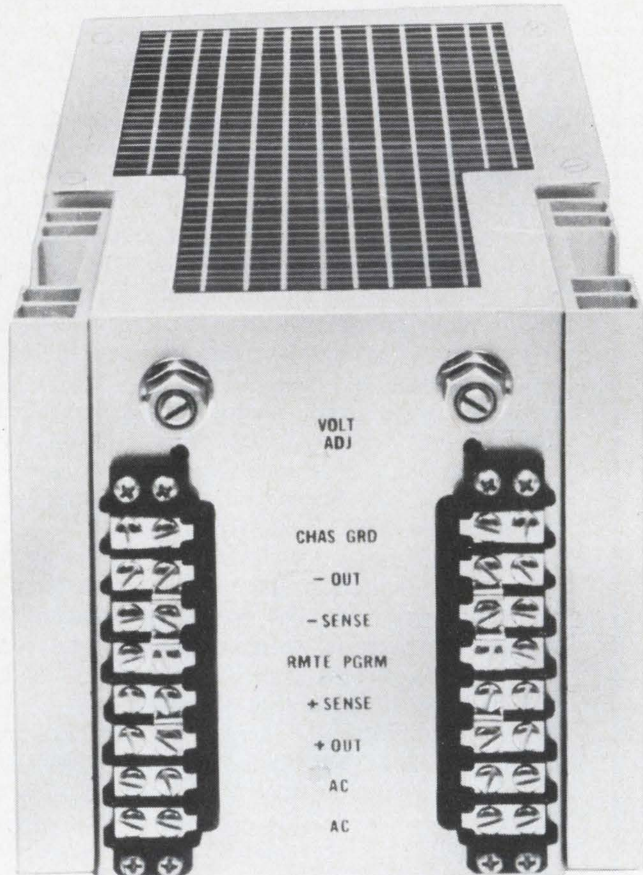
Test your retention

Here are questions based on the main points of this article. They are to help you see if you have overlooked any important ideas. You'll find the answers in the article.

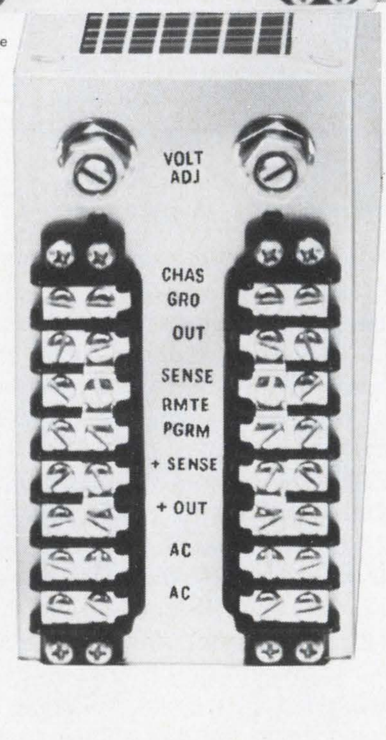
1. For what types of circuits would you not use successive approximation methods?

2. Suppose that the diode of Problem 1 were replaced with two series diodes with the characteristic shown in Problem 2. Calculate the conditions for maximum voltage drop across one of the diodes.

3. Calculate the output voltage for the two-level logic example for the worst-case condition with the output voltage high, i.e., case 5 in the truth table.



Dual output SCDE power supply package



Dual output SCDC power supply package

Now you can get two separate outputs from a single regulated dc power supply. Con Avionics new dual output power supplies save you both money and space in your system.

There are two dual output power supply packages. Each has hundreds of output combinations from which you can choose. For added flexibility, you can mount these power supplies on either of two mounting surfaces. Even a panel surface as small as 2⅝" is enough for mounting one of these remarkable dual output units.

The power supplies are unconditionally guaranteed for five years. They have a Mean Time Between Failure of 50,000 hours.

Con Avionics has a data sheet which includes all the technical data and prices. For a copy write, use the Readers Service Card, or call Mr. Gerry Albers.

Use electromagnetic deflection systems

for designing alphanumeric displays. Beam settling time, display accuracy and bandwidth trade-offs are detailed.

For large-screen displays electromagnetic deflection of a cathode-ray-tube (CRT) electron beam costs less and offers better bandwidth than an electrostatic scheme. The many circuit and component parameters involved, however, make the practical design of such a display complicated and time-consuming.

The purpose here is to give the designer guidelines for optimal design, to indicate the trade-offs to him, and to show the interrelationship of different parameters. Simple formulas of sufficient accuracy will enable him to find the deflection power, amplifier bandwidth, amplifier gain, settling time and ramp delay. A practical example will demonstrate how a typical alphanumerical display system is designed in conjunction with a plan position indicator (PPI) radar.

The three main parts of a deflection system are the CRT, the deflection yoke and the deflection amplifier. Each is characterized by a number of parameters that have to be matched to a specific application. The key parameter is the deflection power because it determines the weight, size and cost of the system.

How to determine the deflection energy

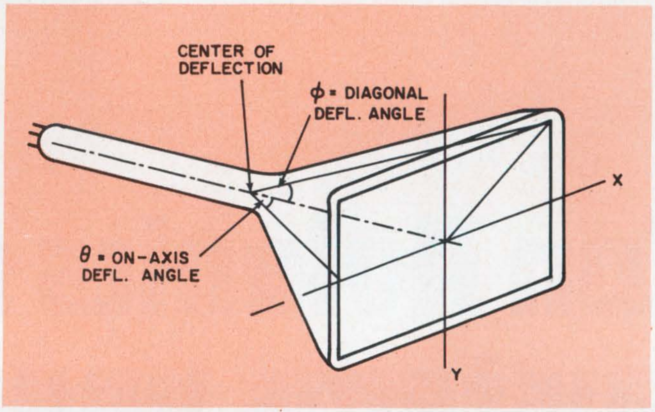
The best way to describe the ability to deflect a CRT electron beam is by the magnetic deflection energy that must be transferred from the power supply to the deflection yoke. It is entirely a function of tube geometry, tube anode voltage and yoke efficiency. The choice of CRT is generally based on such system considerations as display brightness, resolution, screen diameter or tube length. The deflection energy for center-to-edge deflection is given by:

$$W = krE_a \sin^2\theta \tan(\phi/2) \text{ joules,} \qquad (1)$$

where:

k = yoke deflection constant in J/V·in.,

Alfred E. Popodi, Design Engineer, Westinghouse Defense and Space Center, Baltimore, and **Robert M. Williams,** Design Engineer, Sanders Associates, Inc., Nashua, N.H.



1. **Only a few CRT parameters** are required to calculate the over-all display system components.

r = inside yoke radius in inches,

E_a = tube anode voltage in volts,

θ = on-axis deflection angle in degrees, measured from center to edge of the useful area,

ϕ = maximum diagonal deflection angle (for a round tube, $\phi = \theta$).

When $\theta \neq \phi$, the deflection energies for horizontal and vertical energies are different (Fig. 1).

The deflection yoke constant, k, is a measure of the yoke efficiency. Its theoretical value is 0.36×10^{-6} J/V·in. Because of the fringe field effects in the yoke, however, the actual value of k is best determined by experimental measurements, since it varies with yoke type. A practical value of k is 0.7×10^{-6} J/V·in.

Figure 2 is a plot of the center-to-edge deflection energy versus deflection angle for different anode voltages, calculated for a tube with a 1-7/16-inch neck diameter and a yoke constant of $k = 0.66 \times 10^{-6}$ J/V·in. An increase in deflection angle from 40° to 51°, for example, doubles the deflection energy. Equation 1 also shows that the deflection energy increases linearly with anode voltage and neck radius.

Calculating deflection power for a given CRT

Since power is the time derivative of energy by definition, the required deflection power depends on the time in which the magnetic energy of the deflection yoke must be changed. The highest power demand exists in a random-access display when a new beam position must be reached to, say, within 0.1% in a given settling time. The fastest possible coil current increase is achieved by applying the full power supply voltage, E_s, of the amplifier to the coil. The current build-up is then given by:

$$E_s = L\,dI/dt + RI, \qquad (2)$$

where:

E_s = deflection amplifier supply voltage in volts,
I = instantaneous yoke current in amperes,
L = yoke inductance in henries,
R = circuit resistance, which is small enough to be neglected.

Solving for the yoke current gives:

$$I = E_s t/L. \qquad (3)$$

Since the magnetic energy of the coil is:

$$W = LI^2/2, \qquad (4)$$

the deflection power becomes:

$$P = dW/dt = E_s^2/Lt_{A\ (max)} = 2W/t_{A\ (max)}, \qquad (5)$$

where:

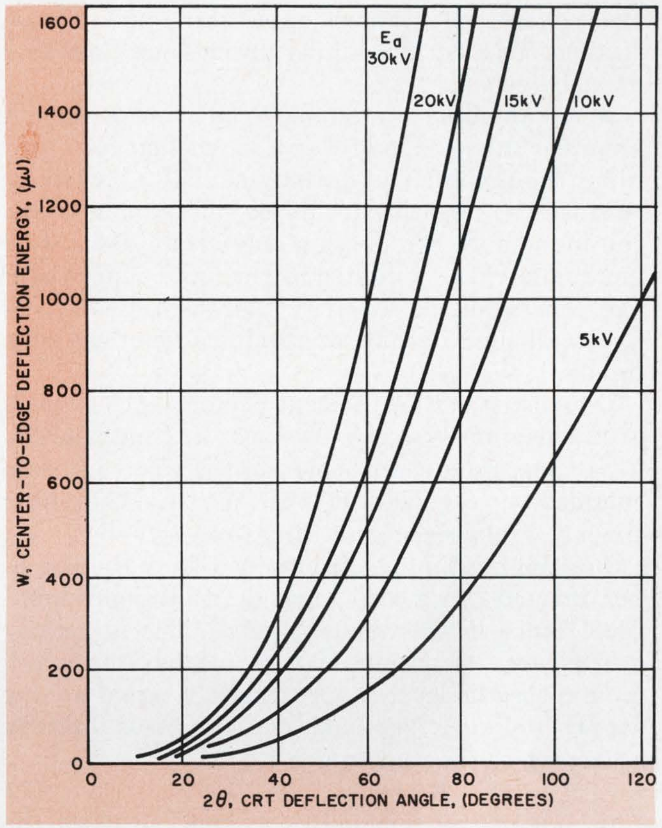
P = peak power for center-to-edge deflection in watts (not necessarily the average or continuous power),
W = stored energy in the coil for maximum deflection in joules,
$t_{A\ (max)}$ = positioning time required to deflect the beam from center to edge, assuming linear current variation, in seconds.

Choosing the deflection yoke

Although only the value of the yoke inductance enters into calculations, other parameters must be carefully considered and the final choice of deflection yoke is dependent on the particular application. The other parameters include self-resonant frequency, flux recovery time, residual magnetism, linearity, perpendicularity and deflection yoke efficiency.

In the following calculations it is assumed that the resonant frequency of the single-ended (one side grounded) yoke is beyond the system operating frequency. The shunting effect of the coil capacitance is also neglected because the output stage is an emitter follower with a low source impedance that makes the time constant very small.

To determine the deflection yoke inductance for a particular CRT, the deflection energy for center-to-edge deflection is calculated from Eq. 1. A tentative supply voltage for the deflection amplifier is chosen from available system power supplies or on the basis of the transistor-driver voltage capabilities. The required center-to-edge settling time, $t_{A(max)}$, must also be known. When power Eq. 5 is used, the yoke inductance becomes:



2. **Deflection energy** required for the display CRT can be determined from this plot, once deflection angle and the CRT anode voltage are known.

$$L = E_s^2\, t_{A\ (max)}^2/2W, \qquad (6)$$

L = yoke inductance in henries,
E_s = amplifier supply voltage in volts,
W = center-to-edge deflection energy in watts,
$t_{A\ (max)}$ = center-to-edge positioning in seconds.

Consider deflection amplifier requirements

Since the deflection yoke constitutes an inductive load for the amplifier, both must be analyzed together. In general, amplifier and yoke are part of a feedback loop where the negative feedback is obtained by sampling the coil current. Figure 3a shows the basic block diagram for the amplifier and Fig. 3b its equivalent servo model. The output voltage, $C(s)$, across the load resistor, R_L, is proportional to the coil current, and $R(s)$ is the system input. $G(s)$ denotes the forward transfer function, which depends on the number of amplifier stages, amplifier gain, the load time constant, T_L, and the feedback ratio, n. This model can serve only for a qualitative discussion for two main reasons:

- Actual amplifiers consist of several stages, each with a different bandwidth. This makes an exact analytical approach painstaking and impractical because of the higher-order equations that must be solved.

▪ The amplifier is assumed to be a linear, class-A amplifier. Inspection of Fig. 3 shows that for a step input the amplifier is initially heavily overdriven, because the negative feedback voltage due to the coil inductance can develop only gradually and its maximum value is limited by the finite supply voltage. The assumed linearity therefore exists only for small-signal inputs or ramp, rather than step, inputs.

One of the most important performance criteria of a deflection system is the spot settling time, t_s. This time, required to position the electron beam completely, consists of two parts—positioning time, t_A, and precision settling time, t_B.

Positioning time, t_A, is obtained from the amplifier response to a step input of maximum amplitude. Since in this mode the amplifier is heavily overdriven, its output voltage reaches the maximum possible level, approximately equal to the supply voltage. The coil current rises linearly according to the rearranged Eq. 3:

$$E_s/L = I_{max}/t_{A\ (max)}. \tag{7}$$

This linear rise terminates at time t_A when the feedback voltage reaches a value high enough to take the amplifier out of the overdriven state. Up to that point, the low-level bandwidth of the amplifier has little significance.

The precision settling time, t_B, is determined by the small-signal bandwidth and amplifier gain after the amplifier has begun to operate as a class-A device. Practical experience shows that good amplifier design can make the center-to-edge positioning time, $t_{A\ (max)}$, 90 per cent of the total settling time, $t_{s\ (max)}$, with about 10 per cent of $t_{s(max)}$ needed for precision settling, t_B. That assumes maximum deflection; for smaller inputs the positioning time lessens, though the precision settling time remains fairly constant. For solid-state deflection amplifiers, total settling time therefore increases with deflection distance (see Figs. 4a and 4b).

The shortest settling time is obtained when the amplifier operates nearly critically damped with a minimum of ringing. Total settling time, $t_{s\ (max)}$, consists mainly of positioning time, $t_{A\ (max)}$, which depends on supply voltage, yoke inductance and center-to-edge deflection current. From Eq. 7 it is given by:

$$t_{A\ (max)} = I_{max}L/E_s. \tag{8}$$

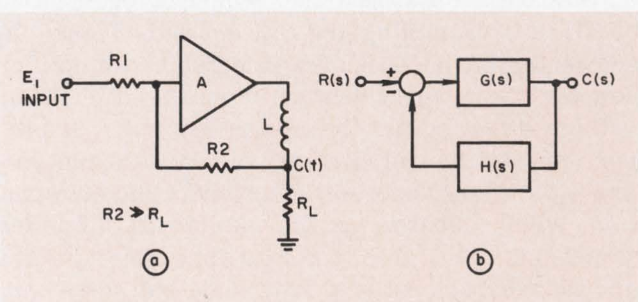
Taking into account the precision settling time, t_B, total settling time, $t_{s\ (max)} = t_{A\ (max)} + t_B$. An empirical expression for this is:

$$t_{s\ (max)} \approx 1.1\ t_{A\ (max)} = 1.1\ I_{max}\ L/E_s, \tag{9}$$

where:

$t_{s\ (max)}$ = total settling time for center-to-edge deflection in seconds,
L = deflection yoke inductance in henries,
E_s = amplifier supply voltage in volts,
I_{max} = center-to-edge deflection current in amperes.

The value of $t_{s\ (max)}$ represents amplifier-dependent current settling time only. If the yoke-dependent flux settling time is significant, it must be added.



3. **Ideal deflection amplifier (a)** and its servo model (b) required to drive the yoke. L is the yoke inductance, R_L is the yoke resistance.

Determining amplifier characteristics

In order to calculate the settling time, small-signal frequency response, amplifier gain, and ramp delay of the system, the amplifier is assumed to have one single, dominant time constant, T_A, described by the 3-dB point of the gain versus frequency curve. In practice, the amplifier is a multipole device with several breakpoints on the response curve, but it has been found that calculations yield accurate results if only the first 3-dB point is considered. Referring to Fig. 3, the transfer function of this system for a step input is given by:

$$C(s) = \frac{E_1An/(1+n+\mathrm{A})}{\left\{ \begin{array}{l} s\{\ s^2[(1+n)T_AT_L/(1+n+A)] \\ +s[(1+n)(T_A+T_L)/(1+n+A)]+1\} \end{array} \right\}}, \tag{10}$$

where:

$T_L = L/R_L$ (yoke time constant),
$T_A = RC = 1/2\pi f_C$ (amplifier time constant),
E_I = input voltage,
A = amplifier open-loop gain,
n = $R2/R1$ (feedback ratio).

The solution of Eq. 10 in the time domain is:[1]

$$\begin{aligned} C(t) = {} & [E_1An/(1+n+A)] \\ & \times \{\ 1 + [1/(1-\zeta^2)^{1/2}]e^{-\zeta\omega_1 t} \\ & \times \sin\ [\omega_1(1-\zeta^2)^{1/2}t - \psi]\ \}, \end{aligned} \tag{11}$$

where:

$$\begin{aligned} \zeta = {} & [(1+m)/2(m)^{1/2}] \\ & [(1+n)/(1+n+A)]^{1/2}, \end{aligned}$$

$$\omega_1 = \{ (1+n+A)/[(1+n)\,T_A T_L] \}^{1/2},$$
$$\psi = \tan^{-1}[(1-\zeta^2)^{1/2}/-\zeta],$$
$$m = T_L/T_A.$$

The equivalent time constant of the amplifier-yoke complex, T_C, is given by the exponent of Eq. 11 as:

$$\begin{aligned} T_C &= 1/\zeta\omega_1 \\ &= 2T_A T_L/(T_A+T_L) \\ &= [2m/(1+m)]T_A. \end{aligned}$$

For short rise times, both the amplifier and yoke time constants should be small. T_L can be made small by using small values of L and large resistors R_L, since $T_L = L/R_L$, but large values of R_L increase power consumption. A more economical approach is therefore to let T_L be large and to concentrate on reducing the amplifier time constant, T_A, to obtain fast rise times. Since $m >> 1$ (in practical cases $m > 1000$), the equivalent time constant of the closed-loop system is:

$$T_C \approx 2T_A. \qquad (12)$$

In other words, the designer, after determining the yoke inductance from Eq. 6, has ample freedom to select R_L without adversely affecting system bandwidth, so long as m is much larger than unity.

Calculating the frequency response

To predict display performance for small signals, such as alphanumeric symbols, the equivalent frequency response of amplifier plus yoke is important. Since $T_C = 2T_A$, the 3-dB point is given by:

$$f_C = 1/(2\pi\, 2\,T_A) = 1/(4\pi\, T_A),$$

where f_C is the closed-loop, small-signal frequency response of the system. In other words, the system bandwidth is half the amplifier open-loop bandwidth.

Determining amplifier open-loop gain

The most desirable operating condition for fast settling time, especially for symbol presentation, is when the system is critically dampened, that is, when $\zeta = 1$. This damping ratio is in accordance with the standard second-order system definition as used in texts on control theory. Then:

$$\zeta = 1 = [(1+m)/2(m)^{1/2}]\,[(1+n)/(1+n+A)]^{1/2},$$
$$A = (1+n)\,(1+m^2-4n)/4m;$$

and if $m >> 1$:

$$A \approx (1+n)m/4. \qquad (13)$$

As in any feedback system, the open-loop gain of the amplifier must be stable and independent of power supplies and temperature, otherwise instabilities due to changes in the frequency-response curve may occur and severely degrade character presentation.

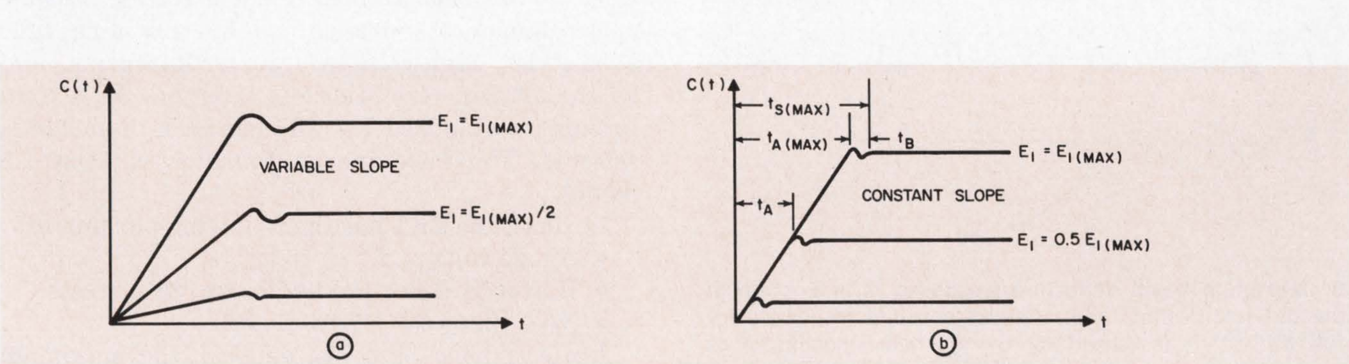
Finding the current settling time

In Eq. 11, the exponential term determines the rate of decay of the transient, oscillatory portion of the amplifier response. It therefore determines the settling time of the underdamped system. The maximum settling error is defined by:

$$\epsilon(\%) = \exp\{-[(1+m)/2m][t/T_A]\}100. \qquad (14)$$

This equation does not contain amplifier gain, A, because in a linear, second-order system the gain influences only the oscillating frequency. Because of the initial assumptions, Eq. 14 does not always supply useful results so Eq. 9 is more accurate. Another difference between the model amplifier and a real device is that Eq. 11 shows that the settling time of the real device depends on the input drive (see Fig. 4b). This is because the mathematical model assumes unlimited supply voltage, resulting in different initial slopes in the output curve. In practice, even for relatively small inputs, the output reaches its maximum possible value, E_s, and for larger inputs, no increase in slope is possible. For this reason, settling time increases with input drive.

Since m in Eq. 14 should be much larger than



4. **Both positioning time, t_A, and settling time, t_s, are** functions of the yoke voltage E_1. Ideal deflection amplifier characteristic (a) assumes constant settling time, while (b) shows a characteristic of a practical amplifier.

unity (see Eqs. 11 and 12), it can be seen that the settling-time error is almost entirely a function of the amplifier time constant, T_A. That is to say, the smaller this time constant is, the faster the exponential tends to zero, thus decreasing the magnitude of the error.

Determining ramp delay

Another important amplifier property is the time lag that exists between a linearly rising input and the actual output function[2]. The solution for the output function in the time domain for a ramp input of duration t_0 is:

$$C(t) = \{ E_1 A\, n/[t_0(1 + n + A)] \} \times \{ t - (2\zeta/\omega_1 + 1/[\omega_1(1 - \zeta^2)^{1/2}] e^{-\zeta\omega_1 t} \times \sin [\omega_1(1 - \zeta^2)^{1/2} t - \psi] \}, \quad (15)$$

where:

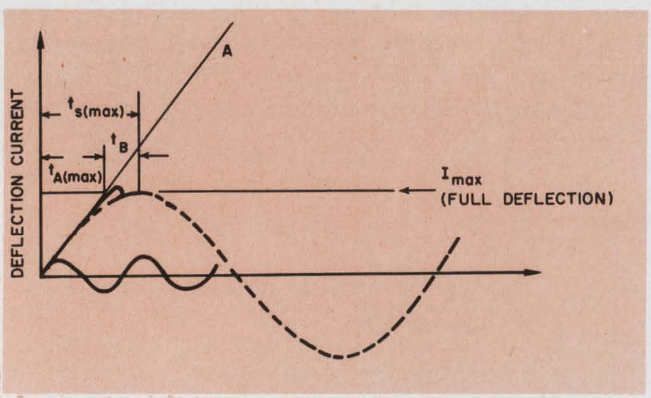
$$\zeta = [(1 + m)/2(m)^{1/2}] [(1 + n)/(1 + n + A)]^{1/2},$$
$$\psi = 2 \tan^{-1}[(1 - \zeta^2)^{1/2}/ - \zeta],$$
$$\omega_1 = \{ (1 + n + A)/[(1 + n) T_A T_L] \}^{1/2},$$
$$e_1(t) = E_1(t/t_0).$$

If $A >> 1$ and $T_L >> T_A$, the time delay between input and output is:

$$t_D \approx (1 + n) T_L/A. \quad (16)$$

Getting maximum deflection frequency

Because of the finite supply voltage of the amplifier, the maximum slope of the current-versus-time curve, or slewing rate, is E_s/L (Fig. 5). For step inputs, the coil current tends to increase toward its steady-state value of E_s/R_L which it never reaches. At the end of the positioning time, $t_{A\,(max)}$, the maximum deflection current I_{max} (CRT beam at the tube edge), is obtained and held at this



5. **Maximum beam deflection frequency** is a function of the deflection amplitude. Highest possible frequency for full deflection is shown by the dashed sinusoid. It is limited by the maximum slewing rate slope (E_s/L) denoted as line A. Higher frequencies are possible for smaller deflections, as the solid-line sinusoid shows.

value by the negative feedback. Since the initial tangent of a sine curve (assuming a sinusoidal input) intersects the I_{max} line at a point $1/(2\pi)$ times the full period (Fig. 5), the theoretically highest frequency possible for full and sinusoidal deflection is:

$$f_{max} = 1/(2\pi t_{A(max)}), \quad (17)$$

or one period is $2\pi t_{A(max)}$ seconds long. For smaller current excursions, the frequency, f_{ss}, is higher:

$$f_{ss} = 100/(2\pi t_{A\,(max)}\, s),$$

where s is the small signal deflection as a percentage of full deflection. Practical values of f_{ss} are somewhat smaller because of the neglected coil resistance and other simplifying assumptions, such as ignoring the coil capacitance and the voltage drop in the sensing resistor.

Designing a display system

Suppose that the following specifications are given for a display:

- Radar plan position indicator (PPI) has random-access capability, so that four alphanumeric symbols can be presented during the radar sweep deadtime at 200 μs.
- Pulse repetition frequency (PRF) of the radar is 400 Hz, so that the pulse repetition time is 2500 μs.
- A round viewing screen is 16 inches in diameter and display brightness and resolution are such that a 16-kV anode voltage is required.
- Character size will be 1% of the full screen diameter, each symbol will take 15 μs to display.
- The highest sweep rate of the PPI is 100 μs.

Based on this information, the display designer can now define the CRT deflection angle and neck diameter.

The deflection angle affects deflection energy most significantly, as shown in Fig. 2. Since a small deflection angle results in a long tube, the length of the display console determines the final choice. In this example where no limit on the console length was given, the half-axis deflection angle, θ, is chosen to be 26 degrees.

The neck diameter of the CRT is directly proportional to the deflection energy. The lowest possible neck diameter is determined by available tube geometries, high-voltage arc-over problems, and by the allowed resolution degradation. As a compromise, a standard 1-7/16-inch neck diameter is selected. The yoke inside diameter is then 1.5 inches.

In short, the CRT has the following parameters:

- Anode voltage, $E_a = 16$ kV.
- Half-axis deflection angle, $\theta = 26$ degrees.
- Neck diameter 1-7/16 inches.

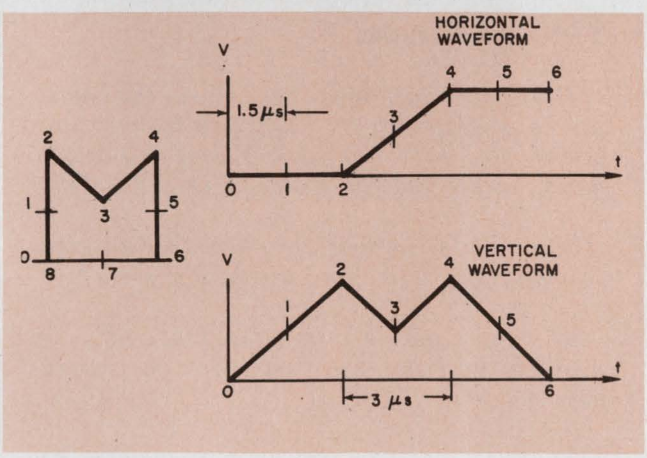
Beam settling time—In general, the maximum allowable settling time is dictated by the number of symbols that must be presented during the radar dead time, which in this example is to be 200 μs. Four symbols must be displayed during that time, and each symbol requires 15 μs of display time. Under worst-case conditions, the four symbols may be at opposite sides of the screen. If the center-to-edge settling time is assumed to be 15 μs, the edge-to-edge settling time is 30 μs. The total time required to display four symbols can then be calculated as follows.

The first character to be displayed at the end of the last PPI sweep requires 30-μs beam-settling time to arrive at the new beam location and then 15 μs for the character itself. All the other symbols also require 45 μs each. After completing the last character, the beam must return to the center of the PPI: this takes another 15 μs. The total time consumed is thus 195 μs, which is less than the specified 200-μs dead time.

From the center-to-edge settling time, $t_{s(max)}$, of 15 μs, the amplifier design will be such that $t_{A(max)} = 0.9, t_{s(max)} = 13.5$ μs.

Symbol generation and symbol quality—Symbols will be generated as straight-line approximations (stroke generator); a maximum number of 10 strokes per symbol with a stroke duration of 1.5 μs is used. To determine the required frequency response of the deflection amplifier, a Fourier analysis of both the horizontal and vertical deflection signals can be made. In most cases it is sufficient to analyze the worst-case waveform and determine from it the frequency response. In this example it is known from experience that the letter "M" represents the worst-case pattern in the repertoire of the symbol generator, for it contains the highest frequencies (see Fig. 6).

In Fig. 6 it can be seen that strokes 7 and 8 are blanked (return) strokes, and strokes 9 and 10 are unused. If a sine-wave approximation is made between points 1 and 5 of the vertical waveform, which contains the higher frequencies, its fundamental frequency is 333 kHz. Practical experience shows that a system bandwidth three times higher is sufficient for acceptable character presentation. The closed-loop bandwidth of the deflection amplifier must therefore be 1 MHz.



6. **Straight-line approximations are used** to form the characters. A maximum of 10 strokes is allowed for any symbol. For an "M" strokes 7 and 8 are blanked (return) strokes; strokes 9 and 10 are not used.

Amplifier power supply—The power-supply requirement is very flexible since it affects only the calculation of coil inductance L, but restrictions may be imposed by the output-stage voltage capability or by the need to use available supplies. In this example (a military system), E_s is assumed to be 28 V.

Finally, the input voltage of the amplifier for full deflection is assumed to be $E_1 = 10$ V.

Once E_a, r, $t_{A(max)}$, E_s and E_1 have been chosen, the following parameters can be calculated: yoke constant k, deflection energy W, deflection power P, yoke inductance L, peak deflection current I_{max}, current-sensing resistor R_L, amplifier bandwidth and open-loop gain, ramp delay, and maximum small-signal deflection frequency f_{ss}.

Deflection energy—The center-to-edge deflection energy is obtained from Eq. 1. Since a round tube is used, $\theta = \phi$. To find the yoke constant, a yoke type must first be selected; in this example it is a single-ended yoke of the Celco FY-536 series.[3] The data sheet lists several current and inductance values for the 26-degree deflection angle and a test anode voltage of 10 kV. For this purpose, any randomly selected yoke inductance may be used to calculate the sensitivity constant for this particular yoke line. A 1-mH yoke is a convenient choice. Rewriting Eq. 1 gives:

$$k = W_1/r_1E_{a1} \sin^2\theta \tan(\theta/2),$$

where:

$W_1 = L_1I_1^2/2 = 10^{-3}\ (0.66)^2/2 = 218\ \mu$J
= deflection energy for the test yoke,
L_1, I_1 and E_{a1} = data-sheet values for the test yoke of the FY-536.

Substituting all values yields a yoke constant of:

$$k = (0.66)\,(10^{-6})\ \text{J/V}\cdot\text{in.}$$

Once k has been calculated, the center-to-edge energy for the actual problem may be worked out:

$$W = (0.66)\,(10^{-6})\,(0.75)\,(16)\,(10^3)\,(\sin 26°)^2(\tan 13°) = 350\ \mu\text{J}.$$

This energy was derived only from CRT and yoke parameters. There is ample flexibility for selecting L, I_{max} and E_s.

Deflection power—The peak power that must be delivered to the deflection yoke to place the beam at the tube edge is:

$$P = 2W/t_{A\,(max)} = (700 \times 10^{-6})/(13.5 \times 10^{-6}) = 51.8\ \text{W}.$$

In many display applications this is also the worst-case requirement. If, for instance, the CRT beam remains at the tube edge, the power supply must deliver 51.8 watts continuously. During beam displacement time, power is delivered to the yoke; in the stationary case, peak power is dissipated in the driver transistor since the dc resistance of the yoke is very small. The actual power dissipation in the driver transistor is therefore dependent on the duty cycle of the display, on the number of symbols, their location at the screen, and on sweep speeds. It is good practice, however, to provide worst-case power capacity, which may be demanded during a failure in the driver circuitry.

Yoke inductance—From Eq. 6:

$$L = (28 \times 13.5 \times 10^{-6})^2/2 \times 350 \times 10^{-6}$$
$$= 204\ \mu\text{H}.$$

Deflection current for center-to-edge deflection—Since $W = L\,I_{max}/2$, then:

$$I_{max} = (2\,W/L)^{1/2}$$
$$= [(2 \times 350 \times 10^{-6})/(204 \times 10^{-6})]^{1/2}$$
$$= 1.85\ \text{A}.$$

Yoke current-sensing resistor—Because the voltage drop across the sensing resistor causes a loss in current rise time, it should be small compared with the supply voltage, E_s. In this example it is assumed to be 10% of E_s. Then the feedback voltage for center-to-edge deflection is $I_{max}\ R_L = 2.8$ V and $R_L = 1.5$ ohms. In high-bandwidth applications it is important that R_L be of the non-inductive type and, since R_L is generally of large dimensions, that its capacitance between body and chassis be kept small.

Maximum small-signal deflection frequency—Since the specified positioning time $t_{A(max)} = 13.5$ μs, the highest possible full-screen, sinusoidal deflection frequency is:

$$f_{max} = 1/2\pi t_{A(max)} = 1/2\pi \times 13.5 \times 10^{-6}$$
$$= 11.8\ \text{kHz}.$$

For a 1% character size, the maximum small-signal bandwidth is a hundred times this value:

$$f_{ss} = 1.18\ \text{MHz}.$$

If the calculated value of f_{ss} is lower than required for symbol presentation, a smaller positioning time, $t_{s(max)}$, must be assumed. Since $t_{A(max)}$ is directly proportional to the amplifier slewing rate, E_s/L, either L can be lowered or E_s increased. Generally, it is easier to reduce L and keep E_s constant.

Amplifier bandwidth—In this example, the closed-loop amplifier bandwidth, f_C, is dictated by symbol quality requirements. Since $f_C = 1$ MHz, the amplifier bandwidth f_A can be found from Eq. 12:

$$f_A = 2f_C = 2\ \text{MHz}.$$

In cases where no explicit bandwidth specification exists, the amplifier response must be such that the requirement for the settling time, t_s, or the ramp delay can be met. The procedure is then to pick a tentative amplifier time constant, T_A, such that $m = T_L/T_A$ is at least greater than 100. Settling time can then be calculated from Eq. 9.

Open-loop amplifier gain—The open-loop amplifier gain is given by Eq. 13:

$$A = (1 + n)\,m/4,$$

where:

$$m = T_L/T_A = 204 \times 10^{-6}/(2\pi \times 2 \times 10^{-6})^{-1}$$
$$= 3840.$$

The value for the feedback ratio, n, can be found from the maximum feedback voltage:

$$n = R2/R1 = E_0/E_1;$$
$$E_0 = I_{max}\,R_L = 1.85\ \text{V}, E_1 = 10\ \text{V}$$
$$\therefore n = 0.185.$$

The amplifier open-loop gain is therefore:

$$A = (1 + 0.185)\,3840/4 = 1140.$$

Settling time—From Eq. 9:

$$t_{s(max)} \approx 1.1\,t_{A(max)} = 1.1\ (L/E_s)\,I_{max}$$
$$= 1.1 \times 204 \times 10^{-6} \times 1.85/28 \simeq 15\ \mu\text{s}.$$

This is the maximum settling time. For smaller deflections, t_s decreases.

Ramp delay—From Eq. 16:

$$t_D = (1 + n)\,T_L/A = 204 \times 10^{-6} \times 1.185/1140$$
$$= 0.21\ \mu\text{s}.$$

In other words, since the maximum sweep speed is 100 microseconds, the CRT spot is 0.21% short of its correct position at the tube edge. ■ ■

References:

1. Dieter R. Lohrmann, "Amplifier has 85% efficiency (Part 1)," ELECTRONIC DESIGN, XIV, No. 5 (March 1, 1966), 38-43, and "Use magnetic deflection to iron out problems (Part 2)," *ibid.*, No. 6 (March 15, 1966), 210-215.
2. *Ibid.*
3. *Application Note for FY-536 Series Yokes*, (Mahwah, N.J.: Constantine Engineering Co.).

Test your retention

Here are questions based on the main points of this article. They are to help you see if you have overlooked any important ideas. You'll find the answers in the article.

1. What is the key parameter in an electromagnetic deflection display system?

2. What and where can trade-offs be made to decrease the deflection energy requirement?

3. What parameters determine the required amplifier bandwidth?

4. What is the positioning time? Settling time?

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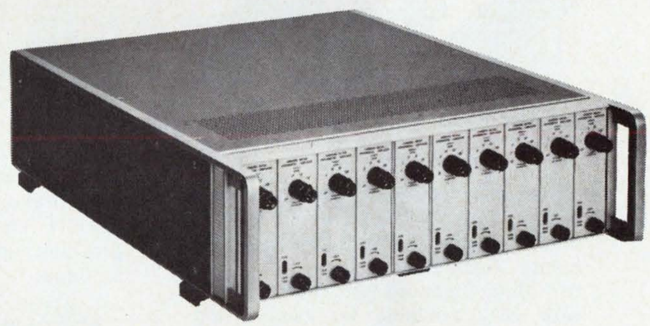
This state-of-the-art HP amplifier measures just 4¾" high by 1⁹⁄₁₆" wide by 15" deep, weighs only 3.5 lbs., including integral power supply. For multichannel use, ten units are mounted in a 5" x 19" modular cabinet which contains input and output connections, power cable, on-off switch, cooling and fuse and mating connectors which are required for multi-channel operation. These modules can be stacked or equipped with tilt stands for bench-top use. When used individually, the completely enclosed amplifier requires a cord connector set that includes a power cord, signal input and output leads, a line fuse and bench mounting plastic feet.



SPECIFICATIONS

Bandwidth:	dc to 75 kHz within 3 db.
Gain:	from 1 to 1000 in seven fixed steps.
Gain Accuracy:	±0.1%
Gain Stability:	±0.01%
Vernier Gain:	continuously adjustable between fixed steps.
Gain Trim:	±3% with sufficient resolution for setting any one gain to ±0.01%.
Common Mode Rejection:	120 db from dc to 60 Hz, 40v p-p tolerance.
Output Circuit:	±10 volts across 100 ohms and 0.2 ohms max. output impedance at dc.
Drift:	±3 uv referred to input, ±0.2 mv referred to output.
Non-Linearity:	Less than 0.01% full scale value, 10 volts.
Overload Recovery Time:	recovers to within 10 uv R.T.I. +10 R.T.O. in 10 msec. for 10 v overload.
Power:	115/230 volts ±10%, 50-400 Hz, 6 watts.
Available Options:	Switch-selected filtering and dual output (±10v; ±10ma; ±100 ma).

For complete specifications and applications assistance, call your local Hewlett-Packard field engineering office, or write: Hewlett-Packard Company, 175 Wyman Street, Waltham, Mass. 02154.

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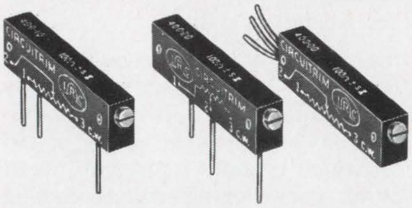
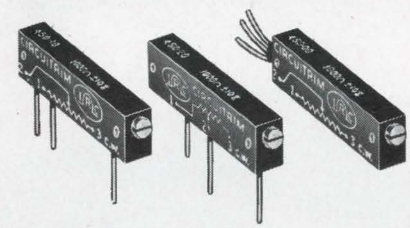
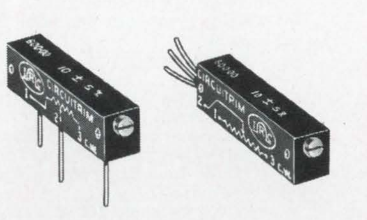


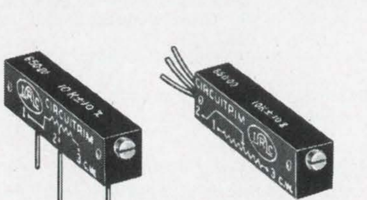
Series 400. Wirewound RT-12 case size with one extra model having staggered RT-11 P.C. pin placement for direct, space savings substitution.



Series 450. Metal Glaze element provides essentially infinite resolution output. RJ-12 size to MIL-R-22097 requirements. Resistance values from 50Ω to 1 Meg. Standard tolerance is ±10% with 20% available for cost-saving applications.

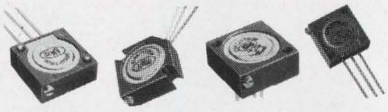


Series 600. RT-11 case size. Wirewound stability and military quality at industrial prices. Well-sealed lightweight diallyl phthalate case.



NEW Series 650. Metal Glaze resistive element built to MIL-R-22097, Characteristic C capability. ±250ppm/°C over range of 100Ω to 10K. Std. tol. ±5%.

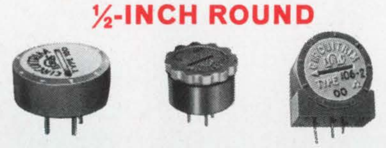
½-INCH SQUARE



Series 205. Standard wirewound units for high-quality industrial needs in all four RT-22 styles. Built, tested and marked to MIL-R-27208 specifications.

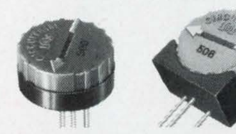
Series 251. RJ-22 styles. Metal Glaze infinite resolution from 100Ω to 1 Meg. Offered in ±5, 10 and 20% tolerances to provide exact performance requirements.

½-INCH ROUND



Series 100. Largest ½″ round selection in the industry. Well-sealed for critical industrial or military use. Single turn, positive stops. Long (0.9″) winding provides superior resolution and closer settings.

Series 150. Metal Glaze companion to wirewound model 100 above. Available in same configurations. 100Ω to 1 Meg. with choice of ±5, 10 and 20% tolerances.

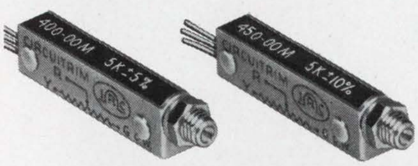


NEW Series 500. Most economical for commercial and industrial use. Two most popular adjustment and mounting configurations. Best wirewound resolution at lowest price.

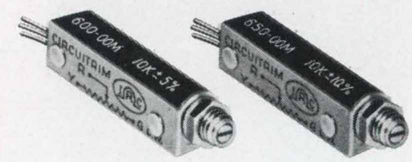
MINIATURE 5/16″ CUBE

Series 300 wirewound and 350 Metal Glaze provide space savings in all P. C. board applications. Panel mount also available.

PANEL MOUNTING



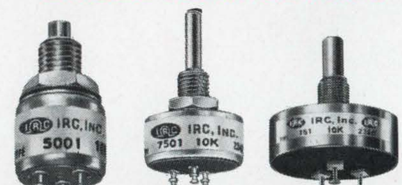
For wirewound Series 400 and Metal Glaze Series 450



For wirewound Series 600 and Metal Glaze Series 650

For ½″ square series — For ½″ round series — For 5/16″ cube series

SINGLE TURN ROTARY



Sturdy metal-cased units for severe environmental conditions. Wirewound stability and ±5% resistance tolerance. Excellent linearity for close setting of comparison and control instrumentation.

Mod.	Case Diam.	Res. Range (Ω)	Power @40°C	Linearity
5001	½″	10 to 50K	2 W	±5%
7501	¾″	50 to 50K	2¼ W	±1%
151	1½″	100 to 100K	3½ W	±0.5%

MOUNTING VARIATIONS

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Precision multi-turns for all applications

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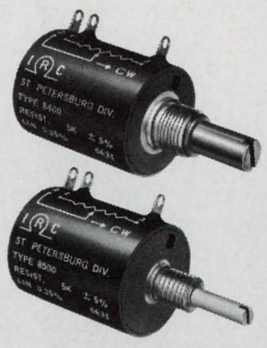
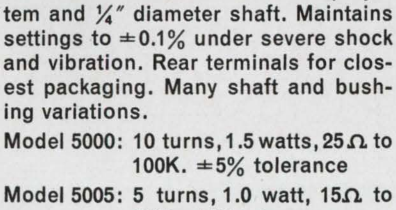


High performance and long life at lowest cost. 10 turns, $\frac{7}{8}$" diameter with only 1$\frac{1}{8}$" behind the panel. 2 watts @ 25°C., derates to zero @ 105°C. 100Ω to 100K, with all popular intermediate values. ±5% tolerance and ±0.25% linearity. Side terminals accept to #14 wire. Model 8400 has $\frac{3}{8}$"-32 bushing, $\frac{1}{4}$" shaft. Model 8500 has $\frac{1}{4}$"-32 bushing, $\frac{1}{8}$" shaft.

Model 7300 has 100 oz.-in. patented stop system and space-saving rear terminals. 10 turns, 2 watts @ 40°C., derates to zero @ 85°C. 100Ω to 100K. ±5% tolerance, ±0.25% linearity.

MINIATURE HIGH PERFORMANCE



Industry's only $\frac{1}{2}$" metal-cased multi-turn trimmer with 100 oz.-in. stop system and $\frac{1}{4}$" diameter shaft. Maintains settings to ±0.1% under severe shock and vibration. Rear terminals for closest packaging. Many shaft and bushing variations.

Model 5000: 10 turns, 1.5 watts, 25Ω to 100K. ±5% tolerance

Model 5005: 5 turns, 1.0 watt, 15Ω to 50K. ±5% tolerance

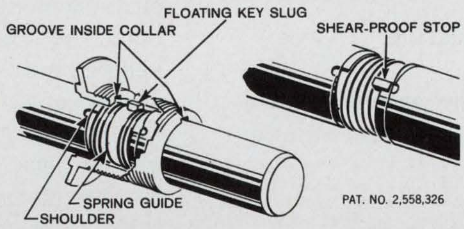
METAL-CASED STANDARD PRECISION

IRC's exclusive line of metal-cased multi-turn potentiometers offer rugged protection and superior shielding. Field tested and approved in every phase of the electronics industry, their case sizes and power handling capabilities are based on widely accepted standards for good design and packaging. Hermetically sealed, panel sealed and moisture sealed versions are also available.

Model	Case Dia.	Turns	Resistance Range (Ω)	Linearity Std. (±)	Power @40°C
7500	$\frac{3}{4}$"	10	50 to 250K	0.5%	3 W
7505	$\frac{3}{4}$"	5	25 to 125K	0.5%	2 W
1000	1"	10	500 to 250K	0.5%	3 W
1005	1"	5	250 to 125K	0.5%	2 W
1215	1"	15	500 to 450K	0.1%	4 W
1220	1"	20	750 to 600K	0.1%	5 W

Standard tolerance: ±5%. Temperature range: -55°C to 125°C. Closer tolerances and linearity available.

RUGGED STOP MECHANISM



Electrical and mechanical functions of IRC metal-cased multi-turns are separate. Positive 100 oz.-in. patented stop mechanism in the shaft and bushing prevents damage to internal parts and catastrophic failure. The wiper contact assembly is relieved of stopping action. This assures setting accuracy, stability and long rotational life.

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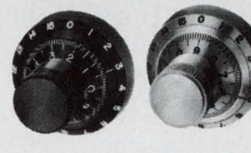
IRC has a full line of turns counting dials for use with 3, 5, 10 and 15 turn potentiometers. Only 1 inch in diameter, they fit $\frac{1}{4}$-inch and $\frac{1}{8}$-inch diameter shafts. Choice of black or clear anodized aluminum finish.



- Easy reading—angular surface gives maximum numeral size. Primary and secondary scale.
- Full range—000 to 999 to indicate up to 10 full turns (to 1499 for 15 turns).
- Accurate reading—reproducible to one part in a thousand. Can estimate to a fraction of a thousandth.
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INFORMATION RETRIEVAL NUMBER 39

Simplify your DVM selection. Compare five methods of analog-to-digital conversion, rather than 300 individual voltmeters. Then choose.

You're in the market for a digital voltmeter.

You consult over 30 manufacturers and get data on more than 300 machines. Chances are you'll be as puzzled at this stage about which one to buy as you were before you began your hunt.

You can reduce your decision-making to choosing from one of five broad categories, rather than from one of 300 individual machines, simply by choosing from among the methods of analog-to-digital conversion.

There are many methods of conversion, but most of those used in today's DVM can be categorized as one of the following:

- Null balance.
- Successive approximation.
- Ramp conversion.
- Voltage-to-frequency integration.
- Dual-slope integration.

The conversion technique is essentially responsible for your DVM's accuracy, noise immunity and speed of operation.

Balance accuracy, speed and noise

Accuracy is the specification most widely used to differentiate one DVM from another: How closely does the instrument reading agree with the true value of the quantity being measured? Accuracy is a measure of the error of an instrument. In the DVM, the main error-contributing factors are component drift with time and temperature, linearity, line voltage variation, noise and digital count ambiguity.

Of these seven factors, the major ones are time or temperature-variable. For this reason, the accuracy of a DVM should always be given with specified time and temperature (see Table).

Most noise encountered with the use of DVMs can be classified as common-mode or normal-mode. Common-mode noise is any undesired signal injected into the voltmeter's measurement circuit as a result of the conversion of noise voltages common to both input leads. The unwanted signal can be rejected if the voltmeter measuring circuit is isolated from the noise. Most instruments use guarded circuitry (a highly isolated metal shield in the voltmeter between the measuring circuit and the noise) to achieve this isolation. The degree of isolation or common-mode rejection ratio (CMR) is defined as the ratio of the amount of noise injected into the instrument to the amount of noise present. Most manufacturers express the ratio in dB as:

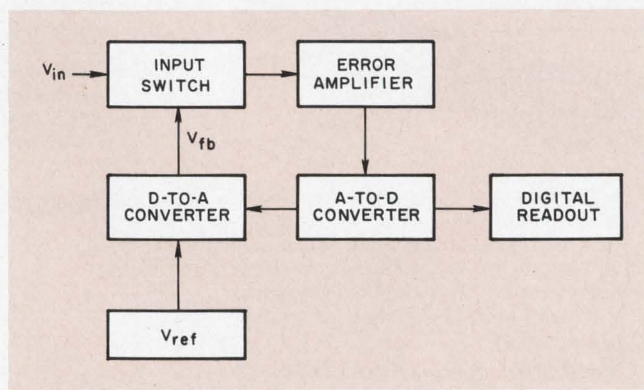
$$CMR = 20 \log \frac{V_{cm}\text{ (measured)}}{V_{cm}\text{ (present)}}$$

Normal-mode noise is any noise that exists between the high and the low input leads of the measurement circuit. Any noise superimposed upon the signal and any common-mode noise developed across the input leads are also considered normal-mode noise. Normal mode noise signals can be rejected by using an active filter or integrator network between the noise and the input to the instrument. The normal mode rejection ratio (NMR) is the ratio of the unwanted noise present in the measurement circuit to the total normal mode noise present. Like CMR, it is given in dB as:

$$NMR = 20 \log \frac{V_{nm}\text{ (measured)}}{V_{nm}\text{ (present)}}$$

The speed of an instrument is defined as the longest time it takes to make a reading to full accuracy on a particular range. However, speed

Tom Bakey, Marketing Manager, Data Technology Corp., Mountain View, Calif.



1. **Null-balance system** is susceptible to noise, since the error amplifier will sense any input noise and drive the system out of balance.

does not come without penalty in a DVM:

- If noise rejection is the prime consideration, input filtering is needed to attain the specified accuracy. But the use of the filter may reduce speed to where the DVM is out of specification.
- If common-mode rejection of the instrument is not sufficient, accuracy is directly affected by the noise injection.
- If the speed of measurement is critical, noise rejection and accuracy may have to be reduced.

To understand where the A-to-D conversion affects each of these factors, we will analyze the theory and operation of each of the five types.

Null balance susceptible to noise

The null-balance DVM is constantly monitoring the input voltage, so that it is very sensitive to input noise. A simplified block diagram of a null-balance circuit is shown in Fig. 1. The input switch is constantly alternating between the input voltage (V_{in}) and the feedback voltage (V_{fb}). The difference between the two voltages is sent to the error amplifier. This difference voltage is then amplified and sent to the A-to-D converter, where it is converted into a digital format. The digital signal developed is used to control the output of the D-to-A converter. It drives the feedback voltage up if it is below the input voltage, or down if it is above the input voltage. When the output voltage to the D-to-A converter (V_{fb}) equals the input voltage (V_{in}), the system is at null, and the digital readout indicates the input voltage.

Because null balance is such a dynamic system, it is highly susceptible to noise. Any noise on the input is sensed by the error amplifier and drives the system out of balance. To prevent this from happening, two solutions are offered: input filtering and sensitivity control.

Placing an input filter between the noise signal and the input will shunt the noise, but it will also reduce the speed of the DVM considerably. The speed of a null-balance instrument is reduced from 100 ms to about 900 to 1000 ms. This can be readily understood if the filter is considered as a fully charged source. Each time the DVM makes a measurement, it draws current from the source and drops the voltage across the filter. Either a large capacitor must be placed across the filter, to maintain its voltage within its accuracy, or the instrument's measurement time has to be extended so the filter can recover.

The sensitivity control also has drawbacks. It will reduce the noise effect, but it will also reduce the resolution and over-all accuracy. The control introduces a dead band of several digits to prevent noisy readout, but the dead band prevents full resolution and accuracy.

The digital output information of the DVM has to be coupled out of the guarded section over several lines, thus causing a reduction in the isolation impedance of the measurement circuit. A CMR of 120 to 140 dB is difficult to attain.

The input to a null-balance DVM is subjected to a varying input impedance. When the system is tracking toward the input voltage, the output of the D-to-A converter is contantly changing. This change is reflected across the input switch to the input voltage. Until the system reaches null, the input is subject to varying impedance.

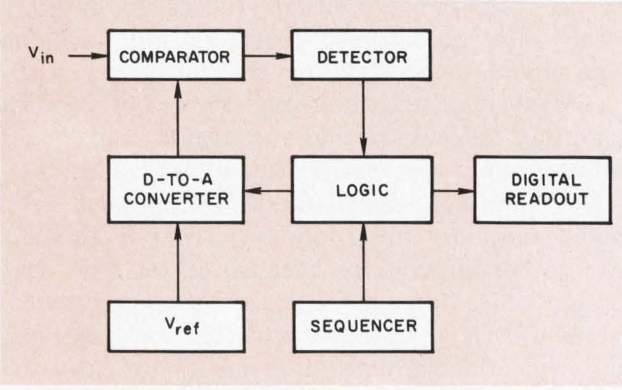
Reliability is an important factor in the null-balance system, since it uses a large amount of components. Both the A-to-D and D-to-A converters are quite critical, and the switching devices in the D-to-A section can cause some serious problems. When reed relays are used, they are constantly being exercised, and so are subject to fatigue failure. Transistor switching can cause severe leakage problems, since the transistor is neither open when it is OFF nor closed when ON.

The speed of a null-balance DVM without filters or sensitivity controls depends on the difference between the input and the feedback voltage. If the difference is on the order of millivolts, then the time required to reach null is a few milliseconds. But if there is a difference of several volts between them, then it will take about 500 to 700 milliseconds to balance.

If you are going to place your DVM in a system, the null-balance unit is not a good choice. It doesn't have a fixed encoding time, and it may or may not need input filtering to accomplish noise rejection. Programing and timing then become difficult.

Successive approximation—fast but noisy

The successive-approximation method (Fig. 2) increases the speed of conversion of the null-balance system, but noise is still a problem. Successive approximation does not dynamically



2. **Successive approximation is faster,** but still noisy. The system performs a "forced null balance" by a continued series of comparisons and detections.

"track" the voltage from the old to the new value; it codes each voltage independent of any past conversion. Its higher speed is obtained by initially taking "giant" steps of feedback voltage to compare with the input. The system generates a set sequence of steps in resolving the input signal. Here's an example of this "forced null-balance" system in operation:

When V_{in} is applied, it is compared to one-half the full-scale voltage (the D-to-A converter is sequenced to supply only one-quarter of the full-scale voltage to the comparator). If V_{in} is above one-half the full-scale voltage, then the converter is sequenced to supply three-quarters of the full-scale voltage to the comparator. Another comparison and detection is made, and the converter is sequenced accordingly. This process continues until the resolution of the system is reached. Even though the instrument may be performing a completely new conversion for each reading, the time it takes to reach the null point is only about 15 to 30 milliseconds. The null-balance system requires several hundred milliseconds.

The successive-approximation system encounters the same normal mode input noise problems that the null-balance system does. And again, filters and sensitivity controls can be used. But the reduction of sensitivity with control also lowers the accuracy and resolution. And when filters are used, they defeat the basic advantage of the system—faster speed. A good noise-rejection filter is slow to respond to input changes. The basic conversion occurs in 15 to 30 milliseconds, but the input filter has to be charged before the measurement is taken. The filter charge time is on the order of 900 milliseconds to one second. Add the filter time to the conversion time, and the over-all speed is reduced to 900 milliseconds to one second.

The reliability of this type of DVM is of the same order as the null-balance unit. The additional circuitry in the sequencer section and the control circuits in the D-to-A converter add to the complexity of the system. The D-to-A switching networks can use either reed relays or transistors. Mechanical reed relays do not have the high MTBF necessary for the constantly exercised converter, and the transistor is not an ideal switching device. Leakage currents and offset voltages can cause errors that affect accuracy.

The successive-approximation approach is a good candidate for high-level (one-to-10-volt) data-gathering systems because of the fast conversion time. But when low-level (one-microvolt-to-one millivolt) signals have to be resolved, noise rejection becomes a prime factor, and the filter slewing time reduces the speed. In a system, digital programing and digital output capability will cause a reduction in common-mode noise rejection. A CMR of 100 dB is the best to be expected at 60 Hz with a 1-kΩ source imbalance.

Ramp conversion: Cheaper, less accurate

The ramp-conversion DVM is by far the most economical unit (about a third the cost of most others). But this cost edge comes with some performance shortcomings.

The object of the technique (Fig. 3) is to measure the length of time it takes for a linear ramp to charge from zero to the input voltage. At the beginning of the measurement, the ramp generator is set to zero, and the clock pulse receives a start pulse. The counter starts to count the clock pulses, and the ramp generator starts to charge toward V_{in}. When the ramp generator reaches V_{in}, coincidence occurs. The comparator then generates a stop pulse for the clock, and the counter stops counting. The time measured between the start and stop pulses is indicative of V_{in} and is displayed on the digital readout.

The ramp-conversion DVM was developed for applications where moderate speed and reduced accuracy were acceptable. All ramp instruments have no more than four digits of resolution.

The ramp generator is normally a constant-current device charging into a capacitor network. The output of the generator is nonlinear and is subject to time and temperature variation. The best accuracy achieved is on the order of 0.05% over a limited time and temperature range.

The technique is also very sensitive to noise signals. The design does not incorporate input filters and therefore has virtually zero NMR. And the absence of a guard shield prevents a high common-mode rejection. Because of this unguarded construction, a CMR is only 60 to 80 dB at 60 Hz, with a 1-kΩ imbalance.

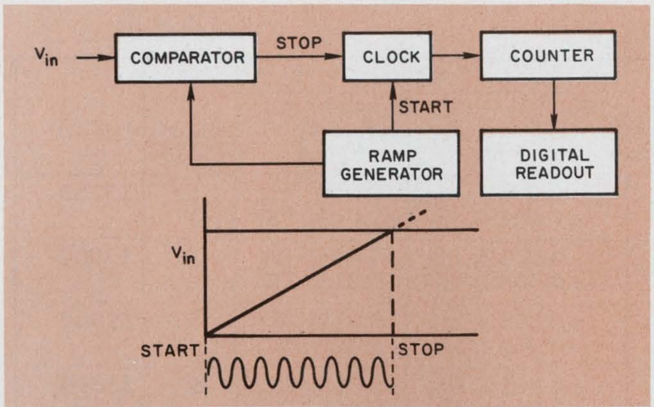
Speeds can range up to 100 milliseconds per conversion. But with negligible NMR and poor CMR, the unit is highly susceptible to noise.

When digital output information for systems applications is required, the CMR is virtually destroyed. The input low lead of the measurement circuit is at ground potential and will not reject any common-mode noise.

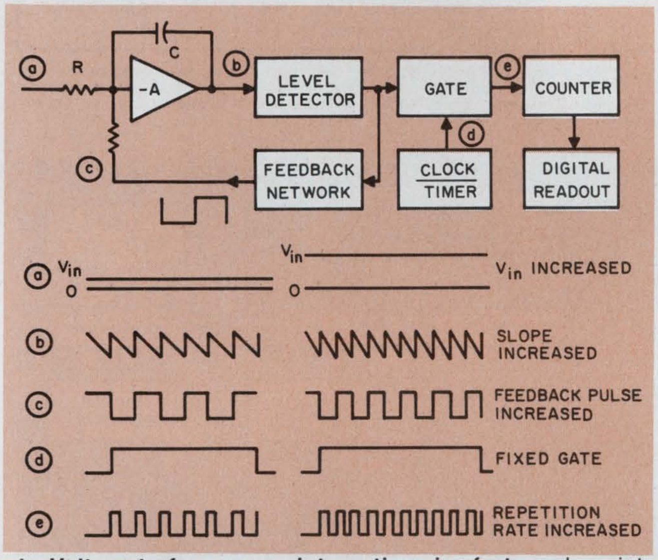
Integration techniques are speedy and quiet

Integration techniques combine speed and good noise rejection. The voltage-to-frequency and dual-slope approaches are the most widely used.

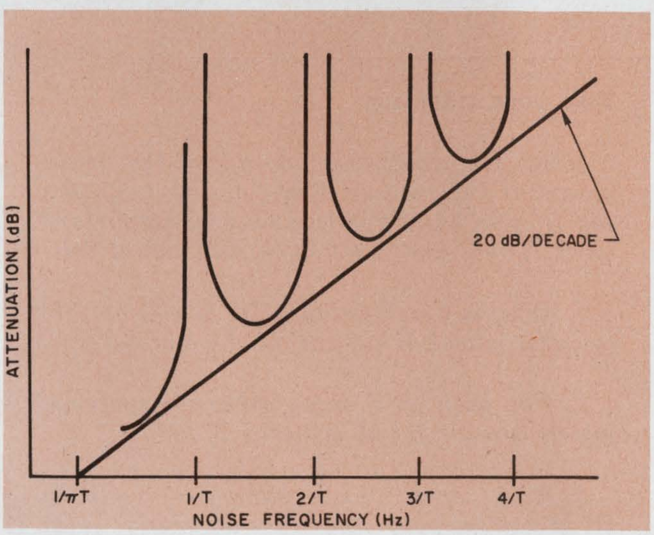
When the input voltage is applied to the integrator network of a voltage-to-frequency machine (Fig. 4a), a negative going ramp is generated at the output of the integrator (4b). The ramp continues to increase until it triggers the level detector. In turn, the level detector output triggers



3. **Ramp conversion measures the time** it takes for the linear ramp to go from 0 to V_{in}. When the clock pulses stop, their duration is indicative of V_{in}.



4. **Voltage-to-frequency integration is fast** and quiet. Accuracy, however, is a a problem for three reasons: C drifts with time and temperature, the clock frequency can shift and zero offset voltages can occur around the integrator input.



5. **Infinite attenuation of noise frequencies** occurs at frequencies that are multiples of the integration time.

the feedback network (usually a pulse generator). The feedback network produces a pulse (4c) that is opposite in polarity to V_{in} and of sufficient amplitude and width to discharge the capacitor and return the input of the integrator to zero. The system then starts all over again. The slope of the ramp voltage out of the integrator network is proportional to V_{in}, and the trigger point of the level detector is fixed. Therefore, as V_{in} is increased, the slope increases and more and more pulses are generated out of the level detector. The repetition rate of the level detector is then a function *of* V_{in}. This rate is gated (4d), counted and then digitally displayed.

The true average value of the input voltage is measured over a fixed sample time, resulting in an infinite rejection of the noise frequency as a function of the sample period. Infinite attenuation of the noise frequencies exists for those frequencies that are multiples of T, the integration time (Fig. 5). The selection of the time is therefore chosen to give the greatest possible noise rejection with reasonable speed.

The integrator provides infinite noise rejection at selected frequencies, while maintaining fast system speeds. For example, infinite noise rejection of 10 Hz, and multiples thereof, can be achieved at speeds up to 10 milliseconds with 0.005% accuracies.

Digital output information is available without degradation in CMR. CMR is on the order of 140 dB at 60 Hz, with a 1-kΩ imbalance.

Long-term accuracy is the big drawback in voltage-to-frequency DVMs:

- The integrator network's capacitor tends to drift over time and temperature and to cause a shift in the output slope.
- The clock frequency can shift and cause the gate circuitry to open or close too early or late causing wrong count indications.
- Zero offset voltages around the integrator input can occur because of the design limitations of the feedback network. The integrating capacitor is charged through one network and discharged through another.

Dual slope raises accuracy specs

The dual slope integration method has the same advantages of the voltage-to-frequency method, with the plus of high long-term accuracy. Here's how it works (Fig. 6):

At the beginning of the measurement, the input switch is set to V_{in} and the counter to zero. V_{in} passes through the integrator and appears at the input of the zero detector as V_{in}/RC. When the counter accumulates its maximum count (normally 100,000) it tumbles over to zero and the logic switches the input switch to the V_{ref}

Table. DVM performance compared

Type of DVM	Speed (ms)	NMR (dB to 60 Hz)	CMR (dB at 60 Hz with 1-kΩ imbalance)	Accuracy (short term) 23° ∓ 1°C 7 hrs	Accuracy (long term) 10° to 40°C 6 mos	No. of digits	Typical cost
Null balance (filter in)	1000	80	100	∓0.005% rdg† ±0.002% FS	±0.01% rdg ±0.01% FS	5	$3200
Null balance (filter out)	500	0	100	±0.005% rdg ±0.002% FS	±0.01% rdg ±0.01% FS	5	$3000
Successive approx (filter in)	900	80	100	±0.005% rdg ±0.002% FS	±0.01% rdg ±0.01%FS	5	$3900
Successive approx (filter out)	25	0	100	±0.005% rdg ±0.002% FS	±0.01% rdg ±0.01% FS	5	$3600
Ramp conversion	100	0	40	±0.02% rdg ±0.05% FS	±0.05% rdg ±0.05% FS	4	$1200
Voltage-to-frequency integration	200	Infinite	140	±0.005% rdg ±0.002% FS	±0.02% rdg ±0.02% FS	5	$3900
Dual slope integration	200	Infinite	140	±0.003% rdg ±0.002% FS	±0.01% rdg ±0.002% FS	5	$2800

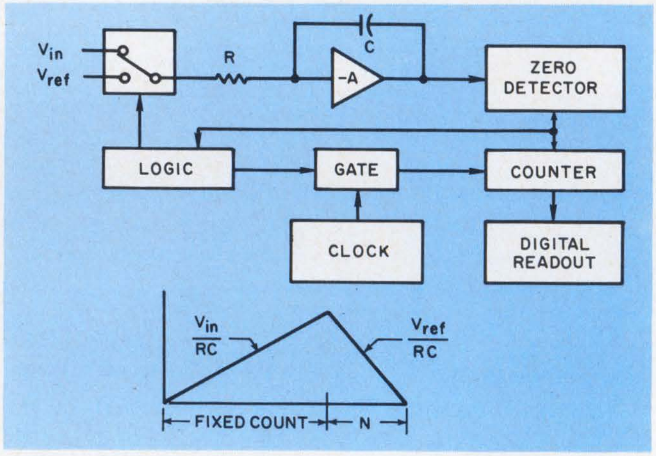
*Prices and number of digits vary widely among different manufacturers. For example, a 'three-and-one-half' digit DVM (3 decades and a fourth digit) can be bought for $299. This dual-slope DVM has an accuracy of ±0.1% of reading and a speed of about 170 ms. On the other hand $6000 will buy a 6-digit DVM, accurate to 0.01%, and with a speed of 250 ms. This unit offers signal outputs for a Clary printer or Flexowriter, or a digital recorder. The prices given above are for typical manufacturers' units.
† Rdg is reading, FS is full scale.

position. V_{ref} starts to discharge the integrator capacitor and the counter starts counting. The input to the zero detector is now V_{ref}/RC. When the integrator capacitor is discharged, the zero detector triggers the logic to stop the counter. The counts accomulated (N) are proportional to the input voltage and are displayed on the digital readout.

This approach has the same excellent advantages as the voltage-to-frequency converter. Noise rejection, speed and accuracy can vary as a function of the user's requirement. Accuracies up to 0.005% can be attained at speeds of 100 milliseconds with infinite noise rejection at 60 Hz. For systems use, digital output information is easily acquired with CMR of 140 dB at 60 Hz, with a 1-kΩ imbalance. Normal-mode noise is virtually rejected as a function of the integrator sample period.

The problems encountered in most integrators are eliminated with dual slope:

- The drift associated with the integrator capacitor has little, if any, effect. Assume that the capacitor does shift, then the input slope V_{in}/RC shifts but is compensated for by the shift in the reference slope V_{ref}/RC.
- The clock frequency can vary considerably, and the voltage indication will remain correct. If the clock frequency varies, then the time to measure the input voltage will change. But the same clock is used to measure the discharge voltage. Therefore, the shift in clock frequency is a relative one and the indication will remain.
- The design takes into consideration the integrator zero offset voltages. The charging and discharging cycle of the integrator capacitor is through the same network. ■■



6. **Dual-slope integration is accurate,** fast, and quiet. Long-term accuracy is high, since shifts in C are compensated for by shifts in V_{ref}/RC. Even if the clock frequency varies, the reading will remain correct.

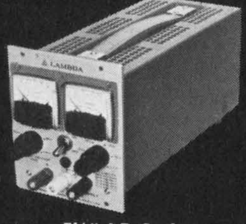
Test your retention

Here are questions based on the main points of this article. They are to help you see if you have overlooked any important ideas. You'll find the answers in the article.

1. Why is a null-balance DVM susceptible to input noise? What can be done about it?

2. For high-level data-gathering systems, which type of DVM is best? Why?

3. Why does the voltage-to-frequency DVM exhibit poor long-term accuracy? How does the dual-slope machine improve this?

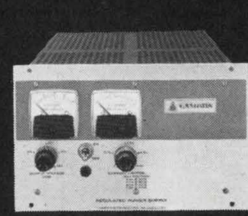


5¼″ LP Series Metered

5¼″ LP Series Non-Metered

5¼″ LH Series ¼ Rack Metered

5¼″ LH Series ¼ Rack Non-Metered



5¼″ LH and LK Series ½ Rack Metered

All from Lambda. Broadest line of all-silicon lab

NEW advanced design dual output lab supplies give you twice the power plus output ranges never before available...plus...

5 Models with two independent DC outputs offer widest choice—Up to ±250 VDC, up to 1.7 amps. Either output may be + or —, or both outputs may be + or —

Series/Parallel operation of both outputs yields two times the voltage or two times the current—up to 500 volts or up to 3.4 amps.

Auto Series/Auto Parallel (master slave) permits tracking to a common reference.

4 Meters provide simultaneous monitoring of both voltage and current.

Most power in a half-rack package.

Overvoltage Protection as an accessory.

Compatible with LP, LH and LK Series rack adapters and other accessories.

Multi-Current-Rated—Only dual power supplies on market with this advanced design feature.

Regulation—.01% + 1mV.

Ripple—500μ VRMS (1.5mVp-p).

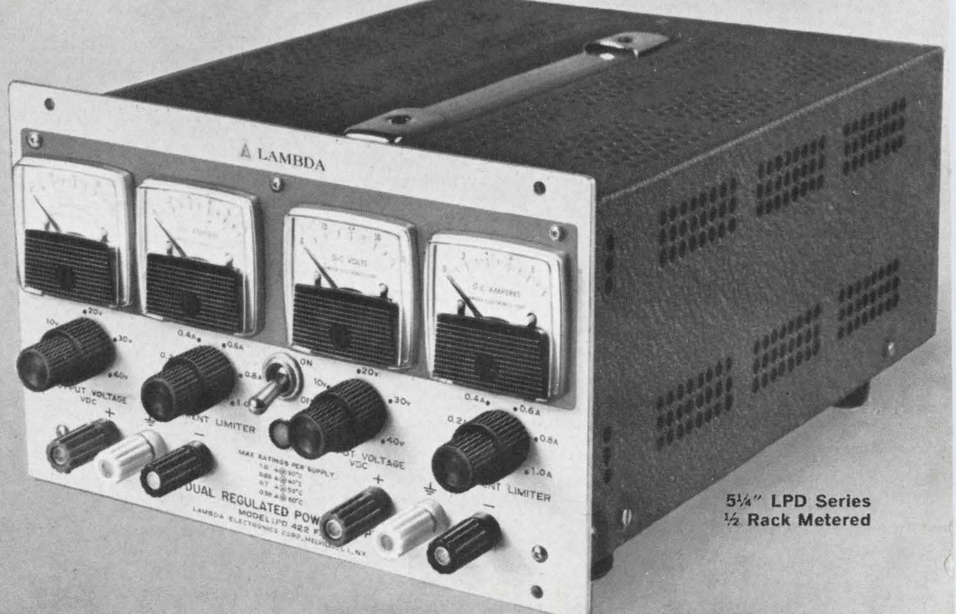
Size: 5$\frac{3}{16}$″ x 8⅜″ x 10⅝″

Model(2)	Voltage Range Per output/ **Outputs in series** VDC	I MAX AMPS AT AMBIENT OF: (1) Per output/**Outputs in parallel** 30°C	40°C	50°C	60°C	Price(2) US and Canada
*LPD-421-FM	0-±20/**0-40**	1.7A/**3.4A**	1.5A/**3.0A**	1.3A/**2.6A**	0.9A/**1.8A**	$325
*LPD-422-FM	0-±40/**0-80**	1.0A/**2.0A**	0.85A/**1.7A**	0.7A/**1.4A**	0.55A/**1.1A**	260
*LPD-423-FM	0-±60/**0-120**	0.7A/**1.4A**	0.6A/**1.2A**	0.5A/**1.0A**	0.4A/**0.8A**	325
LPD-424-FM	0-±120/**0-240**	0.38A/**0.76A**	0.32A/**0.64A**	0.26A/**0.52A**	0.20A/**0.40A**	325
LPD-425-FM	0-±250/**0-500**	0.13A/**0.26A**	0.12A/**0.24A**	0.11A/**0.22A**	0.10A/**0.20A**	350

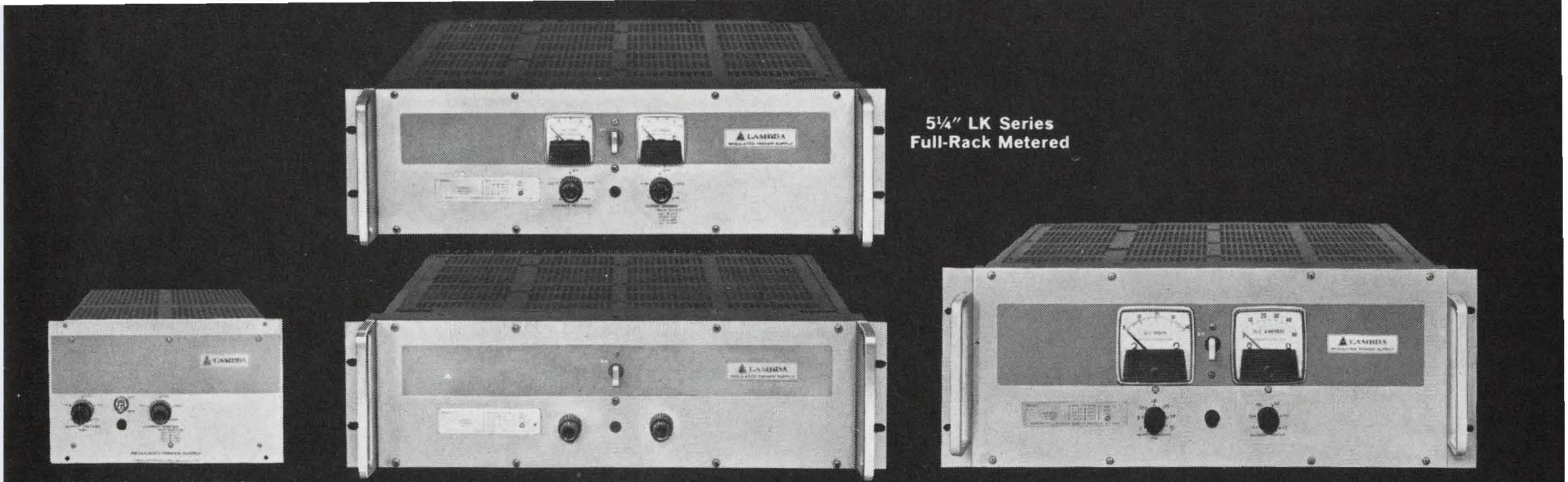
* Overvoltage Protection available as an accessory. Each output requires separate OV accessory—add $35.00 for each output.

(1) Current rating applies over entire voltage range. Ratings based on 57-63 Hz operation.

(2) Prices are for metered models. LPD Series models are not available without meters.



5¼″ LPD Series ½ Rack Metered



5¼″ LK Series Full-Rack Metered

5¼″ LH and LK Series ½ Rack Non-Metered

5¼″ LK Series Full-Rack Non-Metered

7″ LK Series Full-Rack Metered

or systems power supplies...bench or rack

or choose from these ¼, ½ and full-rack Lambda supplies

Size 5³⁄₁₆″ x 4³⁄₁₆″ x 10″

Model [2]	Voltage Range	CURRENT RANGE AT AMBIENT OF: [1]				Price [2]
		30°C	40°C	50°C	60°C	
LP 410	0-10 VDC*	0-2A	0-1.8A	0-1.6A	0-1.4A	$129
LP 411	0-20 VDC*	0-1.2A	0-1.1A	0-1.0A	0-0.8A	119
LP 412	0-40 VDC*	0-0.70A	0-0.65A	0-0.60A	0-0.50A	114
LP 413	0-60 VDC*	0-0.45A	0-0.41A	0-0.37A	0-0.33A	129
LP 414	0-120 VDC	0-0.20A	0-0.18A	0-0.16A	0-0.12A	149
LP 415	0-250 VDC	0-80mA	0-72mA	0-65mA	0-60mA	164

Size 5³⁄₁₆″ x 4³⁄₁₆″ x 15½″

Model [2]	Voltage Range	CURRENT RANGE AT AMBIENT OF: [1]				Price [2]
		30°C	50°C	60°C	71°C	
LH 118-A	0–10VDC	0–4.0A	0–3.5A	0–2.9A	0–2.3A	$180
LH 121-A	0–20VDC	0–2.4A	0–2.2A	0–1.8A	0–1.5A	170
LH 124-A	0–40VDC	0–1.3A	0–1.1A	0–0.9A	0–0.7A	170
LH 127-A	0–60VDC	0–0.9A	0–0.7A	0–0.6A	0–0.5A	185
LH 130-A	0–120VDC	0–0.50A	0–0.40A	0–0.35A	0–0.25A	240

Size 5³⁄₁₆″ x 8⅜″ x 15⅛″

Model [2]	Voltage Range	CURRENT RANGE AT AMBIENT OF: [1]				Price [2]
		30°C	50°C	60°C	71°C	
LH 119-A	0–10VDC	0– 9.0A	0– 8.0A	0– 6.9A	0–5.8A	$289
LH 122-A	0–20VDC	0– 5.7A	0– 4.7A	0– 4.0A	0–3.3A	260
LH 125-A	0–40VDC	0– 3.0A	0– 2.7A	0– 2.3A	0–1.9A	269
LH 128-A	0–60VDC	0– 2.4A	0– 2.1A	0– 1.8A	0–1.5A	315
LH 131-A	0–120VDC	0– 1.2A	0– 0.9A	0– 0.8A	0–0.6A	320

Model [2]	Voltage Range	CURRENT RANGE AT AMBIENT OF: [1]				Price [2]
		40°C	50°C	60°C	71°C	
LK 340-A	0–20VDC	0– 8.0A	0– 7.0A	0– 6.1A	0–4.9A	$330
LK 341-A	0–20VDC	0–13.5A	0–11.0A	0–10.0A	0–7.7A	385
LK 342-A	0–36VDC	0– 5.2A	0– 5.0A	0– 4.5A	0–3.7A	335
LK 343-A	0–36VDC	0– 9.0A	0– 8.5A	0– 7.6A	0–6.1A	395
LK 344-A	0–60VDC	0– 4.0A	0– 3.5A	0– 3.0A	0–2.5A	340
LK 345-A	0–60VDC	0– 6.0A	0– 5.2A	0– 4.5A	0–4.0A	395

Size 5¼″ x 19″ x 16½″

Model [2]	Voltage Range	CURRENT RANGE AT AMBIENT OF: [1]				Price [2]
		40°C	50°C	60°C	71°C	
LK 350	0–20VDC	0–35A	0–31A	0–26A	0–20A	$675
LK 351	0–36VDC	0–25A	0–23A	0–20A	0–15A	640
LK 352	0–60VDC	0–15A	0–14A	0–12.5A	0–10A	650

Size 7″ x 19″ x 18½″

Model [2]	Voltage Range	CURRENT RANGE AT AMBIENT OF: [1]				Price [2]
		40°C	50°C	60°C	71°C	
LK 360 FM	0–20VDC	0–66A	0–59A	0–50A	0–40A	$995
LK 361 FM	0–36VDC	0–48A	0–43A	0–36A	0–30A	950
LK 362 FM	0–60VDC	0–25A	0–24A	0–22A	0–19A	995

LP NOTES

*Overvoltage Protection available as an accessory—$35.00 each.

1 Current rating applies over entire voltage range. Ratings based on 57-63 Hz operation.

2 Prices are for non-metered models. For metered models, add suffix (FM) and add $10.00 to price.

LK-LH NOTES:

1 Current rating applies over entire voltage range.

2 Prices effective Feb. 1, 1968. Prices are for non-metered models (except for models LK360FM, LK361FM, and LK362FM which are metered models not available without meters). For metered models, add suffix (FM) and add $30.00 to price.

3 Overvoltage Protection up to 70 VDC is available as a bolt-on accessory for models with suffix (—A). To order, add suffix (OV) and add $35.00 to the price. For full-rack models, overvoltage protection up to 70 VDC is available as a built-in option. To order add suffix (OV) and add $90.00 to price of models LK350-352; add $120.00 for models LK360FM-362FM.

4 Chassis Slides for full rack models: Add suffix (CS) to model number and add $60.00 to the price except for models LK360FM-362FM, for which add $100.00.

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INFORMATION RETRIEVAL NUMBER 41

Fewer sections and better specs

are the conflicting demands on filter designers. A simple way to predict all losses accurately helps balance them.

"We want fewer filter sections and greater accuracy. We need the space," says the systems engineer to the filter designer. Besides getting saddled with such demands, the filter man must also face the fact that circuit elements seldom live up to expectations of performance, especially in miniaturized forms.

Only more accurate design will help him. The following method helps him predict circuit performance with the lossy elements used in practice.

The procedure uses low-pass reference models —even or odd orders—as a starting point for the design. The actual coil Q is compared with an ideal coil Q, and their ratio is used to find, from a set of attenuated curves, the cutoff frequency that would ensure the required bandwidth and attenuation. This modified bandwidth is then used to determine the component values of the filter from a table of normalized component values. The technique is particularly valuable in multichannel high-capacity multiplex systems and in satellite communication networks, where the tolerance in pass-band response is very tight—all the available system bandwidth must be squeezed into the pass band.

The technique involves only one assumption: uniform loading. The data are usable for both Butterworth and Chebyshev filters.

No more guessing

The usual design approach involves estimation of the dissipate roll-off, mostly due to inductors, and allowing extra bandwidth to compensate. The approach is based on the ready availability of data on the components of lossless and loss-compensated low-pass filters.[1] The final outcome depends on the engineer's skill in guessing.

There is, however, a simple and accurate way to predict exact bandwidth needs and design a filter without guessing. This takes into account available off-the-shelf components, predicts actual operating losses and pinpoints the modifications needed to the design bandwidth. Since low-pass filters are well understood, they are used as reference models.

William C. Kole, Senior Engineer, Raytheon Co., Norwood, Mass.

Compare ideal and actual coils

The procedure is based on comparing the Q of the available coil in the actual filter with the Q of the inductor in an ideal low-pass filter. The notation and definitions are the conventional ones. The center of the design bandwidth is defined as $\omega_c = 2\pi f_c$, in radians per second. The coil Q is a function of frequency:

$$Q = \omega_c L/r,$$

where r represents the core and copper losses at ω_c, and appears in series with the coil.

The minimum Q required by the low-pass reference model is denoted by q_{min}. It may be found from the roots of the transfer-function polynomial by taking the reciprocal of the real part of the root nearest the $j\omega$ axis.

In a Butterworth-type low-pass filter, the roots of the transfer function lie on a unit circle in the S plane. For example, a third-degree ($N = 3$) Butterworth has the transfer function:

$$T(s) = 1/(s^3 + 2s^2 + 1).$$

The left-hand plane roots lie on a circle at $(s + 1)\ (s + 0.5 \pm j0.866)$, from which:

$$q_{min} = 1/\sigma_{min} = 2.0.$$

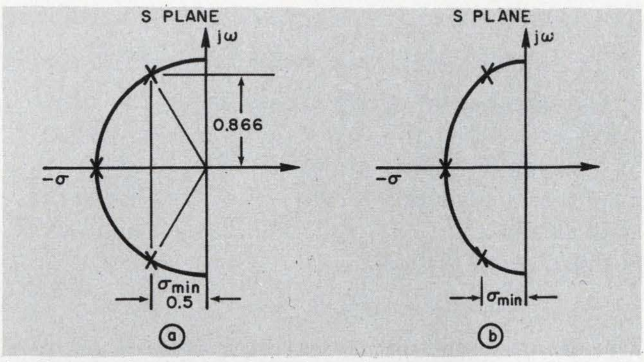
The roots are plotted in Fig. 1a.

For Chebyshev filters the roots of the transfer function lie on an ellipse. The low-pass filter's q_{min} varies directly with the maximum pass-band ripple. A higher ripple factor means greater out-of-band rejection for a given shape factor and requires higher q_{min}. Taking a third-order filter as an example again, with a 2-dB pass-band ripple the transfer function is:

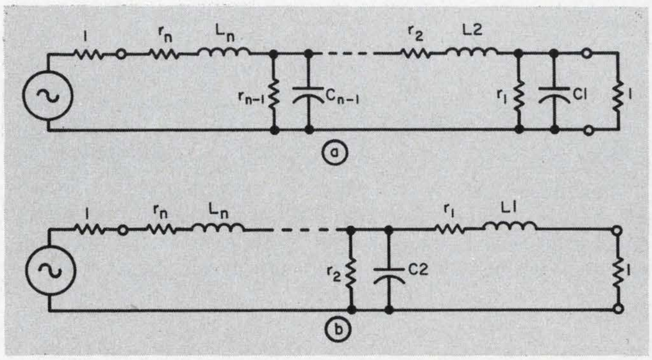
$$T\ (s) = 1/(s^3 + 0.7378216s^2 + 1.02219s + 0.32689). \qquad (2)$$

The roots on the left-hand S plane are at $(s + 0.36891)\ (s + 0.1844559 \pm j0.9230771)$. These values are shown in Fig. 1b.

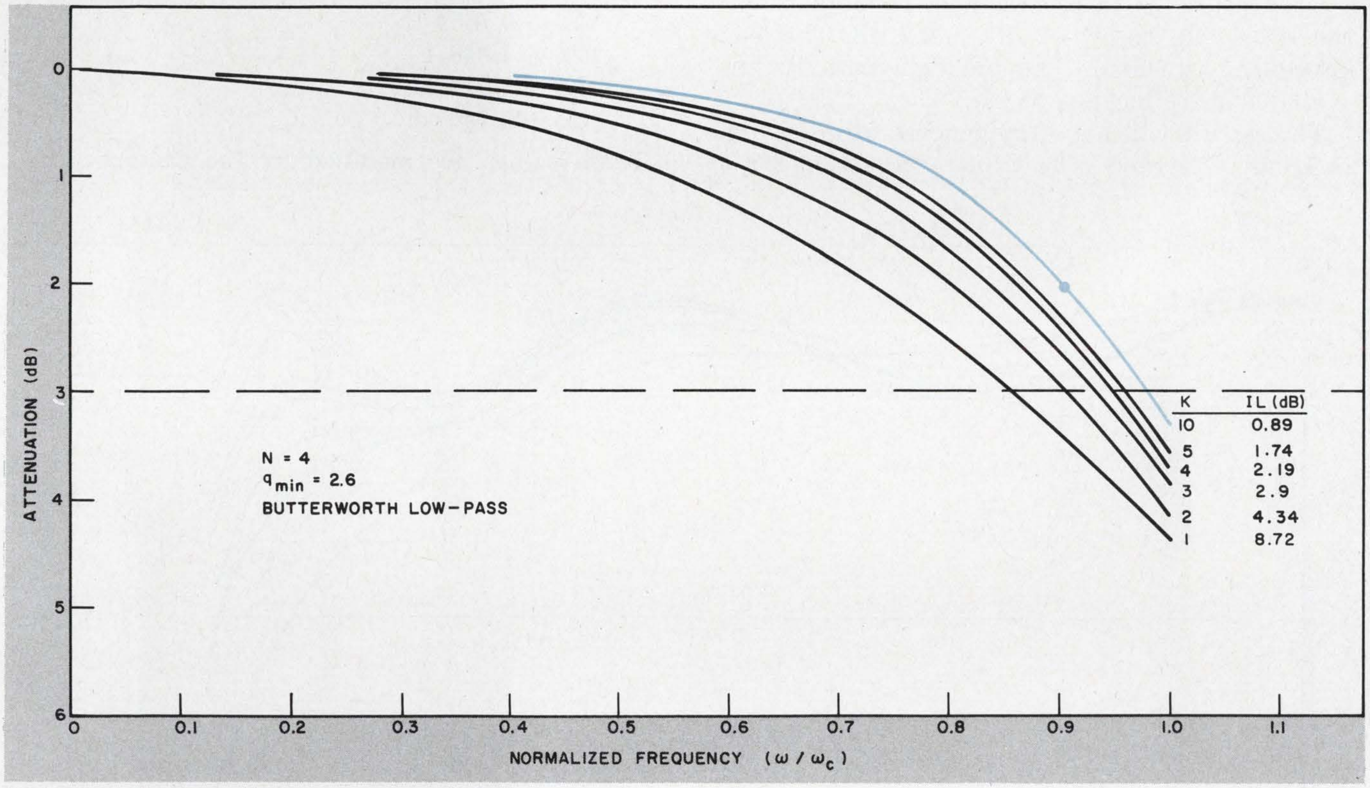
Depending on the order of the filter, two



1. **Roots of transfer functions** for Butterworth filters lie on a unit circle (a) in the S-plane. For Chebyshev types, they are on an ellipse (b). The minimum Q of a low-pass filter is the reciprocal of σ_{min} for both types, which is the real part of the root nearest the $j\omega$ axis.



2. **Two standard low-pass filter configurations are used in most designs.** For even-order types, (a) is used as the standard circuit, and for odd-order ones, (b) is the usual circuit. The resistances r_n compensate for copper and core losses.



3. **Curves of attenuation** versus normalized frequency for a family of fourth-order low-pass Butterworth filters. The K factors are the ratio of the available coil Q to the minimum required, which is 2.6 in this case. The curves were plotted with an IBM 7044 computer program that also calculated the expected insertion loss (IL) for each value of K. The curve in color refers to a design example in the text.

standard circuit configurations can be set up. For an even order, the circuit in Fig. 2a may be taken as standard, and for odd-order filters, the circuit in Fig. 2b is the usual form.

The element values in both circuits are normalized to a load of 1 ohm ($R_L = 1\ \Omega$). The normalized element values are represented by L_n and C_n. The copper and coil losses are included in r_n, which may be expressed as:

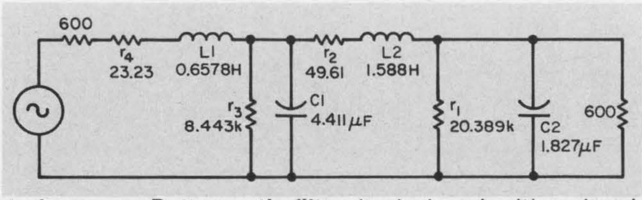
$$r_n = L/Kq_{min} \quad \text{or} \quad Kq_{min}/C,$$

where $K = Q_{available}/q_{min}$ and may be any number.

With the value of q_{min} for a particular filter as the unit of comparison, the series and shunt resistances may be computed for uniform loading.

For both the Butterworth and Chebyshev types, the unit cutoff frequency indicates the band-edge ripple point. For all Butterworth types, $\omega_c = 1$ corresponds to the 3-dB point, if $K = \infty$ ($Q = \infty$). For Chebyshev filters, $\omega_c = 1$ corresponds to the band-pass limit. (For a 2-dB ripple, $\omega_c = 1$ is the 2-dB bandwidth.)

Curves of attenuation versus normalized frequency have been prepared for values of $K = Q_{available}/q_{min}$ using an IBM 7044 computer pro-



4. **Low-pass Butterworth filter** is designed with a bandwidth that ensures the specified response in the specified range. Resistances r_2 and r_4 stand for core and copper losses and r_1 and r_3, for losses in the capacitors.

gram. A few design examples will illustrate the use of the curves.

Design examples illustrate the process

Assume a fourth-order ($N = 4$) low-pass Butterworth filter is to be designed. Its response at 100 Hz should be at —2 dB ± 0.2 dB. The load impedance is 600 Ω. The inductor that fits the available space has a Q of 26.

The circuit will have the general form of Fig. 2a since N is even. The transfer function for a fourth-order filter yields $q_{min} = 2.60$.[2] Therefore:

$$K = Q_{available}/q_{min} = 26/2.60 = 10.$$

The question of at what frequency the attenuation will reach the specified value is answered by the appropriate curve in Fig. 3 (for this example, the colored curve). The filter has a 2-dB attenuation at $\omega/\omega_c = 0.9$. The design bandwidth is therefore modified:

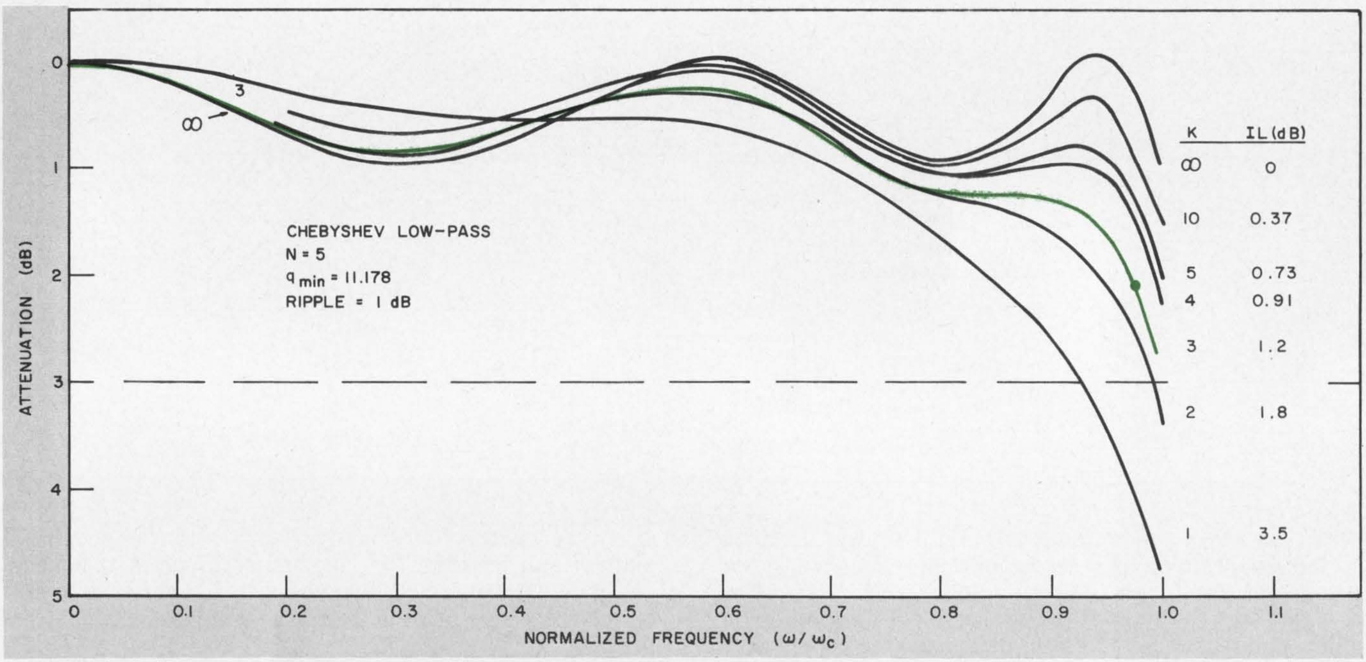
$$f_{c\ (design)}' = 100/0.9 = 111.1 \text{ Hz}.$$

The design bandwidth must be increased by 11.1 Hz to meet the specified performance.

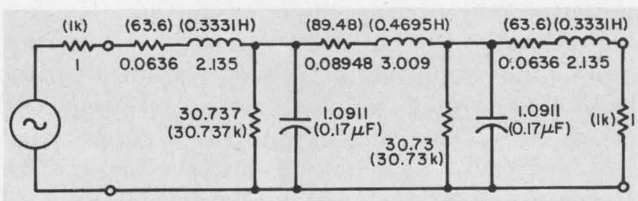
Since the components are frequency-sensitive, they will have to be changed too. The standard normalized values for low-pass types are listed in most books on network synthesis.[3] Using the notation in Fig. 4, they are:

$L1 = 0.7654$ H,
$C1 = 1.848$ F,
$L2 = 1.848$ H,
$C2 = 0.7654$ F.

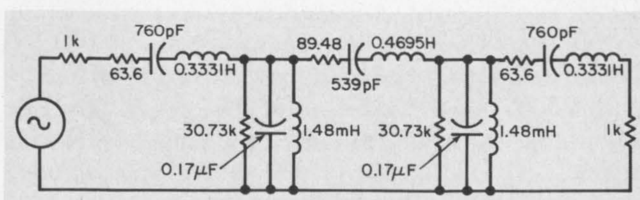
These values are modified by the factors:



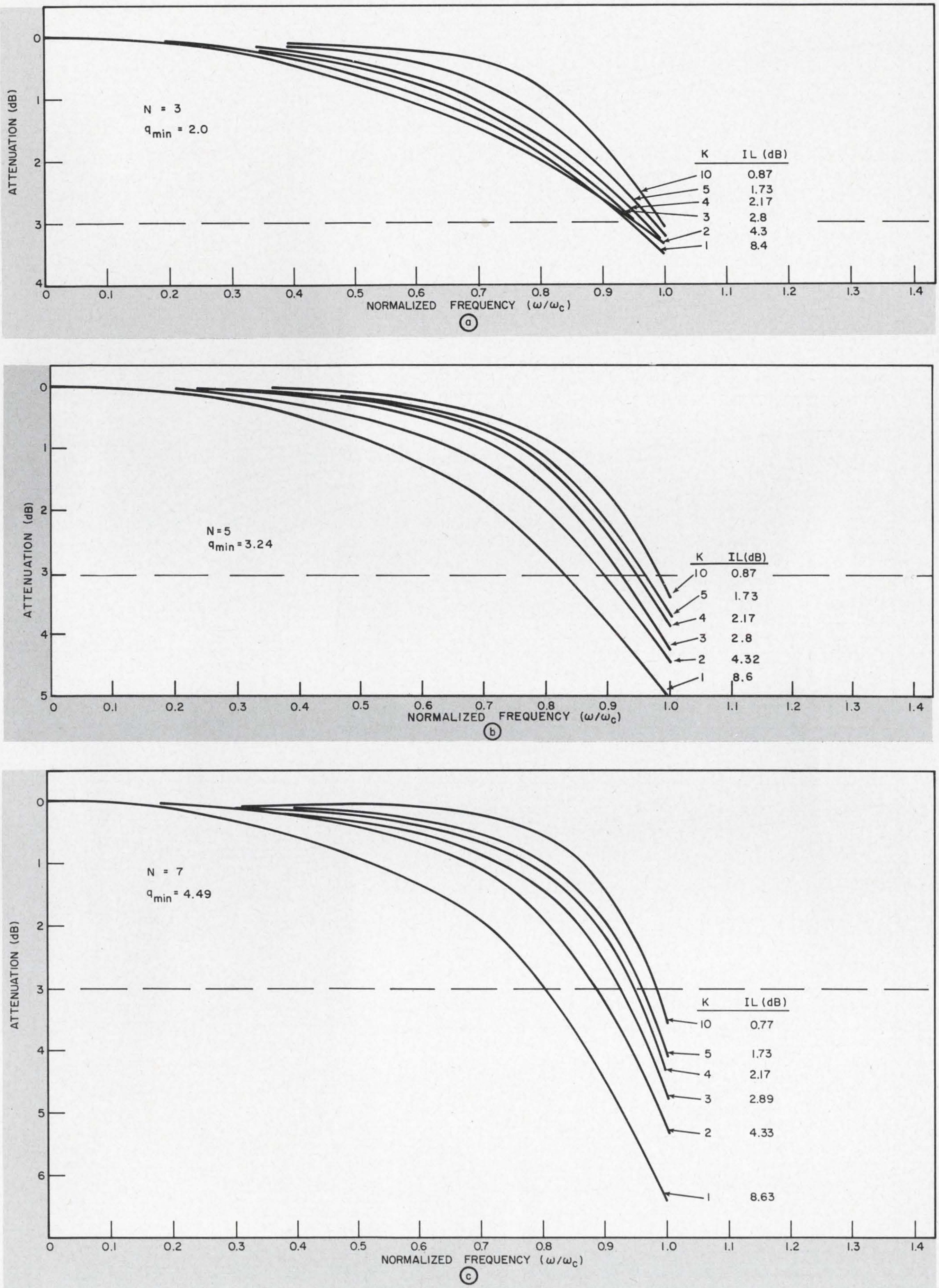
5. **Design curves for fifth-order Chebyshev filters** show changes in response as the K factor varies from unity (when the ideal coil is used) to virtually infinity (when the available Q is much larger than required.)



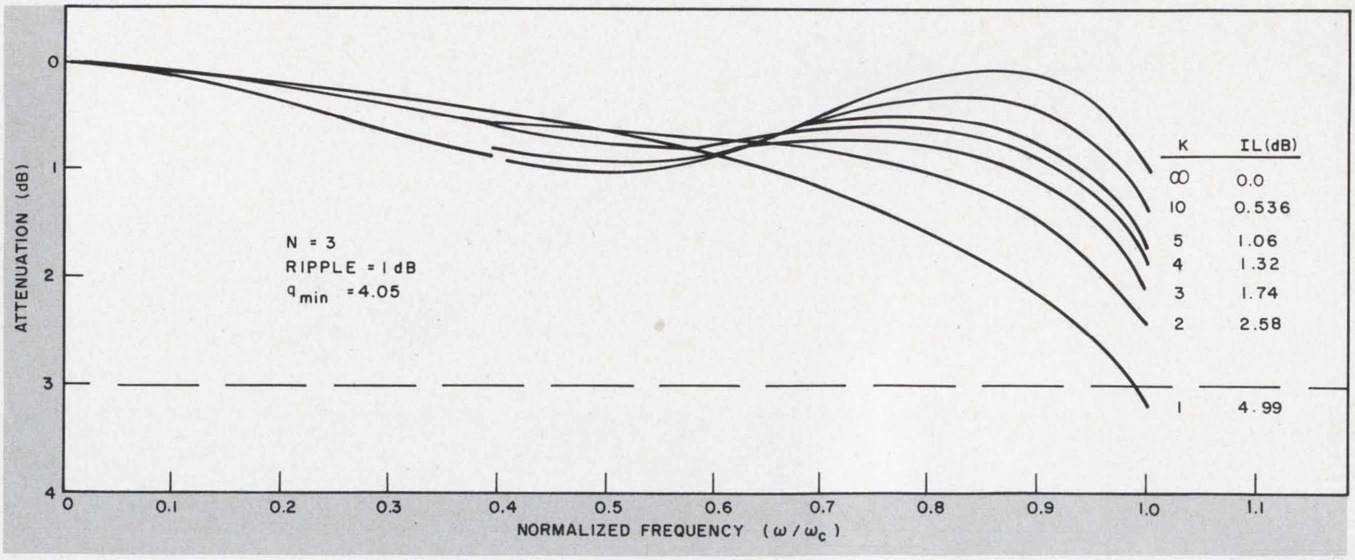
6. **Chebyshev band-pass filter** has a pass-band ripple of 1 dB and a bandwidth of 1020 Hz, which guarantees a 1-kHz bandwidth between the 2-dB ±0.5-dB points. The final component values in parentheses reflect the changes from low-pass to band-pass.

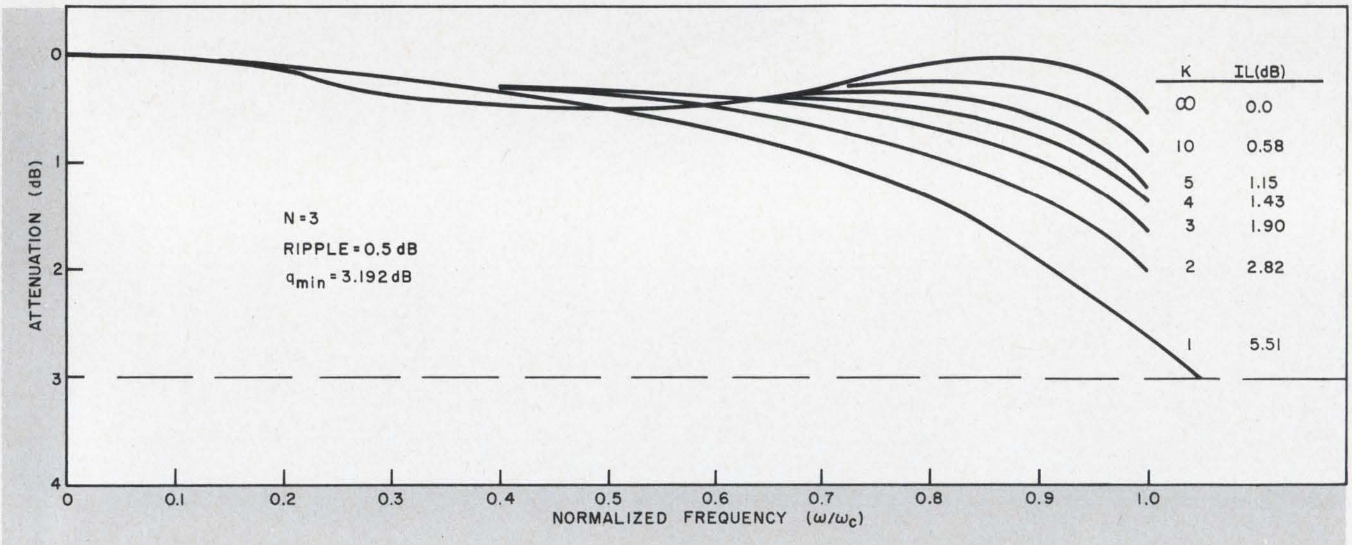


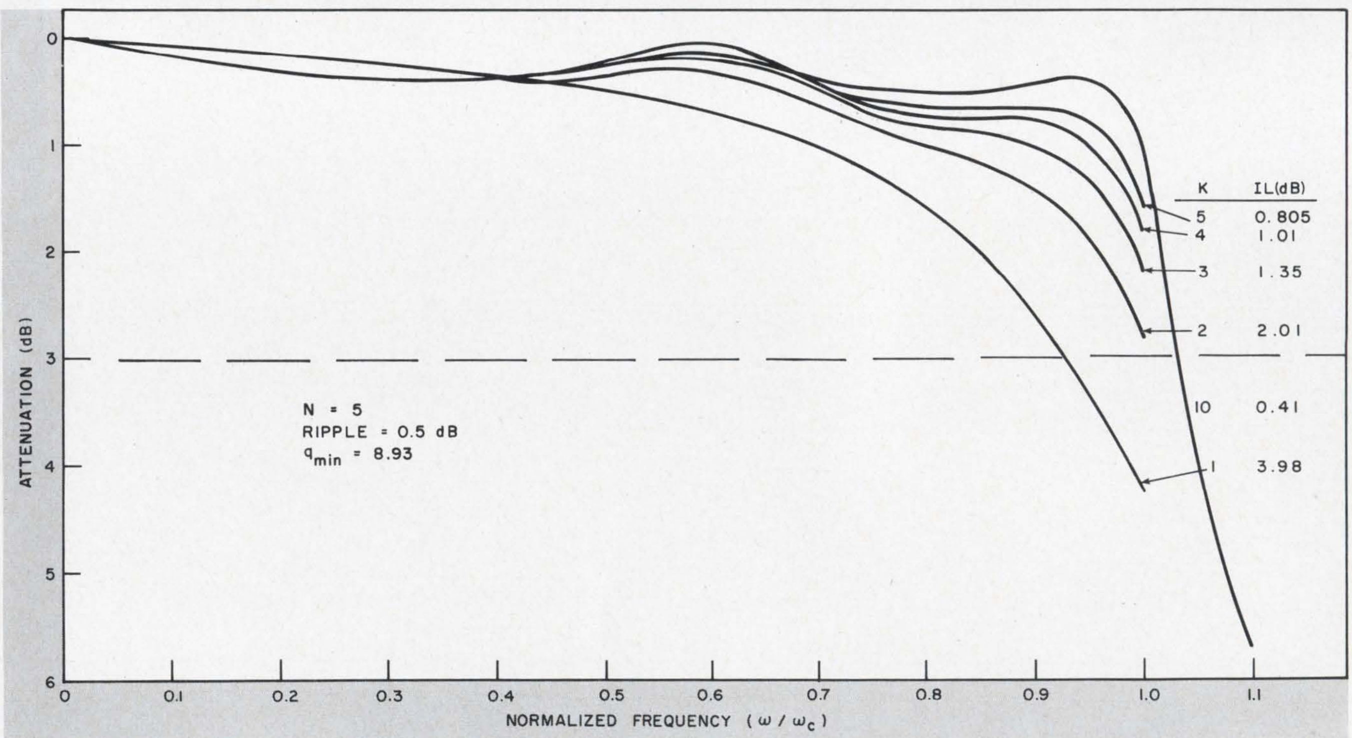
7. **The resonant circuits in the Chebyshev filter** are completed by adding the shunt inductances and series capacitances. The capacitors may be considered lossless. This can be closely approximated with high-quality filter capacitors.



8. **A family of attenuation curves for a group of Butterworth filters** depict responses for low-pass types of the third (a), fifth (b) and seventh (c) orders. In all cases uniform loading is assumed.







9. **Curves for Chebyshev filters** show attenuation for third- and fifth-order types and several ripple factors as K is varied. Uniform loading is assumed. For other specifications interpolation will give good results.

$$L_o = R/\omega_c = 600/981^{\cdot 26} \times 10^2 = 0.85944 \text{ H},$$
$$C_o = 1/R\omega_c = 1/600 \times 6.98126 \times 10^2$$
$$= 2.38734\ \mu\text{F},$$
since $\omega_c = 2\pi f_c = 6.98126 \times 10^2$.

To obtain the proper component values, $L1$ and $L2$ are multiplied by L_0 and $C1$ and $C2$ by C_0. The results are shown in Fig. 4.

The series resistances in Fig. 4 account for copper and core losses in inductors $L2$ and $L4$:

$$r_2 = \omega_c L2/Q_{available} = 49.61\ \Omega,$$
$$r_4 = \omega_c L4/Q_{available} = 23.232\ \Omega.$$

The shunt resistances compensate for losses in the capacitors:

$$r_1 = Q_{available}/\omega_c C1 = 20.389\ \text{k}\Omega,$$
$$r_3 = Q_{available}/\omega_c C3 = 8.443\ \text{k}\Omega.$$

The improvement in design comes from the fact that the exact frequency at the specified 2-dB points can be read off from the appropriate curve (in this case at $\omega/\omega_c = 0.9$). The cutoff frequency can therefore be calculated accurately.

The computer program that supplied the attenuation curves also calculated the insertion loss. Its calculation showed the insertion loss for this filter to be 0.89 dB. The measured value came close: 0.9 dB.

Band-pass design needs extra factor

The design of band-pass filters is a bit more involved, because their Q requirement is higher than that of low-pass types. The increase is by a factor $f_0/\Delta f$, where f_0 is the center frequency and Δf is the bandwidth. This change, of course, means that K is also increased by $f_0/\Delta f$.

The design procedure is illustrated by the following example. A band-pass filter is needed at a center frequency of 10 kHz, with a bandwidth of 1 kHz between the 2-dB $\pm$ 0.5-dB points. The filter should have a response of a fifth-order Chebyshev type, with a maximum pass-band ripple of 1 dB. The load is 1 kΩ.

Since it is an odd-order filter, the general form of the circuit is that of Fig. 2b. Coils at 10 kHz have Qs of 330. The value of q_{min} is 11.178.[4] Therefore:

$$K = (330/q_{min})\ (f_0/\Delta f) = 330/11.178 \times 10$$
$$= 2.95.$$

For $N = 5$, a 1-dB ripple and $K = 3$, the attenuation curves in Fig. 5 show the upper frequency of the band to be:

$$\omega/\omega_c\big|_{2\text{dB}} = 0.97.$$

Therefore:

$$f_{c\ (design)} = 1000/0.98 = 1020 \text{ Hz}.$$

The expected insertion loss of 1.2 dB is listed alongside the $K = 3$ curve.

The element values for the ideal case appear in Fig. 6. The practical values are obtained by multiplying all resistances by 10^3, all inductances by R/ω_c and all capacitances by $1/R\omega_c$—just as in the case of the low-pass Butterworth:

$$R/\omega_c = 0.15603 \text{ H},$$
$$1/R\omega_c = 0.15603\ \mu\text{F},$$
$$\omega_c = 2\pi 1020.$$

The last step is to complete the resonant circuit in each branch by adding a series capacitance to each inductor and a parallel inductance to each capacitor:

$$C_{series} = 1/\omega_0^2 L_{series},$$

$$L_{shunt} = 1/\omega_0^2 C_{shunt}.$$

The final circuit configuration is shown in Fig. 7.

Now all resistors are associated only with the inductors, and represent the copper and core losses, while the capacitors may be considered lossless. This situation is closely approximated in practice by the use of high-quality filter capacitors. The spread in element values may be reduced by appropriate impedance transformations, which will not be considered here.

Attenuation curves for a group of Butterworth low-pass filters are plotted in Fig. 8 up to the seventh order. The attenuation of a group of Chebyshev filters is plotted in Fig. 9. The curves include responses up to the fifth order with three different ripple factors.

If the design requirements are different, interpolation will give a good approximation. ■■

References:

1. H. P. Westman (ed.), *Reference Data for Radio Engineers* (4th ed.; New York: International Telephone and Telegraph Corp., 1956), Chaps. 6, 7 and 8.
2. Louis Weinberg, *Network Analysis and Synthesis* ("Electrical and Electronic Engineering Series" [New York: McGraw-Hill Book Co., 1962]), p. 495.
3. *Ibid.*, p. 605.
4. *Ibid.*, p. 514.

Test your retention

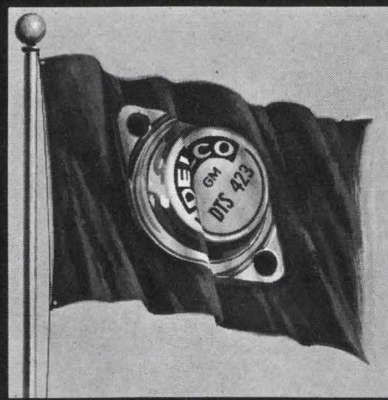
Here are questions based on the main points of this article. They are to help you see if you have overlooked any important ideas. You'll find the answers in the article.

1. How is the cutoff frequency determined?

2. What assumption is this technique based on?

3. Which filter types can be designed by this method?

4. Why is the design of a band-pass filter more complex than that a low- or high-pass?



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Groundless circuits make sense

when a general treatment is needed. One floating matrix supplies all equations for all configurations of active circuits.

Pull the ground out from under your network—literally. Make the network independent of a reference level and the analysis will be simpler. A single matrix can describe three circuit configurations of a transistor amplifier: common-base, common-emitter and common-collector.

In conventional analysis the input, output and reference terminals are assigned ordinarily. But a more general representation is made possible by "floating" the network. In this case, unlike the conventional treatment, any arbitrary pair of terminals of the network can serve as the input port, and any other pair as the output.

For an easier understanding, consider Fig. 1, a three-terminal network with no assigned ground. The matrix equation for this network is:

$$\begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} y_{11} & y_{12} & y_{13} \\ y_{21} & y_{22} & y_{23} \\ y_{31} & y_{32} & y_{33} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix}$$

or:

$$[I] = [Y]_{FP}[V],$$

where $[Y]_{FP}$ is the floating-point or indefinite Y matrix.

It can be shown that the sum of each row and each column of the floating-point matrix is zero; that is, the matrix is singular.

In the circuit equations, there is a redundancy: there are only two independent currents although three are listed in the matrix. Applying Kirchoff's current law to node 0 gives:

$$I_1 + I_2 + I_3 = 0.$$

As the network is linear, each voltage source in Fig. 1 may be treated separately; its sum will give the same result as if all three sources were applied simultaneously. Since the sources V_1, V_2, and V_3 are arbitrary, they can be considered one at a time if the other two are set equal to zero. If $V_3 = V_2 = 0$, the matrix yields:

$$\begin{aligned} I_1 &= y_{11} V_1, \\ I_2 &= y_{21} V_1, \\ I_3 &= y_{31} V_1. \end{aligned}$$

These three equations are added:

$$I_1 + I_2 + I_3 = V_1(y_{11} + y_{21} + y_{31}) = 0.$$

Alvin Wald, Assistant Research Scientist, New York University Medical Center, New York City.

Since V_1 is not required to be zero and the above equation must be satisfied:

$$y_{11} + y_{21} + y_{31} = 0.$$

Then $V_1 = V_2 = 0$ and $V_1 = V_3 = 0$ are taken in turn, in order to show that the sum of the other two columns is zero, too.

Since the network equations must hold for all conditions, consideration must also be given to the situation where a ground terminal does exist. If terminals 1, 2, and 3 are connected to a common potential, node 0, then $V_1 = V_2 = V_3 = V_0$, and no current will flow; hence:

$$I_1 = I_2 = I_3 = 0.$$

The matrix equations:

$$\begin{aligned} I_1 &= y_{11} V_1 + y_{12} V_2 + y_{13} V_3, \\ I_2 &= y_{21} V_1 + y_{22} V_2 + y_{23} V_3, \\ I_3 &= y_{31} V_1 + y_{32} V_2 + y_{33} V_3, \end{aligned}$$

are modified by the fact that $I_1 = I_2 = I_3 = 0$:

$$\begin{aligned} 0 &= V_0 (y_{11} + y_{12} + y_{13}), \\ 0 &= V_0 (y_{21} + y_{22} + y_{23}), \\ 0 &= V_0 (y_{31} + y_{32} + y_{33}). \end{aligned}$$

Since V_0 is not necessarily zero and the equations must be valid, the sum of each row is zero.

The floating-point matrix can also be applied to a network represented by impedances. The procedure is identical and proves the results for impedances. The generalized network in Fig. 2 may be used for the analysis. The same procedure makes it possible to write the matrix equations directly:

$$\begin{aligned} V_1 &= I_1 (z_{11} + z_{12} + z_{13}), \\ V_2 &= I_2 (z_{21} + z_{22} + z_{23}), \\ V_3 &= I_3 (z_{31} + z_{32} + z_{33}). \end{aligned}$$

The three currents may again be assumed to be equal when all terminals are connected to a common node: $I_1 = I_2 = I_3 = I_0$ and $V_1 = V_2 = V_3 = 0$. The matrix equations then become:

$$\begin{aligned} 0 &= I_0 (z_{11} + z_{12} + z_{13}), \\ 0 &= I_0 (z_{21} + z_{22} + z_{23}), \\ 0 &= I_0 (z_{31} + z_{32} + z_{33}). \end{aligned}$$

As I_0 is arbitrary and not necessarily zero, the sum of each row of the indefinite Z matrix is shown to be zero. Also it can be shown that the sum of each column is zero.

Impedance matrix helps with tubes and transistors

One use for the floating-point matrix is in the description of transistor and vacuum-tube circuits. A single matrix describes the work and allows any pair of the terminals to become the input or output port. Figure 3 shows the equivalent circuit of a pentode. The indefinite Y matrix for this circuit is:

$$[Y_{FP}] =$$

$$\begin{array}{cc} & \begin{array}{ccc} g \qquad\qquad & p \qquad\qquad & k \end{array} \\ \begin{array}{c} g \\ p \\ \\ k \\ \\ \end{array} & \begin{bmatrix} s(C_i + C_{gp}) & -sC_{gp} & -sC_i \\ g_m - sC_{gp} & [g_p + s(C_0 + C_{gp})] & (-g_p - g_m - sC_0) \\ -g_m - sC_i & -g_p - sC_0 & [g_p + g_m + (C_i + C_0)] \end{bmatrix} \end{array}$$

The admittance matrix for a grounded-plate stage (cathode follower) is obtained simply by striking out the p row and column. The matrix that relates the output to the input is then:

$$\begin{bmatrix} I_g \\ I_k \end{bmatrix} = \begin{bmatrix} s(C_i + C_{gp}) & -sC_i \\ -g_m - sC_i & [g_p + g_m + s(C_i + C_0)] \end{bmatrix} \begin{bmatrix} V_{gp} \\ V_{kp} \end{bmatrix}$$

For a grounded-cathode stage, the k row and column are stricken out:

$$\begin{bmatrix} I_g \\ I_p \end{bmatrix} = \begin{bmatrix} s(C_i + C_{gp}) & -sC_{gp} \\ g_m - sC_{gp} & g_p + s(C_0 + C_{gp}) \end{bmatrix} \begin{bmatrix} V_{gk} \\ V_{pk} \end{bmatrix}$$

Application of the indefinite Z matrix can be illustrated with the transistor circuit of a low-frequency T model (Fig. 4).

The matrix equation for this circuit is:

$$\begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} r_b + r_e & -r_e & -r_b \\ -r_e + \alpha_0 r_c & r_e + r_c(1 - \alpha_0) & -r_c \\ -r_b - \alpha_0 r_c & -r_c(1 - \alpha_0) & r_b + r_c \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix}$$

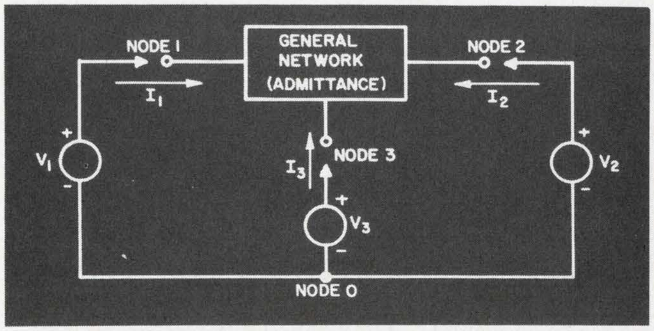
or:

$$[V] = [Z]_{FP}\,[I].$$

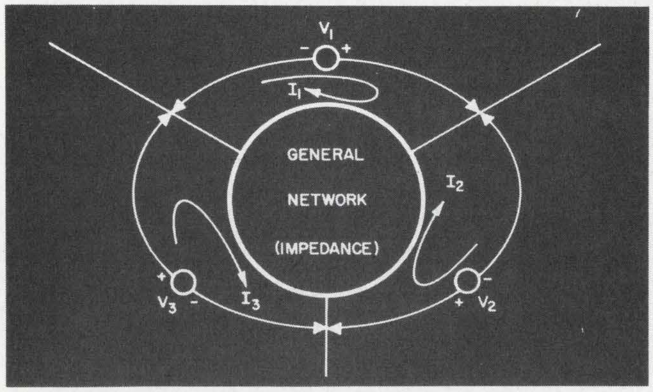
For this circuit, the floating matrix is:

$$[Z]_{FP} = \begin{array}{cc} & \begin{array}{ccc} b \qquad\qquad & c \qquad\qquad & e \end{array} \\ \begin{array}{c} b \\ c \\ e \end{array} & \begin{bmatrix} r_b + r_e & -r_e & -r_b \\ -r_e + \alpha_0 r_c & r_e + r_c(1 - \alpha_0) & -r_c \\ -r_b - \alpha_0 r_c & -r_c(1 - \alpha_0) & r_b + r_c \end{bmatrix} \end{array}$$

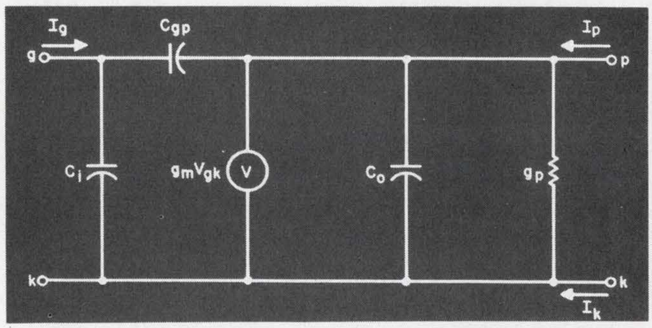
Again, when a circuit configuration with a particular reference is being considered, that row and column are deleted. Care is needed, however, for the sign of the remaining impedance elements may change, because the direction of current and voltage in the floating circuit do not necessarily correspond to the conventional two-port representation. There are no general rules for predicting this sign change. Each situation must be examined separately in the light of the sign convention



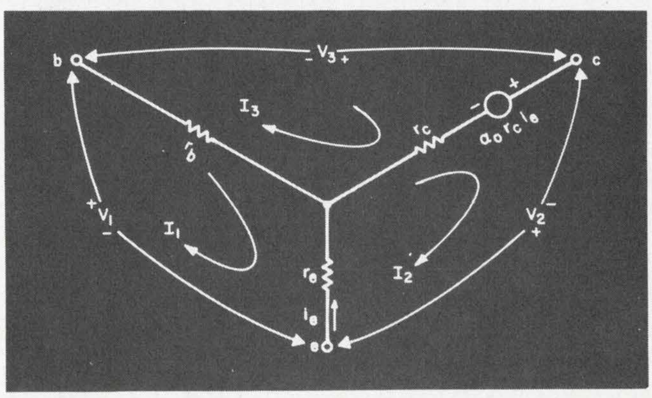
1. **This three-terminal network has no assigned ground:** it "floats." Any pair of terminals may be used as an input or output port. The floating admittance matrix is set up in the text with the aid of this circuit.



2. **For a floating impedance matrix,** use this network. The circuit is particularly useful for analysis of transistors and their cascaded stages.



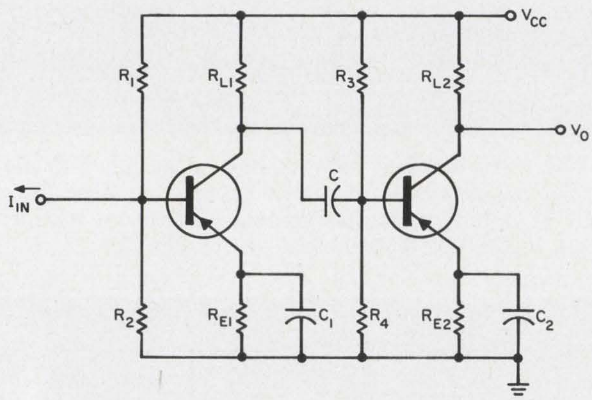
3. **Equivalent circuit of a pentode** helps establish the appropriate floating admittance matrix. One matrix is sufficient to describe all modes of operation.



4. **Low-frequency T model of a transistor** is in floating form. The impedance matrix is found in the text.

Putting the technique to work

As an example of the floating-point-matrix technique in practice, consider this transistor amplifier circuit:



The combined cascaded network derived in connection with Fig. 6 can be applied to the analysis of this amplifier circuit. The transistor is a 2N1925, a pnp germanium, general-purpose, medium-power device. The h parameters obtained from the data sheet and typical values are:

$h_{ie} = 2.2 \times 10^3$ ohms,
$h_{fe} = 68$,
$h_{oe} = 40 \times 10^{-6}$ mhos,
$h_{re} = 6 \times 10^{-4}$ (neglected in the design).

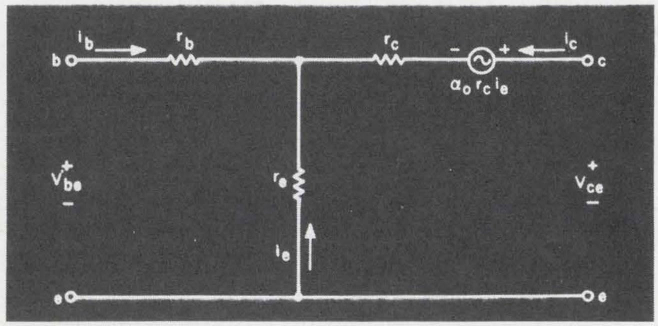
These small-signal parameters are typical values measured at a frequency of 1 kHz with an emitter current of 1 mA and a collector-to-emitter voltage of 5 volts.

For circuit performance, only the small-signal ac characteristics are of interest. For this reason, the circuit components, which determine the transistor operating point, are not chosen. Standard design approximations are used in the analysis.

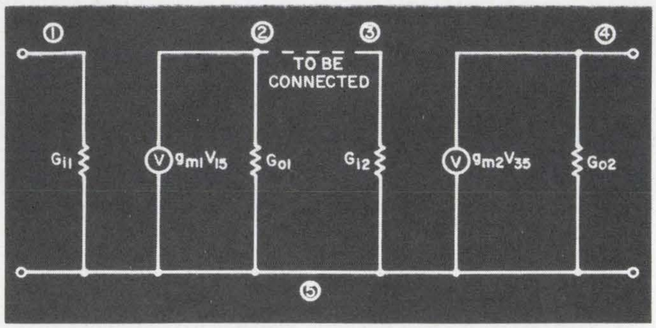
In the circuit, the input impedance of the second stage is approximately $h_{ie} = 2.2 \times 10^3$ ohms. This is true as long as $R_{L2} < 1/h_{oe} = 25$ kΩ—a reasonable assumption for small-signal conditions. The input impedance of the first stage, loaded by the input of the second stage, can also be approximated by $1/h_{oe}$. The first-stage output impedance is a function of the driving source impedance, and ranges from $1/h_{oe}$ for a source impedance greater than h_{ie} to $[h_{ie}/(r_e + r_b)]/h_{oe}$ for a source impedance less than $r_e + r_b$, that is, about 400 ohms. If a current source of reasonably high impedance is postulated, then the output impedance of the first stage will be $1/h_{oe} = 25$ kΩ. This impedance acts as the second stage input impedance and is larger than h_{ie} by enough for the second-stage output impedance also to be approximated by $1/h_{oe}$.

Since there is little shunting of the base currents by the driving impedances, the transconductance, g_m, is equal to $h_{fe}/h_{ie} = 31 \times 10^{-3}$ mhos. The voltage input to the circuit is $h_{ie}I_{in}$ and the output voltage is:

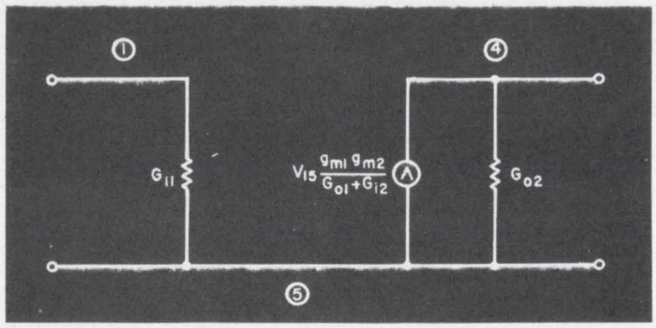
$$V_o = V_{in}\, g^2_m/(1h_{oe} + h_{ie})$$
$$\approx (h^2_{fe}/h^2_{ie}) I_{in}$$
$$= 0.96 \times 10^{-3} \times I_n \text{ volts.}$$



5. **Deletion of the appropriate row and column** from the floating matrix, based on Fig. 4, establishes the common-emitter configuration.



6. **The cascading of two common-emitter stages** of a transistorized amplifier is simplified by the lack of a reference level.



7. **Equivalent circuit of a transistor amplifier.** Its matrix is derived in the text with the aid of standard matrix reduction techniques.

chosen. As an example, for a common-emitter circuit the e row and column are deleted. The equivalent circuit for this configuration is shown in Fig. 5. The matrix equation is:

$$\begin{bmatrix} V_{be} \\ V_{ce} \end{bmatrix} = \begin{bmatrix} r_b + r_e & r_e \\ r_e - \alpha_0 r_c & r_e + r_c(1 - \alpha_0) \end{bmatrix} \begin{bmatrix} i_b \\ i_c \end{bmatrix}$$

The change in the sign of the matrix elements is the result of the convention used. Comparison of Figs. 4 and 5 shows that $v_{ce} = -V_2$ and $i_c = -I_2$.

Another useful application of the floating-point matrix is in cascading and condensing networks. Consider, for instance, the cascading of two common-emitter stages of transistor amplifiers. A typical circuit is shown in Fig. 6. The floating-point matrix for the unconnected circuit is:

$$[Y]_{FP} = \begin{array}{c@{}c} & \begin{matrix} 1 & 2 & 3 & 4 & 5 \end{matrix} \\ \begin{matrix} 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{matrix} & \begin{bmatrix} G_{i1} & 0 & 0 & 0 & -G_{i1} \\ G_{m1} & G_{o1} & 0 & 0 & -G_{o1} - g_{m1} \\ 0 & 0 & G_{i2} & 0 & -G_{i2} \\ 0 & 0 & g_{m2} & G_{o2} & -g_{m2} - G_{o2} \\ -G_{i1} - g_{m1} & -G_{o1} & -G_{i2} - g_{m2} & -G_{o2} & G_{i1} + G_{i2} + G_{o1} + G_{o2} + g_{m1} + g_{m2} \end{bmatrix} \end{array}$$

To connect nodes 2 and 3, rows 2 and 3 are added together, and columns 2 and 3 are added together:

$$[Y]'_{FP} = \begin{array}{c@{}c} & \begin{matrix} 1 & (2+3) & 4 & 5 \end{matrix} \\ \begin{matrix} 1 \\ (2+3) \\ 4 \\ 5 \end{matrix} & \begin{bmatrix} G_{i1} & 0 & 0 & -G_{i1} \\ g_{m1} & G_{o1} + G_{i2} & 0 & -g_{m1} - G_{o1} - G_{i2} \\ 0 & g_{m2} & G_{o2} & -g_{m2} - G_{o2} \\ -G_{i1} - g_{m1} & -G_{o1} - G_{i2} - g_{m2} & -G_{o2} & G_{i1} + G_{i2} + G_{o1} + G_{o2} + g_{m1} + g_{m2} \end{bmatrix} \end{array}$$

This is also a floating-point matrix, with the sum of each column equal to zero. This matrix could have been obtained directly from the circuit diagram, but the floating-point matrix shows the resultant matrix immediately when two arbitrary network nodes are connected together.

To eliminate a node, use standard reduction techniques. The floating-point matrix is partitioned:

$$[Y_{nn}]_{FP} = \left[\begin{array}{c|c} Y_{mm} & Y_{m1} \\ \hline Y_{1m} & Y_{11} \end{array}\right],$$

where the m^{th} node (corresponding to the m^{th} row and column) of the original m-by-m matrix is to be eliminated. The condensation formula, which is to be applied to the original matrix, is:

$$[Y_{mm}]' = [Y_{mm}] - 1/y_{11}\, [Y_{m1}]\, [Y_{1m}].$$

In order to apply this formula to eliminate node $(2 + 3)$ of the previous matrix, the $(2 + 3)$ row and column are moved to the last (m^{th}) position in the matrix:

$$\begin{array}{c@{}c} & \begin{matrix} 1 & 4 & 5 & (2+3) \end{matrix} \\ \begin{matrix} 1 \\ 4 \\ 5 \\ (2+3) \end{matrix} & \begin{bmatrix} G_{i1} & 0 & -G_{i1} & 0 \\ 0 & G_{o2} & -g_{m2} - G_{o2} & g_{m2} \\ -G_{i1} - g_{m1} & -G_{o2} & G_{i1} + G_{o1} + G_{i2} + G_{o2} + g_{m1} + g_{m2} & -G_{o1} - G_{i2} - g_{m2} \\ g_{m1} & 0 & -G_{o1} - G_{i2} - g_{m1} & G_{o2} + G_{i2} \end{bmatrix} \end{array}$$

Now the condensation formula is applied:

$$[Y]'_{FP} = \begin{array}{c@{}c} & \begin{matrix} 1 & 4 & 5 \end{matrix} \\ \begin{matrix} 1 \\ 4 \\ 5 \end{matrix} & \begin{bmatrix} G_{i1} & 0 & -G_{i1} \\ 0 & G_{o2} & -g_{m2} - G_{o2} \\ -G_{i1} - g_{m1} & -G_{o2} & G_{i1} + G_{o1} + G_{i2} + G_{o2} + g_{m1} + g_{m2} \end{bmatrix} \end{array}$$

$$- \frac{1}{G_{o1} + G_{i2}} \begin{bmatrix} 0 \\ g_{m2} \\ -G_{o1} - G_{i2} - g_{m2} \end{bmatrix} [g_{m1} \quad 0 \quad -G_{o1} - G_{i2} - g_{m1}]$$

$$= \begin{array}{c@{}c} & \begin{matrix} 1 & 4 & 5 \end{matrix} \\ \begin{matrix} 1 \\ 4 \\ 5 \end{matrix} & \begin{bmatrix} \quad & \quad & \quad \\ & & \\ & & \end{bmatrix} \end{array} - \frac{1}{G_{o1} + G_{i2}} \begin{bmatrix} 0 & 0 & 0 \\ g_{m1}\, g_{m2} & 0 & -g_{m2}\,(G_{o1} + G_{i2} + g_{m1}) \\ -g_{m1}\,(G_{o1} + G_{i2} + g_{m2}) & 0 & (G_{o1} + G_{i2} + g_{m2})\,(G_{o1} + G_{i2} + g_{m1}) \end{bmatrix}$$

$$= \begin{array}{c@{}c} & \begin{matrix} 1 & 4 & 5 \end{matrix} \\ \begin{matrix} 1 \\ 4 \\ 5 \end{matrix} & \begin{bmatrix} G_{i1} & 0 & -G_{i1} \\ -\dfrac{g_{m1}\, g_{m2}}{G_{o1} + G_{i2}} & G_{o2} & \dfrac{g_{m1}\, g_{m2}}{G_{o1} + G_{i2}} - G_{o2} \\ -G_{i1} + \dfrac{g_{m1}\, g_{m2}}{G_{o1} + G_{i2}} & -G_{o2} & G_{i1} + G_{o2} - \dfrac{g_{m1}\, g_{m2}}{G_{o1} + G_{i2}} \end{bmatrix} \end{array}$$

The result is still a floating-point matrix, with the sum of each row and each column equal to zero. The equivalent circuit for this matrix is shown in Fig. 7. ■ ■

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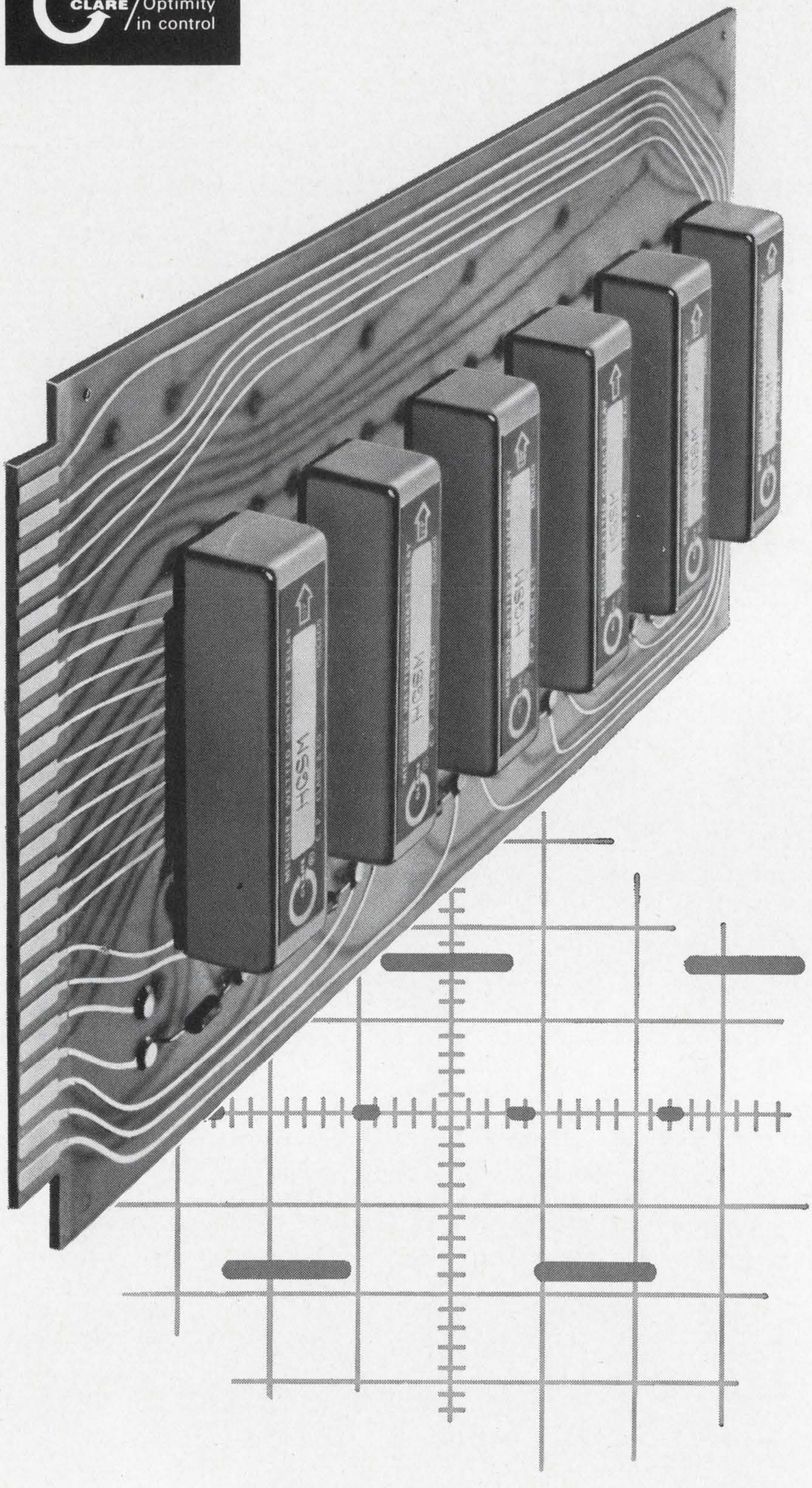

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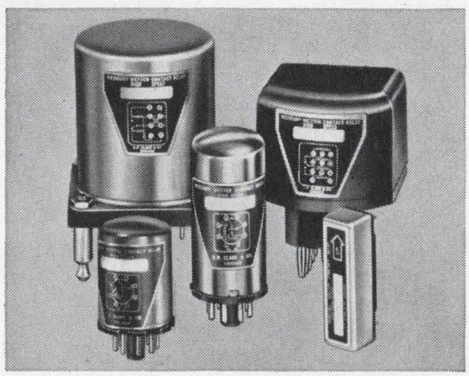

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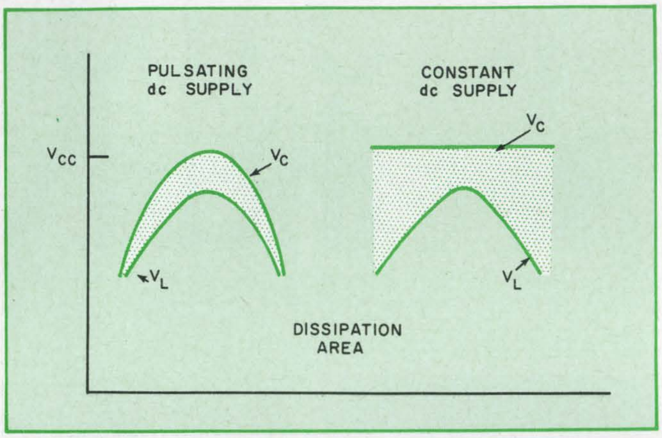
INFORMATION RETRIEVAL NUMBER 44

What are the power limitations on integrated circuits?

The only power limitations on integrated circuits are linked with the removal of heat from where it is generated. As with transistors, properly applied heat-sink arrangements would enable integrated circuits to operate at dissipations of large magnitude. The ceramic and Kovar headers on which most integrated circuits are mounted, however, are relatively poor thermal conductors and it is they that are chiefly responsible for the lower limitations on most commercially available integrated circuits. For technical analysis, the problem is analogous to a series of resistors in which the series resistors are, respectively, the reverse-bias pn junction, the silicon material, the die-to-header bond, the package or case and the heat sink, if any, to the ambient. Minimizing the thermal resistance of each segment would give integrated circuits power ratings on a par with those of the highest-power transistors. Today integrated circuits are commercially available with power capabilities in the one-watt range. Most of them are audio-amplifier types, including both monolithic and hybrid structures.

In addition to the use of heat sinks, are there other ways to increase the power capability of an integrated circuit?

Yes. There are two widely used techniques. The first, sometimes called class-D or -B operation, is where power is supplied only when an incoming pulse is at the input. In this fashion, power output can be increased without boosting dissipations, and extremely high efficiencies can be achieved. Now 2-, 3-, 4-, 6- and 8-phase clocking arrangements with similarly phased power supplies are being used to take advantage of this principle. They permit higher dissipation from individual integrated circuits, particularly where the whole combination of circuits working at different phases is placed on a single chip. The technique can be expected to be used more and more as integrated circuits increase in complexity.



A pulsating dc supply may be used in Class-B circuits to reduce collector-to-emitter voltage and hence dissipation. Since the collector-to-emitter voltage equals the difference between the supply and the output voltages, it will approach zero as the output voltage increases.

The other technique, which is related to the first, is used to achieve high power at microwave frequencies. In this case, the antenna or output is segmented into a phased array, and each element is fed from its own separate circuit. The duty cycle of each element is sufficiently low for large peaks of power to be handled with ease.

What is the state of the art of custom LSI circuits?

Large-scale integration has been widely discussed at most technical conferences for the past two years. A number of approaches to LSI have been described in the literature and government reports, pictures have been shown and laboratory-test results have been reported. At the beginning of this year, however, no supplier of integrated circuits had large-scale integrated circuits available on a commercial or even a sample basis. Extremely few commercial users have been able to obtain any samples to test and evaluate, let alone quantities sufficient for prototype design work.

Test your IC IQ is a collaboration between the editors of ELECTRONIC DESIGN and the staff of the ICE (Integrated Circuit Engineering) Co., Phoenix, Ariz. Readers of this new column are invited to submit their questions to Test your IC IQ, ELECTRONIC DESIGN magazine, 850 Third Ave., New York, N.Y. 10022.

Has any standard definition been set for LSI?

No definition of LSI has formally been adopted yet. At the industry meetings at which the term has been commonly used, the consensus seems to define LSI as the equivalent complexity of 100 gates in a single package. That is roughly equivalent to 50 flip-flops in a package, or, at an average of ten components per gate, a thousand components interconnected into a single integrated circuit. The wide use of the term LSI and the lack of conflicting descriptions suggest that those three equivalent definitions will become standard by common usage.

What are the difficulties in fabricating both high-speed linear circuits and high-speed saturating logic circuits in the same silicon wafer?

The prime difficulty in fabricating high-speed linear and saturating logic circuits at the same time stems from the gold doping of the silicon wafer. To increase the switching speed of saturated logic circuits, the lifetime of the material is killed by diffusing gold atoms into the junction areas. This gold doping, however, does not give good characteristics to linear circuits and it is difficult to isolate the areas to be doped so that both devices may be made on the same wafer. Many companies are working on techniques to pattern the areas of gold doping, but at present they are mostly in the laboratory stage. The diffusion coefficient of gold is very large at all normal diffusion temperatures. This large diffusion coefficient coupled with lower solubility, results from the diffusant locating interstitially within the crystal lattice. The gold diffusant provides recombination centers and thus has the effect of reducing lifetime. Silver also has a large diffusion coefficient.

Will the flip-chip bonding technique be applicable to large-scale integration?

A flip-chip bonding technique might be a practical way to obtain economical and reliable LSI without suffering high yield losses. A complete wafer of silicon cannot be bonded by flip-chip techniques but individual circuits or the circuit die from a wafer may be bonded by flip-chip techniques, after being tested, to build up a complete LSI system. The opportunity to repair and pretest the individual circuits in this manner would make high-yield, relatively low-cost, LSI construction possible.

How can special integrated circuits be specified without a black-box specification?

Black-box specifications are generally not the best way to obtain optimum design characteristics in an integrated circuit. For best results, the circuit designer must work directly with the processors to arrive at the best compromises in the construction of the circuit. These compromises cannot be transmitted in terms of black-box specifications. For optimum circuit designs, the designer must therefore have access to a facility, either in house or with a very cooperative manufacturer.

How much digital work will go MOS, assuming that MOS processing is under good control?

MOS processing techniques will not take over the whole digital-circuit area. The speed capabilities of MOS are inherently limited by the normal RC time constants involved in the designs. MOS devices, however, because their economical construction and applicability to large-scale integration, will be used in logic systems where their speeds match requirements. At present it is estimated that about 15 to 20 per cent of the entire digital market would be suitable to MOS speeds.

What effect will LSI have on circuit testing?

LSI is already having a great effect on the techniques currently being used for testing integrated circuits. LSI testing requires more detailed information to be provided by the testing at several stages in the processing. Discretionary wiring depends on this testing before the additional interconnections necessary to complete the LSI circuit are made. The test information necessary to permit discretionary wiring is accumulated and evaluated in the computer that makes the arrangement for such wiring. LSI represents the next level of complexity beyond integrated circuits, just as integrated circuits required an additional degree of testing complexity beyond discrete components. In LSI, as with integrated-circuit testing, component parameters cannot usually be measured accurately. Rather, the total circuit function must be evaluated, preferably by go/no-go arrangements.

At present there is no way to check an LSI circuit completely by normal testing techniques. Because of the extremely large number of possible interactions and lead and signal combinations, it is almost impossible to check an LSI system completely so no standard testing devices exist yet. It is expected that approximately 10 per cent of the circuitry and component area will be devoted to test devices built into an LSI system. These will be auxiliary circuits designed to provide automatic testing and to pinpoint trouble spots. So far this is seen as the only economical way to test large circuits.

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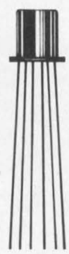

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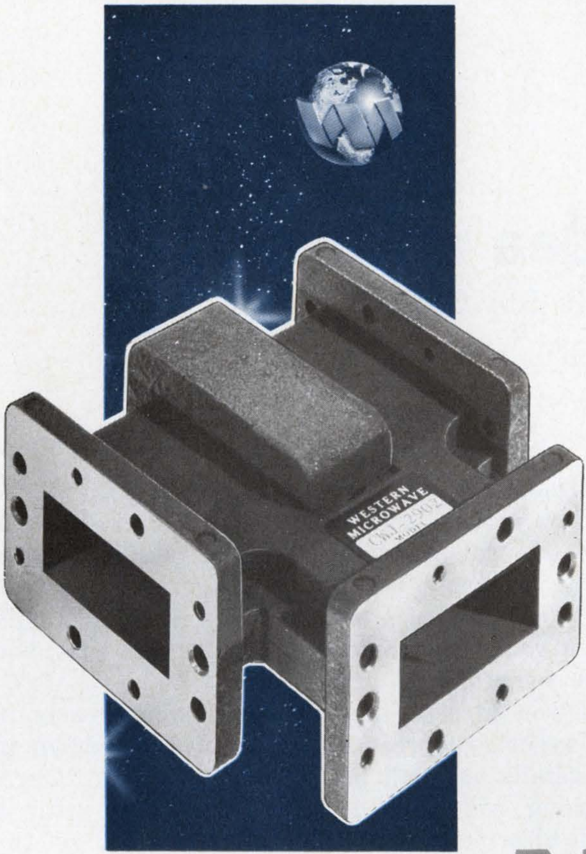

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CWJ-2903	6.425 - 7.125	26	.15	1.05	3.25	3.0	CMR-137
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INFORMATION RETRIEVAL NUMBER 46

Put that new-product idea across

by presenting it in a 'selling' way. Here is a step-by-step procedure on writing an effective report.

"I came up with a million dollar idea, turned it over to our management, and you know what happened? They sat on it for a year and a half, and now our competition has come out with an almost identical product!"

Chances are this person has only himself to blame. He failed to get his idea across. The best idea is useless unless you can communicate it in the right way to the right people—the people who can turn your idea into reality.

How do you get an idea accepted? By writing a lucid, selling engineering report.

Practically every new idea has to be presented in formal fashion. Before your immediate supervisors can recommend action on your idea, they must have written facts to back them up.

Written presentations fall into two categories:

1. Proposals—attempts to sell your company's services or products to an outside customer.

2. Reports—attempts to sell your own idea to your own company.

(Basic points on writing a selling proposal were discussed in the article "Making Your Proposal Sell," ED 11, May 24, 1967, pp. 96-99. This discussion consequently will cover the writing of a report. However, many of the techniques used in writing proposals apply to the preparation of reports, and vice versa.)

In writing a technical report, keep your reader in mind. Clearly understand this point: the management view of the value of any technical idea *focuses on its profit-making potential.*

Constantly remember that your reader probably does not have the technical background you have. So make certain that you do not get wrapped up in technical jargon that may be clear to you but meaningless to your reader.

Writing the engineering report may call for breaking some old habits. Let's examine, first, how not to write the report.

Do not organize it this way:

- Introduction.
- Technical discussion.
- Summary.

This format—widely used by engineers in writing technical papers—is the best way to assure that few, if any, people in management will read it. Usually the technical section will be read only after you have convinced the reader that you have something to offer.

If you present the technical section early in the report, the reader will get bogged down in its details and will put it aside to read "later." Nothing will happen "later." Instead, after a lapse of some time, it is probable you will get the report back with a polite explanation: "It's a good idea, but I don't think our company is ready to get into it. Maybe at some later time we can rehash it."

This is just another way of saying, "I couldn't wade through your report." Because of its poor organization, you failed to get your idea across.

Use the right format

For a far better chance of securing management approval of your technical idea, *do follow* this format:

- Purpose.
- Conclusions.
- Recommendations.
- Market and cost.
- Technical discussion.

Note that in this format you sell the reader first and then conclude the report by substantiating the soundness of your "sell" in the technical discussion. Let's consider each of these in detail.

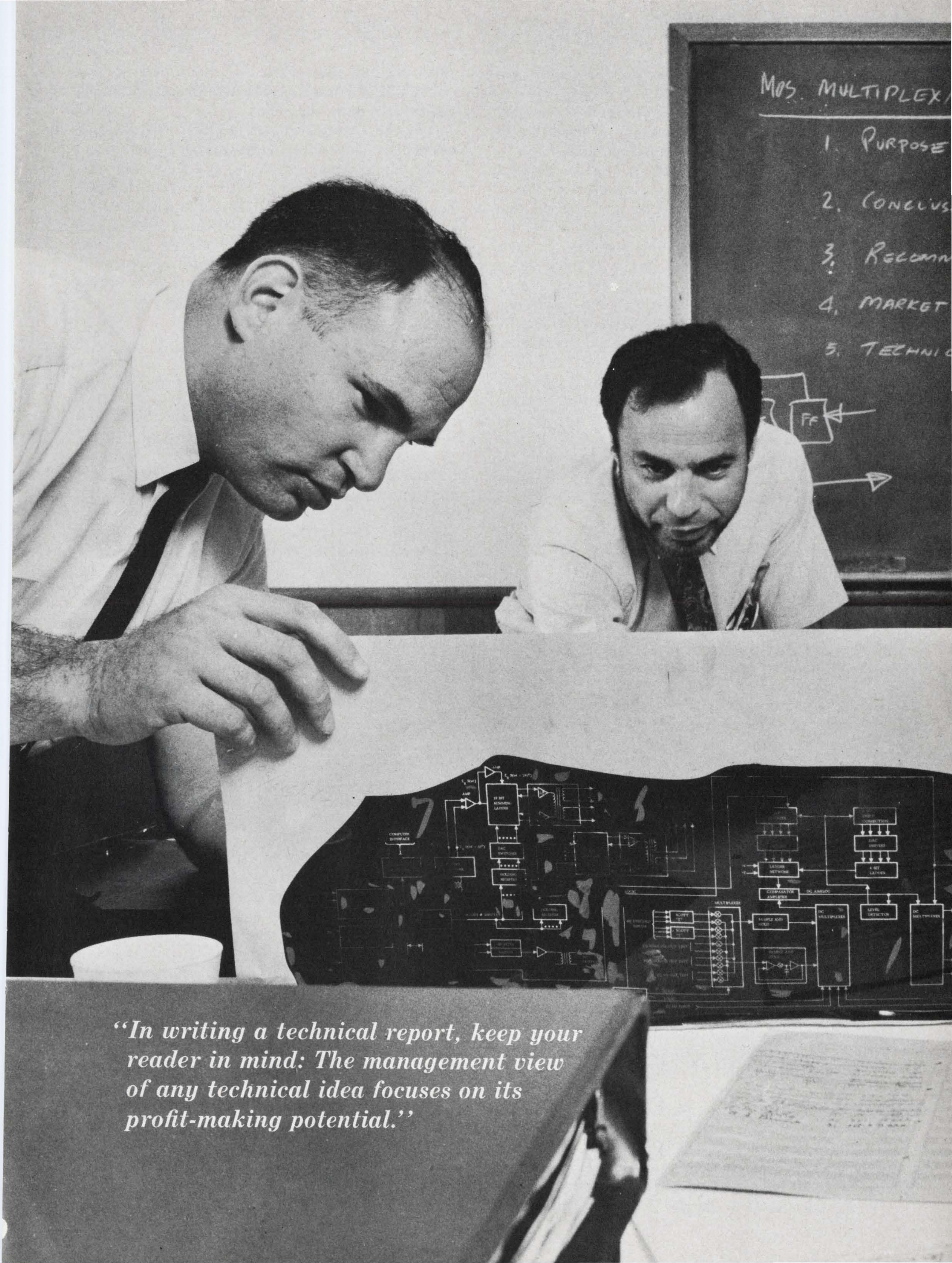
Open your presentation by stating the purpose of the report. Avoid jargon. Use simple language, be concise. Don't include superfluous information.

Don't write it this way:

"The purpose of this report is to describe a new, unique, all-solid-state, all-purpose, fully automated, versatile fly catcher. It is superior to

Peter N. Budzilovich, Technical Editor, Electronic Design, New York, N.Y.

Preparing a report are Michael Jacobs (left), publications project coordinator, and Murray Hoffman (right), senior project engineer, Proposals and Project Office, Autonetics' Data Systems Div., North American Rockwell.



"In writing a technical report, keep your reader in mind: The management view of any technical idea focuses on its profit-making potential."

all fly catchers now on the market because it has a wide-band amplifier with a gain of over 160 dB. Using integrated organizational flexibility coupled with systematized management options, it will result in a parallel reciprocal capability."

After reading such verbiage, the reader still doesn't know: Is this a paper to be presented at a technical conference? Are we going to sell the device? Is there a profit to be made?

The flashy talk will get you nowhere. In fact, afer reading it, your supervisor, who most likely is a practical man, may yawn, put the report aside and reflect: "Maybe our public relations people will want to schedule it at a conference."

Here is the *correct way* to write the same opening statement:

"The purpose of this report is to present conclusions, recommendations and technical discussion that show the feasibility of developing and marketing a new automatic fly catcher."

This example is concise and to the point. It answers the key questions and is devoid of superfluous information.

Give your conclusions

Your conclusions constitute the key section. Here you tell management what the prospects are for successful marketing on the basis of the data you will describe later in the technical discussion. Again, simple, concise language must be used.

Don't do it this way:

"At this time, it may be concluded that more studies are required in order to explore fully the unique promise of the fly catcher. In particular, we want to develop a more accurate mathematical model, so that the calculus of variations, a powerful method, can be applied. More specifically, an approximate solution for the integral (see page 37) must be checked, using a new Liapunov function. It may result in a new approach to the stability of nonlinear systems of the fifth order."

There are at least two fatal flaws in this approach: Not only does it contain technical mumbo-jumbo, but the conclusion reflects a negative, uncertain attitude—"more studies are required," "an approximate solution . . . must be checked."

Even if the reader is not bored, he is certain to react negatively: "If it needs more study, why present it now? Come back when you have something more concrete to propose."

Now, consider the *correct way* to put the point across:

"On the basis of the data in Section 4, Market and Cost, and Section 5, Technical Discussion, the following conclusions can be made:

"There is a growing market for fly catchers.

"Present manual fly catchers retail for X.

"The proposed automatic fly catcher can be retailed for half that price.

"The production of automatic fly catchers does not involve new technology.

"We can manufacture the product with existing equipment, thus minimizing capital outlay."

Anything beyond what is said here will only obscure your point. Your reader can see that you have approached the problem in a business-like fashion: you looked at the market place, you discovered a demand for the product, you solved the technical problem of supplying an improved product for the existing market, and you indicated that the company's initial outlay would be small.

Recommend the approach

Having convinced your reader that you have a money-making proposition, tell him how you feel it should be achieved. This is Section 3, "Recommendations."

Don't write it this way:

"On the basis of this report, we recommend that our unique fly catcher be mass-produced at any and all costs. We'll make it all back in a jiffy, and the market will be saturated before the competition comes into the play."

All you have told your reader is: "Let's do it on my say so." You haven't told them how or why your report should be accepted and how it can be carried out.

Do write this section of your report so that it contains all the necessary comments:

"On the basis of the above conclusions and other facts in the remainder of this report, the following recommendations can be made:

"A program to convert the laboratory model into a production prototype should be started.

"A detailed marketing survey should be conducted to prepare a specific marketing plan.

With this, the "sell" part of the report is finished. Whether or not the rest of it will be read depends on how well you succeed in convincing your reader that you have something realistic.

Note that thus far there has been no attempt to sing the praises of technical excellence, ingenuity, etc. Neither were there lengthy discussions of the frequency responses of the fly catcher, its bandwidth and the size of the flies it is intended to catch.

Present market and cost facts

Now that you have sold the reader (your supervisor) you must give him the ammunition to push your idea and win the support of his supervisors. You do this in the body of the report. Note once again that since the ultimate goal of any program is to turn a profit, you place the market survey ahead of the technical discussion.

It may be difficult to prepare this part of the report yourself. You may have to enlist the aid of your company's sales and marketing people to compile all the data. Find the best way possible to assemble all the facts on the number of existing devices sold annually, the dollar volume and past trends. If you are proposing an entirely new product, cite the need (again in terms of possible demand and sales dollars).

Present the complete picture of what it will cost your company to enter the market. These costs, by necessity, will cover only the technical side of the story—that is, how many engineering and supporting personnel hours will be needed to develop the product and how many weeks or months the development project will take to complete. As an engineer, you are not expected to include promotion and advertising costs.

Give a full description of the production facilities that will be required to produce the anticipated number of units. In particular, pay attention to the capital equipment outlays.

Here is the place to include development, preproduction and production schedules. Use simple milestone charts (see accompanying chart).

Besides providing useful information, this method also serves to indicate that you have approached the whole problem in a sound, businesslike fashion.

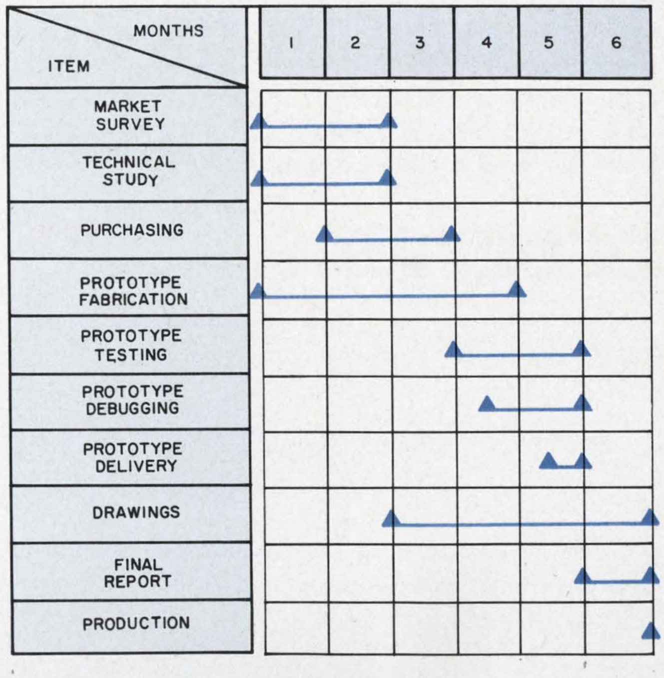
Present the technical meat

Now that the reader is interested and convinced that your idea will result in a profit-making product, explain it to him technically. Once again, use simple language and avoid double-talk and jargon. The whole intent is to explain your idea without confusing or impressing the reader with high-sounding, meaningless phrases. Your supervisors will not back up something they don't understand.

A good way to open a technical section is to explain (qualitatively) how the over-all system operates. A table of preliminary specifications should be included here. A functional block diagram of the system should also appear here.

Once the system is defined and explained in the functional block diagram, describe each block. This is the place for detailed schematics and detailed descriptions of how each circuit operates. Explain all operations in a simple, straightforward fashion. Again, this reminder: Even if management is technically oriented, don't expect it to be as knowledgeable about the specific subject as you are.

Throughout this discussion, pinpoint areas where some difficulties may be experienced in production, tight component tolerances or special testing requirement. In fact, include a section entitled "Anticipated Difficulties," where a list of all troublesome areas is spelled out.



A detailed milestone chart illustrates your businesslike approach to introducing a new product. It demonstrates your understanding of the total company operation, as well as the functions of each department.

A general format of the technical section could be as follows:

- Technical discussion.
- System description.
- Subsystems.
- Testing requirements.
- Incoming inspection requirements.
- Anticipated difficulties.

This completes the presentation. What you have done boils down to this:

1. You have told the reader why he should follow your advice.

2. You have told him how to implement your approach.

3. You have given your immediate supervisor enough ammunition to secure higher management approvals.

In short, you have sold your idea. ■■

Test your retention

Here are questions based on the main points of this article. They are to help you see if you have overlooked any important ideas. You'll find the answers in the article.

1. Why is the format of the report crucial to acceptance of your ideas?

2. What is meant by "writing for the reader"?

3. Why is "technical discussion" placed at the end of the report?

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E. F. Buehring, President, LTV Electrosystems, Inc.

Modified univibrator averts timing errors

Problem: Design a univibrator circuit that can time-synchronize the trailing edge of the output pulse with the origin of the input pulse. Conventional univibrator circuits are subject to output pulse-timing errors produced by varying input pulse amplitudes.

Solution: Add a simple, one-stage, delay compensation amplifier to the conventional univibrator circuitry, to produce a univibrator output pulse whose trailing edge is independent of the amplitude of the input pulse.

The timing circuit consists of a conventional univibrator, Q_1 and Q_2, a spiker circuit, and a one-stage compensation transistor amplifier, Q_3.

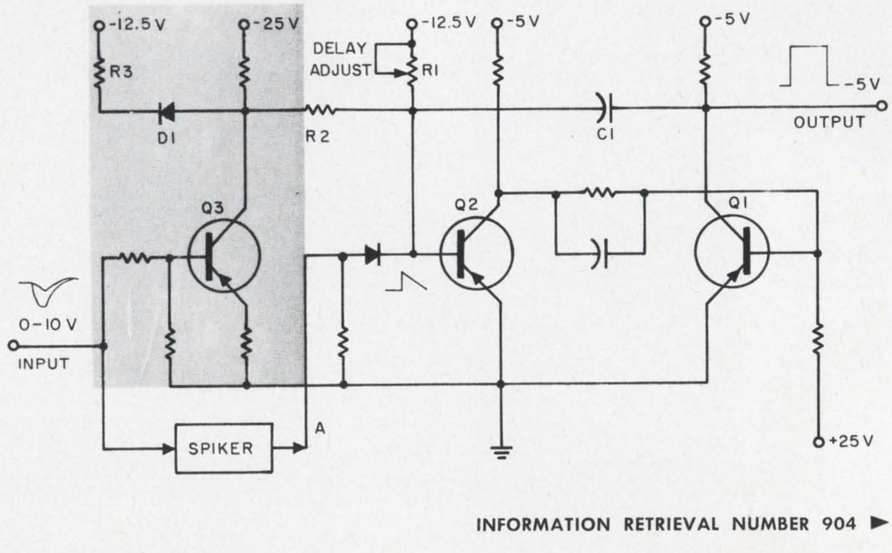
In the quiescent state, Q_2 is conducting; Q_1 and Q_3 are biased off. An input pulse is applied simultaneously to the spiker circuit and to the base of Q_3. The spiker applies a positive spike to the base of Q_2, switching it off. When Q_2 stops conducting, sufficient current flows to the base of Q_1 to bias it into the conduction region. Q_1 turns on and generates a positive-going output pulse. Q_2 is held in the cutoff state by the potential across capacitor C_1, and it remains biased off until C_1 is sufficiently discharged.

In a conventional univibrator, the discharge of C_1 is governed by the current flowing through R_1. However, in the compensated univibrator, the discharge of C_1 is governed by a discharge path through both R_1 and R_2. The potential existing at point A determines the discharge current through R_2.

An input pulse drives Q_3 into a state of increasing conduction, causing the potential at A to increase from -22 V to the clamp potential of -12.5 V. This decreases the discharge current flowing through R_2. From the time the clamp potential is reached to the end of the discharge, the discharge rate of C_1 is nearly constant and slower than its initial discharge rate For high-amplitude input pulses, the threshold of Q_3 and the clamp potential are reached quickly. For low-amplitude input pulses, the potential at point A increases less rapidly, and the nearly constant discharge rate is reached at a later time.

Thus C_1 discharges more rapidly for low-amplitude input pulses than for high-amplitude, cuasing the compensated univibrator to turn off earlier.

Low-amplitude inputs reach the triggering threshold of Q_2 later than high-amplitude inputs, causing a delay in the occurrence of the leading edge of the output pulse. The discharge



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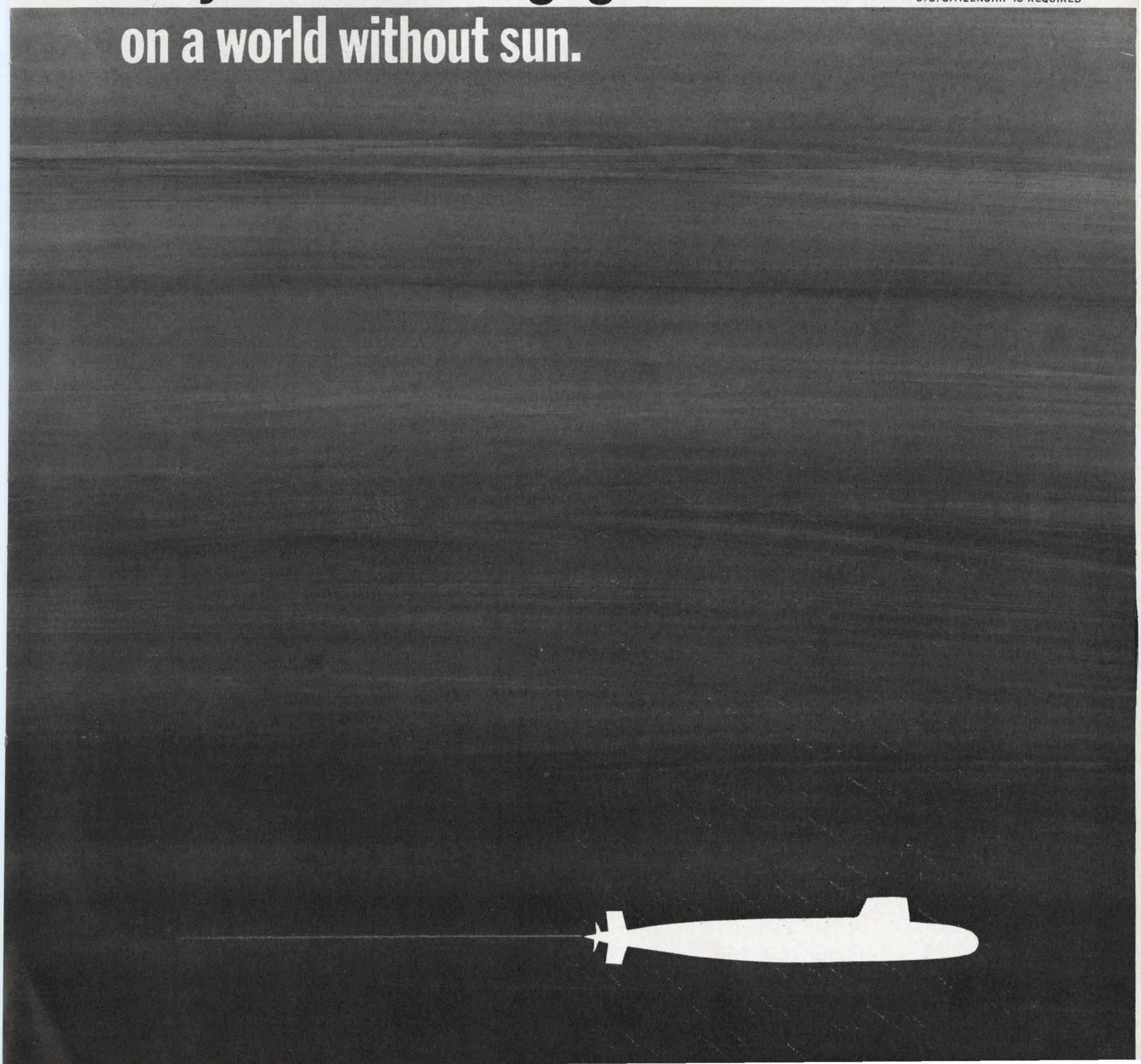


control of C_1, however, compensates for this delay by producing narrow output pulses for small inputs and wide output pulses for large inputs. This effect causes the trailing edge of all output pulses to occur at the same time regardless of input pulse amplitude. Manual adjustment of R_1 determines the pulse delay time through C_1 in the compensated circuit. Resistor R_3 and catching diode D_1 are added in the collector circuit of Q_3 to enhance the compensation for input pulses of high amplitude.

This circuit can function with double RC-differentiated input pulses and requires no delay-line wave-shaping or zero-crossing techniques.

Additional details are contained in: The Review of Scientific Instruments, vol. 34, no. 11, pp. 1248-1253, November, 1963.

Inquiries concerning this innovation may be directed to: Office of Industrial Cooperation, Argonne National laboratory, 9700 Cass Avenue, Argonne, Ill., 60439. Reference: B67-0130.

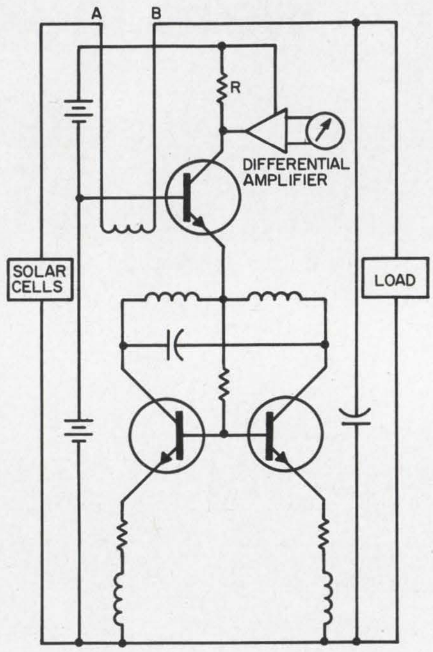
Get the most from solar cells

Problem: Design a circuit that will enable a solar-cell power supply to deliver maximum electrical power to a load.

The absolute values of electrical power generated by solar cells vary quite drastically with differing environmental conditions (temperature, energetic-particle radiation, and illumination) in which the cells operate. Under many conditions, operation of the cells at a preselected voltage or current will not transfer maximum power to the load.

Solution: A circuit senses the magnitude of the slope dE/dI, of

the *E-I* (voltage-current) characteristic curve and compares it with a reference voltage, which represents the slope corresponding to the desired operating limits (95 per cent of the maximum power point).



An ac voltage of constant magnitude is applied across points *A* and *B*. The ac loading effect, inversely proportional to slope dE/dI of the E-I characteristic curve, will reflect a current through the transformer. This results in a voltage across *R*. This voltage, corresponding to dE/dI, is then compared with a reference voltage that represents the desired slope. The differential amplifier will balance at the desired slope, and the meter indication will be either positive or negative (above or below the desired slope). This voltage difference can be used to control the power applied to the load.

Inquiries concerning this innovation may be directed to Technology Utilization Officer, Goddard Space Flight Center, Greenbelt, Md. 20771 (B67-10061).

HMED's Looking For Engineers Who Can Look Over State-Of-The-Art Horizons In:

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Logistics Engineering
Transmitter Design
Mechanical & Environmental Engineering
Advanced Techniques Development

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INFORMATION RETRIEVAL NUMBER 912

GENERAL ELECTRIC

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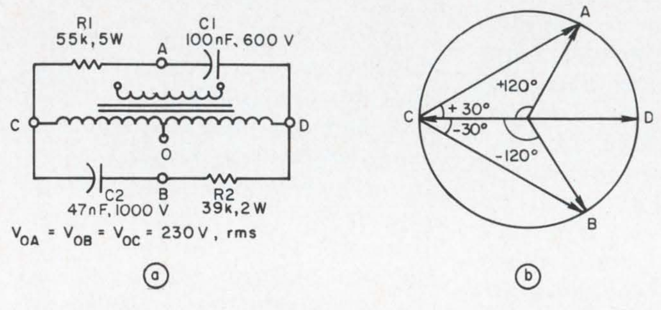
Three-phase output from single-phase line

A three-phase source is often required for testing such three-phase equipment as meters, indicators and relays and for demonstration purposes, This circuit affords a three-phase supply that is both simple and inexpensive.

The circuit consists of a transformer with a center-tapped secondary winding to which two series RC networks are connected (Fig. 1a). The component values are chosen so that the voltages between the RC connection points (*A* and *B*) and one transformer terminal (*C*) are leading by 30° with respect to the voltage across the transformer (V_{CD}). It follows that the voltage across one half of the secondary (V_{OC}) is equal in magnitude to the voltages (V_{OA} and V_{OB}) between the center tap and the RC connection points. A phase difference of plus and minus 120° exists (Fig. 1b), fulfilling the requirements of a three-phase supply.



Three-phase output from a single-phase is obtained from a center-tapped transformer.

All three output voltages will vary equally when the primary voltage is changed; the phase relationship, however, will not be affected. Thus the three-phase output can be controlled by a single variable transformer.

A. G. Engelter, Electronic Engineer, National Research Institute for Mathematical Sciences, Pretoria, Republic of South Africa

VOTE FOR 311

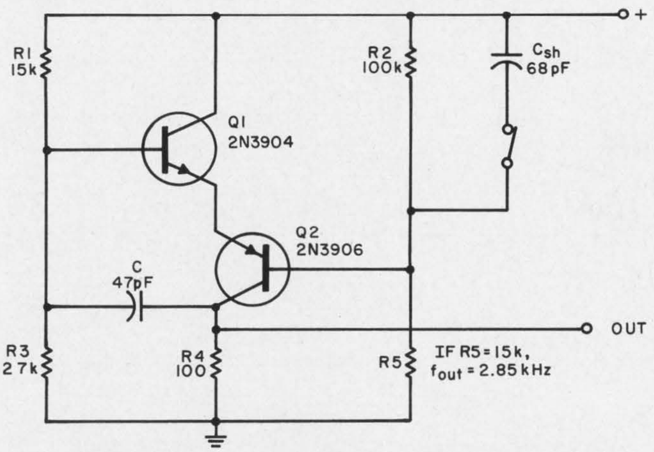
Sensitive trigger circuit controls power SCR

Coupling a pnp transistor and a npn transistor as shown in the figure causes a square wave to be generated across *R4*. It has very fast rise times, and even at low frequencies a single small capacitor can be used. The supply voltage can be up to the sum of the maximum V_{CE} of each transistor, while they are either conducting or blocking.

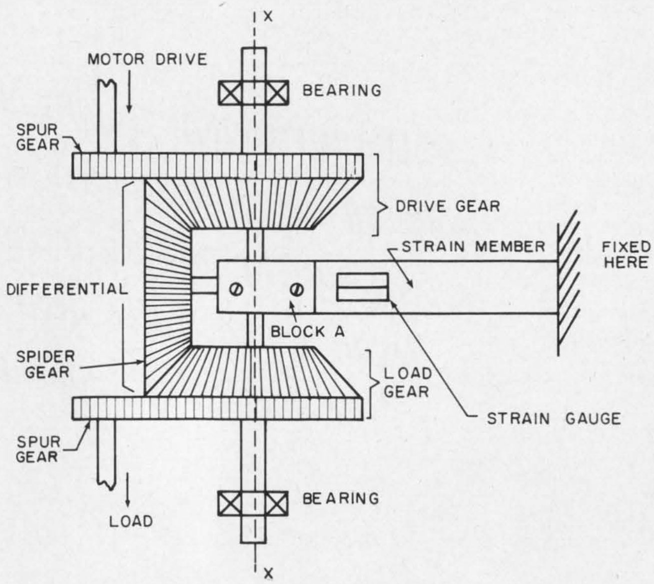
On application of the supply voltage, *C* charges to the voltage determined by *R1* and *R3*. Before reaching that voltage, the base voltage, V_{b1}, reaches a value of 2 × 0.6 V (for silicon transistors) positive in relation to V_{b2}, which is determined by *R2* and *R5*. *Q1* and *Q2* begin to conduct; V_{R4} at once increases. V_{b1} then increases until the base-collector diode of *Q1* is forward-biased and *Q1* saturates. The rate of increase of V_{R4} slows and finally stops. Now *C* begins to discharge and V_{b1} decreases; so does V_{e1} (emitter voltage of *Q1*), further decreasing V_{R4}. This process continues until V_{e1} becomes less than 0.6 V positive in relation to V_{b2}, cutting *Q1* and *Q2* off. The cycle then repeats.

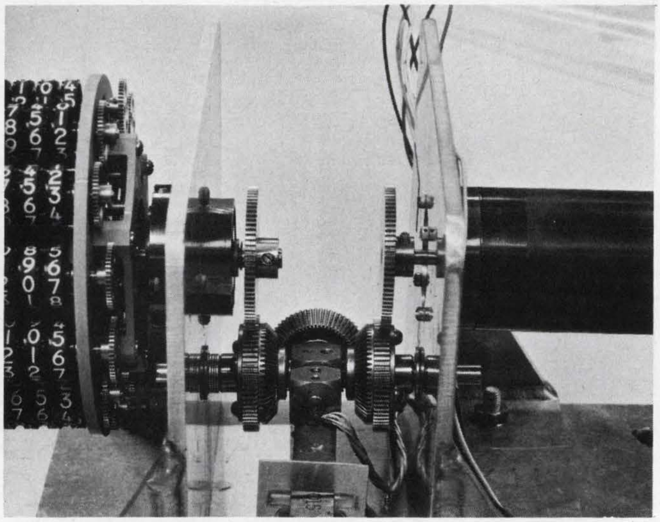
Since the frequency depends on the charge and discharge of *C*, determined by *R1*, *R3* and *R4*, and V_{R4} is limited by the value of V_{b2}, determined by *R2*, and *R5* and the supply voltage all these components influence the frequency. The limiting value of V_{b2} is the peak-point voltage of the transistor.

If *R2* is shunted with another capacitor, C_{sh}, then, after connecting the supply voltage, V_{b2} is instantaneously equal to the supply voltage. The discharge time of C_{sh} can be varied by means of means of *R5*. After switching on the supply voltage, V_{b1} rises and V_{b2} decreases. If V_{b2} reaches a value of 2 × 0.6 V negative relative to V_{b1}, the circuit begins to operate. C_{sh} makes the square



A high-power SCR can be phase-controlled with this circuit by replacing dc power supply with a rectified sine wave, limiting it to about 15 V with a Zener diode.





Simple and accurate torque sensor is built with a differential and a stationary strain member. An actual test set up is shown in the photo.

wave heavily asymmetrical, while, if *Q1* and *Q2* start to conduct at once, V_{b2} goes positive because of the shunt capacitor. When *C* begins to discharge, V_{b1} does not have to decrease much to cut off *Q1* and *Q2*. The circuit will not generate short pulses.

If, instead of a dc supply, a half- or full-wave rectified sinesoid is used and a large part of it is limited with a Zener diode, it is possible to control phase by varying *R5*. If the first pulse fires an SCR, the average voltage across the SCR load can be varied by means of *R5*.

If $C = 47$ nF, $C_{sh} = 68$ nF, $R5 = 15$ kΩ and the rest of the components are as shown (supply voltage is 12 V dc), the output frequency is 2.85 kHz.

Onno Kruller, Electronic Engineer, Villa La Salle, Quebec, Canada.

VOTE FOR 312

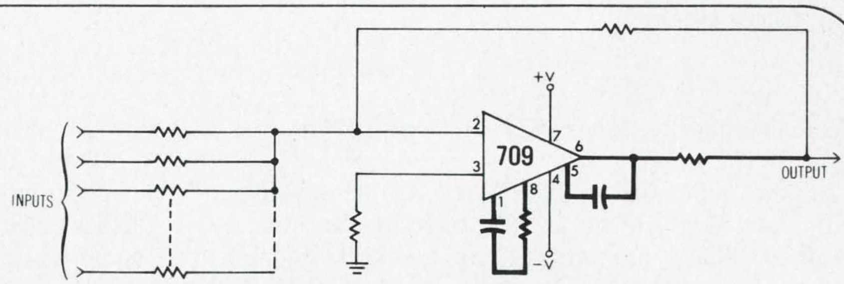
Torque sensor uses simple strain gauges

For the optimum design of an electromechanical system that includes motor-driven loads, the time-torque characteristics of these loads must be known. Once they are, it is possible to choose a drive motor that is exactly adequate, and not too large with the consequent penalties in size, cost and power consumption.

The loads are sometimes calculated, but usually there are too many unknowns for accurate results. There are various ways to measure torques with either direct mechanical or electrical strain gauges. Direct-current strain gauges mounted on the drive shaft need slip rings for current transfer from the rotating shaft. Reactive types can be used without slip rings but the circuitry involved is more complicated. The straight mechanical types are not very flexible and are unsatisfactory for dynamic measurements. The simple dc strain-gauge type of dynamometer shown here is easy to build, requires no slip rings, and lends itself to the measurement of a wide range of torque loads.

If a load is driven through a differential, the transmitted torque is applied to the spider crossarm schematic. If this crossarm is fixed through a simple strain member (beam), the strain in the beam will be a measure of the transmitted torque. Mounting wire strain gauges on this beam member makes a simple dc-operated measuring system. The dynamic response is limited only by the angular inertia of the moving parts between

GOOD



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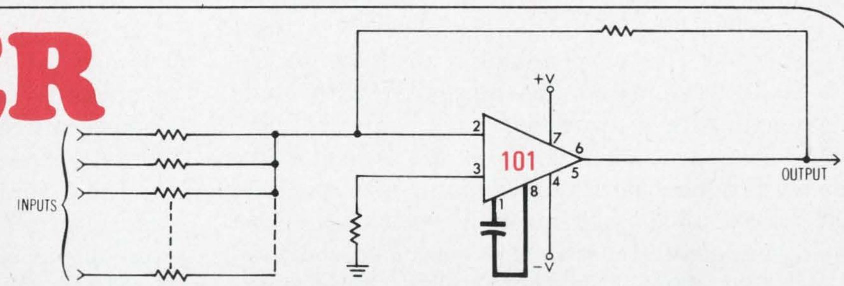

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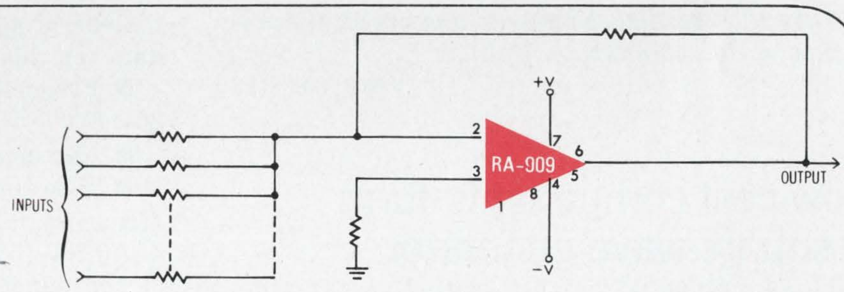

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INFORMATION RETRIEVAL NUMBER 49

the load and the drive gear and the spring constant of the beam.

In the schematic those parts are the spider gear, load gear, block *A* and part of the strain member. The dynamometer can be calibrated by applying known torque loads around shaft *X-X*. A convenient way to do that is to load a loading beam fixed to block *A* with a series of known weights. The torque will be the product of these weights and the perpendicular distance to the axis *X-X*. Torques can be measured with shaft rotation in either direction.

The sequence timer used on the Agena space booster produces on its drive motor a torque load that increases sharply at each switch sequence. The dynamometer system just described was used to test that timer (see photo). The strain-gauge output was recorded on a strip chart with excellent results.

Taft R. Wrathall, Engineer, Lockheed Missiles & Space Co., Sunnyvale, Calif.

VOTE FOR 313

Low-cost components form a square-wave generator

This inexpensive battery-operated, variable-frequency square-wave generator has fast rise and fall times, is both simple and portable, and as a battery-operated device is virtually free from 60-hertz noise.

Rise and fall times, settling times, and the frequency range are comparable to costlier commercial units. With the addition of appropriate terminals, the unit can be powered by external power supplies to conserve the batteries.

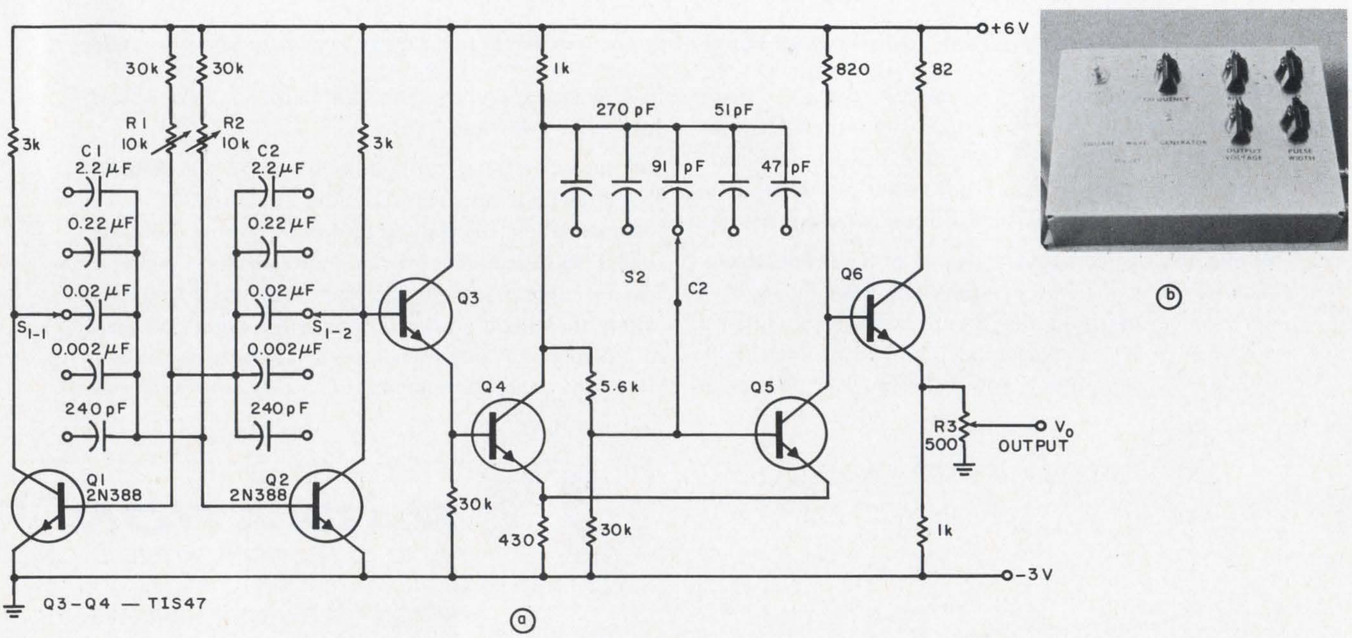
An astable multivibrator, *Q1*, *Q2*, is coupled to a Schmitt trigger, *Q3*, *Q4*, *Q5*, *Q6*, as shown in Fig. 1a. The multivibrator's frequency is determined by a selector switch, which inserts the appropriate capacitors from the *C1* and *C2* capacitor banks for the desired range. Potentiometers *R1* and *R2* change the pulse width and provide a more continuous frequency range. The over-all frequency range can easily be changed by changing the *C1* and *C2* capacitor banks.

The Schmitt trigger is direct coupled, and uses capacitor set *C2* to vary the rise and fall times of the output signal. Potentiometer *R3* is an output level control.

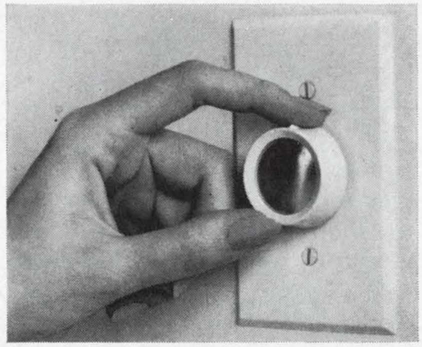
Figure 1b shows the relative size of a complete generator.

General specifications and typical performance data for this circuit include:

- Frequency or repetition rate—approximately 20-100,000 Hz.
- Maximum output voltage ≈ -0.4 to $+4.4$ V.
- Rise times with 620-Ω load, $C2 = 240$ pF, frequency ≈ 10 kHz:
  - 0.3 V to 2 V in 20 ns; $V_o = 4$V (V_o = total output voltage).
  - 0.3 V to 4 V in 40 ns; $V_o = 4$ V.
  - 0.3 V to 2 V in 40 ns; $V_o = 2$ V.
- Fall times with 620-Ω load and $C2 = 240$ pF:
  - 2 V to 0.3 in 35 ns; $V_o = 4$ V.
  - 4V to 0.3 V in 60 ns; $V_o = 4$V.
  - 2 V to 0.3 V in 45 ns; $V_o = 2$ V.



Rise times down to 20 ns are obtained from the square wave generator (a). It can be housed in a small, inexpensive aluminum chassis (b). It can be operated either on batteries or off an external power supply.



Lutron needed: the best combination of small size, reliability and low cost in capacitors for solid state dimmers.

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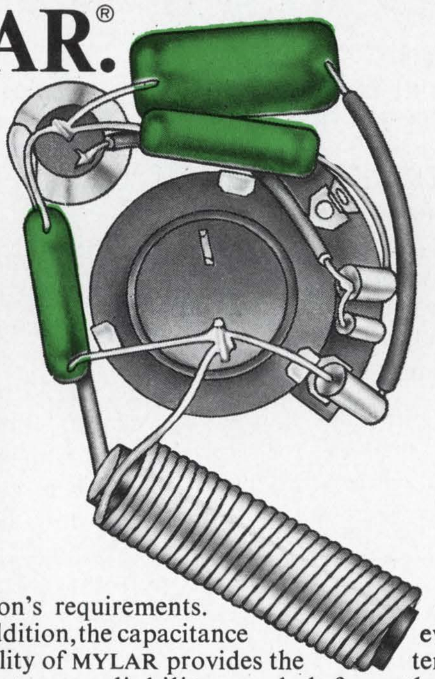

"Only capacitors of MYLAR* give us the size and reliability we must have, and at low cost," says Joseph M. Licata, Chief Engineer Lutron Electronics Co., Inc.

Lutron's broad line of dimmers is miniaturized to fit single gang boxes for quick, easy installation. Because MYLAR has extremely high dielectric strength in thin gauges, capacitors made from this polyester film can be manufactured small enough to meet Lutron's requirements.

In addition, the capacitance stability of MYLAR provides the long-term reliability needed for trouble-free brightness control of all types of incandescent and fluorescent lighting.

Voltage requirements for Lutron's dimmers are 200 to 600 volts, and in many instances these units operate around the clock. Lutron's own tests and experience indicate capacitors of MYLAR perform well in these conditions, even under extremes of humidity and temperature. Lutron has also found that in many cases, capacitors of MYLAR cost less than paper.

If capacitor size, reliability and price are important to you, check into MYLAR by writing: Du Pont Co., Room **5742A**, Wilmington, Delaware 19898. (In Canada write: Du Pont of Canada, Ltd., P.O. Box 660, Montreal, Quebec.)

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INFORMATION RETRIEVAL NUMBER 50

■ Settling times with 620-Ω load and $C2 =$ 240 pF:

500 ns to 4 V; $V_o = 4$ V.
400 ns to 2 V; $V_o = 2$ V.
1 μs 4 V to ground; $V_o = 4$ V.
1 μs 4 V to ground; $V_o = 2$ V.

Settling times were measured with a type-Z preamplifier at 50 mV/cm, within 1 mV of final value.

This generator can be used in testing low-speed and medium-speed circuits, and in special analog circuit applications where fast settling times are required. In the latter application, it is superior to many of the more expensive commercial units.

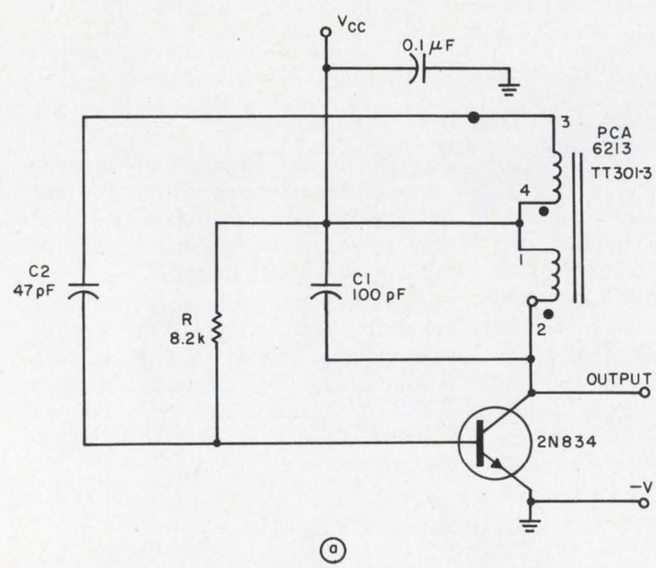
Charles D. Brower, Electronic Technician, IBM, Rochester, Minn.

VOTE FOR 314

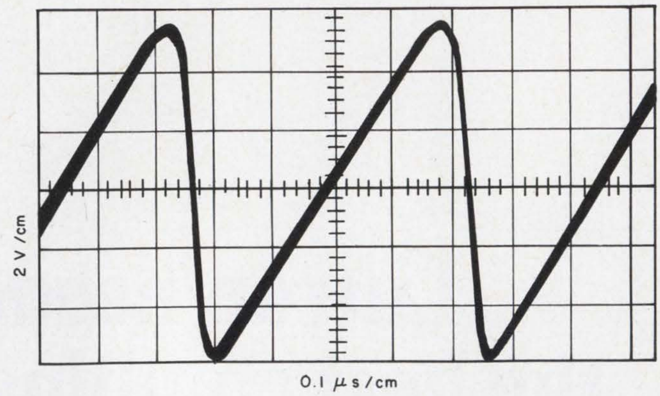
Blocking oscillator gives high-speed linear ramp

High-speed linear ramps are often required for pulse-position modulators, pulse-width modulators and multipliers. Conventional methods make it difficult to obtain good linearity for repetition rates above 1 MHz without excessive complexity. A simple means of generating linear high-speed ramps is an over-damped blocking oscillator (Fig. a).

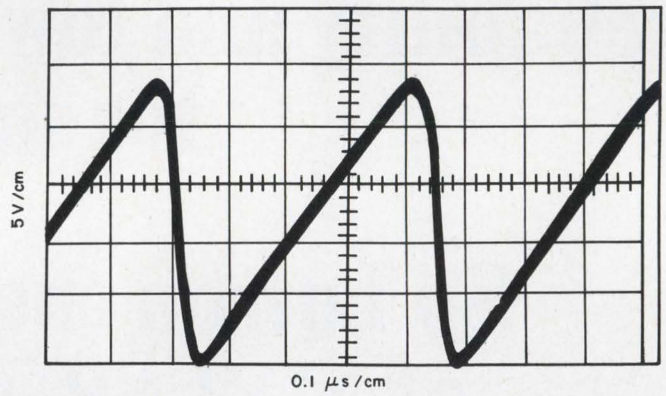
The generator is a standard blocking-oscillator circuit with a damping capacitor across the collector winding. It operates best with a relatively large primary inductance. The circuit shown operates at 2 MHz and generates a ramp of 23 volts' amplitude with a linearity of 1% between the 10% and 90% points. This ramp represents a truncated segment of a sine wave, which for the first few degrees approximates a straight line.



(a)



(b)



(c)

High-speed linear ramps are obtained from a modified blocking oscillator (a). Waveforms for $V_{cc} = \pm 6$ and ± 12 V dc are in (b) and (c), respectively.

One cycle of oscillation begins with regenerative turn-on of the transistor, pulling the collector to ground, and charging the 100-pF capacitor, *C1*, to the supply voltage and the 47-pF capacitor, *C2*, to somewhat above the supply voltage. When the transistor bottoms, the *C2* charging current drops to zero, allowing the transistor to turn off. *C1* now begins to discharge into the collector winding and the output rises linearly. The collector voltage rises to approximately twice the supply voltage (Figs. b and c) because of the resonant action of *C1* and the primary winding. As the collector rises, *C2* discharges through *R1*. After it discharges to the transistor base offset voltage, regenerative turn-on occurs and the cycle repeats.

The period of oscillation is determined by *C2* and *R1*. For a 3-to-1 turns ratio on the transformer, the period is approximately equal to 1.35 *RC*.

Peter Yanczer, Senior Engineer, Emerson Electric Co., St. Louis.

VOTE FOR 315

Buffer element used for long-duty-cycle one-shot

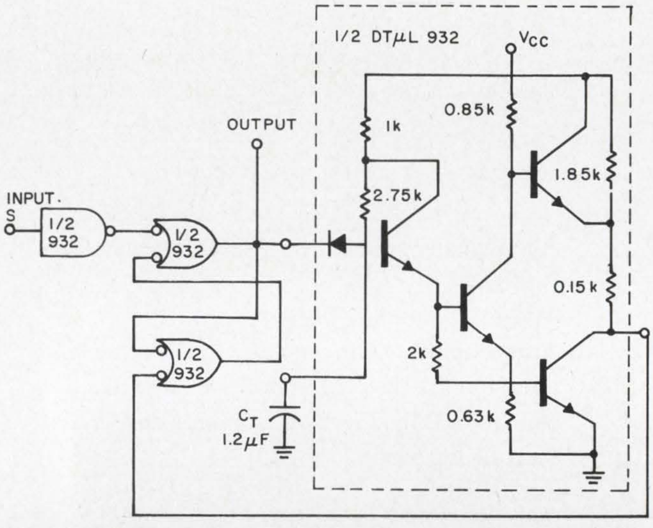
The Fairchild DTμL 932 buffer element can be used (see schematic) as a monostable multivibrator capable of duty cycles up to 95%. Output pulse widths up to 4 ms can be readily achieved.

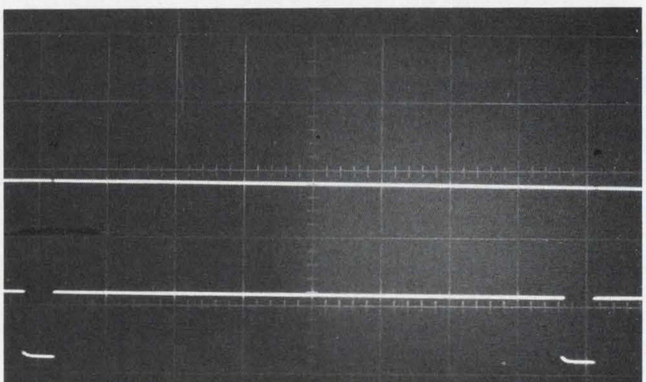
In the circuit a set pulse at the input causes the cross-coupled NOR gates to set a 1 on the input of the second NAND through the input diode. Capacitor C_T limits the voltage rise on the base of the input transistor until C_T charges from V_{cc} through the 1-kΩ and 2.75-kΩ resistors to the voltage necessary to cause it to conduct. Thus the charge time of C_T determines when the reset pulse is delivered to the cross-coupled NOR gates.

Beneath the schematic is an oscilloscope photograph showing the set pulse on the upper trace and the output pulse on the lower trace.

Walter L. Wagner and Carl F. Mattes, Electronic Engineers, Naval Air Development Center, Warminster, Pa.

VOTE FOR 316





Long-duty-cycle multivibrator (top) uses only one discrete component, C_T. Upper trace (bottom) is the set pulse, lower trace is the output pulse. Horizontal scale is 500 μ/cm, vertical is 5 V/cm.

Window discriminator is built with μA709

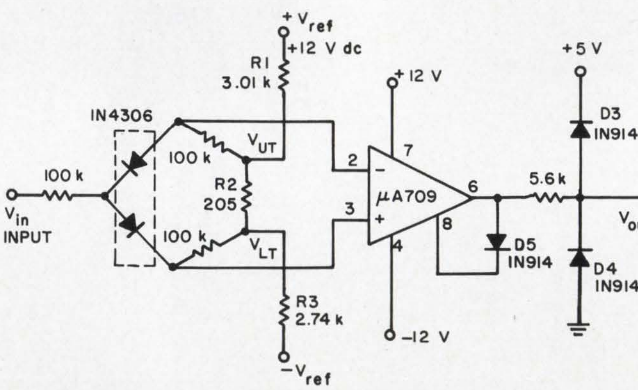
The μA709 can replace the μA711 as a window discriminator with the added advantage of high input impedance and higher input voltage. The exchange involves some sacrifice in temperature dependance (see figure).

Matched diode pair *D1* and *D2* eliminates the need for a second differential amplifier by steering the input signal. When V_{in} is at the center of the window, both *D1* and *D2* conduct equally. The amplifier is kept at negative saturation by the differential input voltage multiplied by the open-loop gain. As the upper or lower limit (set by *R1*, *R2* and *R3*) is exceeded, one diode will cease to conduct and the polarity of the differential input voltage will reverse. The amplifier will then switch into positive saturation.

D5 prevents a latch-up condition; *D3* and *D4* convert the output into a digital signal. With the values shown, the upper threshold voltage, V_{UT}, is 6 volts and the lower threshold voltage, V_{LT}, is 5.2 volts.

Don Atlas, Project Engineer, General Precision, Inc., Little Falls, N.J. Work was done when the author was with Avion Electronics, Inc.

VOTE FOR 317



High-impedance window discriminator is built with a single μA709 and a few precision resistors.

IFD Winner for November 8, 1967

E. J. Kennedy, Development Engineer, Instrumentation and Controls Div., Oak Ridge National Laboratory, Oak Ridge, Tenn. His Idea "Inexpensive 6-V reference is also temperature-stable," has been voted the $50 Most Valuable of Issue Award.

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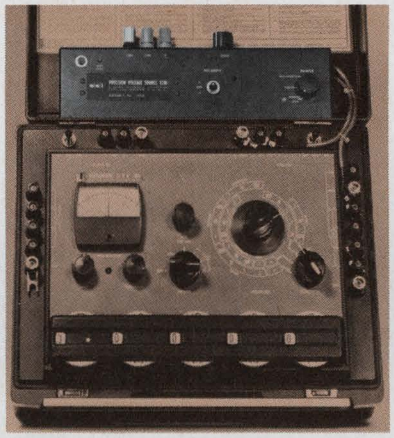
The 1310 adapter is a follower amplifier which converts the high output impedance of the PVB to a low output impedance for calibrating voltmeters, recorders, vacuum tube voltmeters, panel meters, etc.

Anything in the range of 5 volts to 50 nanovolts can be calibrated. The system is battery operated.

The 1310 is priced at $300, while the 300 PVB delivers its own 0.02% accuracy and all-purpose measuring potential for just $940. (The PVB can be used as a five-range potentiometric voltmeter, 10-range Kelvin resistance bridge, 3-range precision voltage source, 8-range ammeter, ratiometer or sensitive electronic null detector.) For more information, circle No. 161 on your reader card.



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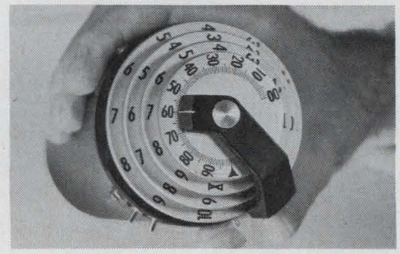
Calibration, test and control instruments that used to have a half-dozen or more decade resistor switches are now sporting the compact look with ESI DEKASTATs. Up to four decades of precision wirewound resistors are coaxially mounted in a single 3″ diameter panel space. Readout is simplified and each decade is independently adjusted, so dialing is rapid. Initial accuracy is 0.01% in any number of resistance values. All units are covered by a two-year warranty.

If you'd like to update your instrument, increase accuracy, make it more saleable, while saving on production time and costs, investigate our DEKASTATs by circling No. 162 on your reader card.



e|s|i® news and innovations in metrology

standards lab

1/5 ppm over 0.1Ω-10MΩ; less space; faster; $6,995.

Can a toiler of the standards lab find happiness with a *resistance comparison system* which claims 1/5 ppm accuracy (0.1Ω-10MΩ range), takes far less space than comparable systems, is four times more efficient and costs only $6,995?

We think so, but some of our standards friends will say there are no shortcuts to precise measurements so it is somewhat heretical to claim improvement in accuracy, packaging, efficiency and price all at once.

Nevertheless our new Model 123 Resistance Comparison System has proved itself on all four counts. Even at 100 megohms, random and systematic errors do not exceed a few parts in 1 million. And extremely rapid system performance is achieved — less than one minute for a typical balance — by applying the latest feedback control techniques in the galvanometer circuit and improving panel control of the classical Kelvin bridge.

The Model 123 combines a direct-reading double ratio set with an extremely sensitive nanovolt galvanometer (effective with any source impedance) and a new DC generator that provides necessary guarding and isolated power output.

ESI makes available a family of standards and transfer standards to complete the System, including our proven 10k resistance standard. Although optional if you already have satisfactory standards for comparison and transfer, our Model 104 Transportable Resistance Standard (instead of a Thomas 1-ohm) is a keystone to achieving full performance with the 123 Comparison System. Circle No. 163 on your reader card.

e|s|i®

Electro Scientific Industries, Inc.

13900 N.W. SCIENCE PARK DRIVE
PORTLAND, OREGON 97229

meter calibration

automated tester saves big money for big calibration labs

Any 0.1% instrument can be tested and calibrated automatically with our new Model 70 Meter Calibration System — typically, a Simpson 260 in less than 10 minutes.

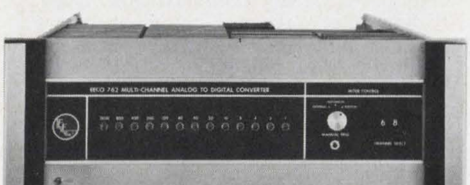
Complete calibration procedure for each of your meters is programmed onto a punched card — operator instructions, error limits, frequency, ranges, etc. Upon instruction from the operator, the Model 70 advances through each checkpoint while printing results on the typewriter. If the meter is out of tolerance, the system tells you how much and where.

Any technician can operate the Model 70 after a half hour demonstration. Repair time is cut, because the trouble area is shown on the readout.

Labor savings justify the $25,000 price tag within a short time, so if your calibration lab faces the kind of pressure that makes this system attractive, circle No. 164 on your reader card.

Only EECO's 762 multi-channel ADC offers...

continuous transient-overvoltage protection



Only the EECO 762 Multi-Channel Analog-to-Digital Converter gives continuous overvoltage channel protection. You get uninterrupted operation with transient overvoltages up to 125 VRMS on any input channel.

A combination high-speed analog multiplexer and high-resolution A-D Converter, the 762 accepts up to 100 analog inputs and samples at rates to 31,700 conversions per second, at full scale accuracies to ±0.02%, ±½ LSB. Channel input impedance is 100 megohms.

Outputs of 11 to 14 binary bits or 4 BCD digits are standard. An optional exclusive feature provides *simultaneous* binary and BCD outputs.

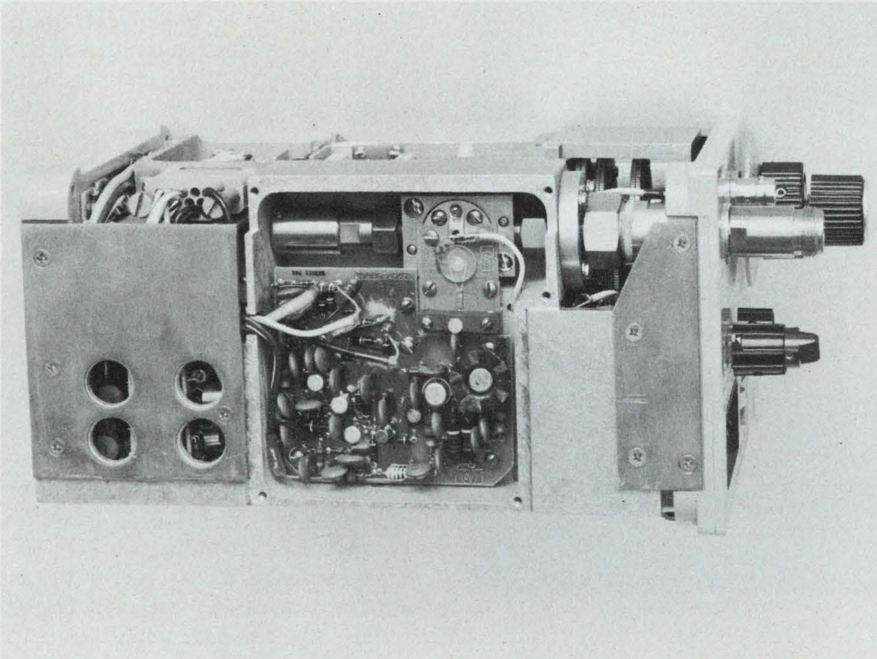
Any channel output can be displayed during multiplexing and digitizing with front panel switches.

Prices start at $3,950 for a 10-bit plus sign, 10-channel model. For complete specifications and prices, write today for the EECO 762 data sheet.

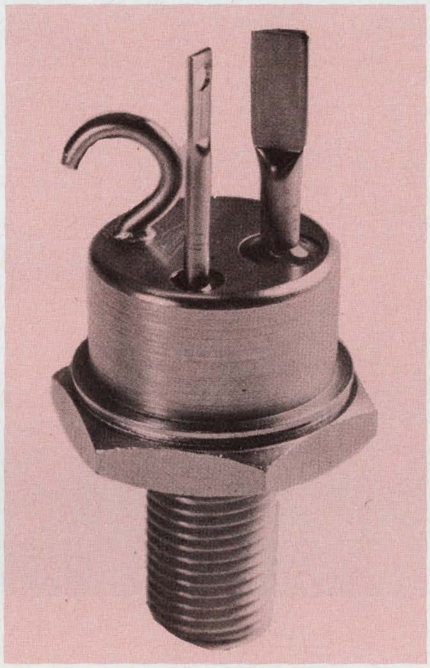
INSTRUMENTS DIVISION
ELECTRONIC ENGINEERING COMPANY OF CALIFORNIA
1601 EAST CHESTNUT AVENUE · SANTA ANA, CALIFORNIA 92701 · (714) 547-5501

INFORMATION RETRIEVAL NUMBER 53

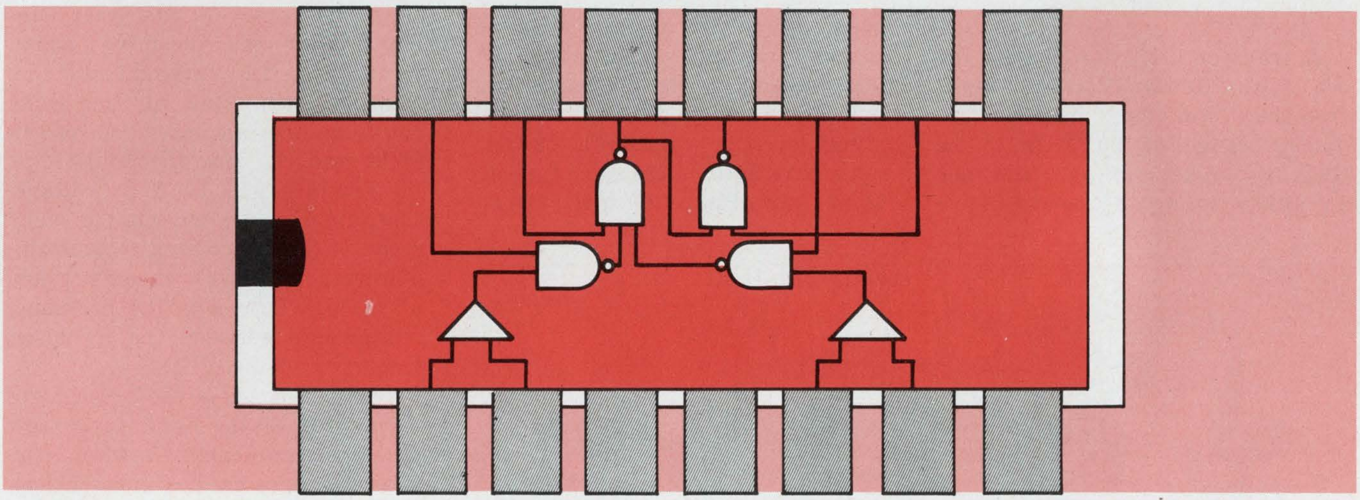
Products



Transfer oscillator plug-in has a frequency range of from 50 Hz to 18 GHz with a sensitivity of −4 dBm. Page 128



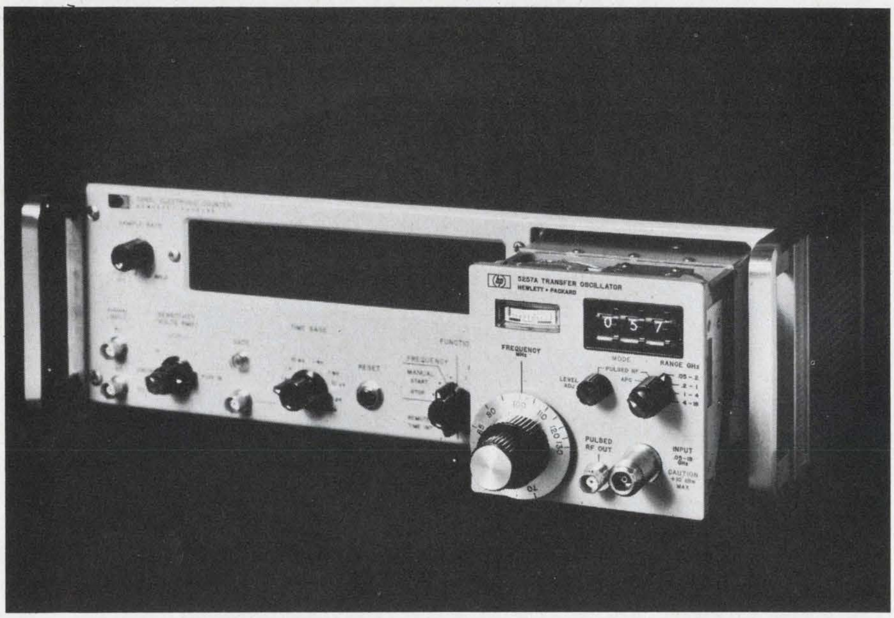
Silicon power transistor will dissipate 350 W. Page 152



Six IC sense amplifiers designed to operate with TTL or DTL circuitry, detect bipolar differential input signals and provide a memory-to-logic section interface. Page 154

Also in this section:

Transfer oscillator measures to 18 GHz



Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000. P&A: $1850; stock.

A transfer oscillator plug-in for use with Hewlett-Packard high-frequency counters has a frequency range of 50 MHz to 18 GHz. No mixer tuning stubs nor any other tuning adjustments have to be made anywhere in the frequency range. Proper tuning is indicated by a meter.

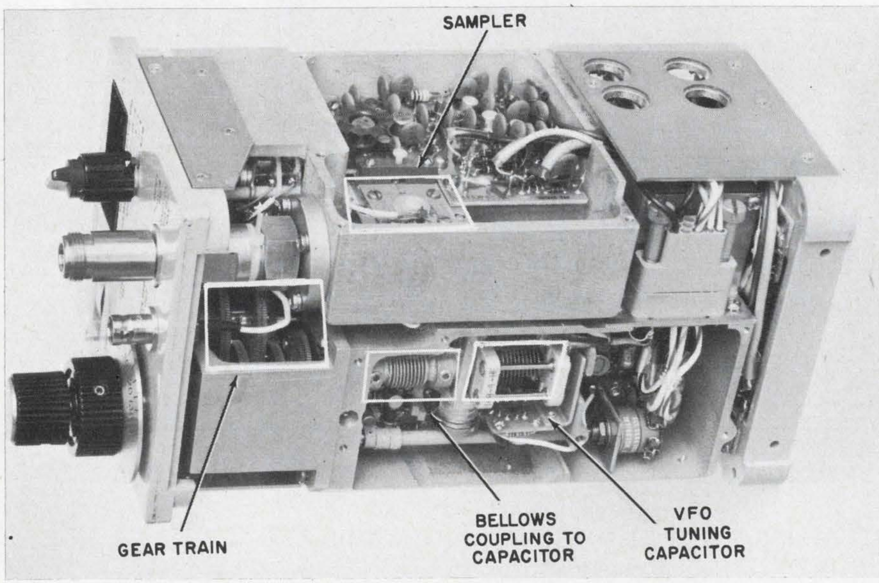
During measurement of cw signals, the readout displays all zeros if the transfer oscillator is not phase-locked to the incoming signal. The unit works with typical signal levels of −8 dBm at 18 GHz with sensitivity increasing typically to −23 dBm at 50 MHz. Sensitivity is −7 dBm (100 mV) from 50 MHz to 15 GHz and −4 dBm (140 mV) from 15 GHz to 18 GHz.

Stability for pulsed rf measurements is ±1 part of 10^7 per minute. The performance of this transfer oscillator is primarily attributable to use of a wide-band sampler in place of both the harmonic mixer and the phase detector of the conventional phase-locked transfer oscillator. The sampler has broader bandwidth and greater sensitivity than a harmonic mixer, particularly at higher frequencies. Furthermore, it does not require a frequency offset to derive "sense" information for phase locking.

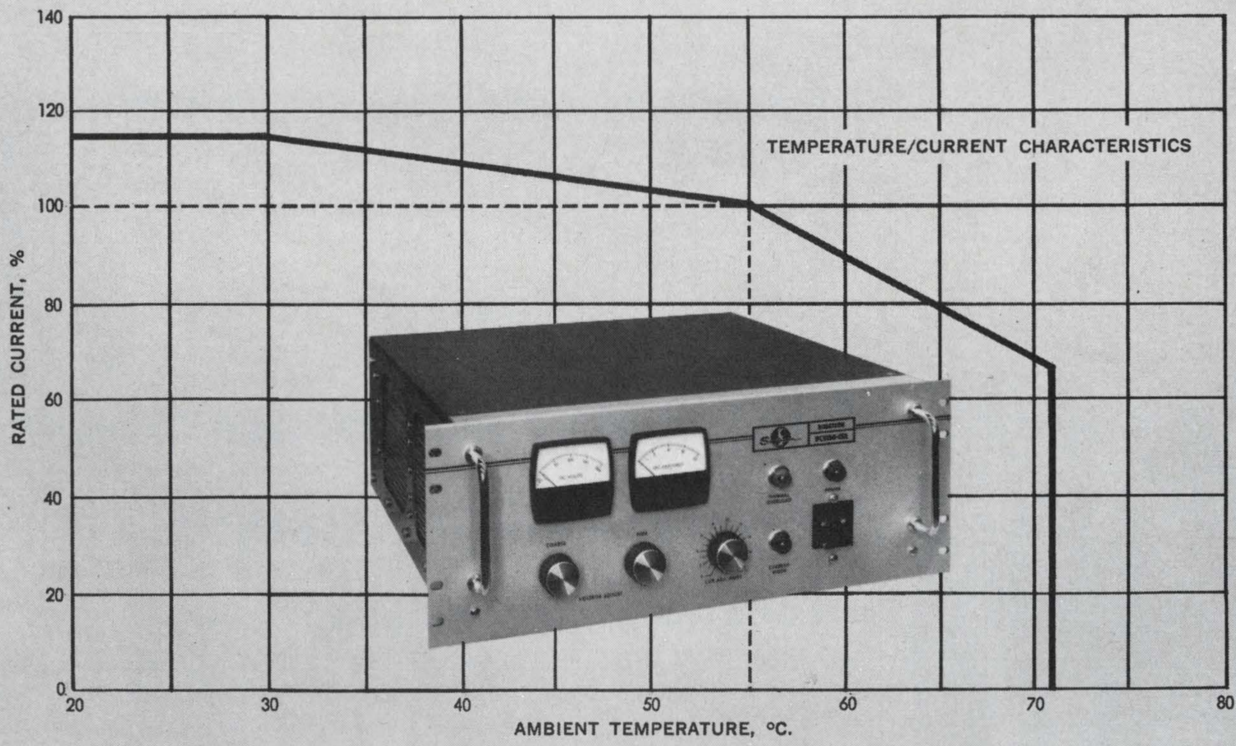
A transfer oscillator is a variable frequency oscillator (VFO) that can be tuned to a frequency that is an exact submultiple of the frequency to be measured. The counter measures the oscillator's frequency, and this is multiplied by the appropriate harmonic factor to obtain the frequency of the incoming signal. The measurement can be made with the accuracy of the counter's time-base oscillator by phase-locking the VFO to the signal. With this transfer oscillator, the VFO is set to an exact submultiple of the incoming signal frequency. The signal will be sampled each time at the same point in the incoming waveform cycle, and the smoothed output of the sampler will be a dc voltage. The sampler does not sample every cycle of the incoming waveform, however, but looks at only every n^{th} cycle, where n is the harmonic relationship between the incoming frequency of the VFO.

The dc output is used to control a varactor in the oscillator's tank circuit, thus phase-locking the VFO to the signal. It also drives the tuning meter. If the VFO is not tuned near a submultiple of the incoming frequency, the smoothed sampler output will be an ac voltage that has an average value of zero. The meter can thus be used as an indicator of correct tuning. The sampler output is also available at a front-panel connector, where it can be examined by an oscilloscope, or used as a down-converted signal for other instruments.

CIRCLE NO. 260



Plug-in's interior shows the cast aluminum chassis and the 636-to-1 gear train, which can position the capacitor rotor within 1/12,000°.



Sorensen DCR Series now with temperature capability to 71°C.

Sorensen Wide Range Power Supplies to 20 kW.

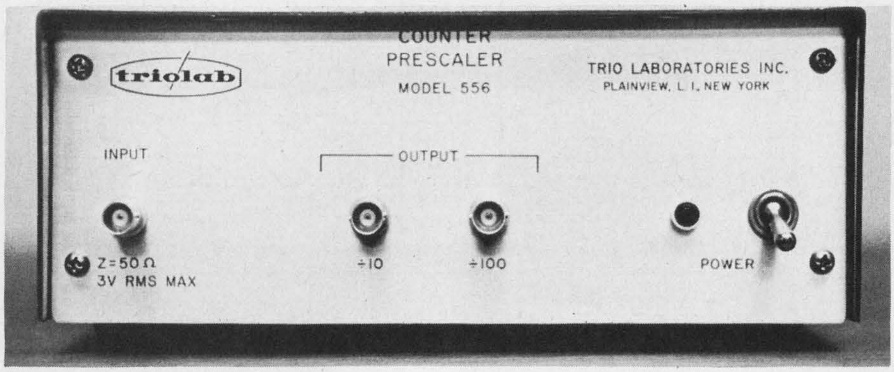
Sorensen's wide range DCR Series has been up-dated and improved. What's new about the DCR's? They are now 100% silicon; ambient temperature capability is now to 71°C. • Four 3-phase models have been added extending power capability to 20 kW; 24 models are now available with ranges up to 300 volts. • Multiple mode programming—voltage/current/resistance. • Voltage regulation, line and load combined, is ±.075% for most models • Constant current range 0 to rated current. • DCR's meet MIL-I-26600 and MIL-I-6181 specifications and conform to proposed NEMA standards. • Front panel indicator for voltage/current crossover. These features of the improved DCR (model numbers will have an "A" suffix) are offered at no increase in price. For DCR details, or for data on other standard/custom power supplies, AC line regulators or frequency changers, call your local Sorensen rep, or write: Raytheon Co., Sorensen Operation, Richards Avenue, Norwalk, Connecticut 06856. Tel: 203-838-6571.

MODEL SELECTION CHART

Voltage	Amps.	Model	Price	Amps.	Model	Price	Amps.	Model	Price	Amps.	Model	Price
0- 20	125	DCR 20- 125A	$1140	250	DCR 20- 250A	$1550	–	–	–	–	–	–
0- 40	10	DCR 40- 10A	360	20	DCR 40- 20A	550	35	DCR 40- 35A	$ 750	60	DCR 40-60A	$ 915
0- 40	125	DCR 40- 125A	1390	125	DCR 40- 250A	2290	500	DCR 40-500A	3750	–	–	–
0- 60	13	DCR 60- 13A	525	25	DCR 60- 25A	850	40	DCR 60- 40A	990	–	–	–
0- 80	5	DCR 80- 5A	360	10	DCR 80- 10A	580	18	DCR 80- 18A	850	30	DCR 80-30A	925
0-150	2.5	DCR 150- 2.5A	360	5	DCR 150- 5A	580	10	DCR 150- 10A	830	15	DCR 150-15A	890
0-300	1.25	DCR 300-1.25A	390	2.5	DCR 300- 2.5A	580	5	DCR 300- 5A	795	8	DCR 300- 8A	890

RAYTHEON

INFORMATION RETRIEVAL NUMBER 200



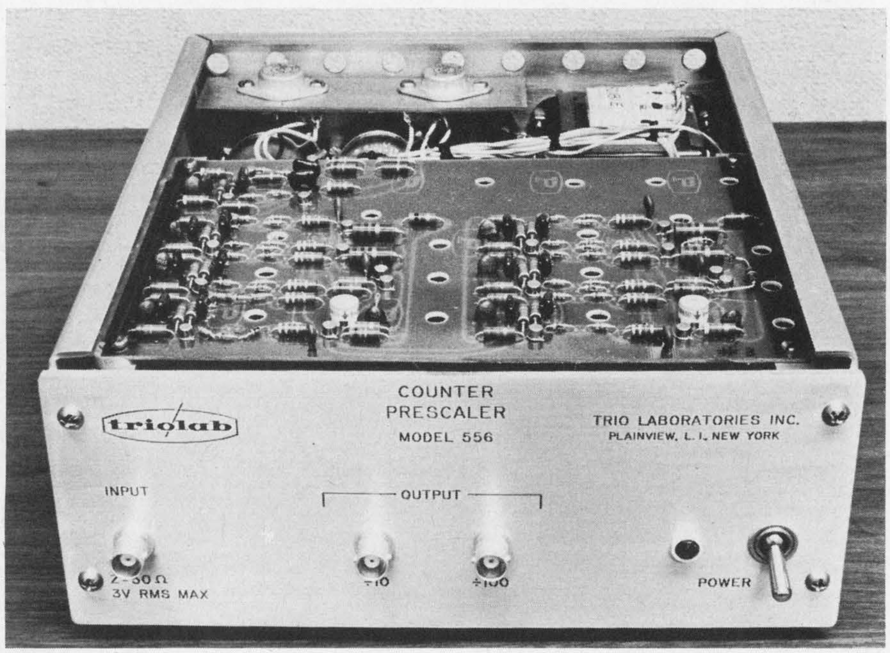
Counter-range extender divides to multiply

Trio Laboratories, Inc., 80 DuPont St., Plainview, N.Y. Phone: (516) 681-0400. P&A: $640; 8 to 10 wks.

Any counter scale can be extended 10 or 100 times higher with this counter prescaler. This alleviates the need to scrap a counter for which no extender is offered.

Trio Labs asserts that this unit will mate with any counter made now. It performs simultaneous scaling functions of divide-by-100 and divide-by-10 over the range of 1 to 150 MHz, without affecting the counter's accuracy or stability. The unit has no controls, just an off-on switch. Its sensitivity is 50 mV rms with an input impedance of 50 Ω. The device achieves an output of 3 V square wave into 1 kΩ and 1 V square wave into 50 Ω.

The instrument's circuitry is all solid-state. A tunnel diode is used as the pulse shaper. The patent-pending dividing circuit uses a flip-flop that operates at a saturated logic level and will rise in 2 ns to a clock of 150 MHz. A way of dividing by any number was chanced upon during preliminary design work. A diode was open in the circuit and instead of dividing by 10 as the circuit was designed to do, it divided by 9. By experimenting with the other diodes and combinations of diodes, division by any multiple could be achieved.



Any counter's scale can be extended 10 or 100 times higher with this counter prescaler. It covers a range of from 1 to 150 MHz in 2 ns.

CIRCLE NO. 261

Cw signal generator spans 10 to 250 MHz

Kay Electric Co., Maple Ave., Pine Brook, N.J. Phone: (201) 277-2000.

The Rada-Pulser 5071B is a pulsed carrier generator. It provides a cw signal from 10 to 250 MHz. The generator provides pulses with a range of widths from 100 ns to 100 μs with less than 20-ns rise and delay times. Pulse-repetition rates are variable from 50 to 5000 pulse/s.

CIRCLE NO. 262

Dc voltage supply produces 0 to 3100 V

Keithley Instruments, Inc., 28775 Aurora Road, Cleveland, Ohio. Phone: (216) 248-0400. Price: $450.

With an output capability of 0 to 3100 V and a stability of 0.01°, this regulated dc high voltage biasing supply is well suited for use with photomultiplier tubes, ion gauges, solid-state radiation detectors and photocells. Zener diodes, and matched input transistors, contribute to instrument accuracy.

CIRCLE NO. 263

Controller-gaussmeter for magnetic tests

Varian, 611 Hansen Way, Palo Alto, Calif. Phone: (415) 326-4000.

Direct field control for any existing magnet system is possible with this controller-gaussmeter. Applications can be made in systems for beam deflection and all general laboratory electromagnetic applications. These Hall-effect instruments provide protection against external field disturbances and measure directly the field intensity in the magnet air gap.

CIRCLE NO. 264

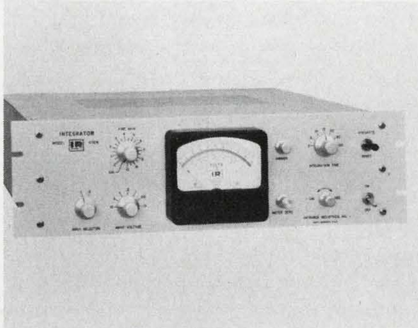
Six-oz amplifier gives tenfold gain

Endevco Laboratories, 1675 Stierlin Rd., Mountain View, Calif. Phone: (415) 968-7744. P&A: $125; stock.

A power amplification and calibration device may be used with any half- or full-bridge strain gauge or other resistance device between 300 and 3000 Ω. The package employs ICs and weighs only 6 oz. It will plug directly into any type of readout system that requires 0.1 mA, providing power to the transducer while amplifying the resulting signal up to 10 times.

CIRCLE NO. 265

Transducer integrator provides one value

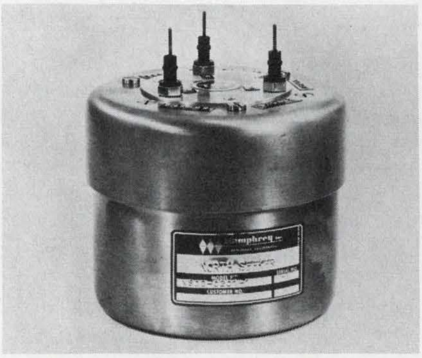


Infrared Industries, Inc., Santa Barbara, Calif. Phone: (805) 451-7252.

Integrating an input signal over a selected period of time to provide a single-valued unambiguous reading is accomplished with this integrator. It is used in low-level measurement systems working with transducers such as infrared detectors. The model 602 has an input impedance of 20 MΩ, and covers a range of 10 mV to 10 V.

CIRCLE NO. 266

Fluid-filled device seeks magnetic north

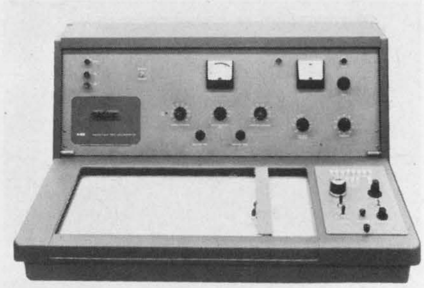


Humphrey Inc., 2805 Canon St., San Diego, Calif. Phone: (714) 223-1654.

For oceanographic applications a magnetic-north fluid-filled transducer is suitable for use in depths to 15,000 ft. The device provides average performance within ±3° of magnetic north and a guaranteed accuracy of ±5°. It is 4 × 4.5 in. and weighs 3.5 lbs. Its enclosure is a hermetically sealed stainless-steel case with optional connector arrangements. The sensing element is an array of permanent magnets.

CIRCLE NO. 267

Spectrometer system includes recorder



Varian, 611 Hansen Way, Palo Alto, Calif. Phone: (415) 326-4000.

A digital recorder and a rugged probe insert assembly are included in this spectrometer system. The A-60D offers signal-to-noise specifications of 18 to 1. A guide sleeve, in conjunction with the long spinner turbine, guides the sample tube into the fragile insert, so that these do not touch. Thus breakage due to inserting the sample tube and spinner turbine in an improper manner is virtually eliminated.

CIRCLE NO. 268

Data amplifier has gain of 12,500

Dana Laboratories, Inc., 2401 Campus Dr., Irvine, Calif. Phone: (714) 833-1234.

Gains up to 12,500, at very low noise levels, are possible with a wide-band dc data amplifier that features good rfi rejection and a high level of common-mode rejection. Full-scale output is ±10 V and ±100 mA. The noise referred to the input at a gain of 1000 is less than 4 μV rms at full bandwidth.

CIRCLE NO. 269

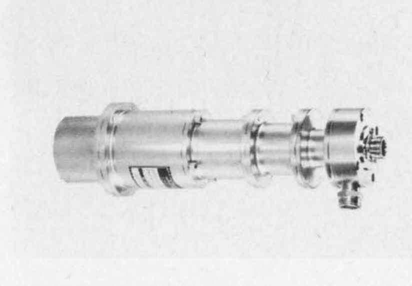
Capacitance test set reads out to 0.7 pF

Test Equipment Corp., 2925 Merrell Rd., Dallas. Phone: (214) 357-6271. P&A: $830; 60 days.

A junction capacitance test set is capable of 1-MHz capacitance measurements. Accuracy is ±1% or ±0.1 pF and the range of the instrument extends to 150 pF. Adjustments, offsetting up to 100 pF of external capacitance, permit the use of external test jigs.

CIRCLE NO. 270

25-kW dummy load weighs 11 pounds



Altronic Research Corp., 13710 Aspinwall Ave., Cleveland. Phone: (216) 851-3220. P&A: $875; 3 wks.

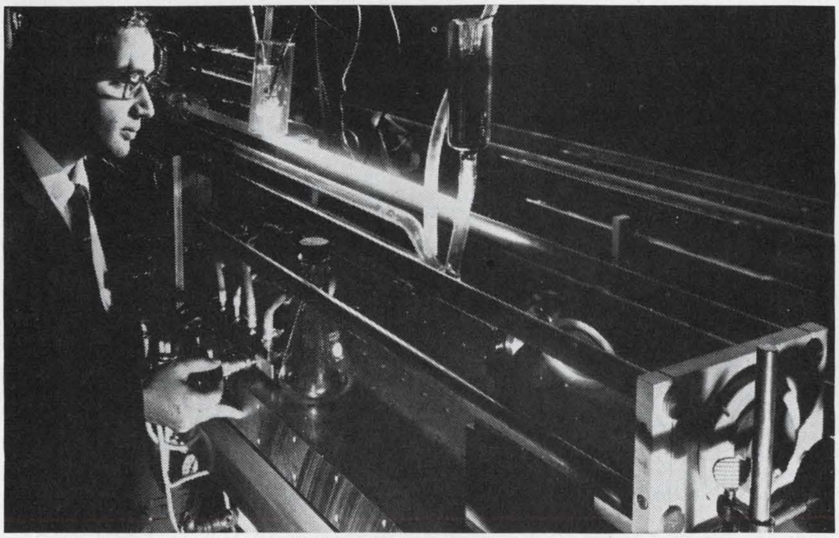
A dummy load for 3-1/8-in. transmission line, handling up to 25 kW, is 15 in. long. Of brass and aluminum construction, the unit weighs 11 lb. Water-cooled, it features an internal pressure drop of less than 10 lb per in.^{2} at a water-flow rate of 6 gallons per minute.

CIRCLE NO. 271

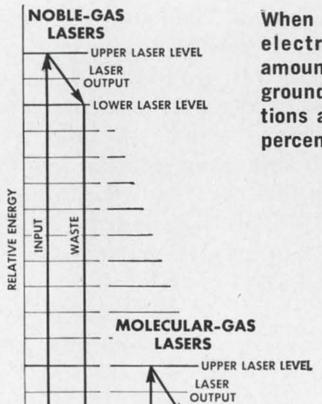
Report from

BELL LABORATORIES

Molecular-gas lasers

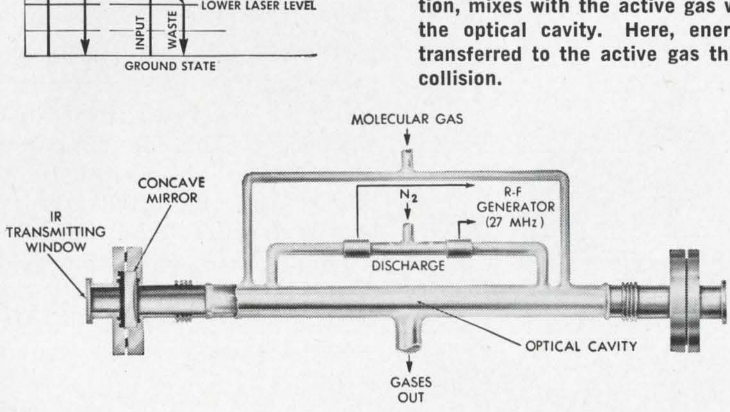


Bell Laboratories research physicist C. K. N. Patel with his experimental "flowing gas" laser. The glowing tube contains nitrogen in which electrical discharge is taking place. The active gas flows through the other, similar-sized tube and the gases meet in the optical cavity. Here, energy is transferred to the active gas through collision.



When a laser operates through energy stored in electron orbits (left), a comparatively large amount is wasted through the long return to ground state. But, when energy is stored in vibrations and rotations within a molecule (right), the percent wasted is much smaller.

The experimental setup which led to development of today's most powerful and efficient CW laser. Nitrogen, carrying vibrational and rotational excitation, mixes with the active gas within the optical cavity. Here, energy is transferred to the active gas through collision.



To produce a photon in a gas laser, an atom or molecule reduces its energy by dropping from the "upper laser level" to the "lower laser level" (graph). From the lower level, the energy usually decreases to absolute minimum—"ground state"—before the atom or molecule can emit another useful photon. This second drop is waste: incoherent light and heat.

Lasers using noble (atomic) gases, like helium-neon or argon, are particularly wasteful in this respect. But a laser using molecular gases, such as carbon dioxide, would operate at lower energy levels and produce less waste radiation.

In investigating new infrared lasers, therefore, scientist C. K. N. Patel of Bell Laboratories employed molecular gases. To experiment with them, he invented a new kind of laser (photo and figures) in which the active (radiation-emitting) gas flows continuously into the optical cavity. There it meets a flow of nitrogen, which is excited by an electrical discharge in a separate tube. In this way, molecules in the active gas are raised to an upper laser level by the transfer of vibrational energy from nitrogen molecules. This prevents the electrical discharge from breaking down the active gas.

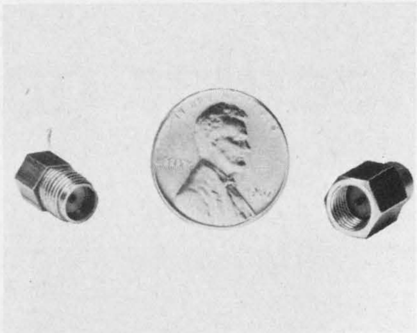
With this technique, Patel demonstrated lasers based on carbon monoxide, carbon dioxide, nitrous oxide, and carbon disulphide. He found that carbon dioxide has the highest efficiency, about 15 percent compared with less than 0.1 percent from previous gas lasers.

Carbon dioxide has another advantage. It is the only known molecular gas that is chemically stable enough to function even if the discharge takes place within it. So in this instance, the "flowing-gas" technique is not required.

Patel also found that the addition of certain gases, such as helium, increases the efficiency of the carbon dioxide laser. Such lasers have been built with continuous outputs of more than 1000 watts at wavelengths of 10.6 microns (infrared).

Bell Telephone Laboratories
Research and Development Unit of the Bell System

1/2-in. terminations span dc to 18 GHz

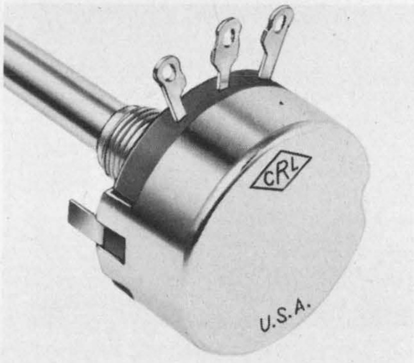


Microlab/FXR, 10 Microlab Rd., Livingston, N.J. Phone: (201) 992-7700.

Compact coaxial terminations cover dc to 18 GHz with a maximum VSWR of 1.15. Two models are capable of handling average power levels of up to 1/2 W. The model TA-C80 has a male connector, a length of 0.5 in., and weighs 0.1 oz; model TA-C81 has a female type connector, a length of 0.465 in. and weighs 0.07 oz.

CIRCLE NO. 272

Potentiometer endures one million cycles

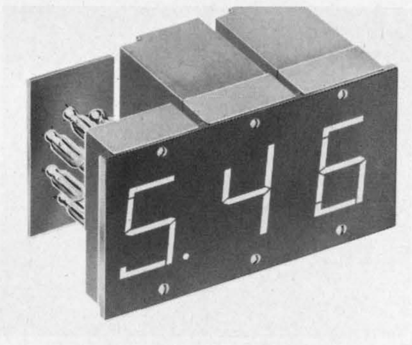


Centralab Div. of Globe-Union Inc., 5757 N. Green Bay Ave., Milwaukee. Phone: (414) 228-1200. Price: 66¢ to 76¢.

Hot-molded carbon potentiometers maintain their 2-1/4-W rating for a one-million-cycle service life. Linear-taper units offer resistance values ranging from 10 Ω to 5 MΩ. Audio tapers (10% resistance at 50% rotation) have a resistance range of 50 Ω to 5 MΩ. Maximum operating voltage is 500 V dc.

CIRCLE NO. 273

Solid-state readout handles BCD code

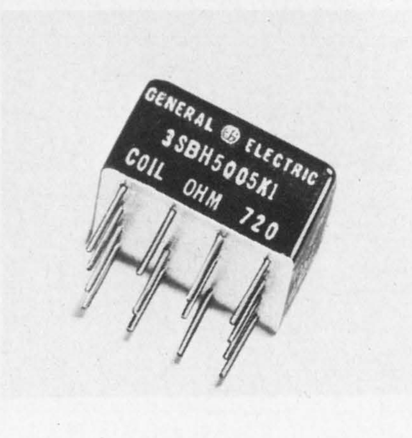


The Mesa Co., Inc., 220 Mill St., Bristol, Pa. Phone: (215) 788-5521. Price: $25.

A digital readout, designed to replace gas-filled-tube-type displays, is 1.97 in. high, 1.07 in. wide and 2 in. deep. It is available with plus-minus sign, decimal point, colon, and may contain as many characters as required. Four-line, 8-4-2-1 BCD signals are translated into the proper patterns with a logic-1 level of 3 V.

CIRCLE NO. 274

Sealed relays control 2 A at 28 V



General Electric, 777 14th St. N.W., Washington, D.C. Phone: (202) 393-3600.

The rating of 150-mil-pin-spaced two- and four-pole relays is 2 A at 28 V. The rated life is 100,000 operations. The 150-mil pin spacing provides ample room for making connections without crowding and still maintaining high electric strength. Electron-beam welding, used for the header-to-enclosure seal, generates very little heat to prevent damage to the glass-bead seals.

CIRCLE NO. 275

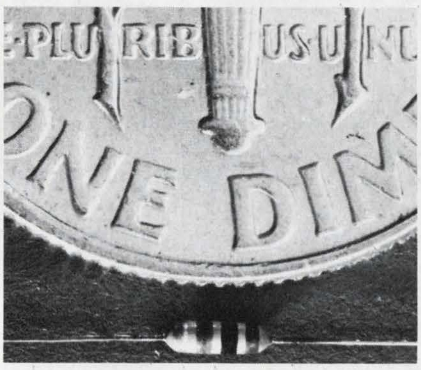
Solderless terminals cut connection time

Hi-Tek Corp., 2220 South Anne St., Santa Ana, Calif. Phone: (714) 540-3520.

Three solderless terminal configurations that can reduce switch connection time by as much as 50% are easily removable for repair or modification, yet still provide contact under severe vibration and environmental conditions. The series includes a wire-wrap terminal for fast, uniform connection with a power tool and two types of quick-connect terminals.

CIRCLE NO. 276

Carbon-film resistors available to 4.7 MΩ

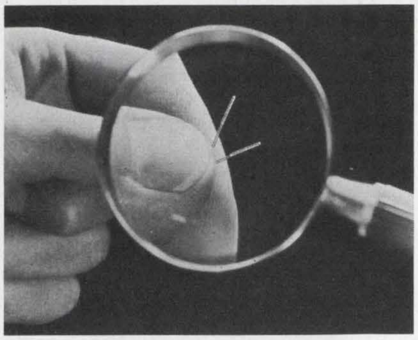


British Radio Electronics Ltd., 1742 Wisconsin Ave. N.W., Washington, D.C. Phone: (202) 338-1520.

Carbon-film resistors are available for IC and other designs that have limited space requirements. The RK1-2 microminiature carbon-film resistor, 0.087 in. in length by 0.032 in. in dia, is supplemented by the miniature RK1-10 (0.134 × 0.055 in.) and the intermediate RK1-5 (0.138 × 0.039 in.). The resistance range of all three is from 10 Ω to 4.7 MΩ.

CIRCLE NO. 277

Glass thermistors function in liquid

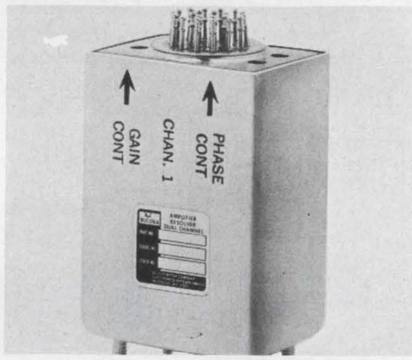


Fenwal Electronics, Inc., 63 Fountain St., Framingham, Mass. Phone: (617) 875-1351.

Tiny glass thermistor probes have a response time that compares favorably with that of glass yet are suitable for high-velocity and liquid-immersion applications, either with or without protective housings. Units are available with resistance values at 25°C from 1000 to 5 MΩ and a temperature span of −50° to 300°C.

CIRCLE NO. 278

Resolver amplifier sums to 0.025%

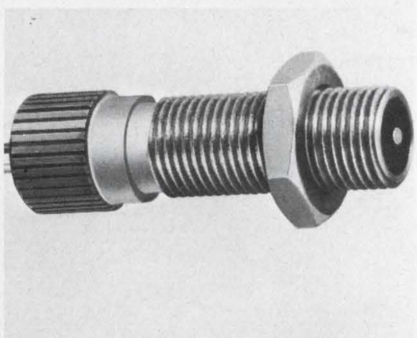


Servo Products, Bulova Electronics, 61-20 Woodside Ave., Woodside, N.Y. Phone: (212) 335-6000. P&A: $165; 6 weeks.

Dual-channel resolver amplifier offering parallel summing is available with from one to three inputs per channel, depending on order specifications. The unit meets MIL-E-5400 and MIL-I-26600 specifications. The input impedance is 200 kΩ ±1% and max signal input, with no damage to amplifier, is 26 V rms.

CIRCLE NO. 279

Magnetic pickup operates to 450°F

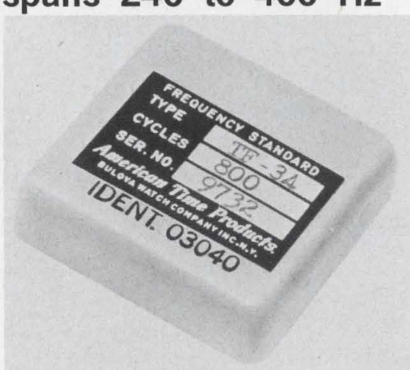


Airpax Electronics, Inc., Seminole Div., P.O. Box 8488, Fort Lauderdale, Florida. Phone: (305) 587-1100.

A magnetic pickup converts mechanical motion into an ac voltage without physical contact or external power. Applications for this pickup include tachometry, counting, positioning, timing, vibration measurement, motion study and computer equipment. The internal portion of the pickup is potted with epoxy resin.

CIRCLE NO. 280

Tuning-fork resonator spans 240 to 400 Hz

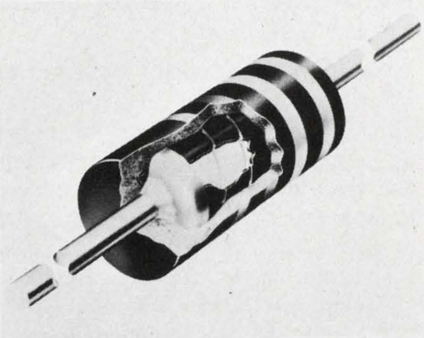


American Time Products, Bulova Electronics, 61-20 Woodside Ave., Woodside, N.Y. Phone (212) 335-6000. P&A: $25; 2 wks.

Tuning-fork resonator weighing 1-1/2 oz is designated the model TF-34. It is available in frequencies from 240 to 4000 Hz but can also be ordered with any fixed frequency up to 15 kHz. The device has an accuracy of 0.2% at 25°C. Lesser accuracies can be obtained over the temperature range of −55°C to 85°C.

CIRCLE NO. 281

Thick-film resistor is rated at 2 watts

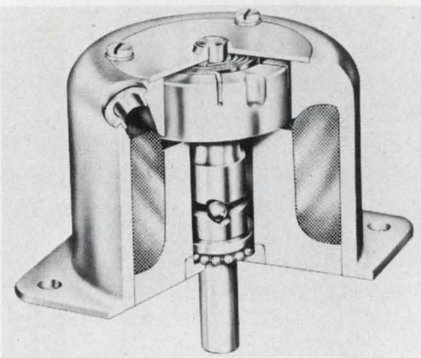


IRC, Inc., 401 N. Broad St., Philadelphia. Phone: (215) 922-8900. P&A: $4.80; (100 lots) 3 wks.

A 2-W fixed resistor uses the same material in its resistance element as previously available 1/4- and 1/2-W components. The material is a thick film of metal alloy that is fused to a crystalline ceramic substrate. The resistor, rated 2 W at 70°C, is offered in values from 10Ω to 470kΩ, at ±2%, ±5% and ±10% tolerance. Temperature coefficient of resistance averages 200 ppm/°C.

CIRCLE NO. 282

Rotary solenoids have no axial motion



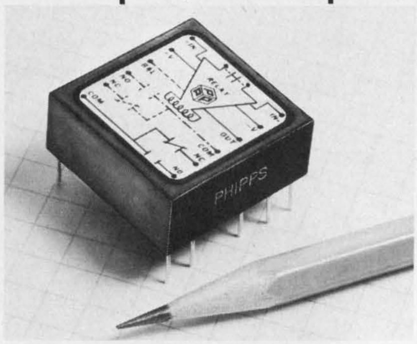
Pathfinder Industries, 1520 S. Lyon St., Santa Ana, Calif. Phone: (714) 542-3521.

Rotary dc solenoids require no splines, linkages or other motion-absorbing devices. These solenoids may be used in applications that cannot tolerate axial shaft movement. As the plunger is drawn across the air gap, cams act on the output shaft which is restrained from axial motion by a thrust and radial bearing. Devices from 30 oz/in./° to 300 lb/in./° can be supplied.

CIRCLE NO. 283

INFORMATION RETRIEVAL NUMBER 64

Low-noise comparators take up 1/2-in.³ space

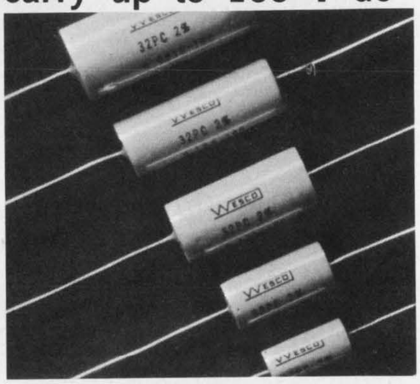


Phipps Precision Products, 7749 Densmore Ave., Van Nuys, Calif. Phone: (213) 785-3109. P&A: $34.95; 1 to 2 wks.

Comparators with differential amplifier inputs and reed-relay outputs eliminate the effect of noise on signal inputs without altering the trip level or input impedance. Comparator hysteresis can be achieved by connecting a suitable resistance across the two hysteresis terminals on the module.

CIRCLE NO. 284

Foil capacitors carry up to 100 V dc

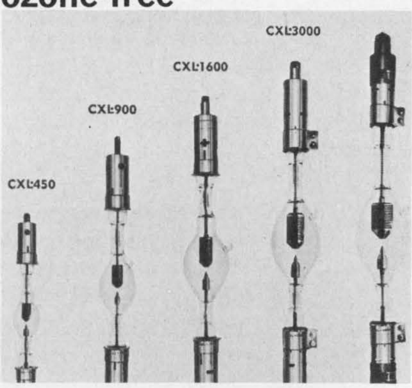


Wesco Electrical Co., Inc., 27 Olive St., Greenfield, Mass. Phone: (413) 774-4358.

Capacitors type 32-PC are available in 50- and 100-V dc models. Operating temperature range is $-55°C$ to $+125°C$ with no voltage derating. Total capacitance change does not exceed $\pm 2\%$ over the entire temperature range and is typically $\pm 0.25\%$ from $-25°C$ to $+85°C$. The stability of these units, is exceeded only by polystyrene in the film dielectric field.

CIRCLE NO. 285

Xenon lamps ozone-free

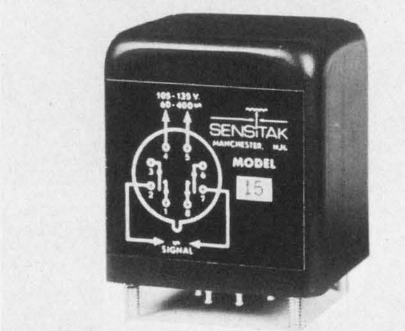


Christie Electric Corp., 3410 W. 67th St., Los Angeles. Phone: (213) 750-1151.

Ozone-free xenon lamps handle 450 to 1600 W. Arc lamps (75-6500 W), horizontally operated xenon lamps (300-200 W), and mercury short arc lamps (100-500 W) are available singly or as part of an entire illumination system. The lamps find application in photochemistry, solar simulation, biology, physics, plant growth, food-processing and graphic arts.

CIRCLE NO. 286

Differential relay has zero error

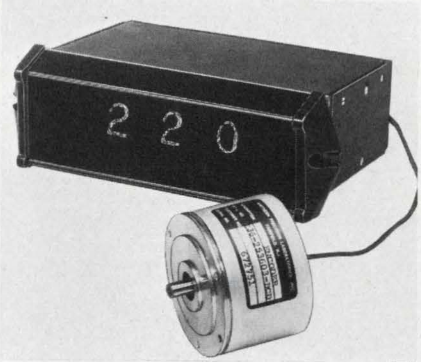


Sensitak Instrument Corp., 531 Front St., Manchester, N.H. Phone: (603) 627-1432. P&A: $31.75; stock.

A servo differential relay consists of an operational amplifier, a power supply and two independent reed switches contained in an epoxy-encapsulated housing. Powered from a 50-to-400-Hz source, the relay operates from transducers powered synchronously from the same supply.

CIRCLE NO. 287

Encoder readout gives shaft position

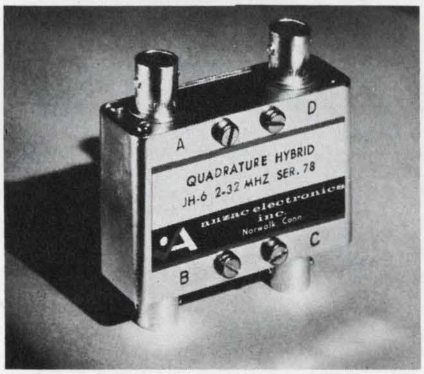


Northern Precision Laboratories, Inc., 202 Fairfield Rd., Fairfield, N.J. Phone: (201) 227-4800.

A shaft encoder readout, containing all necessary interface decoding logic and lamp-drive power supplies, will produce a visual display of remote shaft position. A complete encoder display system consists of only two components: the encoder and its corresponding readout display module. Auxiliary BCD (8-4-2-1) and decimal outputs are available.

CIRCLE NO. 288

Quadrature hybrid covers hf band

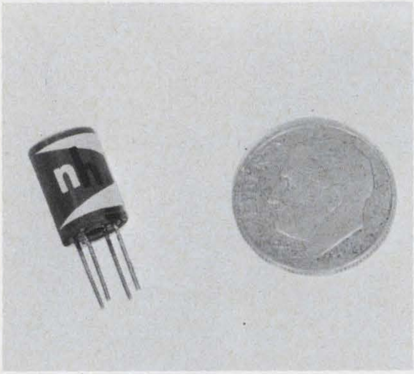


AR-Anzac Electronics Co., 121 Water St., South Norwalk, Conn. Phone: (203) 853-9411. P&A: $475; stock.

The model JH 6 quadrature hybrid covers the entire 2–32-MHz frequency band and measures 2.3 × 1.5 × 0.8 in. A signal fed into the device divides equally within 0.5 dB between the unit's two output ports. Outputs exhibit a 90° ± 3% relationship over the full band. Insertion loss is less than 0.8 dB. Isolation is greater than 20 dB.

CIRCLE NO. 289

Adjustable coils span 1 to 1000 μH

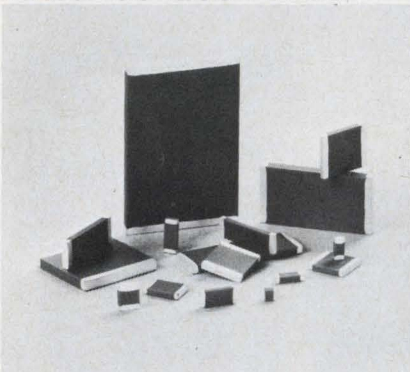


North Hills Electronics, Alexander Place, Glen Cove, N.Y. Phone: (516) 671-5700. P&A: $4.50; stock.

Subminiature adjustable coils designated the 600 series are shielded and designed for printed-circuit applications. These inductors cover the range from 1 μH to 1000 μH and can be employed over the 100-kHz-to-30-MHz range. Values other than standard are made to order. Typical standard values are 1 μH, Q 90 at 7900 kHz and 1000 μH, Q 90 at 790 kHz.

CIRCLE NO. 290

Chip capacitors rated at 200 Vdcw

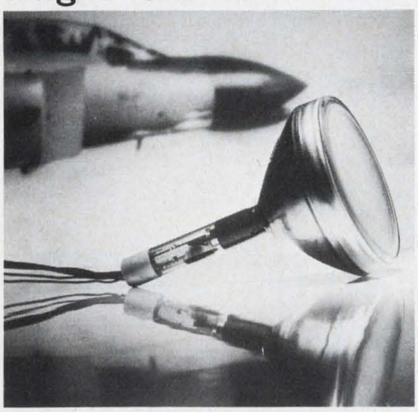


U.S. Capacitor Corp., 2151 N. Lincoln St., Burbank, Calif. Phone: (213) 843-4222. P&A: 13¢ to $1.86; 10 days.

A line of miniature chip capacitors for use in thick- or thin-film hybrid circuits is available in a capacitance range of 120 pF to 3.3 μF with ratings of 50, 100, and 200 Vdcw. Standard tolerance is ±10% with ±5% and ±20% available. Sixteen body configurations range from 0.75 × 0.035 × 0.04 in. to 0.865 × 0.595 × 0.08 in.

CIRCLE NO. 291

Five-inch CRT weighs one lb

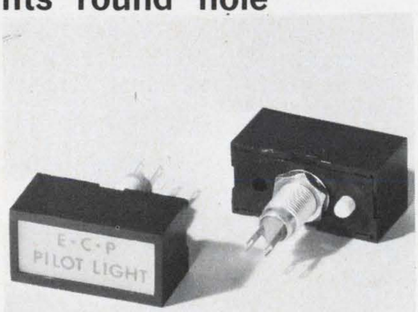


Westinghouse Electric Corp., Box 2278, Pittsburgh. Phone: (412) 391-2800.

A compact high-brightness CRT features 70° magnetic deflection and 4-mil line width. The CRT's 5-in.-dia aluminized faceplate allows 90% light transmission. The electrostatically focused CRT weighs 1 lb, is less than 8 inches long, and has a 0.87-in.-dia neck. Other features include flying leads and low deflection power requirements. The tube is available with most standard JEDEC phosphors.

CIRCLE NO. 292

Rectangular light fits round hole

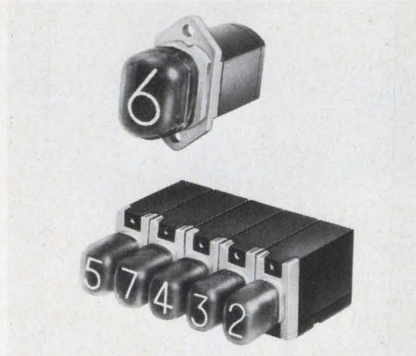


E C P Corp., 4726 Superior Ave., Cleveland. Phone: (216) 391-0444.

Offering a 1-1/2-by-1/2-in. rectangular message area, this pilot light has space for up to 39 letters. It is mounted in a 13/32-in.-dia round hole; no special tools are required for installation. The rectangular plastic lens is easily removed for marking. Relamping is done from the front and 6-, 12-, 24- or 28-V lamps may be used.

CIRCLE NO. 293

Indicator tube drivers use IC construction

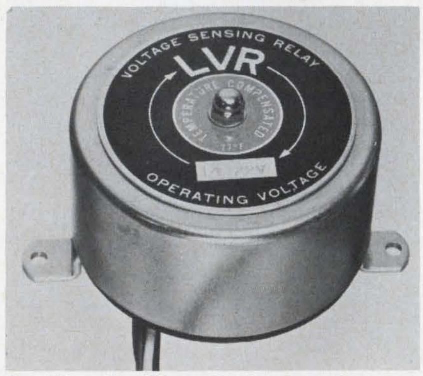


Burroughs Corp., Plainfield, N.J. Phone: (201) 757-5000. P&A: $26; stock.

Driver modules for Nixie tubes that use integrated circuits accept 4-line 8-4-2-1 BCD inputs that are compatible with TTL and DTL. Modules are available to drive both standard and miniature rectangular Nixie tubes and are or will be produced with and without memory. The miniature series is offered in a housing measuring only 1.87 in. deep by 0.48 in. wide by 0.96 in. high.

CIRCLE NO. 294

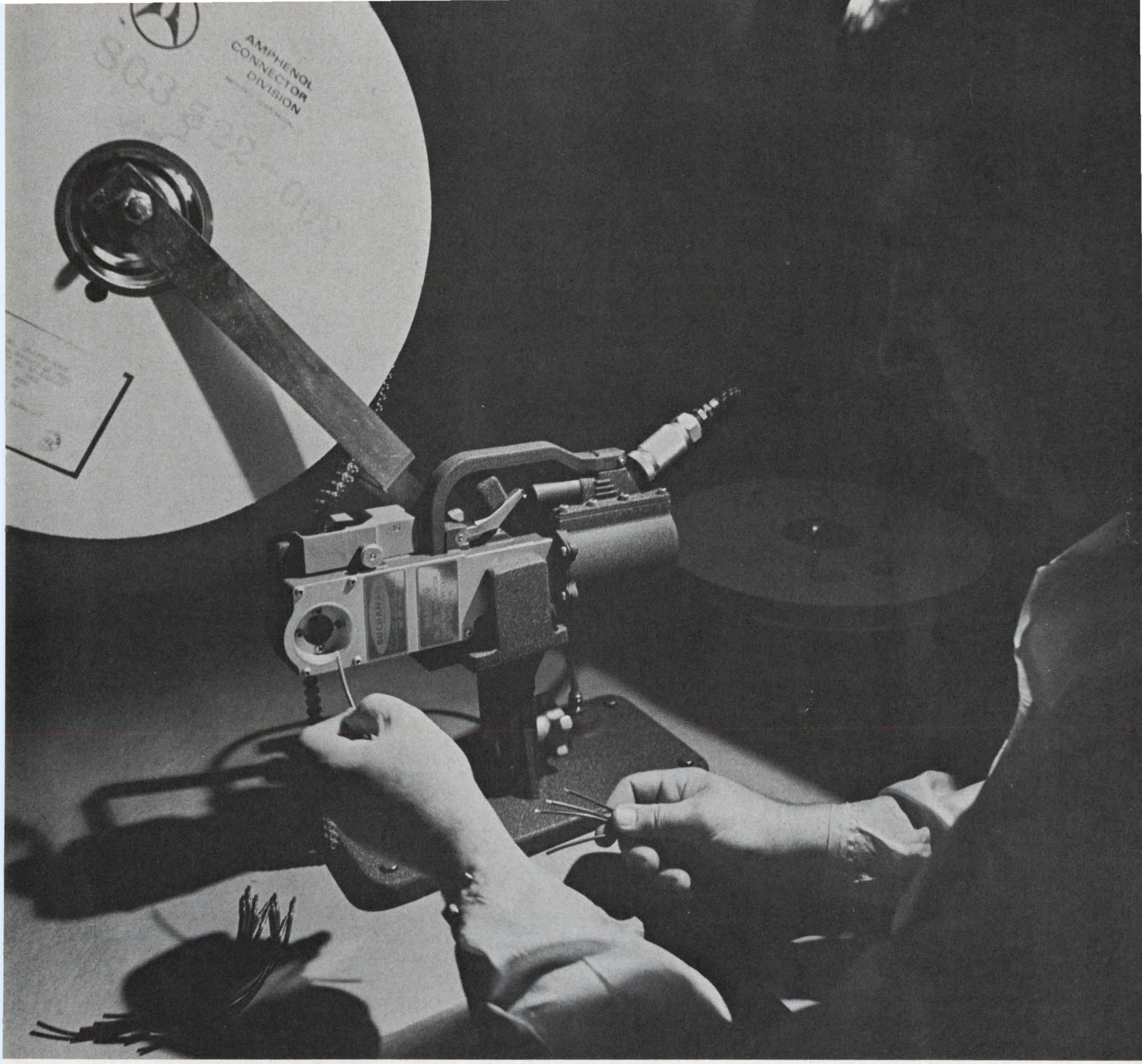
Relay functions for ac- or dc-sensing



La Marche Manufacturing Co., 106 Bradrock Dr., Des Plaines, Ill. Phone: (312) 299-1188.

This voltage-sensing relay is designed for use in supervisory control equipment. Three versions are offered: the LVR-A is an ac differential relay; the LVR-D, a dc differential, and the LVR-M, a dc voltage relay. All relays are temperature-compensated and will operate from 0° to 60°C. The voltage-sensing device is transistorized with a Schmidt trigger circuit.

CIRCLE NO. 295



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MIL-C-39029	(MIL-C-5015 connectors)
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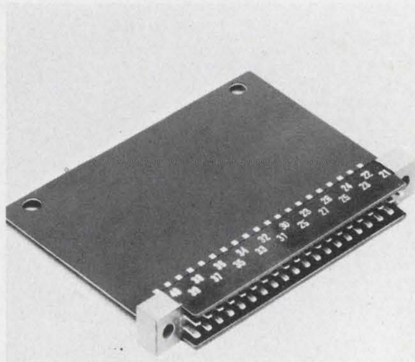
IC connector accepts 40 pins

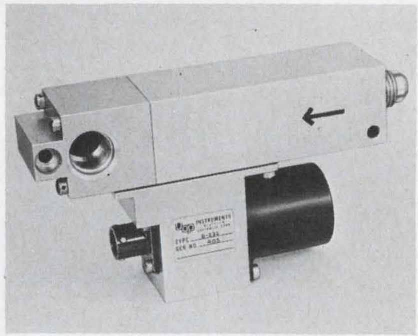


Elco Corp., Willow Grove, Pa. Phone: (215) 659-7000. P&A: $3.05; 8 wks.

Incorporating 40 contacts spaced on a 0.1-in.^{2} grid, this IC connector is used with metal-plate connection systems. It incorporates a heat sink that acts as a structural base. It will accommodate printed circuits or substrates and can be used for flat-pack IC packaging applications. The connector has a glass-filled diallyl phthalate insulator.

CIRCLE NO. 296

Liquid-flow switch protects circuits



UOP Instruments Div. of Universal Oil Products Co., 30 Algonquin Rd., Des Plaines, Illinois. Phone: (312) 824-1155.

Liquid-flow switch protects electronic equipment by sensing unsafe operating temperatures of low coolant flow. The unit automatically deenergizes the electronic circuit, preventing damage to electronic equipment. A self-contained dpdt relay provides a contact rating of 10 A resistive at 30 V dc.

CIRCLE NO. 297

Servo amplifier handles 250 W

Inland Controls, Inc., 342 Western Ave., Boston. Phone: (617) 254-0442.

A silicon transistor, wide-band dc servo amplifier drives dc torque motors or any load requiring up to 250 W of control power. A dc operational preamplifier preceding a fixed-gain dc power amplifier provides adjustable gain and accommodates custom servo-compensation networks.

CIRCLE NO. 298

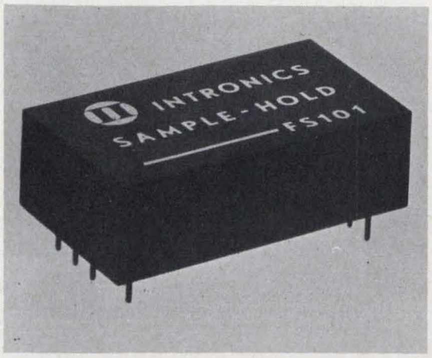
4-lb servo amplifier supplies 1.5 kW

Westamp, Inc., 1542 15th St., Santa Monica, Calif. Phone: (213) 393-0401. P&A: $1188; 30 days.

A 4-lb ac servo amplifier provides 1.5-kW output with 115-V, 400-Hz power input. Both phases of the servo motor are driven so that there is negligible power to the motor at null and no standby heating. An integral two-speed network and quadrature rejection circuit are included.

CIRCLE NO. 299

Sample-hold module short-circuit-proof

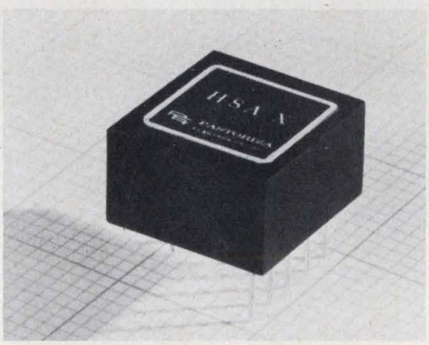


Intronics Inc., 57 Chapel St., Newton, Mass. Phone: (617) 332-7350. P&A: $185; stock.

The FS101 is an encapsulated sample-hold module with a solid-state switch, holding capacitor and non-inverting buffer. The output is short-circuit-protected, and no external adjustments or feedback networks are required. Applications include multiplexing, pulse height measurement, randam or periodic sampling, and use with analog-to-digital conversion systems.

CIRCLE NO. 321

Op amp uses FET input

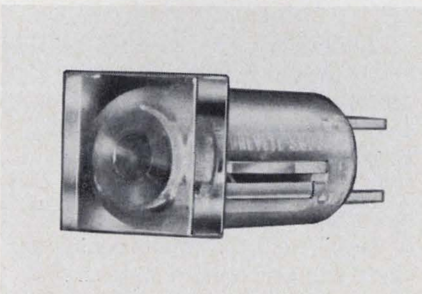


Pastoriza Electronics, Inc., 385 Elliot St., Newton Upper Falls, Mass. Phone: (617) 332-2131. P&A: $130; 30 days.

An operational amplifier that features a FET input has 40-V/μs slew rate, 2-μs settling time, and low output impedance at high frequency. Measuring 1.125 $\times$ 1.125 $\times$ 0.6 in., it weighs 20 g. Input impedance is better than 20 MΩ and open-loop gain exceeds 10,000 for a 1 kΩ load.

CIRCLE NO. 322

Square lamp burns for 25,000 hours

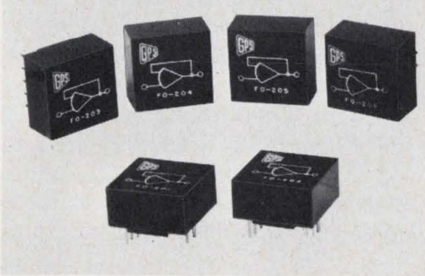


Chicago Switch Div., F & F Enterprises Inc., 2035 Wabansia Ave., Chicago. Phone: (312) 489-5500.

A neon glow indicator featuring a 25,000-hour operating life is available with red, amber, clear and opal lenses. The lights snap easily into place and are self-securing. Square lenses permit side-by-side mounting for compact installations. All assemblies are complete with lamp.

CIRCLE NO. 323

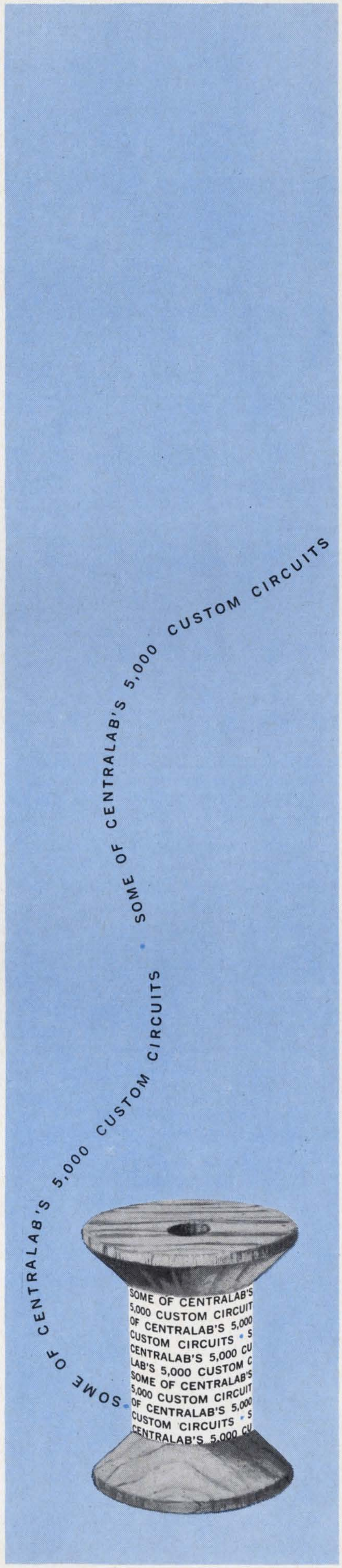
Positive followers have FET input



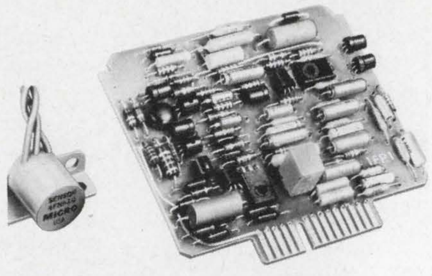
GPS Instrument Co., Inc., 188 Needham St., Newton, Mass. Phone: (617) 969-9405. Price: $18 to $135.

Six FET-input positive followers feature bandwidth from 2 to 50 MHz and slewing rates from 3 V/μs to 60 V/μs. Up to 20-mA output current is available for driving low-impedance loads, while quiescent currents are typically in the 5 mA range.

CIRCLE NO. 324



Proximity switch responds in 20 ms

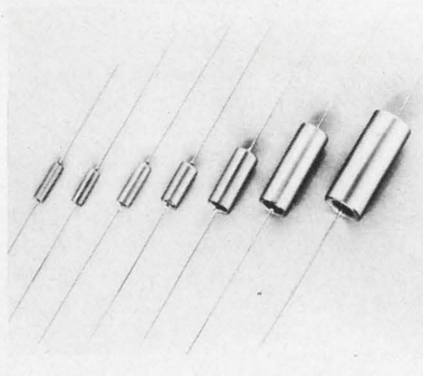


Micro Switch Div. of Honeywell Inc., 11 W. Spring St., Freeport, Ill. Phone: (815) 232-1122.

Without moving parts, the type FN/FP miniature proximity switch operates from $-106°F$ to $+250°F$ in 20 ms. The two-unit switch weighs less than 3 oz and includes a shielded sensor and a solid-state switch. The switch unit can be located up to 250 ft from the sensor and leads may be bundled with other wiring.

CIRCLE NO. 325

Miniature capacitors use polycarbonate foil

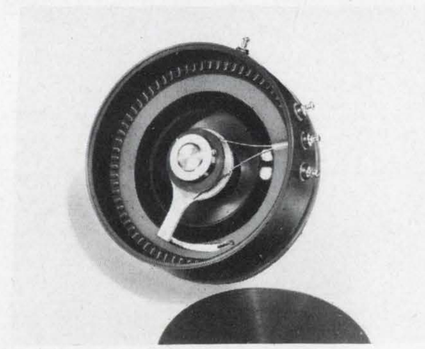


The Gudeman Div., Gulton Industries Inc., 340 W. Huron St., Chicago. Phone: (312) 642-9280.

Miniature polycarbonate-foil capacitors designated the No. 401 series, are suited for applications where high insulation resistance, minimum capacity change with temperature and low dissipation factor are critical. The electrical characteristics of the polycarbonate are similar to polystyrene, but with an added operational temperature range from $+85°C$ to $+125°C$.

CIRCLE NO. 326

Plastic potentiometers from 500 Ω to 50 kΩ



Bliss-Gamewell Div. of E. W. Bliss Co., 1238 Chestnut St., Newton, Mass. Phone: (617) 244-1240. P&A: $125; 60 days.

Conductive plastic linear-output potentiometers offer a linearity of $\pm 0.035\%$ in the electrical-function-angle range from 340° to 356°. This 2-in.-dia unit has infinite resolution and resistances from 500Ω to 50 kΩ, $\pm 10\%$. The Model 32C-1 is supplied in a metal case prepared for servo mounting.

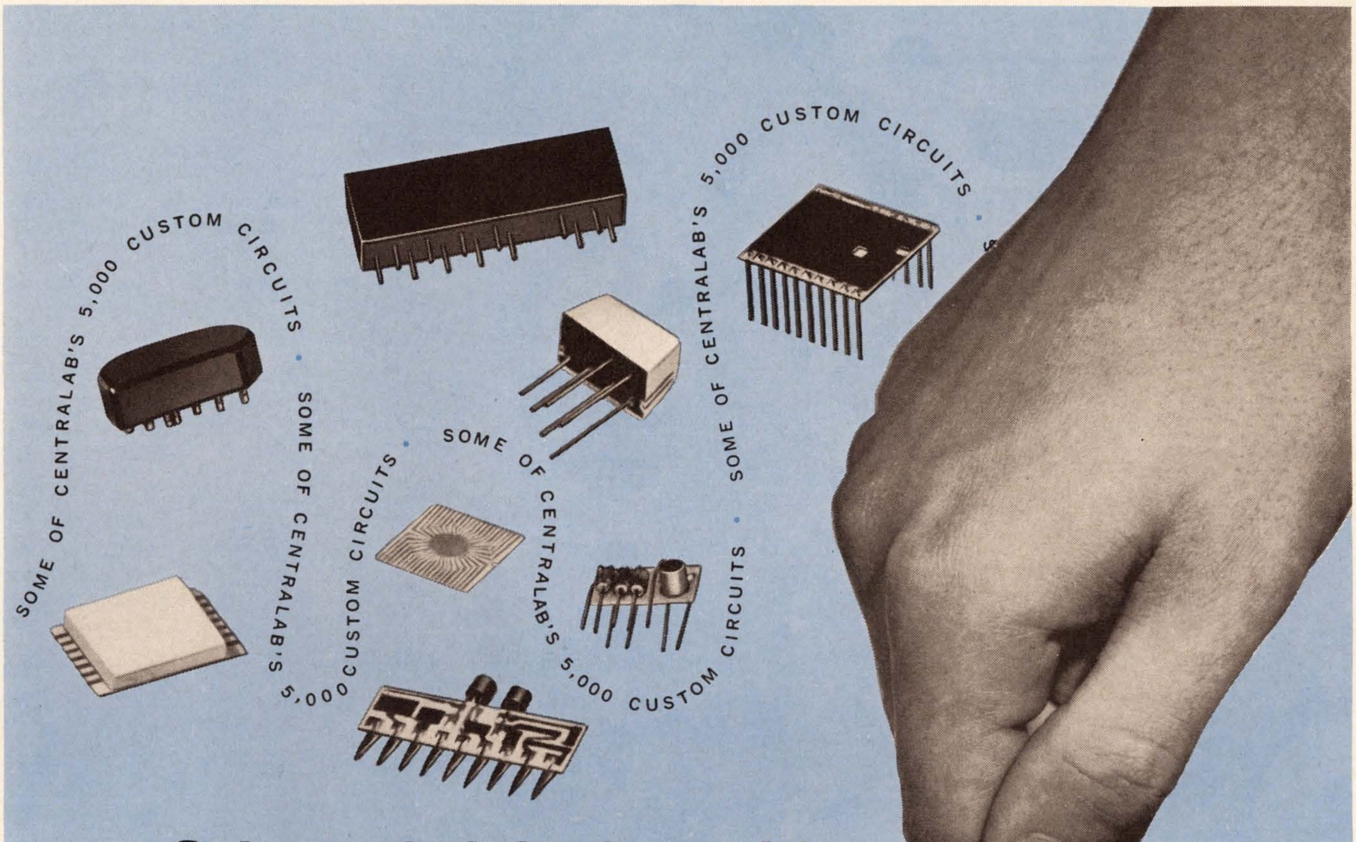
CIRCLE NO. 327

Silicone rubber caps change lamp colors

APM Hexseal Corp., Englewood, N.J. Phone: (201) 569-5700.

Tinted silicone rubber caps easily slip over a bulb to change its light color. The caps provide a variety of colors for pushbutton lights including green, yellow, amber, red, and blue. The filters can withstand 500°F and are immune to salt spray, sunlight and most acids. Models are available in a large range of sizes.

CIRCLE NO. 328



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INFORMATION RETRIEVAL NUMBER 70

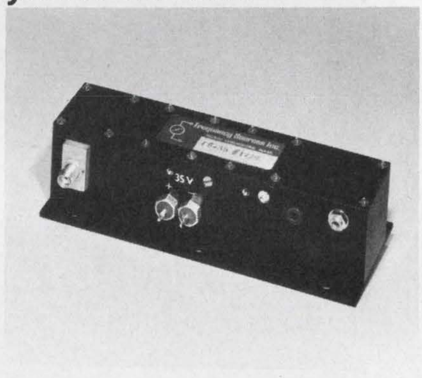
Infrared detector responds in 20 ms

Advanced Kinetics, Inc., 1231 Victoria Street, Costa Mesa, Calif. Phone: (714) 646-7165.

Ready in 20 ms for use in plasma physics, laser experiments, infrared-radiation-source studies and infrared spectrometry, this bolometric type of infrared detector is for applications requiring direction over a large wavelength interval. It is comprised of a crystal, a cryogenic container and a bias circuit.

CIRCLE NO. 329

Ku-band source yields 50 mW

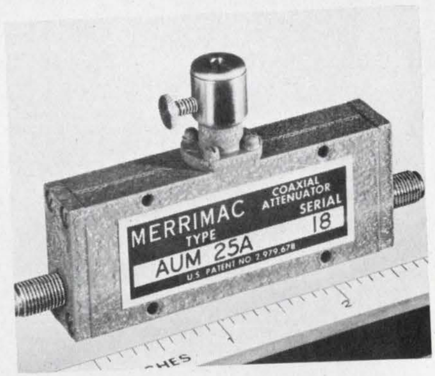


Frequency Sources Inc., Kennedy Dr., P.O. Box 159, North Chelmsford, Mass. Phone: (617) 251-4921. P&A: $1230 ea.; 4 wks.

Ku-band solid-state sources that have a 50-mW capabiilty at 17.2 GHz are capable of operating in the range of 10.5 to 18 GHz. The devices are designed for MIL-E-5400 requirements. They operate from −30°C to +70°C with an output power of 25 mW. An OSM output connector is standard; a waveguide output is available.

CIRCLE NO. 330

Coaxial attenuator performs at 12 GHz



Merrimac Research & Development Inc., 41 Fairfield Pl., W. Caldwell, N.J. Phone: (201) 228-3890. P&A: $185; stock.

A continuously variable coaxial attenuator covers a frequency range from 0.5 GHz to 8 GHz with a VSWR not less than 1.5. It is usable at frequencies from 0.3 GHz to 12 GHz. Insertion loss is less than 1 dB and attenuation range, depending on frequency, extends from 0-to-10 dB to 0-to-40 dB.

CIRCLE NO. 331

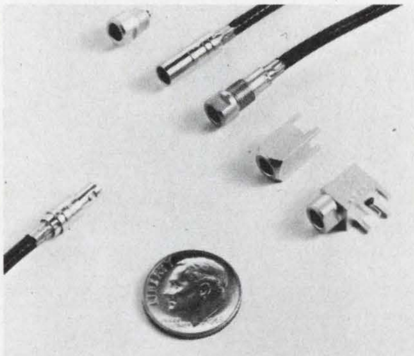
150-mW oscillator ranges to 1 GHz

The Stanley Schwartz Co., 211 E. 43 St., New York. Phone: (212) 867-1630. P&A: $250; stock.

Over its entire 500-MHz-to-1-GHz tuning range, 150 mW of output power is provided by this fundamental oscillator. The oscillator, model ETS 3751-2, is voltage-tunable, with a control voltage of 0 to 28 V. The device is 5/8 × 1 × 2 in. long. Linearity deviation is <5%.

CIRCLE NO. 332

Coaxial connector withstands 500 V

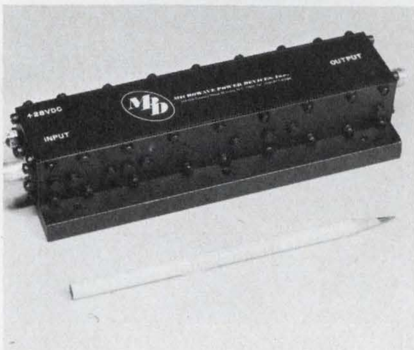


Lemosa, Inc., 465 Calif. St., San Francisco. Phone: (415) 989-5515. Price: $4 to $10.

Subminiature 50-Ω coaxial connectors handle 500 V. This series of connectors includes a cable plug and five receptacles. The shells are gold-plated to a thickness of 0.08 mils and the contacts to a thickness of 0.12 mils. A crimp sleeve helps assembly of the coaxial cable to the plug. The VSWR is 1.045 at 1 GHz, 1.14 at 10 GHz, and contact resistance is less than 0.003 Ω.

CIRCLE NO. 333

Power amplifiers generate to 25 W

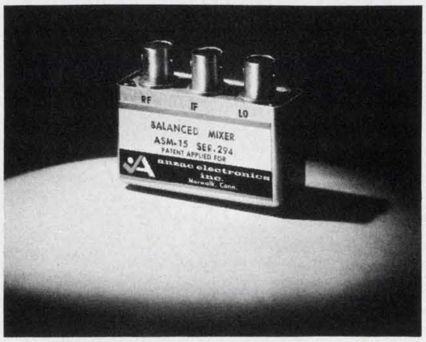


Microwave Power Devices, Inc., 114 Old Country Road, Mineola, N.Y. Phone: (516) PL7-0236.

A line of solid-state transistor amplifiers is capable of generating up to 25 W at 250 MHz and 10 W at 1 GHz. Various power and bandwidth combinations are available. The amplifiers employ a combination of lumped strip-line techniques and are capable of driving load VSWRs of 2.5 to 1, at any phase, with negligible detuning or change in input VSWR.

CIRCLE NO. 334

Balanced mixer handles 1 GHz



A-R-Anzac Electronics Co., 121 Water St., Norwalk, Conn. Phone: (203) 853-9411. P&A: $110; 4 wks.

A balanced mixer that features matched, easily replaceable, Schottky-barrier diodes, accepts rf and local-oscillator signals over a 0.2-to-1-GHz frequency range and provides i-f output from dc to 500 MHz. Local-oscillator–rf isolation is above 35 dB and conversion loss is less than 8.5 dB. Maximum input power is 400 mW.

CIRCLE NO. 335

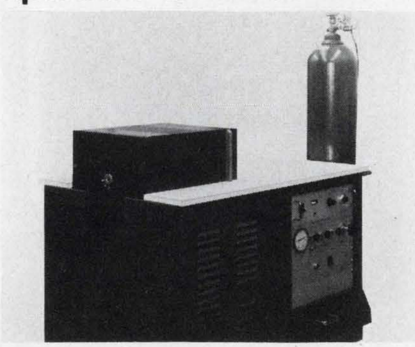
Fm TV relay links operate at 8 GHz

RHG Electronics Laboratory, Inc. 94 Milbar Blvd., Farmingdale, N.Y. Phone: (516) 694-3100.

Air-to-ground relay links operating between 4 and 8 GHz with 20-W output and 10 MHz base band, feature solid-state design except for the TWT amplifier. Both receiver and transmitter are self-contained and require only a power source to process TV or wideband telemetry data. The systems are designed to MIL-E-5400 Class II.

CIRCLE NO. 336

Black-body source operates at 3000°C

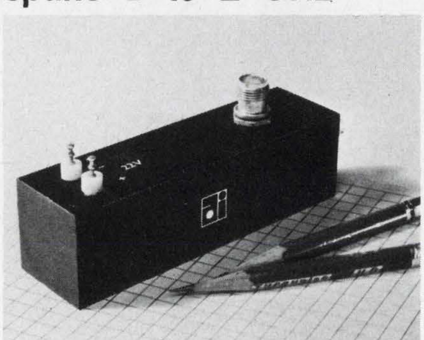


Electro Optical Industries, Inc., P.O. Box 3770, Santa Barbara, Calif. Phone: (805) 968-2591.

Black-body sources with proportional control for use as a working standard of radiant energy operate from 1000°C to 3000°C. They are designed to provide true black-body radiation over the entire temperature range. The unit is packaged in a self-contained rolling cart. In addition a 10-in. vertical motion of the source is provided.

CIRCLE NO. 337

Low-noise oscillator spans 1 to 2 GHz



Alpha Industries, Inc., 381 Elliot St., Newton Upper Falls, Mass. Phone: (617) 969-6480.

Mechanically tunable over any 10% bandwidth between 1 and 2 GHz, this solid-state fundamental oscillator provides high harmonic rejection and low fm noise. Specifications include an output power of 200 mW min, a frequency stability of $\pm 0.050\%$, and an input power of 2.5 W. The device operates across a temperature range of $-55°C$ to $+125°C$.

CIRCLE NO. 338

Diode switch covers 0.5 to 12 GHz

Somerset Radiation Laboratory, Inc., 2060 N. 14th St., Arlington, Va. Phone: (703) 525-4255. P&A: $195; 15 days.

Designed to be used in 3-mm subminiature cable systems, this coaxial switch covers the 0.5-to-12-GHz range. It demonstrates a 50-dB isolation at 9 GHz, 0.5-to-2-dB insertion loss, 1-W cw and 100-W peak power. The range is realized by integrating silicon pin diodes into a filter and by taking advantage of dc paths, external power sources and filters.

CIRCLE NO. 339

S-band diplexer has 20-dB isolation

TRF, Inc., 6627 Backlick Rd., Springfield, Va. Phone: (703) 451-5131.

The TRF model DKG-001 subminiature diplexer permits operation of two S-band transmitters as close together as 1% in frequency. Isolation is 20 dB minimum between channels at a maximum insertion loss of 1 dB. The device is 3 × 1.1 × 0.75 in. with an operating temperature range of $-30°C$ to $+85°C$. As an option, isolators can be provided as part of the filter structure.

CIRCLE NO. 340

Silicon power transistor will dissipate 350 watts

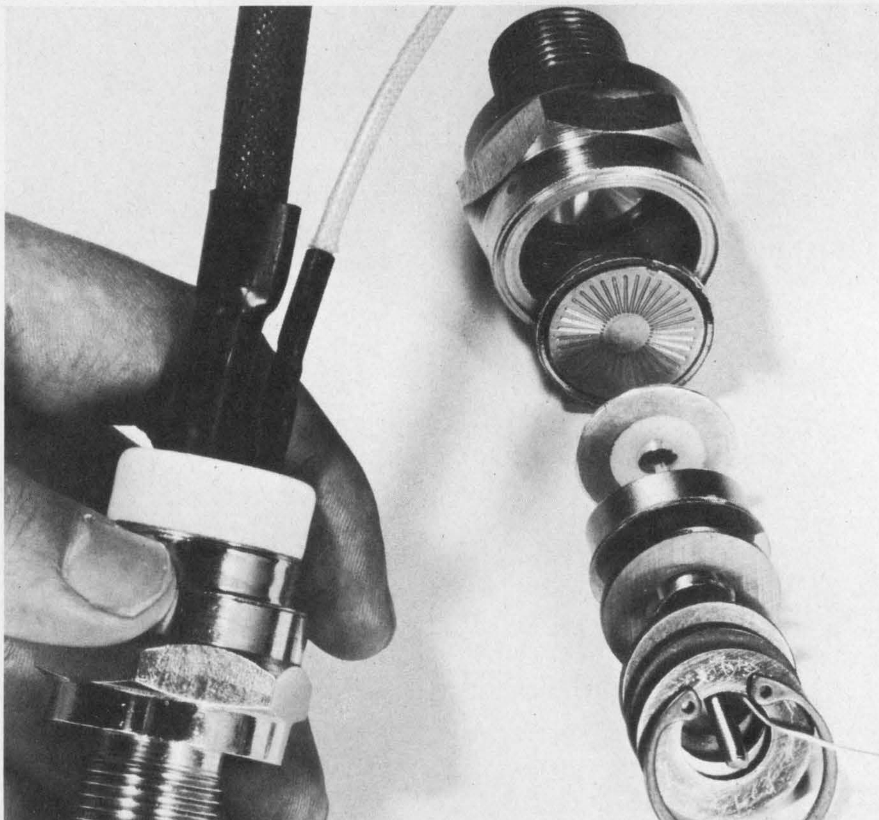
Westinghouse Semiconductor Division, Youngwood, Pa. Phone: (412) 925-7272. P&A: $140; 2 to 4 wks.

Able to dissipate 350 W with collector currents up to 150 A, this diffused silicon power transistor, type 1441, provides a high current-handling capability for power-switching applications such as regulators and amplifiers.

The transistor exhibits a saturation voltage of 2 V maximum at 100 A and is rated in 20-V steps from 40 to 120 V_{ceo} sustaining. Minimum gain is 10 at collector currents of 50, 75 and 100 A. The typical gain-bandwidth product is 1 MHz. Junction temperature may range from −65° to +200°C, permitting reliable operation even under extreme ambient conditions. Thermal-fatigue-free operation is ensured by compression-bonded encapsulation in a hermetically sealed case, nominally the equivalent of a TO-114.

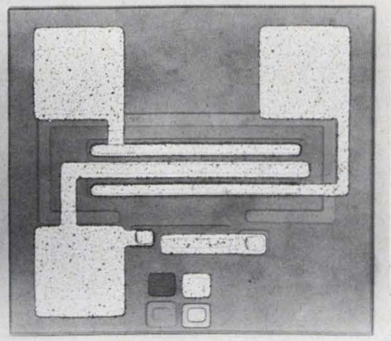
This technique and the use of Westinghouse's sunburst junction design account for the high ratings this device can achieve. The compression-bonded encapsulation holds the junction in place by spring pressure alone. Eliminating the solder joint between the junction and the package minimizes thermal impedance and eliminates thermal-fatigue failures. The diffused junction is designed as a sunburst to give maximum emitter-base area.

CIRCLE NO. 341



Compression-bonded encapsulation is what holds this transistor's junction in place. This technique eliminates soldering and uses spring pressure.

Silicon rectifiers withstand 1 kV

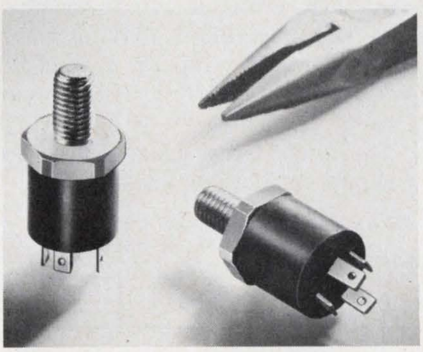


Sarkes Tarzian Inc., Semiconductor Div., 415 N. College Ave., Bloomington, Ind. Phone: (812) 332-1435. Price: $2.25 to $7.20.

A series of 12-A single-phase full-wave silicon rectifiers, measuring 0.56 in. in dia and 1.316 in. high, mounts through a single hole. Available in PIV ratings from 100 to 1000 V, the rectifiers have avalanche characteristics and are unaffected by normal transients. Ambient operating temperature is 55°C, with convection cooling on a 5 in.^{2} heat sink.

CIRCLE NO. 342

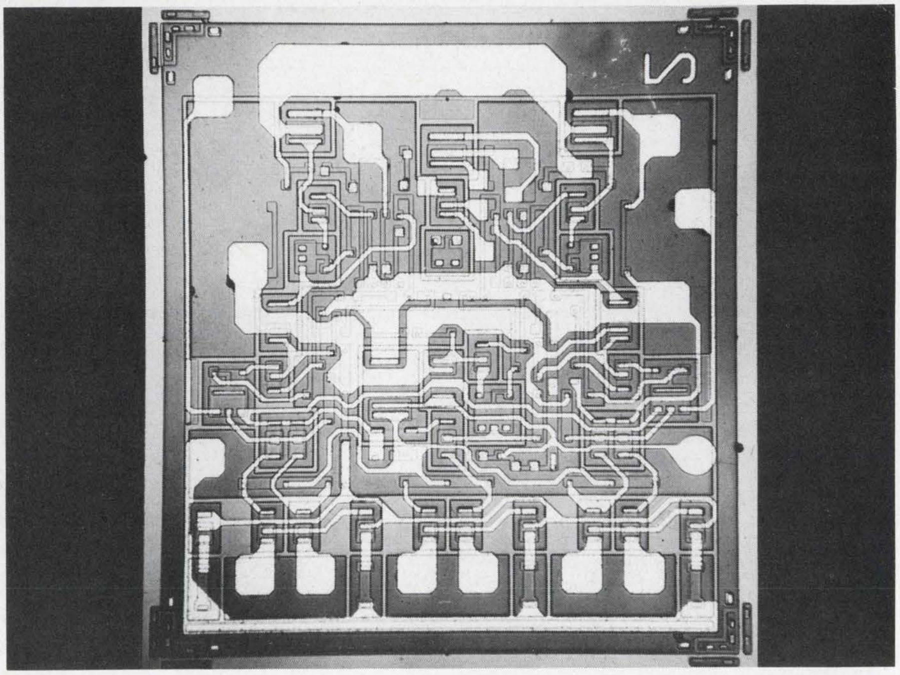
P-channel transistor operates to 80 V



General Instrument Corp., 65 Gouverneur, Newark, N.J. Phone: (201) 485-2100. P&A: $10. (1 to 99) stock.

P-channel enhancement-mode MTOS transistor will operate at 80 V maximum. Known as MEM 556, the transistor's high voltage capability makes it desirable for multiplexing, series and shunt chopping, commutating, and logic circuits involving high-signal voltages as well as numerical readout driving applications.

CIRCLE NO. 343

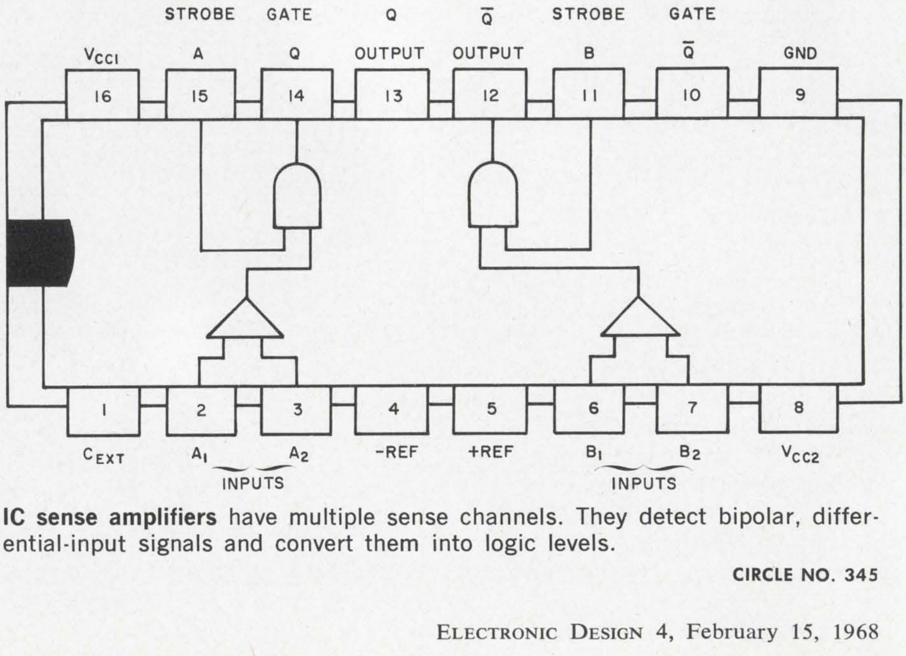


Six IC sense amplifiers lean toward memory systems

Texas Instruments Inc., P.O. Box 5012, Dallas. Phone: (214) 238-2011. P&A: $8.90 to $13.20; stock.

A generation of integrated circuit sense amplifiers—monolithic circuits with multiple sense channels in a single package—is designed for high-speed coincident-current computer memory systems. The six ICs detect bipolar, differential input signals from the memory, and provide an interface between memory and logic sections. Pulses originating in the magnetic-core memory are detected and translated into logic levels compatible with standard TTL or DTL circuitry. Three basic circuit designs are available—two versions of dual preamplifiers driving common-output circuits, or two complete sense amplifiers in a single package.

The devices are encapsulated in a 16-pin dual in-line package.



IC sense amplifiers have multiple sense channels. They detect bipolar, differential-input signals and convert them into logic levels.

CIRCLE NO. 345

MOS dual flip-flop has 48 devices

Radio Corp. of America, Electronic Components and Devices, Harrison, N.J. Phone: (201) 485-3900.

This complementary n- and p-channel MOS IC is a dual-data-type flip-flop mounted in a 14-lead ceramic dual-in-line package. It has quiescent power dissipation of 10 nW, a 10-V logic swing, 4-V noise immunity, operation up to 4 MHz and a fanout capability of up to 50 per flip-flop. It provides two identical, independent flip-flops with data, reset and clock inputs, and one and zero outputs. Each flip-flop comprises 12 n-channel and 12 p-channel enhancement-type MOS transistors.

CIRCLE NO. 346

MOS shift register functions to 16 bits

National Semiconductor Corp., 2950 San Ysidro Way, Santa Clara, Calif. Phone: (408) 245-4320. P&A: $18 to $45; (1-24) stock.

Dual 16-bit MOS static shift register designated the MM404 is designed with MOS P channel enhancement mode transistors. Significant features of the device are a V_{DD} supply voltage of -10 V, and single clock amplitude and a V_{GG} supply of less than 16 V. It will operate from dc to 1 MHz with a power consumption of 1.5 mW/bit.

CIRCLE NO. 347

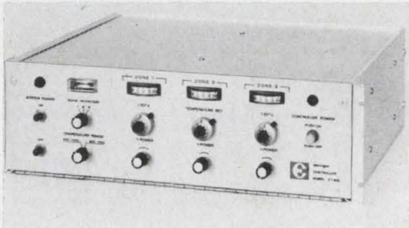
Rf amplifier attains 84-dB gain

Fairchild Semiconductor, 313 Fairchild Dr., Mountain View, Calif. Phone: (415) 962-2530. P&A: $10 (1-99); stock.

This high-gain, wide-bandwidth rf amplifier provides 84-dB total gain from input to output. A key feature of the μA719 is the automatic gain control of its first stage, which permits the device to be used in both am and fm systems that require agc. It operates over a frequency range of 100 kHz to 50 MHz for amplifier 1, and from dc to 50 MHz for amplifier 2.

CIRCLE NO. 348

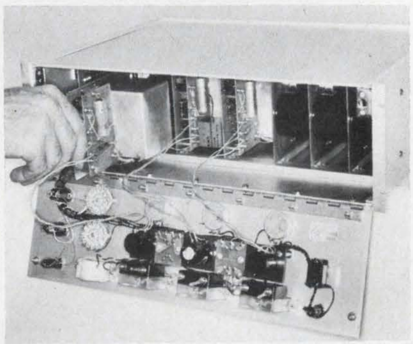
Furnace controller accurate to 0.1°C



Electroglas, Inc., 150 Constitution Dr., Menlo Park, Calif. Phone: (415) 325-1536.

Controlling furnaces to within 0.1°C is the job of this circuit system, which centers around four solid-state, plug-in circuit boards. Components of the system are combined in a controller for use with three-zone semiconductor diffusion furnaces. Known as the Model CT-300, this chopperless instrument has an operational range of 500°C to 1400°C with a set point accuracy of 0.1°C and a long-term stability of 0.25°C.

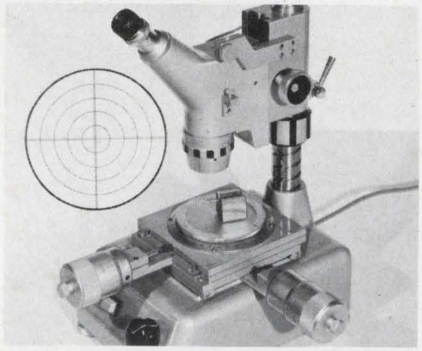
The four plug-in circuit boards used in the system are a regulated power supply, two high-gain amplifier configurations, and a trigger circuit for control of SCRs or similar power devices at the furnace. The number and combination of circuit boards depend on the final function of the controller. In the three-zone controller there are seven circuit boards: one power supply, three amplifiers, and three trigger circuits, one for each furnace zone. In this case, the controller operates on the master-slave principle, with the two end zones of the furnace slaved to the center-zone thermal parameters through a thermocouple network.



Seven plug-in circuit boards make up the diffusion furnace controller.

CIRCLE NO. 349

Measuring microscope zooms to 80 power

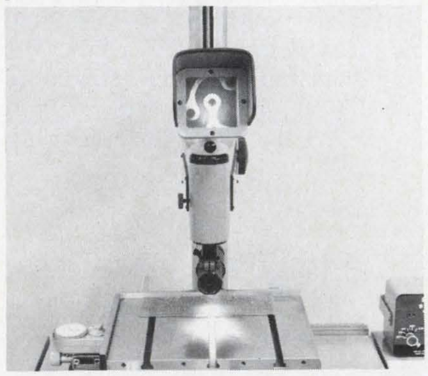


Titan Tool Supply Co., Inc., P.O. Box 1682, Buffalo, N.Y. Phone: (716) 873-9907. Price: $850.

A toolmaker's microscope with zoom-optics provides measurements in three coordinates and angular readings to 0.1°. The optical system gives a range of magnification, from 30 to 80 power, which can be adjusted without changing focus. Cross-hair location is not changed by the zooming operation.

CIRCLE NO. 350

3-in. scope views printed boards

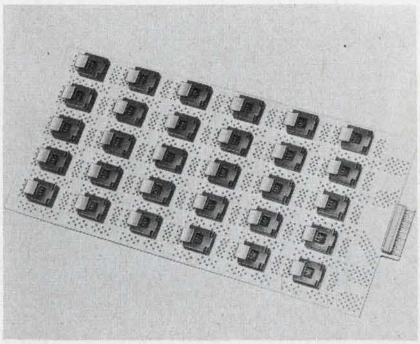


Assembly Engineers, Div. of The Rucker Co., 3650 Holderge Ave., Los Angeles. Phone: (213) 870-9861.

A 3-in.-dia optical viewing scope permits X and Y coordinate with an accuracy of ± 0.0005 in. Used as an accessory to a coordinate-measuring machine, the scope presents a clear, direct image of the features to be checked and is available in magnifications for 5, 10 and 20 power.

CIRCLE NO. 351

Epoxy breadboard handles 14-lead ICs

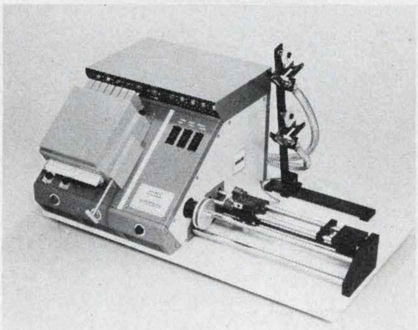


Barnes Corp., Lansdowne, Pa. Phone: (215) 622-1525. P&A: $90-$190; 3 wks.

This breadboard designed for environmental aging or circuit evaluation of up to 30 standard 14-lead flat-pack ICs at temperatures ranging from −65° to 150°C is constructed of epoxy glass. It makes use of high-temperature polysulfone flip-flop sockets, which provide accurate component-positioning, and molded barriers for positive lead separation, so that all forces are equally distributed and no force is exerted on the body/lead junctions.

CIRCLE NO. 352

Coil-winding machine is card-controlled

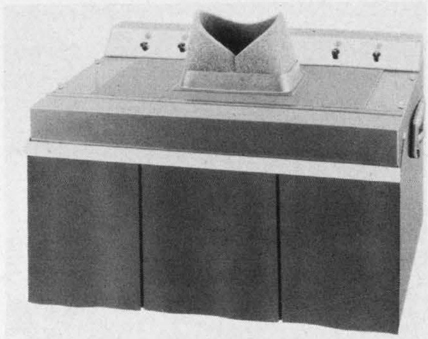


Eubanks Engineering Co., 225 W. Duarte Rd., Monrovia, Calif. Phone: (213) 358-4531.

The ACW-10A automatic coil winder can be electronically programed by inserting an IBM card to wind automatically at speeds up to 8000 turns per minute. Features include an electronic counter that provides turns-count accuracy withing 1/4 turn at all speeds, and a counter that controls the length of winding and the number of turns per layer.

CIRCLE NO. 353

Fluorescent inspector used to test components



Ultra-Violet Products, Inc., 5114 Walnut Grove Ave., San Gabriel, Calif. Phone: (213) 283-3193.

This portable darkroom instrument emits a large amount of black light intensity for good definition and accuracy in fluorescent analysis of electronic packaging. Two black light sources are combined with a contrast control filter to give the printed-circuit board or component an even fluorescence with sharp clarity. This allows for the detection of the smallest flaw or contamination. All controls are on a top panel.

CIRCLE NO. 354

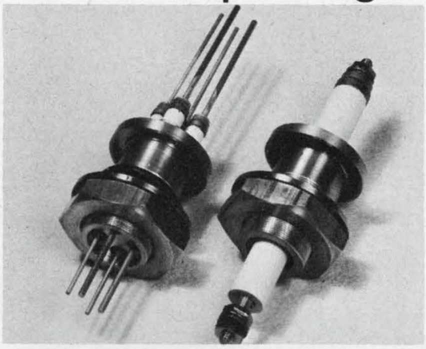
High-vacuum system attains 5×10^{-11} torr

Ilikon Corp., Natick Indust. Center, Natick, Mass. Phone: (617) 655-1771.

This system meets the rapid pump-down requirements of high-vacuum applications (to 1×10^{-8} torr) in 30 minutes. By changing the bell-jar seal, the system achieves the low pressure needed in ultrahigh-vacuum work (to 5×10^{-11} torr). Typical uses include thin-film deposition, dc and rf sputtering, component-reliability testing, materials research and space simulation.

CIRCLE NO. 355

Two feedthroughs for use in sputtering

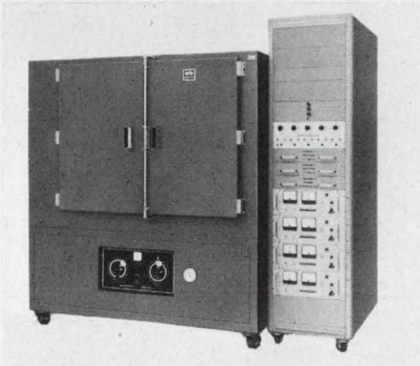


Ceramaseal, Inc., New Lebanon Center, N.Y. Phone: (518) 933-6101.

High-voltage demountable feedthrough for sputtering applications has vacuum-brazed alumina-ceramic-to-metal seals. Two designs of the feedthrough are available—a single conductor unit 804C2350-5 rated at 12-kV dc max operating voltage at 30 A max; and a four-pole unit 808C2658 Parts 1, 2, and 3 with 1-kV dc max operating voltage rating.

CIRCLE NO. 356

Circuit-aging system handles 3800 at a time

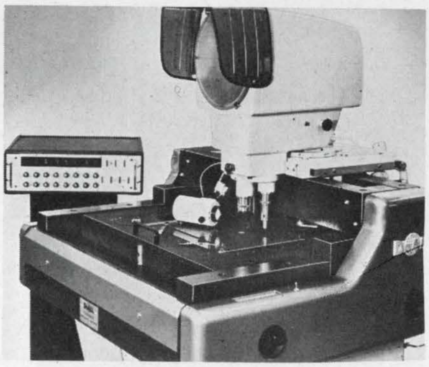


Marin Controls Co., 517 Marine View Ave., Belmont, Calif. Phone: (415) 591-8924.

Up to 3800 microcircuits can be tested at one time with a microcircuit life-aging system that provides quality control on the assembly line. A flexible base assembly configuration allows conversion from one test to another. The assembly holds any type of microcircuit package during testing, and establishes and controls the signal or dc test configuration.

CIRCLE NO. 357

Coordinate measurer reads out to 0.001 in.

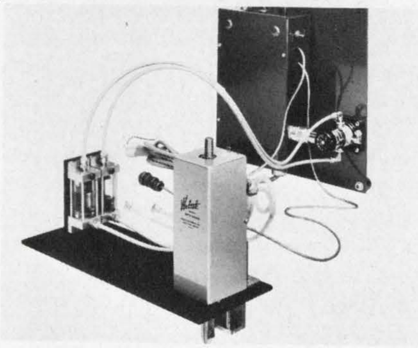


DoAll Co., Des Plaines, Ill. Phone: (312) 824-1122.

Bridge-type coordinate-measuring machines use a digital readout. Several different measuring systems are offered to suit the accuracy needed for work with microminiature circuitry, mask operations and large photographic plates of printed circuits. For close work, the machine is offered with a digital system on both the x and y axes. This gives a least-count reading of 50 μin.

CIRCLE NO. 358

Welding head provides 15-lb force



Wells Electronics, Inc., 1710 S. Main St., South Bend, Ind. Phone: (219) 288-4651.

With a force range of 8 oz to 15 lb, this welding head has a 1-in. stroke. Other force ranges can be furnished on request. It is also possible to add, as an accessory, a "search" position on the control circuitry so that the head can be manually operated. Since the head is designed for boom mounting, there is no throat-depth limitation.

CIRCLE NO. 359

MATERIALS

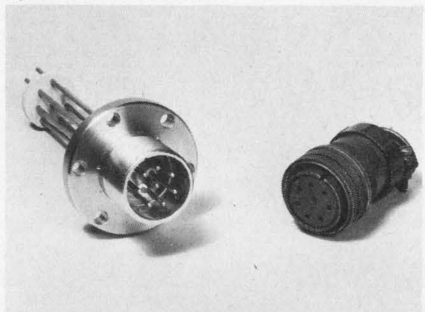
Ceramic-base adhesive holds at 4400°F

Aremco Products, Inc., P.O. Box 145, Briarcliff Manor, N.Y. Phone: (914) 672-0685. P&A: $90/quart; stock.

A ceramic-base adhesive with temperature limits to 4400°F can be applied to a wide range of materials including ceramics, glass, quartz, graphite, and metals. Available in a premixed paste, the material is heat-cured at 1100°F and can then be used at temperatures up to 4400°F. Dielectric strength is 250 V/mil.

CIRCLE NO. 360

Vacuum feedthrough operates at 450°C

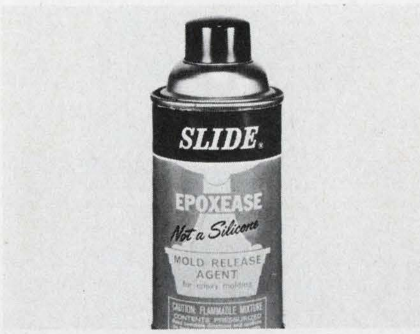


Ceramaseal, Inc., New Lebanon Center, N.Y. Phone: (518) 933-6101.

An eight-pin feedthrough, bakable to 450°C, provides air-tight penetration of high-vacuum equipment by four pairs of thermocouple leads or current-carrying conductors. The feedthrough has four copper-constantan conductor pairs; other materials can be supplied. Current ratings per conductor are 2 A for stainless steel, 15 A for nickel, and 30 A for copper.

CIRCLE NO. 361

Mold release agent for resin compounds



Percy Harms Corp., 7349 N. Hamlin Ave., Skokie, Ill. Phone: (312) 679-0587.

A nonsilicone release agent in an aerosol is called Slide Epoxease. It helps in releasing molds that use epoxy and polyester resins as well as other resinous compounds. Epoxease can be used in conjunction with steel, aluminum, stone, epoxy, plaster or treated-wood surfaces. It can be used during laminating as well as pressure-molding.

CIRCLE NO. 362

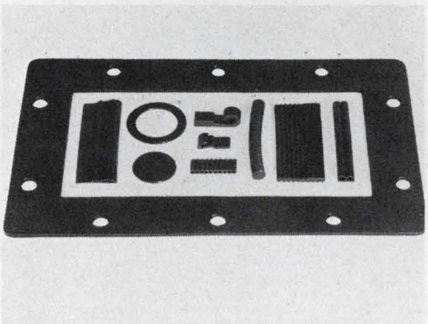
Silica-ceramic paint is corrosion-resistant

Aremco Products, Inc., P.O. Box 145, Briarcliff Manor, N.Y. Phone: (914) 762-0685. P&A: $17.50 a quart (base); $12.50 a pint (activator); one week.

A silica-ceramic base paint that can be applied to ceramics, glass, metals and plastics offers a tough impervious coating suitable for use in temperatures as high as 500°F. It is available as a two-part system consisting of a base and an activator. Once mixed the paint can be brushed, sprayed or spatulated.

CIRCLE NO. 363

Conductive vinyl shields and seals

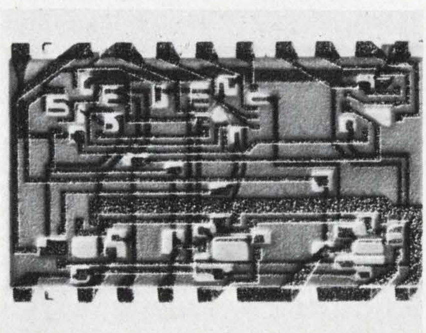


Chemelec Products, Inc., Cherry Hill, N.J. Phone: (609) 424-1470.

The physical and electrical properties of conductive vinyl provide simultaneous RFI shielding and pressure-sealing qualities over a wide temperature range. Its conductivity is uniformly distributed and controllable. In pressure-sealing applications, the vinyl's excellent memory and compressibility will seal against lateral leaks completely.

CIRCLE NO. 364

Glass-ceramic paste used as dielectric



Electro-Science Laboratories, Inc., 1133-35 Arch St., Philadelphia. Phone: (215) 563-1360. Price: $14.50/oz.

Crystallizable glass dielectric coating is for use with conductive glazes to print crossovers, multilayer circuits and the interconnection of ICs. The paste has excellent adhesion to high alumina ceramics as well as conductive glazes. Dielectric strength of a 2-mil film is 500 V; dielectric constant at 1000 Hz is 40 to 45.

CIRCLE NO. 365

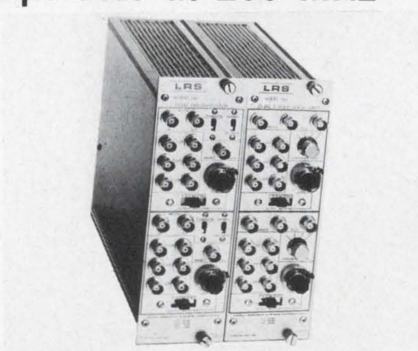
Tape recorder operates at 2 MHz

Winston Research Corp., 6711 S. Sepulveda Blvd., Los Angeles. Phone: (213) 670-3305.

Two-MHz operation at 120 in./s with a signal-to-noise ratio exceeding 20 dB are features of this tape recorder. Designed in accordance with IRIG standards, the unit is modular in construction. This permits a range of operating capabilities, including reproduce channel selection, automatic sequencing, seven- or 14-track operation, monitor capabilities and five speeds of operation.

CIRCLE NO. 366

Dual-logic module operates at 200 MHz



LeCroy Research Systems Corp., 1 Hayes St., Elmsford, N.Y. Phone: (914) 592-5010.

A dual-pulse amplitude discriminator, a dual three-fold logic unit and a dual two-fold logic unit make up the 160 series of high-speed logic instruments. All three units operate at 200 MHz. The model 161 is a dual, dead-timeless pulse-amplitude discriminator. The model 162 is a dual, direct coupled, three-fold logic unit. The model 164 is a dual high-speed, two-input AND gate.

CIRCLE NO. 367

Dual processor computer swings 500,000 operations/s

Honeywell Computer Control Div., Old Conn. Path, Framingham, Mass. Phone: (617) 879-2600. P&A: $163,000; 4 months.

Honeywell's Computer Control Div. has introduced a general-purpose dual processor computer, which it said will perform more than 500,000 operations/s. The company announced that three of the new IC computers have been ordered by Conductron-Missouri, a division of Conductron Corp., for use in trainers simulating the Boeing 747 superjet.

The basic DDP-324 has two processing units, each with 8192 of private memory and 8192 words of shared memory. Word length is 24 bits. Each private memory may be expanded up to 24,576 words. Shared memory may be used for common data and as a communications link between the processors and input and output devices. DDP-324 software consists of 380 programs compatible with DDP-224, -124 and -24 computers. Included are a FORTRAN IV compiler, compatible symbolic assembler, systems, input-output, math, test and utility programs. Basic input-output structure is made up of a typewriter, and paper-tape reader and punch. The typewriter, which operates at 15 characters/s, serves as an input keyboard and a supervisory printer under interrupt control. The paper-tape reader operates up to 300 characters/s; the punch up to 110 characters/s. Each processing unit can multiply and divide under hardware control. Indirect addressing, a fully buffered channel and one hardware index register are also provided as standard features. Additional index registers are available as options. Standard options include direct memory access channels, multilevel priority interrupt, fully-buffered-channel (FBC) shared setup and time, multiplex units. Up to 16 priority levels per processor can be assigned to external interrupt signals and parts of the program using the multilevel priority interrupt. Peripheral options include a magnetic-tape system, 200-cards/min card reader and a 300-lines/min line printer.

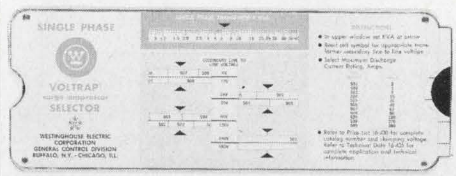
CIRCLE NO. 368

Dual processor computer performs 500,000 operations/s.

Design Aids

Sampling aid

Sampling Scope circular slide chart presents all of the sampling plans in Military Standard MIL-STD-150D. This device gives acceptance and rejection numbers as a function of lot size, level of inspection, and acceptable quality level (AQL) for single, double, and sampling plans. It is made of plastic and is 9 in. in diameter. *Available for $10 from TAD Products Corp., 639 Massachusetts Ave., Cambridge, Mass.*

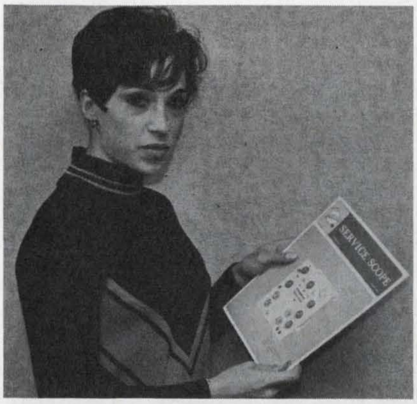


Suppressor selector

This slide-rule-type selector allows choice of the correct Westinghouse Voltrap surge suppressor for any application. Surge suppressors are designed to protect solid-state power devices, such as diodes and thyristors, from damage due to transient overvoltage by providing a shunt discharge path. The slide selector is simple to use. Setting the slider at the appropriate transformer kVA matches transformer secondary line-to-line voltage against the corresponding surge suppressor selenium cell symbol. The cell symbol is the key to a table provided on the slide selector, which gives the maximum discharge current rating for that application. Both single- and three-phase applications are covered by the selector. A brochure provides information on the circuit design, operation, ratings, construction, and applications of the surge suppressors. Circuit diagrams and rating curves for various applications are given, and a catalog number interpretation table is also included. Westinghouse Electric Corp.

CIRCLE NO. 369

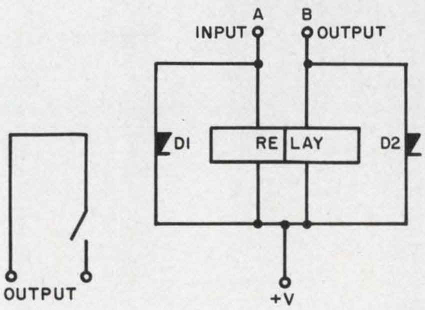
Application Notes



Time-domain testing

This pamphlet begins with a comparison between two methods of testing transmission lines—sine-wave testing and voltage step-function testing. The sine-wave testing method is known as frequency-domain reflectometry and the voltage step-function method is known as time-domain reflectometry. That is followed by a basic description of TDR testing principles; reflections from capacitors and inductors; reflections from resistive discontinuities; coaxial-cable response to a step signal; and special applications. Tektronix, Inc.

CIRCLE NO. 371

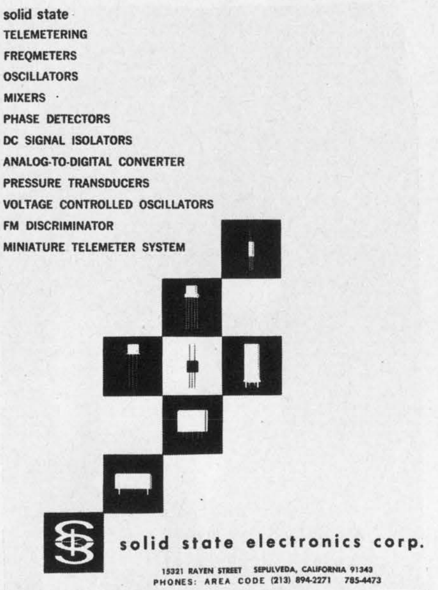


Dry reed switches

Dry Reed Switches deals in depth with such subjects as factors affecting reed characteristics, contact switching life, solenoid operation and coaxial relays, and includes typical circuits for various applications including logic functions. A number of life performance curves are illustrated, providing a tangible means of life assessment under varying operating conditions. M-O Valve Co., Ltd.

CIRCLE NO. 372

New Literature



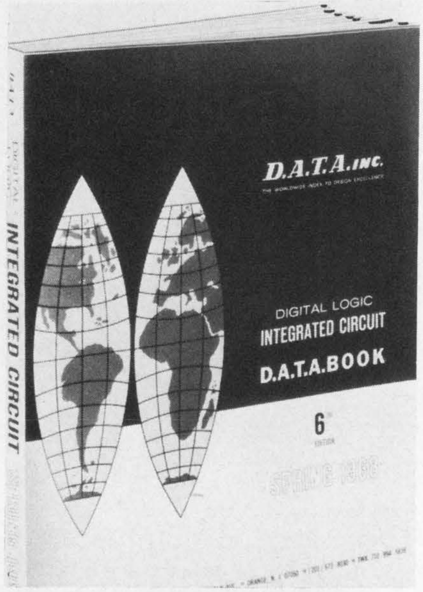
Telemetering modules

Fm-fm telemetering modules including voltage-controlled oscillatos, dc amplifiers, dc signal isolators, frequency-to-dc converters, tone oscillators, pressure transducers and laboratory telemetering system, are described in a 40-page catalog. All units are of solid-state design and can be utilized for military, industrial, and research applications. Solid State Electronics Corp.

CIRCLE NO. 373

Plastic testing

Effect of Low Temperature (0° to —65°F) *on the Properties of Plastics* is a report that shows the the effects of low temperature on the mechanical, electrical and thermal properties of plastics. The information is presented by plastic family (in alphabetical order) and is divided into three parts: thermoplastics, thermosets and foams. Other compilations have covered the cryogenic range, ambient and the very high temperatures, but this is the first report on the less severe temperature extremes which both industry and defense material are likely to encounter. *Available for $3 from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Va.*



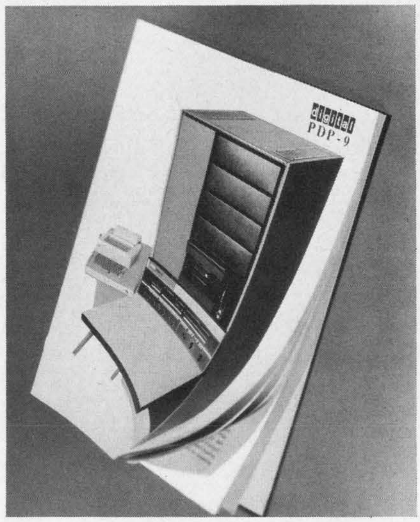
6,500 IC types available

The spring 1968 edition of *The Digital Logic ICs Data Book* reports that 6549 off-the-shelf types are now manufactured by 88 companies throughout the world. New devices are entering the market daily. In the past 6 months 1137 new types were added. The IC book is indexed in type-number order and cross referenced to electrical characteristics. The devices are classified into the following technical sections: amplifier, flip-flop, clock or multivibrator, counters, decoders, gates, shift register and time delay. Logic and outline drawings of each type are included. The book is issued on a subscription basis, consisting of 2 complete issues in the spring and fall. *Available for $32.50 from D.A.T.A., Inc., P.O. Box 46X, Orange, N.J.*

Ceramic compositions

A four-page folder on the properties of ceramic compositions describes the physical, electrical, mechanical and thermal properties of seven alumina compositions, as well as steatite, zircon, forsterite and beryllia ceramics. A graph shows volume resistivity measurements for alumina ceramics. Silk City Industrial Ceramics, Inc.

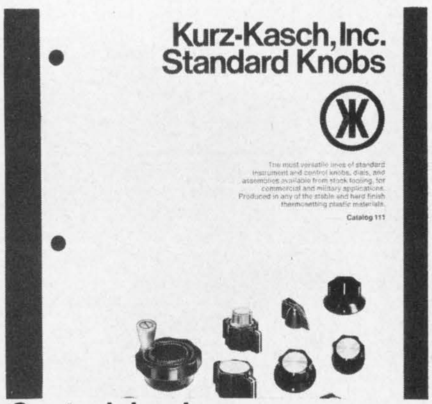
CIRCLE NO. 374



Computer system

The PDP-9 computer system for complex problems in data acquisition, process or instrument control, computation or man/machine communication is explained in a 50-page brochure. Processor and memory specifications, input-output facilities, instructions, software, options and detailed application information also are covered. More than a score of charts, graphs and pictures are included. Digital Equipment Corp.

CIRCLE NO. 375

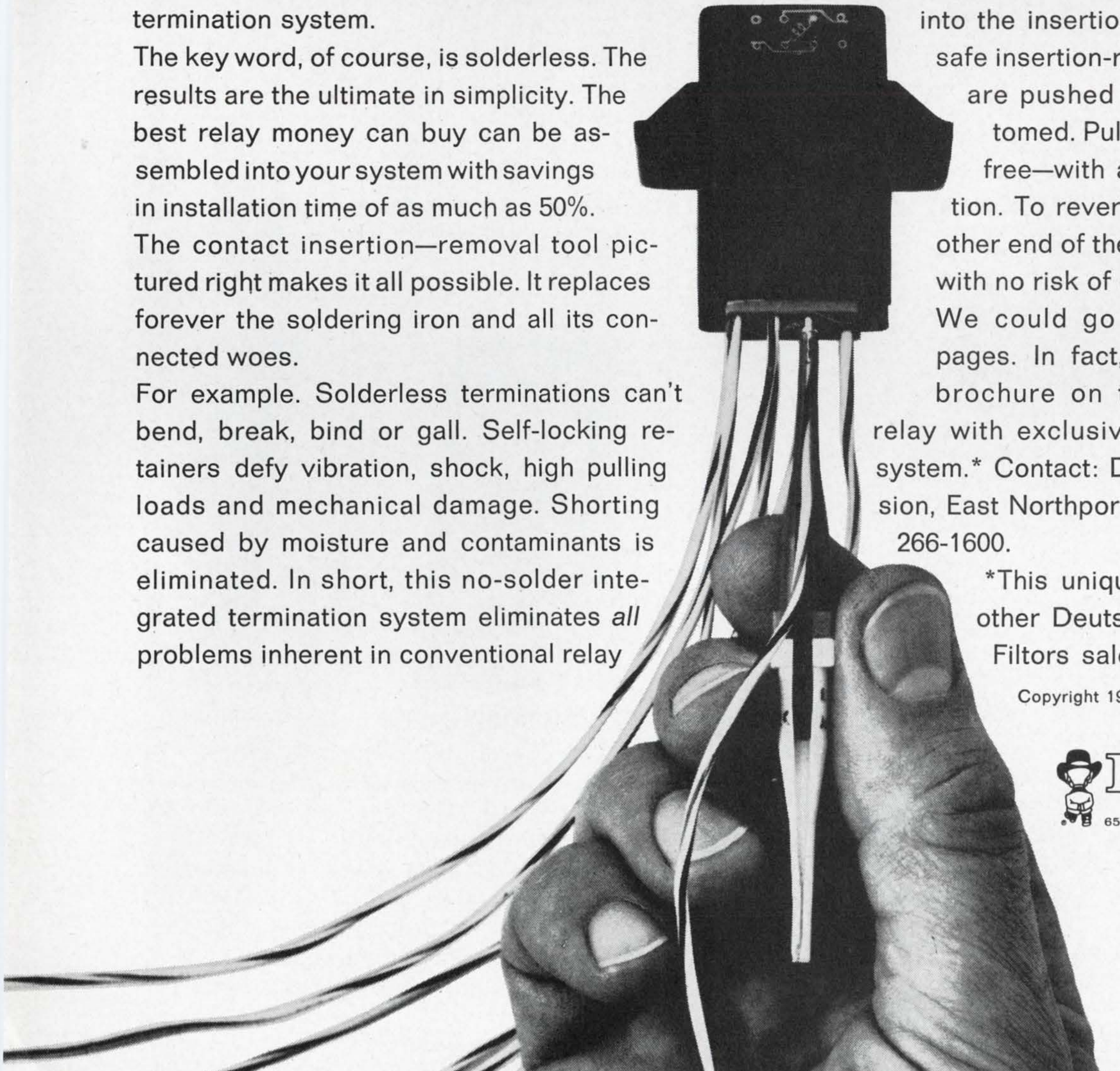


Control knobs

Over 350 instrument and control knobs are described in a 24-page catalog. The catalog contains thermosetting-plastic and metal knobs in a variety of sizes, designs, colors and functions. Selection guide and all dimensions are included. Kurz-Kasch, Inc.

CIRCLE NO. 376

Deutsch-Filtors announces a new no-solder relay termination system.



We've made the best even better. We took a Deutsch-Filtors Blue Ribbon BRF 10-amp relay—each one is fully tested for total dependability—and added a unique, time-saving solderless termination system.

The key word, of course, is solderless. The results are the ultimate in simplicity. The best relay money can buy can be assembled into your system with savings in installation time of as much as 50%.

The contact insertion—removal tool pictured right makes it all possible. It replaces forever the soldering iron and all its connected woes.

For example. Solderless terminations can't bend, break, bind or gall. Self-locking retainers defy vibration, shock, high pulling loads and mechanical damage. Shorting caused by moisture and contaminants is eliminated. In short, this no-solder integrated termination system eliminates *all* problems inherent in conventional relay termination; whether soldering to hooked leads, relay sockets, or printed circuit boards.

Here's how. Just crimp the wire with a standard MIL-T-22520 crimping tool. Insert the wire into the insertion end of a NAS-type fail-safe insertion-removal tool. Tool and wire are pushed into connector until bottomed. Pull tool free and you're home free—with a firmly locked-in connection. To reverse the process, insert the other end of the tool and remove the wire with no risk of damage.

We could go on talking about it for pages. In fact, we have. Send for our brochure on the new BRF-TJ 10-amp relay with exclusive integrated termination system.* Contact: Deutsch-Filtors Relay Division, East Northport, New York 11731 / (516) 266-1600.

*This unique system is available on other Deutsch relays. Your Deutsch-Filtors salesman has all the details.

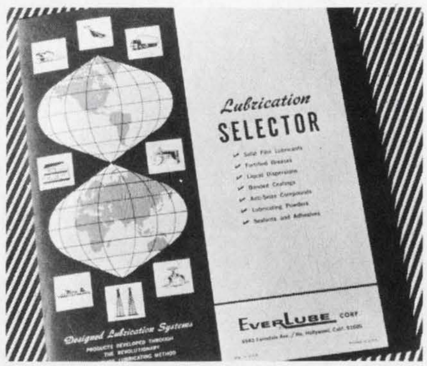
DEUTSCH
FILTORS RELAY DIVISION
65 Daly Road · E. Northport, Long Island, New York

INFORMATION RETRIEVAL NUMBER 94

Rectifiers and diodes

Descriptions, ratings and specifications for Zener voltage regulator diodes, voltage reference diodes and low-power silicon rectifiers are included in a 48-page catalog. It lists 66 different series of Zener regulator diodes ranging from 150 mW to 50 W in nine package designs. In addition, there are 11 different series of voltage reference diodes listed with nominal temperature coefficient ratings to five parts per million, as well as 34 different series of low-power silicon rectifiers in current ranges from 0.4 to 16 A and voltage ratings (maximum peak reverse) ranging from 50 to 100 V. International Rectifier.

CIRCLE NO. 377



Lubrication guide

The EverLube Selector Guide is a 24-page publication dealing with the recommended use and reference information on the complete product line. The guide includes complete data on bonded solid-film lubricants, fortified greases, liquid dispersions, antiseize compounds, corrosion- and abrasion-resistant paints, lubricating powders, sealants and adhesives. EverLube Corp. of America.

CIRCLE NO. 378

Urethane properties

The properties of 10 urethane compounds—elastomeric materials, foams and adhesives—can be found on this reference chart. These products find many applications in the production of mechanical rubber goods, seals, coatings and foams in the electronic, aerospace and industrial fields. Furane Plastics, Inc.

CIRCLE NO. 379

Circuit etching

Six-color, eight-page brochure describes the Etchant Regeneration System (ERS) for process control in printed-circuit etching. ERS eliminates rejects due to etchant depletion, maintains constant etch rate, close tolerances and maximum production automatically. It simplifies waste disposal problems, reduces etchant cost and provides opportunity for extra savings in reclaimed copper. Graphs, photomicrographs and a schematic floor plan supplement the test. Chemlea Corp.

CIRCLE NO. 380

Epoxy resins

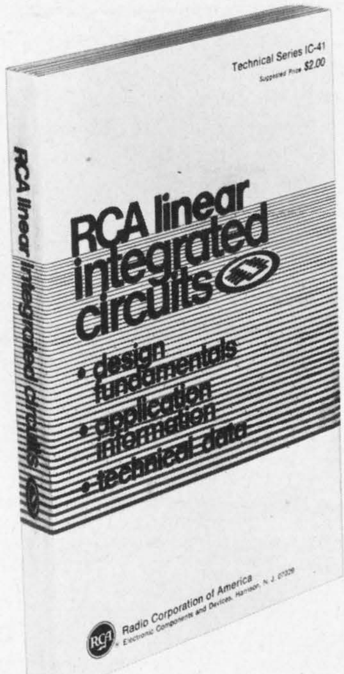
Brochures on the five lines of Scotchcast liquid resin systems give complete details on the standard resins in each family, including typical cured-state physical and electrical properties, handling properties and other information. The 8-page brochures are color-coded for family identification and are illustrated with property charts and application photos. 3M Company.

CIRCLE NO. 381

Piezoelectric ICs

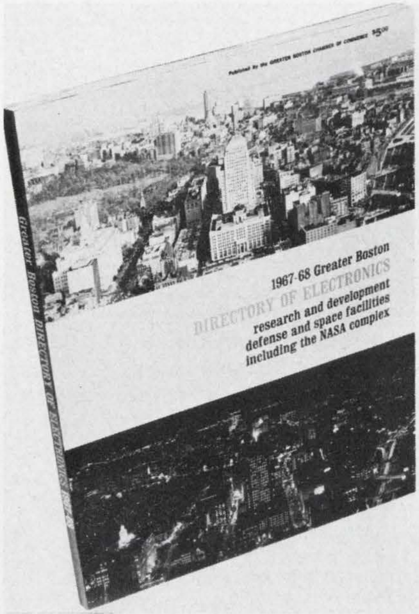
Technical Bulletin 951087 explains the new IC Piezoelectric (I.C.P.) approach to measuring pressure, force, vibration and shock. It describes crystal transducers containing ICs, which are also available as "connector" or "in-line" amplifiers for changing conventional piezoelectric transducers into ICP instruments. By lowering the output impedance at the transducer, this approach simplifies instrumentation systems and enhances their performance. ICP transducers use regular cables, drive long cables, and connect directly to readout or recording instruments. PCB Piezotronics, Inc.

CIRCLE NO. 382



Linear ICs

The latest *RCA Linear Integrated Circuits Manual,* includes the latest available information on design, packaging, and application of linear integrated circuits. Design equations and performance criteria are derived for basic circuit configurations. Circuit diagrams, descriptive data, and applications information are provided for a family of integrated circuits. *Available for $2 from Commercial Engineering, RCA Electronic Components and Devices, Harrison, N.J.*



Boston's electronics

A *Directory of Electronics,* including research and development defense and space activities, has been published by the Greater Boston Chamber of Commerce. The listing includes companies, military facilities and government centers involved in electronic or scientific research in the Greater Boston area, which includes 78 eastern Massachusetts communities. Manufacturing and research spans from electronics for home stereo equipment to sonic probes for oceanographic research and components for computers. The alphabetical listings describe the major activities, name key personnel and give the total number of employees, indicating the distribution between research and nonresearch occupations. *Available for $5 from the Research & Development Division, Greater Boston Chamber of Commerce, 125 High St., Boston, Mass.*

Conductive coatings

A foldout six-page guide to silver, gold, platinum and palladium conductive coatings details the properties, uses, application methods and other characteristics for use on nonconductive materials ceramics, glass, quartz, mica, plastics, paper and some metals. Fire-on and bake-on methods of coating are described in addition to listings of conductivity ratings. Fansteel Metallurgical Corp.

CIRCLE NO. 383

Electronic Design

ELECTRONIC DESIGN'S function is:

- To aid progress in the electronics manufacturing industry by promoting good design.
- To give the electronic design engineer concepts and ideas that make his job easier and more productive.
- To provide a central source of timely electronics information.
- To promote two-way communication between manufacturer and engineer.

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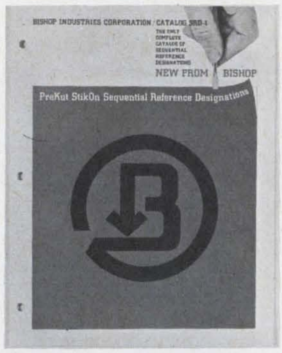

Bishop Industries now offers the only complete catalog of sequential reference designations, letters and numbers, especially developed for the electronics industry. The new 12-page Catalog No. SRD-1, features the time saving, easy to use, StikOn drafting aids in the most commonly used sizes for electronic circuit and assembly layouts. Individually precut symbols are available in opaque black, transparent red and blue. Also reverse black, red and blue for absolute registration on two sided boards from single art. Included are illustrations, range of sizes and complete price and ordering information. Send today for your free copy.

BISHOP INDUSTRIES CORP.
11728 Vose Street
North Hollywood, California 91605

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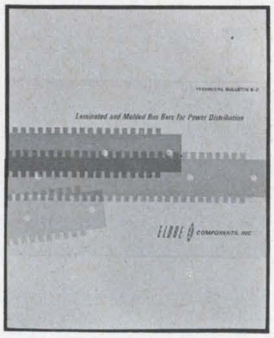
Bus Bars For Noise Reduction



A 16 page Technical Bulletin is now available, describing a new concept in power or signal distribution. Basic mechanical and electrical design principles, along with descriptive pictures and diagrams, are included in this bulletin. These compact buses can replace bulky cable harnesses and repetitive wiring for computer or modular application. This method of construction satisfies the demanding requirements of low inductance and resistance of high speed, solid state systems, while controlling electrical noises.

Visit us at the Nepcon/West Show, Booth 541

Eldre Components, Inc.
1239 University Avenue
Rochester, New York 14607

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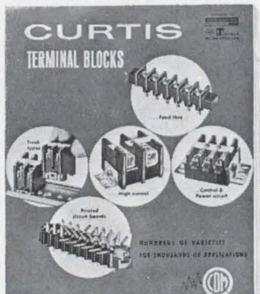
Terminal Block Selector



A new 24-page, completely illustrated catalog contains photos, descriptions, ratings, engineering drawings, and prices of the complete line of Curtis terminal blocks. Included are printed circuit, insulated feed-thru, quick disconnect, track type, and high current terminal blocks. Handy selection chart quickly locates the perfect block for your particular requirements. Send today for your free copy.

Curtis Development & Mfg. Co.
3236 North 33rd Street
Milwaukee, Wisconsin 53216
See Us at Booth 4E12, IEEE Show

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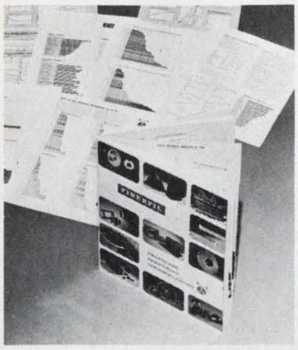
Manufacturers

Advertisements of booklets, brochures, catalogs and data sheets. To order use Reader-ServiceCard.
(Advertisement)

Free Fiberfil Reinforced Thermoplastics Manual



This 32 page engineering manual gives complete data on thermoplastic injection molding compounds with fiberglass to greatly improve performance. It contains properties comparisons, including dielectric performance on all reinforced thermoplastics. Many electrical-electronic applications show how the materials are being used. Test data is included on eleven basic resins, long glass and short glass reinforced grades and many specialized materials. This is the standard reference on FRTP's, prepared by the oldest and largest maker of fiberglass reinforced thermoplastics. For a free copy circle this number.

Fiberfil Division, Rexall Chemical Co.
1701 N. Heidelbach,
Evansville, Indiana 47717

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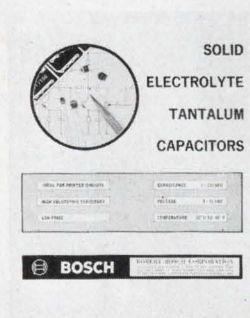
LOW COST TANTALUM CAPACITORS



This catalog and application bulletin on BOSCH low cost tantalum capacitors provides technical data, performance tables, mechanical dimensions, curves and formulas, as well as complete order information.

BOSCH solid electrolyte tantalum capacitors are especially suitable for applications where low cost, high volumetric efficiency, electrical stability, and mounting on printed wiring boards are desirable.

ROBERT BOSCH CORPORATION
2800 South 25th Avenue
Broadview, Illinois 60153

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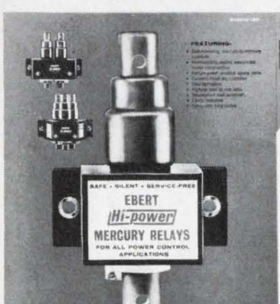
MERCURY RELAYS FOR POWER CONTROL APPLICATIONS



New comprehensive catalog fully describes the complete line of safe, silent, service-free Ebert **Hi-power** Mercury Relays. Available in 1, 2 and 3-pole units in several ratings to 60 kW., they offer greater load capacity, ease of installation, and guaranteed long life. Unaffected by adverse ambient conditions and physical or thermal shock they feature self-renewing mercury contacts, hermetically sealed epoxy-clad metal tube construction, and highest load to size ratio. Complete physical and electrical specifications are given.
Engineers will find this an excellent guide in selecting relays for all power control applications.

EBERT ELECTRONICS CORP.
130 Jericho Tpke.,
Floral Park, N. Y. 11002

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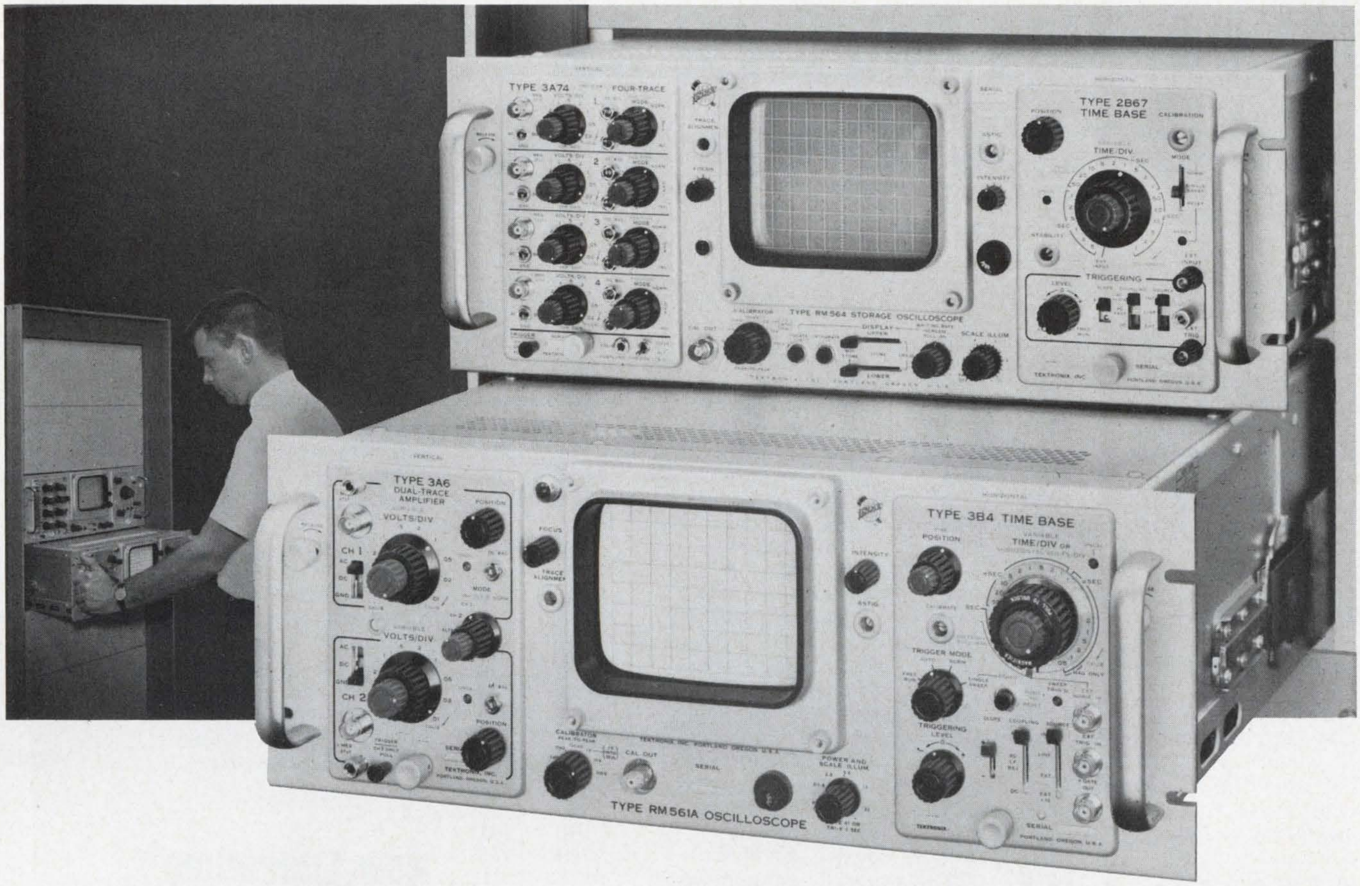
Advertisers' Index

Career Advertising



plug in a Tektronix rack-mount oscilloscope

- Conventional or storage
- Multi-trace, differential, sampling and spectrum analyzer plug-ins
- 7 inches of rack height

The Type RM561A 7-inch high rack-mount oscilloscope provides conventional oscilloscope performance with measurement capabilities extending from DC through 1 GHz with appropriate plug-in units. It has an 8 by 10-cm CRT with a bright P31 phosphor and an illuminated, internal graticule.

The measurement system illustrated consists of the Type RM561A with the Type 3B4 Time-Base Plug-in and the Type 3A6 Dual-Trace Amplifier. The Type 3B4 provides versatile triggering and calibrated sweep speeds from 5 s/div to 50 ns/div. A direct-reading magnifier provides up to X50 magnification about the center of the CRT. The Type 3A6 Dual-Trace Amplifier has DC-to-10 MHz bandwidth and 35-ns risetime over its 10 mV/div to 10 V/div deflection range.

Type RM561A Oscilloscope	$ 580
Type RM561A MOD 171A (Includes slide-out tracks)	$ 630
Type 3B4 Time Base	$ 425
Type 3A6 Dual Trace Amplifier	$ 525

The Type RM564 split-screen storage oscilloscope is virtually two instruments in one. It offers all the advantages of a storage oscilloscope plus those of a conventional plug-in oscilloscope. The contrast ratio and brightness of stored displays are constant and independent of viewing time, writing and sweep speeds, and signal repetition rates. The entire screen or either half can be used for storage and/or conventional displays. In the stored mode, either half of the screen can be erased independently of the other half. A rear panel connector permits remote erasure of either or both halves of the display.

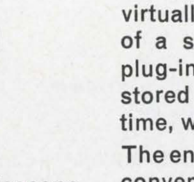
The plug-ins shown in the Type RM564 are the Type 2B67 Time-Base Unit that has calibrated sweep speeds from 5 s/div to 1 μs/div extending to 200 ns/div with the X5 magnifier, and the Type 3A74 Four-Channel Amplifier that provides DC-to-2 MHz bandwidth over its 20 mV/div to 10 V/div calibrated deflection range.

Type RM564 Storage Oscilloscope	$1025
Type RM564 MOD 171A (Includes slide-out tracks)	$1075
Type 2B67 Time-Base	$ 225
Type 3A74 Four-Channel Amplifier	$ 625

U. S. Sales Prices FOB Beaverton, Oregon

For a demonstration, contact your nearby Tektronix Field Engineer or write: Tektronix, Inc., P. O. Box 500, Beaverton, Oregon 97005.

Conventional or storage oscilloscopes



...with multi-trace, differential, sampling and spectrum analyzer plug-ins

INFORMATION RETRIEVAL NUMBER 101

Information Retrieval Service

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

Design Aids

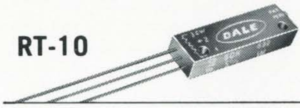
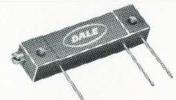
Application Notes

Reprints Available

One simple, rugged design adds reliability to all three rectilinear Mil wirewound styles

RT-10, RT-11, RT-12 — Dale meets all three with a single design. You benefit from this simplification through increased reliability, faster delivery, better price. Call us today!

1. **ALL-MOLDED HOUSING** design eliminates seal problems. Meets MIL-STD-202 and MIL-R-27208A.
2. **RUGGED COLLECTOR SYSTEM** assures you of noise levels well below mil requirements.
3. **FULL LENGTH WINDING** allows increased power handling capability. Permits use of large diameter thermoconductive mandrel which eliminates "hot spots" by acting as high mass heat sink.
4. **1-PIECE WIPER ASSEMBLY** of precious metal insures setting stability under all environmental conditions.
5. **STAINLESS STEEL ADJUSTMENT SCREW** is electrically isolated by insulated head. Metal-to-metal clutching prevents over-travel damage.
6. **CONSTANT LEAD SCREW SEAL** is assured by shaft-retaining spring which maintains unvarying pressure against high temperature silicone rubber "O" ring.

DALE MIL-R-27208A MODELS		
RT-10		Model 691 P.C. Pin Model 697 Flex. Leads
RT-11		Model 1287 P.C. Pin Model 1288 Flex. Leads
RT-12		Model 1680 P.C. Pin Model 1697 Flex. Leads
RT-22		5000 Series — ½" square-trim models meet RT-22, made with same basic design considerations shown here.

WRITE FOR CATALOG B — containing specifications on 57 Dale T-Pots including many special models.

DALE®

DALE ELECTRONICS, INC.
1328 28th Avenue, Columbus, Nebraska

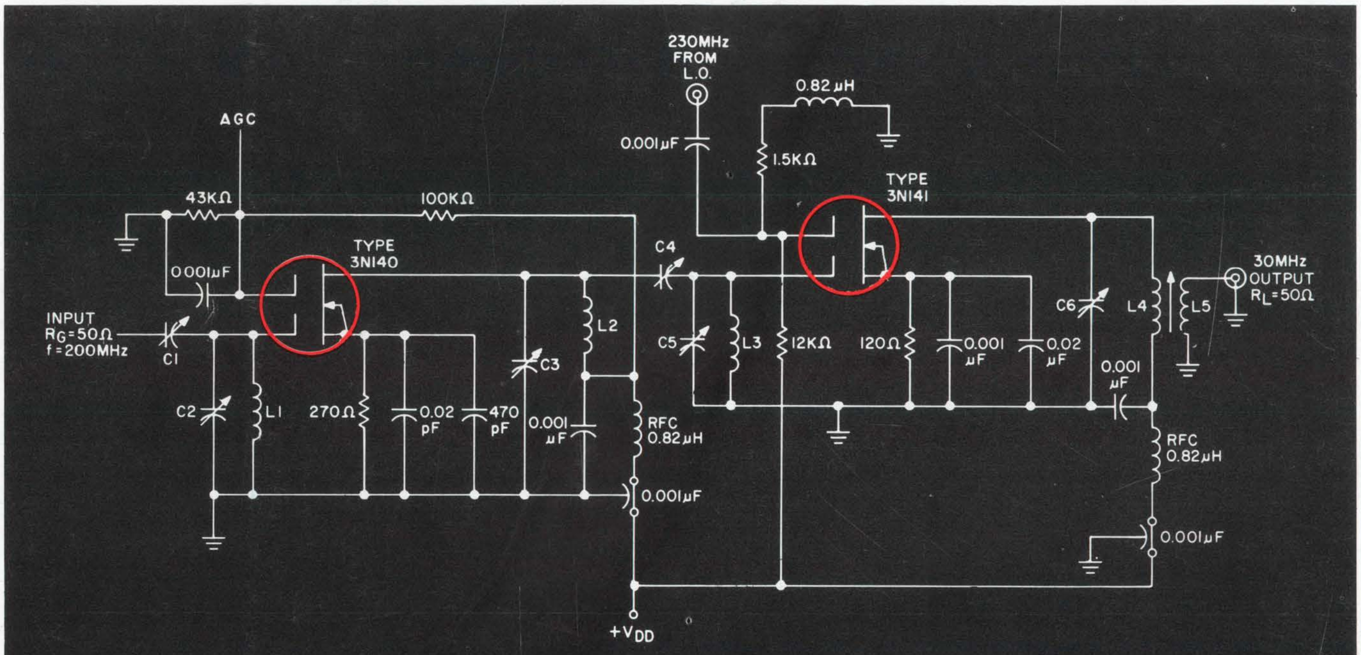
SEE OUR SPECIFICATIONS IN VSMF THE MICROFILM CATALOG FILE

INFORMATION RETRIEVAL NUMBER 243

RCA Announces Dual-Gate (MOS) FET'S

- Unneutralized 200 MHz Power Gain 18dB typ
- Feedback Capacitance 0.03pF max
- Transconductance 10,000 umhos typ

For the first time in communications history!... all solid-state VHF receivers with vacuum-tube front-end performance



All solid-state front-end using the RCA 3N140 as RF amplifier and the RCA 3N141 as mixer.

98¢

1000 units

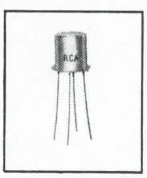
is the low price for the RCA 3N140 dual-gate RF Amplifier

RCA'S DUAL INSULATED-GATE DEPLETION TYPE (MOS) FET'S COMBINE THE BEST FEATURES OF VACUUM-TUBES AND BIPOLAR TRANSISTORS

The RCA 3N140 RF Amplifier and 3N141 Mixer Feature...

SERIES CONTROL ELEMENTS FOR:

- Improved Crossmodulation Performance
- Reduced Spurious Response
- Unconditionally stable at VHF
- Reduced Oscillator Feedthrough
- Increased Gain Control Range



TO-72

INSULATED GATES FOR:

- Increased Signal handling without Diode-Current Loading
- Negligible AGC Power
- Improved Thermal Stability

ELECTRICAL CHARACTERISTICS

3N140 and 3N141

Gate-to-source cutoff voltage
$V_{G_1S}(Off) = V_{G_2S}(Off) = -4V$ max.

Gate Leakage Current
$I_{G_1SS} = I_{G_2SS} = 1nA$ max.

Forward Transconductance
G_{fs} (Gate No. 1-to-drain) = 6,000 µmhos min.
10,000 µmhos typ.

200 MHz Power Gain (unneutralized) (3N140)
G_{ps} = 16dB min.
18dB typ.

200 MHz Noise Figure (3N140)
N.F. = 4.5dB max.
3.5dB typ.

Developed and introduced by RCA, the 3N140 and 3N141 Dual Insulated-Gate (MOS) FET's are two of the most revolutionary transistors on the market today. For technical data and application information write RCA Commercial Engineering, Section EG2-2, Harrison, N.J. 07029. Check your RCA Distributor for his price and delivery.

RCA

INFORMATION RETRIEVAL NUMBER 244