Electronic Design

VOL. 16 NO. 5

FOR ENGINEERS AND ENGINEERING MANAGERS

MARCH 1, 1968

Will this integrated circuit fail? A good part of the answer lies in its package. Make meaningful decisions at early stages, select materials and processes carefully and you've gone a long way to filling the 'standards gap' for IC packages. Set your own package standards by following the logical procedure that starts on page 56.

UTC
PIONEERS IN MINIATURIZATION
NEW BIT-250™ LINE
SMALLEST METAL-ENCASED TRANSFORMERS AVAILABLE!
UTC BIT 250-12 1-3 5 10KC 1 2 3 4 5
BIT-250's achieve outstanding reliability, in a profile compatible with Flat Packs and IC's, while maintaining response and power levels found only in larger units. MIL-T-27B, Grade 4, completely ruggedized. Seventeen items immediately available from stock, plus specials to your requirements.
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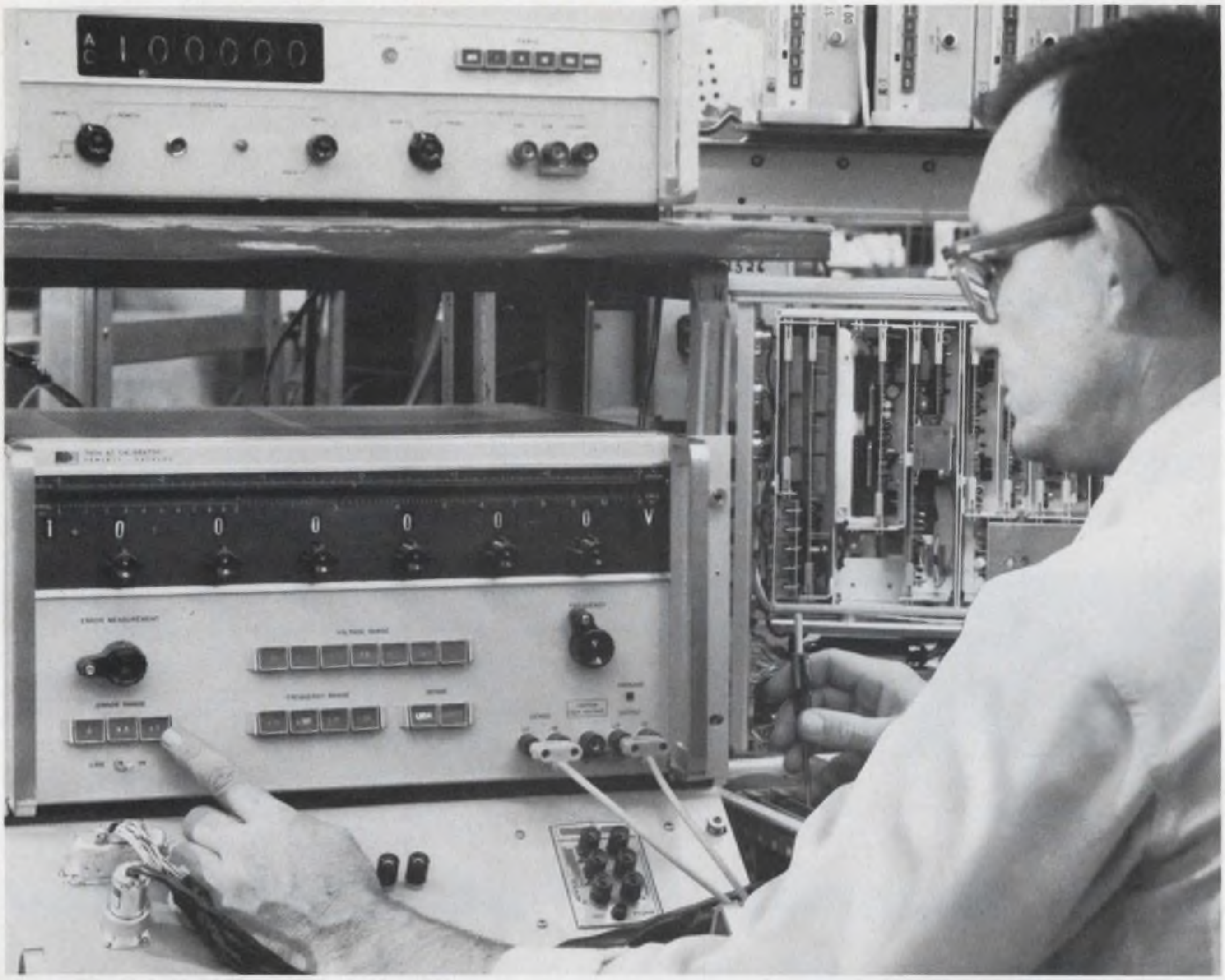
In CANADA: A. C. SIMMONDS & SONS LTD., Agincourt, Ontario

CUT AC CALIBRATION TIME IN HALF



NEW hp 745A AC Calibrator is a self-contained AC calibration system that you can depend on for accuracy and stability in checking out digital, differential and analog ac voltmeters. Use it in production test areas and in calibration and standards labs to reduce calibration time by at least 50%—with push-button range selection . . . dial your voltage, dial your frequency. There is no external thermocouple, no nulling, no transients, no extra instruments to compound your set-up and increase your costs.

Direct error measurement in terms of percent-of-setting makes instrument calibration a simple set-read operation. To use it, press error range button and dial your plus or minus error until voltmeter under test reads the preselected voltage. Any error up to ±3% is read directly on the top dial.

Operator oriented for easy, fool-proof measurements. Current limiting protects 745A from direct load short. Voltage range automatically resets to 1 mV range when 745A is turned off, to protect any instrument being calibrated from an accidental overload on turn-on. No need to disconnect instrument being tested, or turn off calibration when switching ranges, because there are no transients when ranges are being switched. Frequency, frequency range, and voltage range are programmable—an extra feature at no extra cost. Calibration of the 745A is simple using a high accuracy dc voltmeter, such as an hp 3420A, and an uncalibrated thermocouple to check flatness.

0.02% accuracy is possible because the output voltage is continually compared to an internal dc reference by a unique technique that makes an internal ac-to-dc transfer measurement twice each second. This also eliminates thermocouple drift and dc reversal error. Voltage accuracy and stability are further assured by precision inductive dividers. Calibrated ac voltages are available from 100 μV to 110 V over the frequency range from 10 Hz to 110 kHz—with an absolute voltage accuracy in the midband of 0.02% of setting and 0.05% up to 110 kHz! Price: $4500.00

To get full information on the lightweight (65 pounds) hp 745A AC Calibrator, call your nearest hp field engineer. Or, write to Hewlett-Packard, Palo Alto, California 94304. Europe: 54 Route des Acacias, Geneva.

097/19

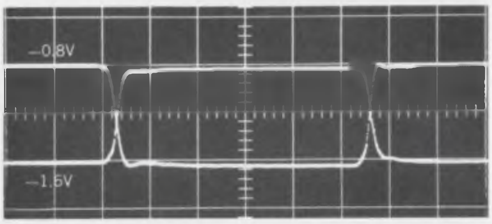
HEWLETT hp PACKARD

WORKING STANDARDS

INFORMATION RETRIEVAL NUMBER 2

250 MILLION PULSES

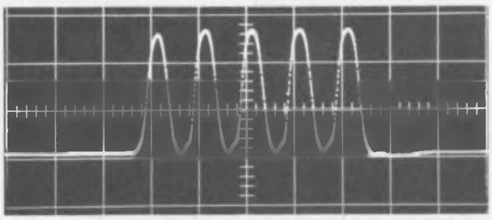
per second A close check of the front panel on the new Datapulse 113 should convince you that it is the most versatile high frequency pulse generator yet designed.



Complementary Output Simulates ECL F/F Output. 5 ns/cm, 500 mV/cm.

The 113 offers repetition rates from 0.5 Hz to 250 MHz, synchronous and asynchronous gating, simultaneous positive and negative outputs, and separate ±2V baseline offset (independent of high resolution amplitude controls). Both outputs may be complemented.

with Built-in Burst Capability



200 MHz Pulse Burst. 5 ns/cm, 0.5 V/cm

The built-in burst capability is there because the 113 is really two pulse generators in one. An HF oscillator provides rep rates from 500 KHz to 250 MHz. An LF oscillator (0.5 Hz to 500 KHz) gates pulse bursts from 10 ns to 10 μs and is used to trigger the unit for low rep rates.

See what we're talking about even better by asking for a demonstration of the 113. Or, write for complete specifications. Price: $3375.00

See the 113. IEEE Booths 2B44-50

Datapulse, Inc., A Subsidiary of Systron-Donner Corporation,
10150 W. Jefferson Blvd., Culver City, California 90230.
Telephone: 213-836-6100, 871-0410. TWX: 910-340-6766. Cable: Datapulse.

EXPORT SALES OFFICE: Systron-Donner International, 888 Galindo Street, Concord, California. Telephone: 415-682-6161.
IN EUROPE: Systron-Donner International S.A., 447, Avenue de Tervueren, Brussels 15, Belgium. Telephone: 71-76-84. Telex: 23606 (Belgium).

DATAPULSE®

INFORMATION RETRIEVAL NUMBER 3

VOL. 16 NO.

Electronic Design 5

FOR ENGINEERS AND ENGINEERING MANAGERS

MARCH 1, 1968

NEWS

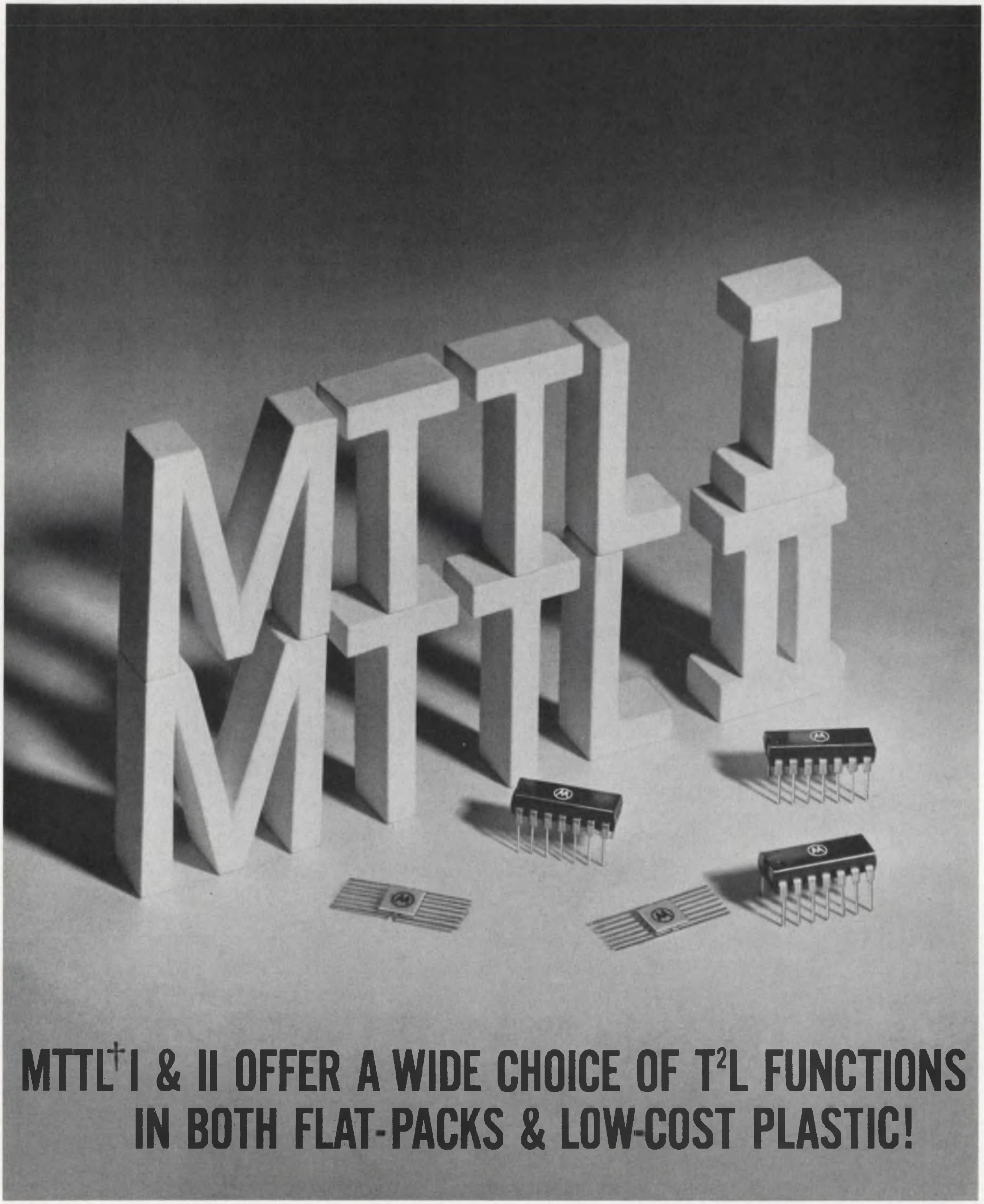
TECHNOLOGY

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. Copyright © 1968, Hayden Publishing Company, Inc. 70,170 copies this issue.

NOW...TWO GENERATIONS OF



†MTTL is a trademark of Motorola Inc.

-where the priceless ingredient is care!

MOTOROLA T^2L INTEGRATED CIRCUITS!

OPTIMUM SELECTION & DESIGN FLEXIBILITY AT LOW COST!

	−55° to +125°C						0 to +75°C					
CIRCUIT DESCRIPTION*	SUHL Type No.	Motorola Type No. F.O. = 15	Motorola Price 100-Up	SUHL Type No.	Motorola Type No. F.O. = 7	Motorola Price 100-Up	SUHL Type No.	Motorola Type No. F.O. = 12	Motorola Price 100-Up (F) 1000-Up (P)	SUHL Type No.	Motorola Type No. F.O. = 6	Motorola Price 100-Up (F) 1000-Up (P)
Dual 4-Input NAND Gate	SG-40-02	MC500F	$5.45	SG-41-02	MC550F	$4.35	SG-42-02 SG-42-03	MC400F MC400P	$3.15 1.75	SG-43-02 SG-43-03	MC450F MC450P	$2.50 1.40
Expandable 4-Wide 2-2-2-3-Input AND-OR-INVERT Gate	SG-50-02	MC501F	6.00	SG-51-02	MC551F	4.80	SG-52-02 SG-52-03	MC401F MC401P	3.50 1.95	SG-53-02 SG-53-03	MC451F MC451P	2.75 1.55
Single 8-Input NAND Gate	SG-60-02	MC502F	5.45	SG-61-02	MC552F	4.35	SG-62-02 SG-62-03	MC402F MC402P	3.15 1.75	SG-63-02 SG-63-03	MC452F MC452P	2.50 1.40
2-Wide 3-Input AND-OR-INVERT Gate with Gated Complement	SG-90-02	MC503F	5.45	SG-91-02	MC553F	4.35	SG-92-02 SG-92-03	MC403F MC403P	3.15 1.75	SG-93-02 SG-93-03	MC453F MC453P	2.50 1.40
Expandable 3-Wide 3-Input AND-OR-INVERT Gate	SG-100-02	MC504F	6.00	SG-101-02	MC554F	4.80	SG-102-02 SG-102-03	MC404F MC404P	3.50 1.95	SG-103-02 SG-103-03	MC454F MC454P	2.75 1.55
Expandable 2-Wide 4-Input AND-OR-INVERT Gate	SG-110-02	MC505F	6.00	SG-111-02	MC555F	4.80	SG-112-02 SG-112-03	MC405F MC405P	3.50 1.95	SG-113-02 SG-113-03	MC455F MC455P	2.75 1.55
Expandable 8-Input NAND Gate	SG-120-02	MC506F	6.00	SG-121-02	MC556F	4.80	SG-122-02 SG-122-03	MC406F MC406P	3.50 1.95	SG-123-02 SG-123-03	MC456F MC456P	2.75 1.55
Quad 2-Input NAND Gate	SG-140-02	MC508F	5.45	SG-141-02	MC558F	4.35	SG-142-02 SG-142-03	MC408F MC408P	3.15 1.75	SG-143-02 SG-143-03	MC458F MC458P	2.50 1.40
4-Wide 3-2-2-3-Input Expander for AND-OR-INVERT Gates	SG-150-02	MC509F	4.90	SG-151-02	MC559F	3.90	SG-152-02 SG-152-03	MC409F MC409P	2.85 1.20	SG-153-02 SG-153-03	MC459F MC459P	2.25 1.20
Dual 4-Input Expander for AND-OR-INVERT Gates	SG-170-02	MC510F	4.90	SG-171-02	MC560F	3.90	SG-172-02 SG-172-03	MC410F MC410P	2.85 1.20	SG-173-02 SG-173-03	MC460F MC460P	2.25 1.20
Dual 4-Input Expander for NAND Gates	SG-180-02	MC511F	4.90	SG-181-02	MC561F	3.90	SG-182-02 SG-182-03	MC411F MC411P	2.85 1.20	SG-183-02 SG-183-03	MC461F MC461P	2.25 1.20
Triple 3-Input NAND Gate	SG-190-02	MC512F	5.45	SG-191-02	MC562F	4.35	SG-192-02 SG-192-03	MC412F MC412P	3.15 1.75	SG-193-02 SG-193-03	MC462F MC462P	2.50 1.40
R-S Flip-Flop	SF-10-02	MC513F	6.00	SF-11-02	MC563F	4.80	SF-12-02 SF-12-03	MC413F MC413P	3.50 1.95	SF-13-02 SF-13-03	MC463F MC463P	2.75 1.55
AND J-K Flip-Flop	SF-50-02	MC515F	7.65	SF-51-02	MC565F	6.10	SF-52-02 SF-52-03	MC415F MC415P	4.40 2.80	SF-53-02 SF-53-03	MC465F MC465P	3.50 2.25
OR J-K Flip-Flop	SF-60-02	MC516F	7.65	SF-61-02	MC566F	6.10	SF-62-02 SF-62-03	MC416F MC416P	4.40 2.80	SF-63-02 SF-63-03	MC466F MC466P	3.50 2.25
Expandable 2-Wide 4-Input AND-OR-INVERT Gate	SG-210-02	MC2100F	7.20	SG-211-02	MC2150F	5.75	SG-212-02 SG-212-03	MC2000F MC2000P	4.20 2.35	SG-213-02 SG-213-03	MC2050F MC2050P	3.30 1.85
Quad 2-Input NAND Gate	SG-220-02	MC2101F	6.55	SG-221-02	MC2151F	5.20	SG-222-02 SG-222-03	MC2001F MC2001P	3.80 2.10	SG-223-02 SG-223-03	MC2051F MC2051P	3.00 1.70
4-Wide 3-2-2-3-Input Expander for AND-OR-INVERT Gates	SG-230-02	MC2102F	4.90	SG-231-02	MC2152F	3.90	SG-232-02 SG-232-03	MC2002F MC2002P	2.85 1.20	SG-233-02 SG-233-03	MC2052F MC2052P	2.25 1.20
Dual 4-Input NAND Gate	SG-240-02	MC2103F	6.55	SG-241-02	MC2153F	5.20	SG-242-02 SG-242-03	MC2003F MC2003P	3.80 2.10	SG-243-02 SG-243-03	MC2053F MC2053P	3.00 1.70
Expandable 4-Wide 2-2-2-3-Input AND-OR-INVERT Gate	SG-250-02	MC2104F	7.20	SG-251-02	MC2154F	5.75	SG-252-02 SG-252-03	MC2004F MC2004P	4.20 2.35	SG-253-02 SG-253-03	MC2054F MC2054P	3.30 1.85
Single 8-Input NAND Gate	SG-260-02	MC2105F	6.55	SG-261-02	MC2155F	5.20	SG-262-02 SG-262-03	MC2005F MC2005P	3.80 2.10	SG-263-02 SG-263-03	MC2055F MC2055P	3.00 1.70
Dual 4-Input Expander for AND-OR-INVERT Gates	SG-270-02	MC2106F	4.90	SG-271-02	MC2156F	3.90	SG-272-02 SG-272-03	MC2006F MC2006P	2.85 1.20	SG-273-02 SG-273-03	MC2056F MC2056P	2.25 1.20
AND J-K Flip-Flop	SF-250-02	MC2109F	9.20	SF-251-02	MC2159F	7.30	SF-252-02 SF-252-03	MC2009F MC2009P	5.30 3.35	SF-253-02 SF-253-03	MC2059F MC2059P	4.20 2.70
OR J-K Flip-Flop	SF-260-02	MC2110F	9.20	SF-261-02	MC2160F	7.30	SF-262-02 SF-262-03	MC2010F MC2010P	5.30 3.35	SF-263-02 SF-263-03	MC2060F MC2060P	4.20 2.70

*Interchange with SUHL** I & II types. **Trademark of Sylvania, Inc. "F" suffix denotes flat-pack. "P" suffix denotes dual in-line plastic package. Sylvania suffix -03 numbers denote dual in-line ceramic packages.

Selection . . . Availability . . . Economy! Three good reasons why you should evaluate MTTL I (MC400/500 series) and MTTL II (MC2000/2100 series) . . . Motorola's answer to the T^2L "availability" problem.

Whether you want the low-cost approach offered by the 14-pin dual in-line plastic package — or have more stringent temperature requirements calling for the 14-pin ceramic flat-pack (−55 to +125°C) — Motorola now offers **the** T^2L circuit for **every** designer. In fact, you can choose from 24 different logic functions, offered in some 150 different types. More importantly, 15 more complex-function circuits, including a 50 MHz Flip-Flop, will be introduced in this line during the next few months.

Now, the computer/industrial system designer can combine the top performance of this highly-popular line with system costs that are competitive with practically any form of I/C logic. For example, the price of the MC2009P J-K AND Flip-Flop is just $3.35, and the MC2001P Quad 2-Input Gate is $2.10 (both 1,000-up). Production quantities are available for all types.

Check These Other Design Advantages:

- **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)**

Evaluation units are now available from your local distributor's warehouse stock. For production quantity pricing and schedules, contact your Motorola field representative. Write for details . . . P.O. Box 955, Phoenix, Arizona 85001.

†MTTL is a trademark of Motorola Inc.

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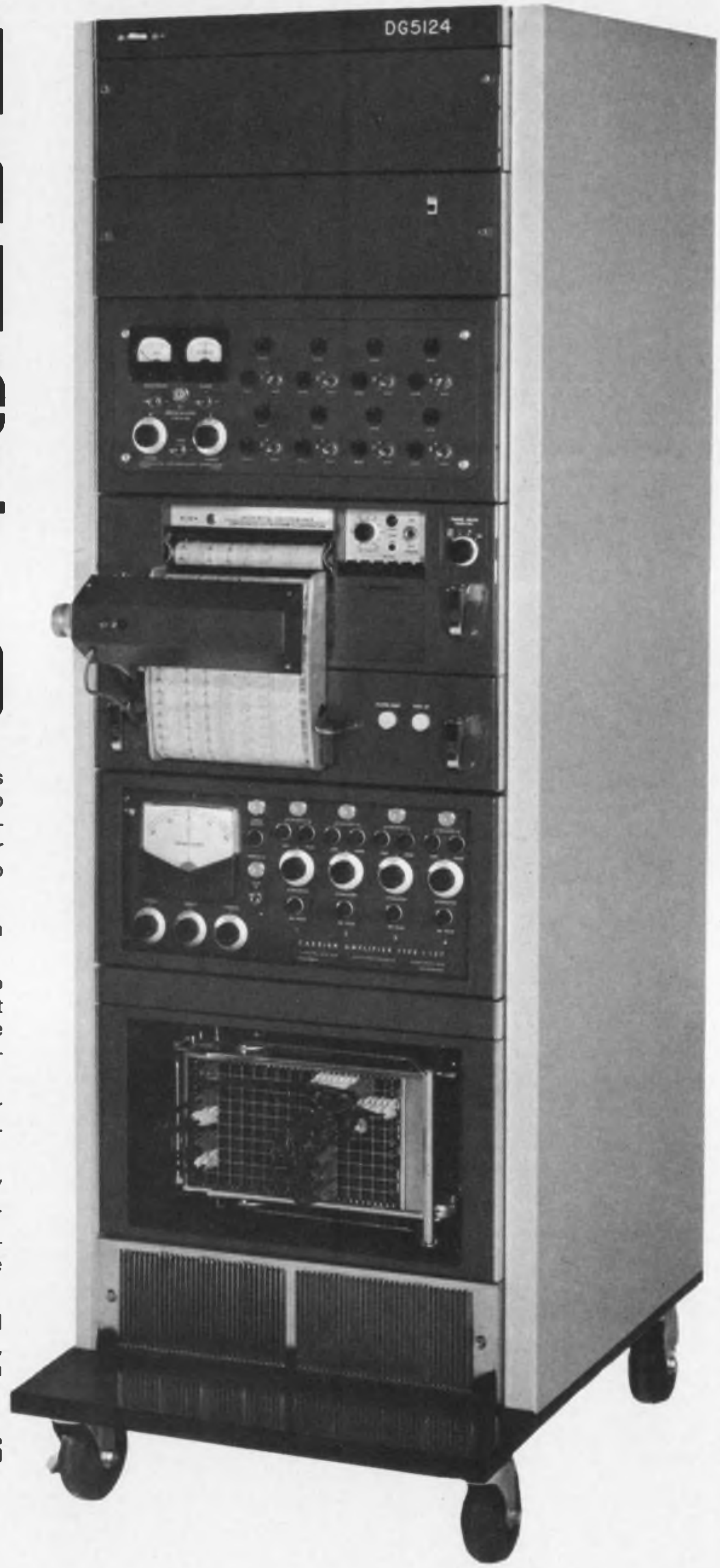
INFORMATION RETRIEVAL NUMBER 4

Now-
any industrial data problem can be solved with one system-



CEC's DG 5000

The reason is surprisingly simple. The DG 5000 series is an assembly of CEC standard products systematized into a *complete configuration*, resulting in outstanding capability for the acquisition and measurement of dynamic or quasistatic data for vibration and stress analysis to structural testing.

Furthermore, the DG 5000 System is uniquely versatile in the *three* ways so important to every industrial user.

1. CEC's building-block concept makes it possible to tailor-make the system to virtually any configuration. It will accept any of the following CEC oscillographs—the 5-126, 5-124, 5-119 and 5-133—and deliver up to 52 recording channels with lightbeam galvanometers.

2. Maximum application flexibility can be provided for variations of system configuration through a programmable building-block interconnection.

3. The DG 5000 System may be *easily and economically* expanded to meet any future configuration requirements.

So if you're concerned with industrial testing problems—from event to readout—the DG 5000 can free you to be concerned about other things.

For complete information, call your nearest CEC Field Office. Or write Consolidated Electrodynamics, Pasadena, California 91109. A subsidiary of Bell & Howell. Bulletin DG 5000-X2.

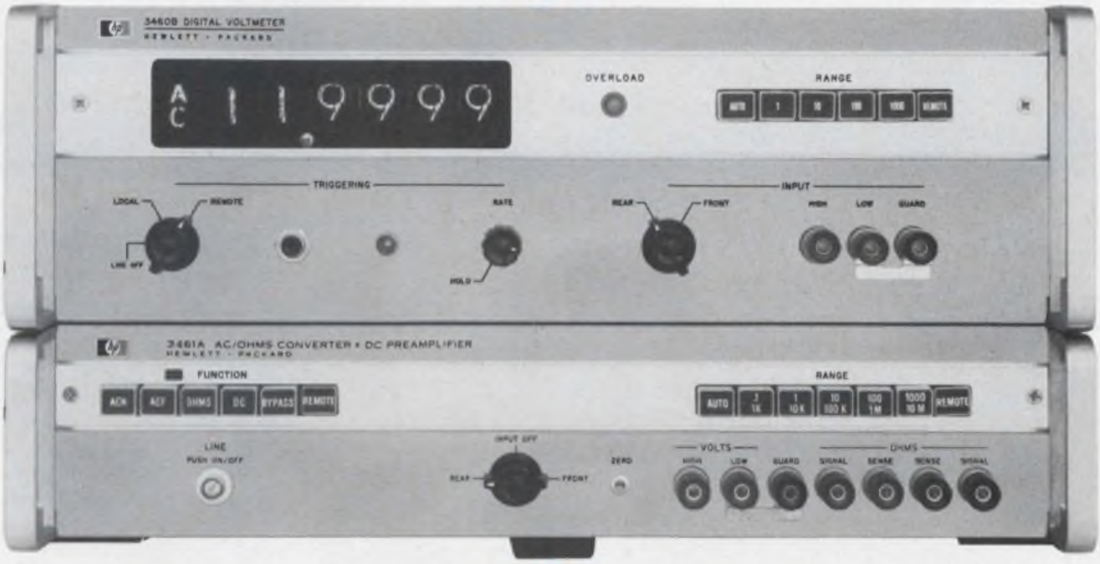
CEC/DATAGRAPH PRODUCTS

BELL & HOWELL

INFORMATION RETRIEVAL NUMBER 5

PERFECT MATES

New Multiple Function Package Combines Accurate DC



With Ohms, AC Volts, DC Microvolts

The hp 3460B Digital Voltmeter and hp 3461A AC/Ohms Converter-DC Preamplifier combine to make a multiple function DVM with high resolution, high accuracy, and high sensitivity. The package has a 20% over-ranging capability, and an accuracy of 0.005% of dc reading, 0.084% of midrange ac reading and 0.012% of ohms reading.

You can make low-level dc voltage measurements with 1 μV sensitivity, wide-range ac voltage measurements from 50 Hz to 100 kHz with 10 μV sensitivity, and accurate resistance measurements from 1 kΩ to 12 MΩ with 10 milliohm sensitivity on the lowest range.

Optional Combinations. To allow minimum investment with flexibility for meeting future requirements, the 3461A can be purchased to include a single function or a combination of functions. Functions not originally purchased can be ordered and easily installed.

Systems Use. High common mode rejection (160 dB at dc and 110 dB at 60 Hz), guarded inputs and speed of reading (2.5 readings/second for ac and 15 readings/second on dc) make the combination ideal for use in digital data acquisition systems. Range, function, trigger and integration period are fully programmable for automated measurements. BCD output (1-2-4-8) contains 6 digits of data, polarity, decimal location and overload information.

To get the complete story on the versatility of this new multiple function combination, call your nearest hp field engineer. Or, write to Hewlett-Packard, Palo Alto, California 94304. Europe: 54 Route des Acacias, Geneva. Prices: hp 3460B Digital Voltmeter, $3600; hp 3461A AC/Ohms Converter-DC Preamplifier (complete), $2075. Prices of 3461A options on request.

097/20A

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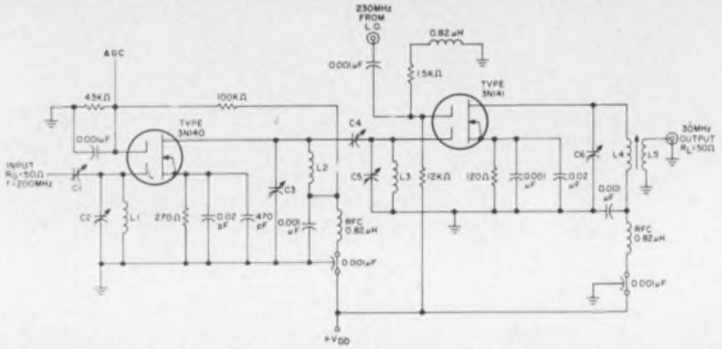
DIGITAL VOLTMETERS

INFORMATION RETRIEVAL NUMBER 6

RCA Solid State Data for Designers



Dual-Gate (Mos) Fet's for vacuum-tube front-end performance

Here are two of the most revolutionary transistors you can work with today—the 3N140 and 3N141 dual-insulated-gate depletion type MOS FET's. Used as an RF amplifier the 3N140 will give you an unneutralized 200MHz power gain of 19dB (typ), maximum feedback capacitance of 0.03pF, transconductance of 10,000 umhos, typically, and the flexibility of working with two independent input electrodes. The 3N141 offers a square law mixing characteristic and excellent isolation between the signal and local oscillator gates which minimizes oscillator pulling under strong signal conditions.

What more do you get? Improved cross modulation performance. Low spurious responses. Exceptional stability at VHF. Reduced oscillator feed-through and increased gain control range with cross-modulation characteristic actually improving near cut-off. Both units feature insulated gates for greater signal handling capability without diode-current loading, negligible AGC power requirement and improved thermal stability. You combine performance characteristics of two well-known devices—vacuum tubes and bipolar transistors—using the best attributes of each. Circle Reader Service #91.

Get your "LINEAR DESIGN LAB" Kit Now

We have a new kit for you—with all the circuits and background materials you need to get your feet wet in linear integrated circuit applications design. For example, 11 different circuits—and with data sheets and application notes for each one. You get all these to work with: RF and IF amplifiers; wideband amplifiers; multifunction amplifiers; op amps; arrays of devices and amplifiers, and our famous "Universal" amplifier. There are 26 units in all—with replacements readily available from your RCA Distributor. Along with the units to make this "lab" complete, you will get the newest RCA Linear Integrated Circuits Manual. (IC-41)

You'll find this kit—$39.95 at your Distributor's*—has it all... in one complete, convenient package that's designed for designers. Circle Reader Service #92.

Suggested Resale Price.

Noise problems? Check these OP AMP units!

Everybody's talking about OP Amp noise—but we've done something about it! Our new "A" family of units are quiet with a capital "Q" as you can see from the specifications. You can build your designs around any of *four* industry standard packages, too... TO-5; flat pack; plastic dual in-line and our new, exclusive ceramic dual in-line... and with either ± 6V or ± 12V supply.

Choose the "package"—and the parameters—from these two lists:

Package style	6-Volt Types	12-Volt Types
Flat pack	CA3008A	CA3016A
TO-5	CA3010A	CA3015A
Dual in-line plastic	CA3029A	CA3030A
Dual in-line ceramic	CA3037A	CA 3038A

Open loop voltage gain	60dB typ.	70 dB typ.
Common-Mode rejection Ratio	94dB typ.	103 dB typ.
Output voltage swing	6.75 V typ.	14 V typ.
Input offset voltage	0.9 mV typ.	1 mV typ.
Input offset current	0.3 uA typ.	0.5 uA typ.
Input bias current	2.5 uA typ.	4.7 uA typ.
Input impedance	20 KΩ typ.	10 K Ω typ.
Output impedance	160 Ω typ.	85 Ω typ.
Noise factor	12 dB max.	16 dB max.
	(@ ±6V, 1KHz)	(@ ± 12V, 1KHz)

Circle Reader Service #93 for full details.

Hermetic Metal Devices at Plastic Prices*

Look what as little as 19¢ will buy*.

The shielding—dissipation capabilities—hermeticity that only a metal package can give, for one thing. That's why we call these units our PHP line—combining **P**rice, **H**ermeticity and **P**erformance... and we have another name for them, too, the Max Value line because they give designers maximum value right across the board! Many of them meet the requirements of MIL-S-19500 (marked with + below).

Pick from any of these 11 PHP

units for your designs (priced from 19¢ to 39¢*):

2N5179+	Low noise UHF Amplifier
2N5180	Low noise VHF Amplifier
2N5181	High gain RF/IF Amplifier
2N5182	High gain RF/IF Amplifier for low current applications
2N5183	1 ampere General Purpose Amplifier
2N5184	High frequency high voltage amplifier
2N5185	High frequency high voltage amplifier
2N5186+	High speed switch
2N5187+	Medium current high speed switch
2N5188+	High speed high voltage ½ amp switch
2N5189	High speed high voltage 1 amp switch

**1,000 units. See your RCA Distributor for his price and delivery.*

For more information about this broad line which can satisfy most of your signal transistor needs, Circle Reader Service #94.

AC Triggers (DIACS) for sale—Right now—in quantity!!

If you've been naving delivery problems on Diacs, rest easy. RCA has a new trigger diode in a hermetic DO-26 case, and the big news is it's available right now in volume quantities. The same RCA assembly line that has been producing millions of lead-mount rectifiers is now rolling out "car loads" of top-quality Diacs. We pass the cost benefits of a mature production line right back to you... and you get the added plus of proven hermetic reliability at plastic prices.

Performance-wise, RCA's new Diac shapes up as follows; typical breakover voltage of 32 V (dc)... excellent breakover voltage symmetry of ± 3 V... Peak pulse current = 2 A ...and low breakover current = 50 uA at breakover voltage.

So if you have Triac circuits that are awaiting triggers, await no longer. Circle Reader Service #95 for details.

RCA—Single source for audio power transistors

Today's audio circuit designer demands a broad line-up of silicon and germanium power transistors. And we'd like to suggest where he should look first for a single source of low cost reliable devices. RCA audio transistors feature the widest choice of silicon power units, making possible quasi-complementary circuits up to 70 watts rms! Matching this silicon capability, we have many fine germanium p-n-p transistors at attractive prices for designers working with the complementary-symmetry approach.

To you, this means an uncompromised choice of quality silicon power transistors (now with 2 pace-setting families in plastic, one having an industry-high dissipation rating of 83 watts, the other 36) for your designs requiring silicon... and a choice of quality germanium power transistors for your designs requiring germanium.. We wrapped up the details on RCA's audio power transistor line in an attractive brochure which includes 11 ready-to-go circuits. Circle Reader Service No. 96 for your copy.

Yes... RCA has photocells!!

And, we feel they're the finest in the industry! Why? Well, our devices right now are meeting the toughest demands in applications such as oil burner controls, coin changers, as well as millions of streetlight controls across the country. We have four basic hermetic packages for you to work with—a 1" diameter cell plus TO-5, TO-8 and TO-18 versions that bring solid-state engineering to light sensitive devices.

Use them in designs like automatic door openers, light flashers, storage level indicators, counters, door openers, tape card readers—wherever you need quality and performance in a photocell control. There are over twenty-five cadmium-sulfide and cadmium sulfo-selenide types in RCA's line... all of them are fully described in a new data sheet. Write in now and we'll also send you a 30-page application brochure packed with "now" ideas on how to use photocells!!

For product information on all items listed above, write RCA Electronic Components and Devices, Commercial Engineering Sec. QG3-1, Harrison, N.J. 07029. For price and delivery see your authorized RCA Distributor.

RCA

FIVE GOOD WAYS TO LEARN ALL
ABOUT THE LATEST IN MICROWAVES

*By visiting all the leading microwave plants and interviewing their best designers and researchers.

*By attending all major conferences on the subject.

*By developing and editing state-of-the-art articles covering latest design techniques.

*By writing extensively about new developments and trends.

*By working for Electronic Design... the magazine whose editors make it their business to know.

Good salary,
excellent benefits, and
association with top professional engineer-writers can be yours.
If you are an engineer with experience in microwaves or communications systems, and are interested in the possibilities, call or write Robert Haavind, Managing Editor, Electronic Design, 850 Third Avenue, New York, New York 10022, (212) PL 1-5530

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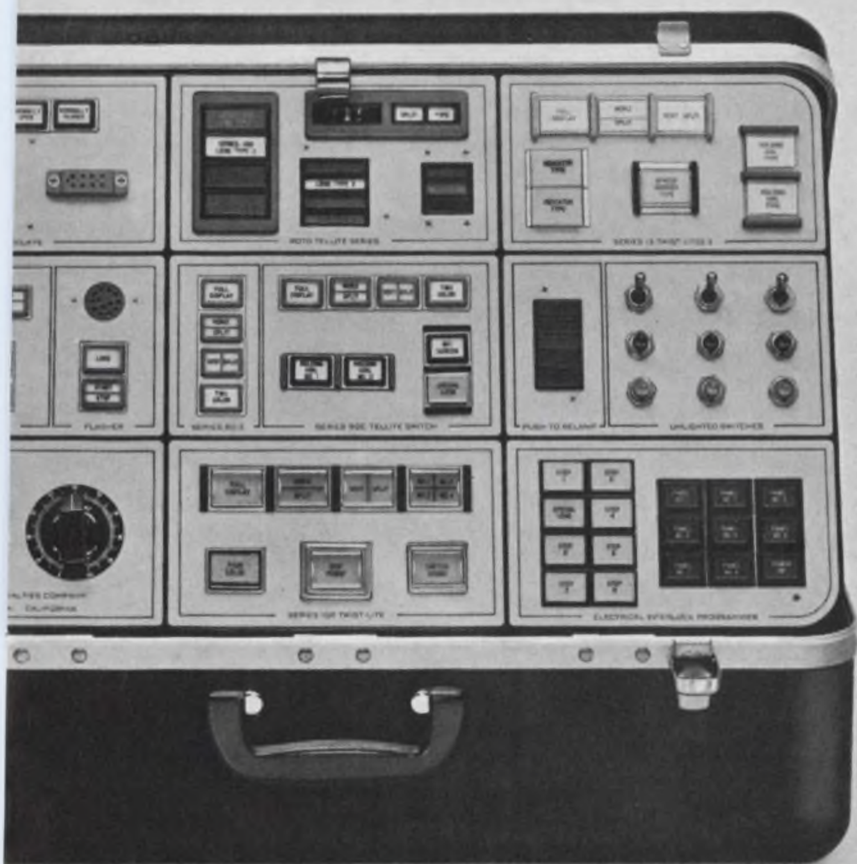

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Please send me your latest catalog on power supply modules:

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INFORMATION RETRIEVAL NUMBER 10

Designer's Datebook

MARCH						
S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24/31	25	26	27	28	29	30

APRIL						
S	M	T	W	T	F	S
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14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

For further information on meetings, use Information Retrieval card.

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. 420

Mar. 21-23
Symposium on Microwave Power (Boston) Sponsor: International Microwave Power Institute; J. Sterling, Raytheon Company, Lexington, Mass. 02173.

CIRCLE NO. 421

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. 422

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

CIRCLE NO. 423

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. 424

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

CIRCLE NO. 425

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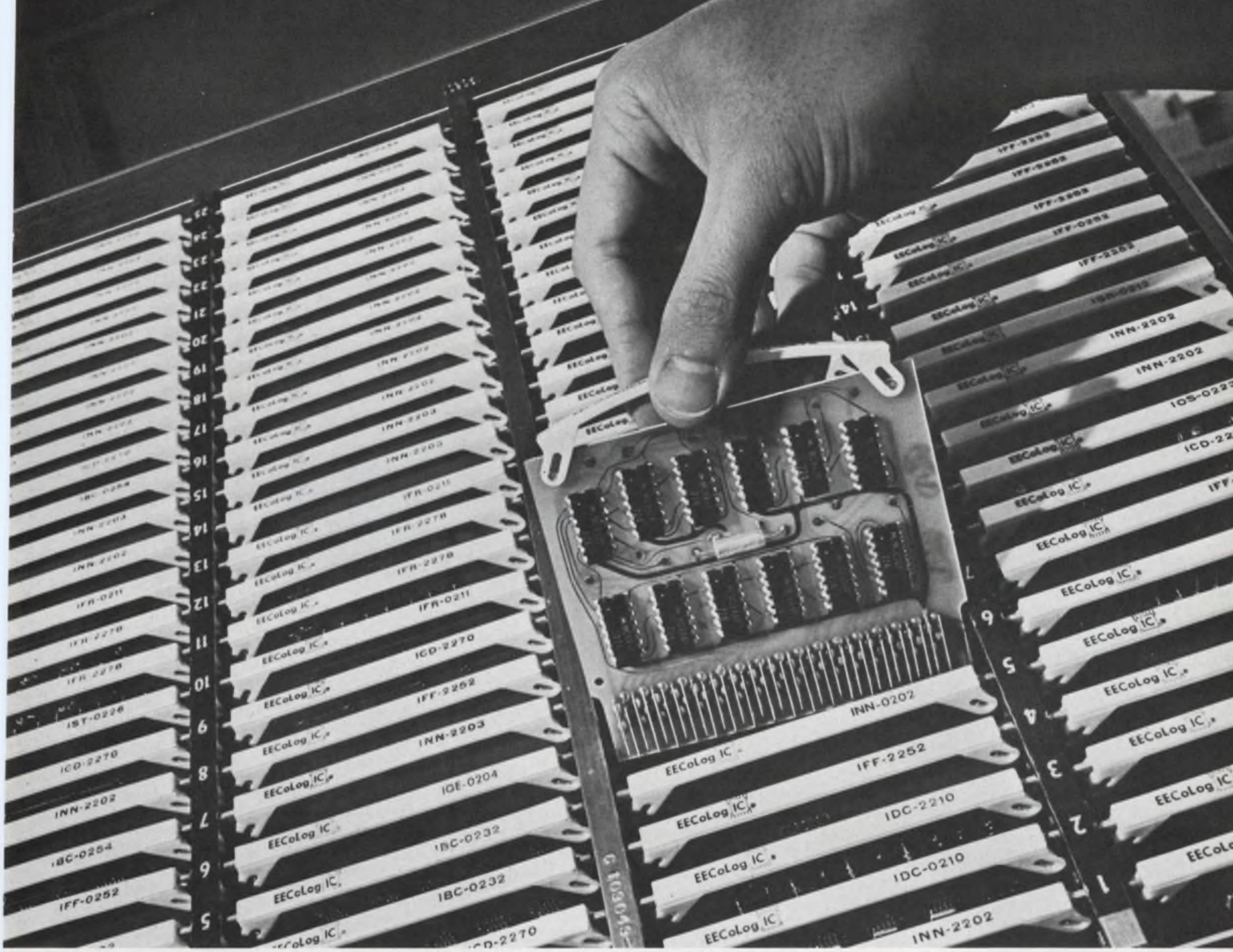

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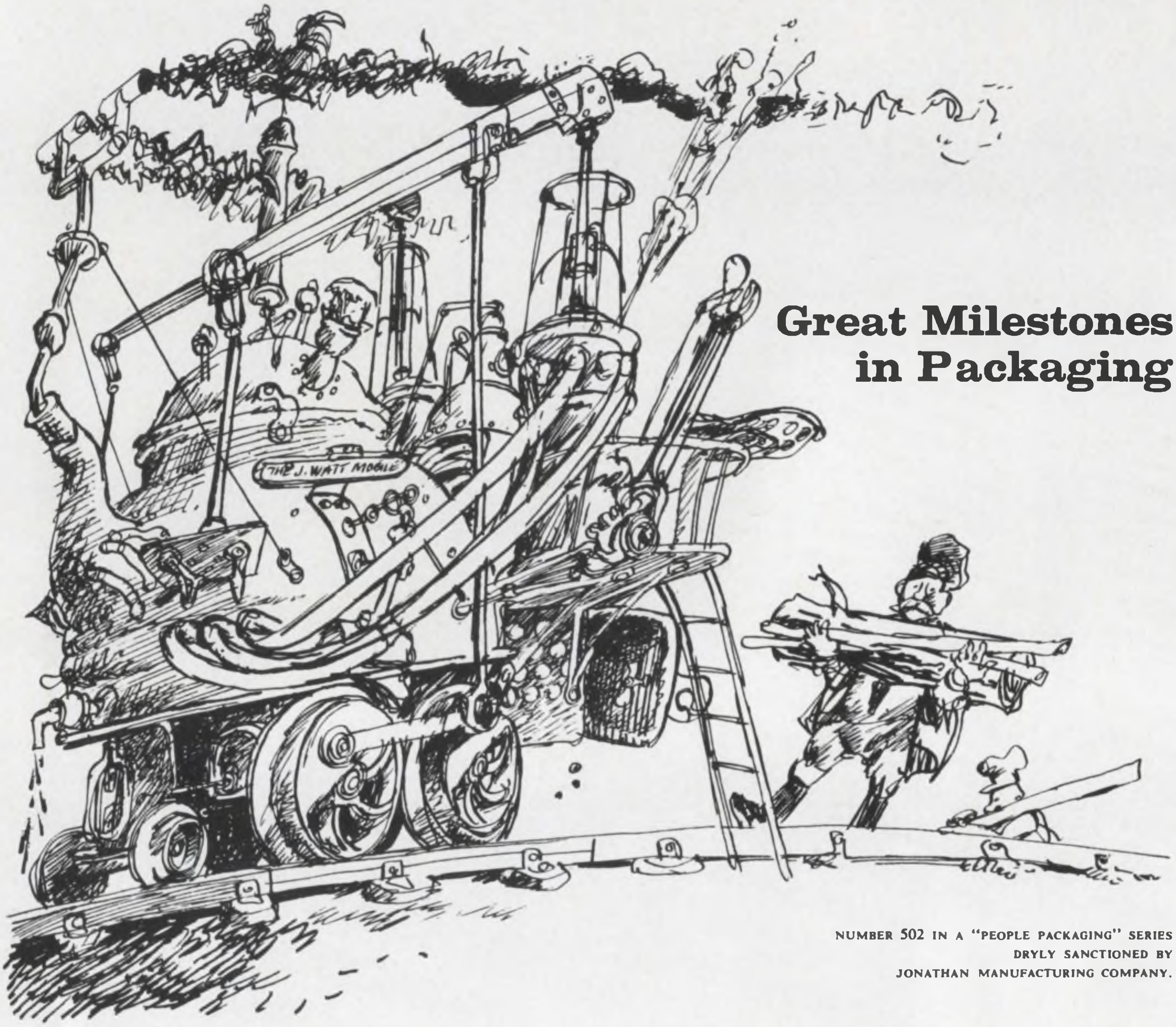

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INFORMATION RETRIEVAL NUMBER 12

INFORMATION RETRIEVAL NUMBER 212 ▶

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2 SELECTION GUIDELINES — Selection of the proper amplifier for every application is made easy. A new series of handy graphs show at a glance the interactions of various key parameters and how they affect circuit performance.

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$2\mu V/°C$, 3×10^5 CMRR

High gain, fast response, lowest voltage drift and best CMRR are outstanding features of models 143 and 147. Chopper stabilized types can often be replaced by these models where low drift and differential inputs are required.

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0.01% accuracy $<1\mu s$

Fast settling time of models 148 and 149 make them ideal op-amps for A/D and D/A converters, sample-and-hold circuits, and other applications where speed is the most important parameter. 0.01% settling time of 1 μs is the fastest available anywhere.

MODEL	141	142	143	147	148	149
OPEN LOOP GAIN	8×10^4	8×10^4	10^5	10^6	3×10^4	10^5
RATED OUTPUT (±10V)	2mA	20mA	20mA	10mA	20mA	15mA
FREQUENCY RESPONSE						
Unity gain, small signal	3MHz	5MHz	5MHz	10MHz	10MHz	15MHz
Full power response, min.	50kHz	150kHz	100kHz	150kHz	500kHz	1.5MHz
Slewing rate, min.	3V/μs	10V/μs	7V/μs	10V/μs	50V/μs	100V/μs
Overload recovery	1.4ms	1.5ms	1.5ms	400μs	15μs	0.5μs
Settling time to 0.01%	—	—	—	—	1μs	1.5μs
INPUT IMPEDANCE	$10^{11}\Omega$	$10^{11}\Omega$	$10^{11}\Omega$	$10^{12}\Omega$	$10^{11}\Omega$	$10^{11}\Omega$
CMRR	1000	2000	40,000	300,000	2000	15,000

MODEL	141			142			143			147			148			149		
TYPE	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
VOLTAGE DRIFT (μV/°C max.)	75	40	25	50	25	15	30	15	7	15	5	2	50	25	15	30	15	7
I_{bias} @ 25°C (pA max.)	50	30	30	50	30	30	30	15	15	30	15	15	50	30	30	30	15	15
PRICE (1-9)	$25	$30	$35	$30	$40	$55	$55	$65	$90	$95	$115	$135	$42	$47	$62	$75	$85	$105

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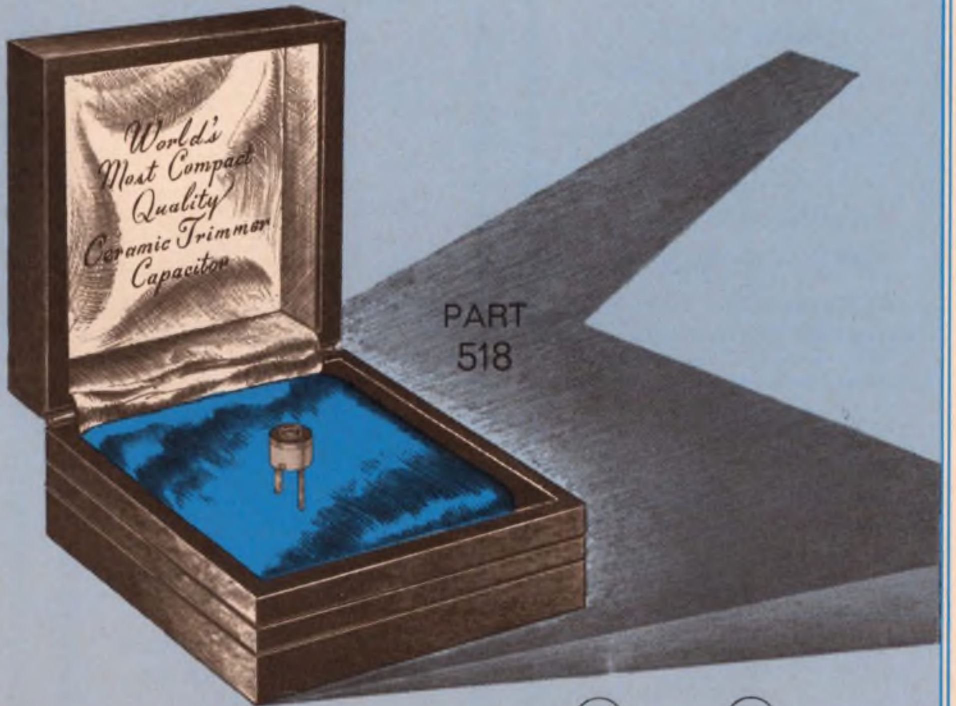

AMAZING 1.0 to 25 pF. CAPACITANCE RANGE IN LESS THAN .007 CUBIC INCH

- **Two mounting arrangements.**
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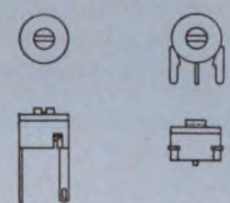

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Operating Temperature Range	−55°C to +125°C
Working Voltage	100 WVdc to 85°C 50 WVdc to 125°C
Dielectric Strength	200 Vdc 1 - 5 sec.

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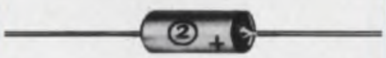

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Type 151D, non-polarized
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to MIL-C-26655 and MIL-C-39003

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for Highest Reliability

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Type 351D, non-polarized
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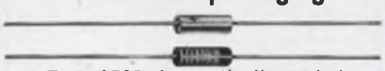
specially sized for "cordwood" packaging



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in Resin-sealed metal cases

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Type 170D, single-ended, non-polarized
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Type 196D, radial lead for printed wiring boards
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Type 926D, 4 lead, .375" x .265" x .065"
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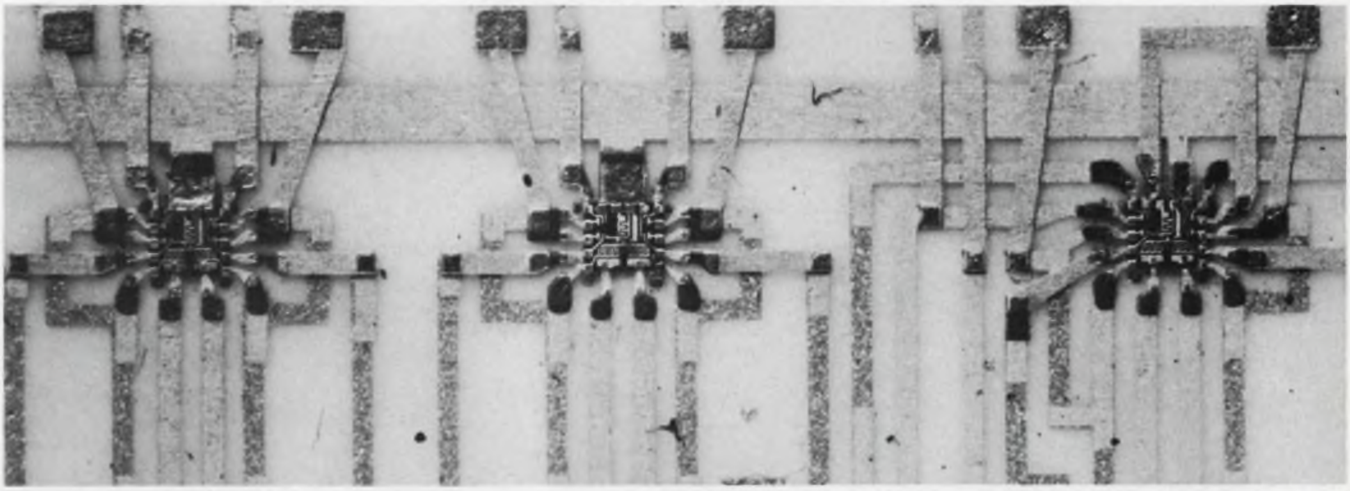
News



Right-side-up flip-chip, using Teflon dielectric, is an example of advances reported at this year's International Solid-State Circuits Conference. Page 25

The Federal Administration's 1969 budget calls for $76.7 billion to be spent on defense needs. A large portion of money will go to next-generation weapon's systems. Page 34

Also in this section:

New from Sprague!

5 Times the Resistance of a Conventional Metal-Film Resistor of Equal Size!

Type	Wattage Rating	Size	Maximum Resistance
Extended-Range Filmistor Resistor	1/10	.095″ D. .250″ L.	1.5 MΩ
Conventional Metal-Film Resistor	1/10	.095″ D. .250″ L.	0.3 MΩ

EXTENDED-RANGE FILMISTOR® METAL-FILM RESISTORS

Substantial saving of space in all wattage ratings—1/20, 1/10, 1/8, 1/4 1/2, and 1 watt—with absolutely NO SACRIFICE IN STABILITY!

Extended-Range Filmistor Resistors now offer, in addition to accuracy . . . stability . . . reliability . . . resistance values in size reductions which were previously unobtainable. Size and weight advantages of Filmistor Resistors now make them ideal for applications in high-impedance circuits, field-effect transistor circuits, etc. Many designs which previously had to settle for the higher temperature coefficients of carbon-film resistors in order to obtain required resistance values can now utilize the low and controlled temperature coefficients of Filmistor Metal-Film Resistors.

Other key features are ±1% standard resistance tolerance, low inherent noise level, negligible voltage coefficient of resistance, and tough molded case for protection against mechanical damage and humidity.

For complete technical data, write for Engineering Bulletin 7025D to Technical Literature Service, Sprague Electric Co., 347 Marshall Street, North Adams, Massachusetts 01247.

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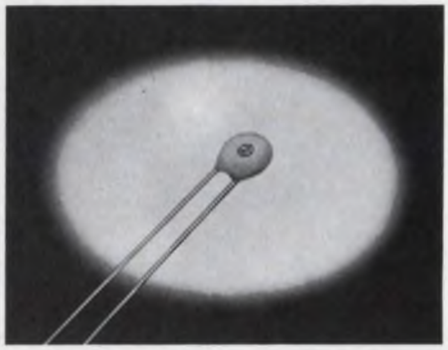
INFORMATION RETRIEVAL NUMBER 81

Epoxy-Dipped Tantalex® Capacitors for Applications Where Tantalum Capacitors Were Previously Too Expensive



The advantages of tantalum, previously available only in expensive industrial capacitors, can now be had in a low cost capacitor — the new Type 196D Solid-Electrolyte Tantalex Capacitor, designed and developed by the Sprague Electric Company.

Intended for industrial electronic and communications applications where costs must be held at a minimum, Type 196D Tantalum Capacitors have a special epoxy-dip coating which insures circuit economy without any sacrifice in dependability. This epoxy coating positively seals the capacitor section while providing excellent electrical insulation. It also protects the capacitor against damage in handling and installation.

The radial lead design of these new solid-electrolyte capacitors is particularly well-suited for printed wiring board applications—their .250″ lead spacing will fit standard .125″ grids.

These low cost tantalums offer high stability — they exhibit very little capacitance change, even at the outer limits of their operating temperature range (—55 C to +85 C). The low dissipation factor of Type 196D Capacitors permits higher ripple currents.

These capacitors meet the environmental test conditions of Military Specification MIL-C-26655B, and are available in a wide range of capacitance values in voltages from 4 to 35 volts d-c.

For complete data or application engineering assistance, write to Tantalum Capacitor Section, Field Engineering Department, Sprague Electric Company, 347 Marshall Street, North Adams, Massachusetts 01247.

INFORMATION RETRIEVAL NUMBER 82

News Scope

Low-budget moon trips will follow Apollo Craft

Despite the National Aeronautics and Space Administration's shrinking budget, a fairly healthy program for exploring the moon was outlined last week by George E. Mueller, NASA's associate administrator for manned space flight. He testified before the Manned Space Flight Subcommittee of the House Committee on Science and Astronautics.

Before he gave his testimony, a NASA spokesman said the U.S. would not send a man on a circumlunar flight, as it is rumored the Russians will do this fall, because we don't need to. Our unmanned Surveyor and Lunar Orbiter craft sent back enough pictures and data to enable NASA to select five suitable sites for landing men. The only reason our astronauts would take a nonstop trip around the moon, the spokesman indicated, is if a subsystem in the Apollo craft failed, making a descent to the moon unsafe.

A number of projects are planned for exploring the moon after the early Apollo's tasks are completed, Mueller told the subcommittee. The first flights in 1969 are intended to collect soil samples and to leave the initial geophysical package that will send back data on such phenomena as the inner structure of the moon, the near-surface layering, radiation environment, seismic measurements and heat flow.

Later missions, Mueller said, will be longer. The distance the astronauts can travel from their lunar module will be greater; the payload to the moon will be bigger, as will the payload of trophies they can bring back to earth.

To extend the radius of exploration on the moon, roving vehicles or flying machines are possibilities. Bendix and Boeing have each built roving vehicle prototypes and Bell Aerosystems Co. of Niagara Falls, N.Y., has done a study of a flying craft.

The guidance accuracy must be improved, Mueller told the Congressmen, to ensure better landing accuracy. If this can be done, later missions can venture outside the established landing sites without using extra fuel.

Extended visits can be accomplished, Mueller said, by sending dual missions to the moon. One Saturn 5 can take supplies, while another sends up astronauts.

Eventually a manned mission just before descending to the moon's surface might eject a small scientific satellite to orbit the moon.

It would measure magnetic fields, radiation environment and the gamma-ray spectrum. It could be used for geodetic tracking and to relay communications.

RCA now marketing its printed circuits

With production of printed-circuit boards more than adequate to supply its own needs, the Radio Corp. of America has raised its output and is going into the business.

New printed circuit line by RCA.

With a new $4-million facility at Moorestown, N.J., plus modernization of its old plant at Camden, the company has more than tripled its production capacity to 30,000 multilayer circuits a month, in addition to 300,000 single- and double-sided circuits. The added capacity has been achieved principally by a high degree of mechanization, especially in the Moorestown plant.

Although RCA will still be its own biggest customer, it plans to sell 30 to 40 per cent of its circuit boards outside, mainly to industrial and aerospace users.

NASA seeks advances in manned-space design

NASA's director of advanced space missions says that the U.S. has the basic technology to send man to the planets of the solar system but that significant changes in system design will be required before long missions can be conducted.

Dr. Franklin P. Dixon, speaking before the IEEE Winter Convention on Aeronautics and Electronic Systems in Los Angeles said that while lunar missions lasting from a few days to a few weeks might be accomplished with existing technologies, missions extending into years, would require more complex subsystems.

"For this reason," he added, "it appears necessary to provide on-board replacement of repair capability during the mission. This requirement will markedly change the design of our present generation of subsystems, to allow the astronauts to diagnose failures, change components and reverify system operation."

The system most affected by this requirement is the data-handling and display system, Dr. Dixon said. He stressed that a data rate of 10^8 bits a day could be generated by a moderately comprehensive experiment program, and that if high-resolution photographs are to be transmitted, the data rate could grow to 10^{11} bits a day or higher.

This data rate may exceed present transmission capability by nearly an order of magnitude. A simple solution to accommodate the difference, Dr. Dixon said, would be to have the crew edit out redundant or meaningless data prior to transmission back to earth.

To free the crew from routine tasks, automatic mounting or subsystems will also be needed, Dr. Dixon said.

Another major system that will require substantial up-rating with longer flights and larger crews is the power supply, he went on. For a crew of six to nine men, Dr. Dixon estimated that more than 10 kw of power would be required. Two power sources are under consideration; the presently used solar-cell system array and an isotone-brayton-cycle dynamic generating system. The latter would use a plutonium-238 isotope to heat an inert gas, such as argon, which would then be expanded through a turbine to generate electrical power. Plutonium-238 is being considered becouse radiation protection from the alpha particles and secondary decay emissions require a relatively light weight shield.

Color video recorder uses tape cartridge

A prototype of a color video tape-cartridge recorder and playback unit for the home-entertainment market has been demonstrated by Arvin Industries, Inc., of Indianapolis. The company expects the unit to be in production in 1969 or early 1970.

The CVR XXI recorder, which reportedly will sell for from $1000 to $1500, instantly plays back, in color, programs televised by a network. Push buttons control operation for both recording and playback, and all levels are set automatically. Up to one hour of material can be recorded on a single cartridge.

The unit employs a longitudinal scanning principle with a stationary head, as opposed to the more conventional helical or transverse, scanning with rotating heads. This is made possible by reversing direction and changing tracks at the end of the 10-track tape in less than a second. The demonstration model used Dupont's CROLYN magnetic tape, though any good-quality, one-half-inch tape can be used, according to Arvin.

Though the transport was developed by Arvin, it employs some of the technology licensed to it by Newell Associates (See "Low-Cost Tape Transport Records 50-MHz," ED 13, June 21, 1967, p. 38).

Telemetry aircraft may monitor missiles

The U.S. may use a fleet of telemetry-acquisition aircraft to receive test data from its new, more complex missile warheads during reentry and the last crucial seconds before they dive into the sea.

The Mitre Corp. at Bedford, Mass., is studying the feasibility of building such a fleet, called Telemetry Range Instrumentation Aircraft. The results of the study will be passed on to the Air Force's Electronic Systems Div., at Hanscom Field, Mass.

Aircraft can do the job better than ships, Mitre says, because they extend the range of line-of-sight transmissions. The improved coverage would permit one aircraft to receive telemetry data from several warheads landing in different places at the same time. With directional antennas, a plane should be able to reacquire the missile's telemetry signal after reentry blackout and provide coverage to impact. The system should also circumvent multipath problems and pick up weak signals.

Enter, the DC-10; Exit the BAC-111?

American Airlines' announced intention to purchase the McDonnell-Douglas DC-10 Airbus is still reverberating throughout the aircraft and avionics industries. The possible buy, $400 million for 25 aircraft delivered by late 1971 and a $400 million option for 25 more delivered in 1973, could influence procurement by competitive airlines, observers feel. Principal losers at least initially, are General Electric and Lockheed Aircraft and its suppliers for a similar Airbus, the L-1011. Also affected by the purchase are many suppliers of airborne electronics equipment.

Observers in Washington feel that a "deal" has been made. American Airlines apparently wants to dump its relatively new, but operationally disappointing British Aircraft Corp. BAC-111s—small twin-engine, short-range jets. It is believed that despite previous statements by a top McDonnell official that GE engines had been selected for the DC-10, Rolls-Royce engines will be purchased instead. Thus by a complex swap, the British would take back the unwanted BAC-111s from American Airlines if it demands British engines on the new Airbus.

Braniff and Mohawk airlines are also reported to dislike their BAC-111s, and both have expressed an intention to purchase an Airbus. The belief is that they, too, will then seek a similar arrangement with Rolls-Royce.

However, the engines may be built in the U.S. This negates any balance of payment argument.

Comsat is soliciting bids for 2 advanced Intelsats

Comsat has let out requests for proposals on two Intelsat communications satellites that would be more advanced than the Intelsat 3 satellites being produced by the TRW Systems Group.

The first new satellite, Intelsat 3.5, would accommodate 1900 two-way voice circuits, compared with 1200 for Intelsat 3, and two prototypes would be launched in mid-1969.

The second proposed satellite, Intelsat 4, would have at least 5000 voice circuits and would provide greater operational versatility. The first of four vehicles would be launched in mid-1970.

When Comsat receives proposals for Intelsat 3.5 on March 9, it will be looking for 1400 circuits, available through narrow-beam antennas, and 500 circuits through global-coverage antennas.

Intelsat 4 will weigh 2430 pounds, in order to house two options: one with 12 transponders and the other with 16.

Proposals are due April 8.

Toroid selection for pulse transformers used to be a nightmare.

But our ferrites have changed all that.

They're Pulse-Rated. A first for the industry.

The only toroids with specified characteristics for pulse transformer applications. Not just the usual irrelevant magnetic properties. Each part is designated as a pulse component, and listed by its pulse inductance, pulse magnetizing current and ET product, according to ASTM methods.

We also guarantee all parameters. Every pulse transformer toroid we make is 100% tested. Performance reliability is assured from samples to production quantities. We make use of automatic high speed testers to guarantee these parameters.

It marks the end of trial and error spec'ing. Especially for computer applications. The 230 mil diameter core is just the first in our series of PR toroids.

For literature or samples of our new PR toroids, write Indiana General Corporation, Electronics Division/Ferrites, Keasbey, N. J.

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"There's another giant in Jolly Green's Valley." (ho ho ho)

Already people are saying that we're much bigger in the relay and timer business than we claim to be. They're saying there's another giant up in the Jolly Green's Minnesota Valley.

That's a bunch of nonsense!

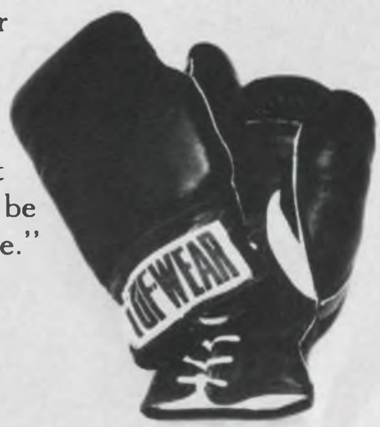
Sure we've cracked some tough nuts for people like 3M Company and Collins Radio and IBM, but that's because we dove into their problems head first and didn't come up until we had an answer. We kinda feel that our customers like that attitude when they come in with a timer or relay problem . . . instead of the Ho Ho Ho they get from some of the giants.

There's usually not much Ho Ho-ing around here until later. Because you can bet that the first time a customer contacts us, it's not with a fat, easy order. He's usually been busting his knuckles for weeks with a tough, dirty little problem. He's finally up against it, and he wants an answer fast.

Sure it's tough!

But, we don't expect people to come around passing out relay or timer orders like popcorn. In fact, when you're a little guy, you expect 'em to come around with problems that will back you up against the wall a few times. But we don't mind . . . we always remember what Pop used to tell us about the village roughneck: "If you just lick 'em once, he'll be your friend for life."

Wanna fight?



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INFORMATION RETRIEVAL NUMBER 16

LSI impresses at solid-state conference

Subnanosecond digital circuits, memories on a chip surge, consumer, microwave ICs gain slowly

Large-scale integration was the theme of the 1968 International Solid-State Circuits Conference held in Philadelphia on Feb. 14-16. The main thrust was in the digital area, where computer designers are concerned about the need for ever-faster storage access times and logic. In fact, the experts foresee subnanosecond logic operation in the next generation of LSI.

The conference, which was divided into formal daytime sessions on the campus of the University of Pennsylvania and informal panel sessions at the Sheraton Hotel, also dealt with microwave and consumer ICs, novel circuit techniques, new devices and new materials, as described in the succeeding pages.

MOS chips accessed at random

They are here.

Ever since the advent of MOS integrated circuits, computer designers have awaited the first random-access MOS memory arrays. Now several companies have shown their intentions:

- Radio Corp. of America, Somerville, N.J., will shortly offer a 16-bit X-Y select array using complementary MOS for customer evaluation.
- Philco-Ford Corp. will place on the market in 1969 a 256-bit chip using p-channel MOS. It will sell for $10, or 4¢ a bit—equivalent to the cheapest cores.
- Fairchild Semiconductor Div. has developed a 64-bit coincident-select array for random-access storage. Fairchild has no present plans for selling these arrays, says Joseph F. Friedrich of Palo Alto, Calif., who presented a technical paper on this development.

These developments are far from evolutionary. Nothing like them has been available up to now. While it is possible today to buy monolithic shift registers handling 100 bits, they cost about $50, or 50¢ a bit—an order of magnitude higher than the 256-bit random-access memory array described to Electronic Design by Donald E. Farina of Philco-Ford's Microelectronics Div., Santa Clara, Calif. Farina was one of the panelists in an informal session devoted to the status of MOS technology.

Farina said that this p-channel MOS array would occupy a single 9000-square-mil chip and would have a cycling time of 200 ns. He predicted that MOS bulk memories in the megabit range would be fabricated in the form of plastic packages, particularly flip-chips, at a cost of 2¢ a bit.

"Six months ago I would not have thought so," he said. He even envisions arrays selling for a penny a bit by 1972.

For the moment, monolithic shift registers, such as the dual 100-bit devices used in International Business Machines Corp.'s series 360, model 85, are faster than MOS random-access memory arrays.

David Lynch of Emerson Electric Co., St. Louis, said in a telephone interview:

"MOS arrays, on the other hand, while only fair in speed, are truly random access, potentially competitive in cost with cores, rugged, capable of high-density packaging, and high-temperature operation and have low power requirements.

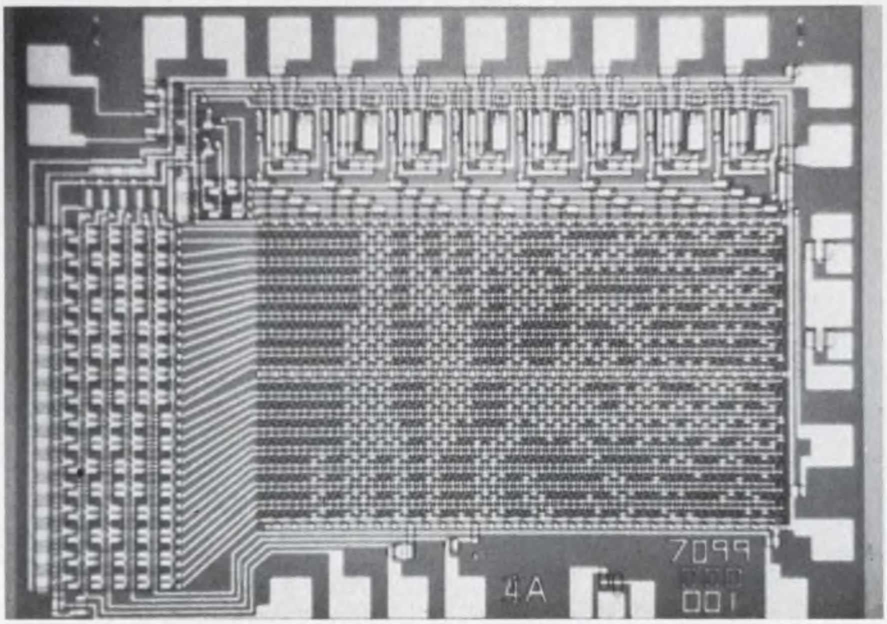
Joseph R. Burns of RCA, a panelist at the informal session on computer memories, feels that complementary MOS technology promises access times that are competitive with shift registers. Thus he would "rule out bipolars except for very, very small high-speed registers."

However, the shift register, too, can be vastly upgraded by the rapidly changing LSI technology.

In a technical paper, Dr. Clare G. Thornton, director of R&D for Philco-Ford's Microelectronics Div., Blue Bell, Pa., predicted that by extending high-density MOS technology, "a 50,000-bit, 10-chip assembly will eventually be fabricated at a cost per bit of a few hundredths of a cent."

A complete digest of technical papers is available for $8 from H. G. Sparks, Moore School of Electrical Engineering, Univ. of Pennsylvania, Philadelphia, 19104.

—*R.N.E.*



1024 bits of read-only memory on a chip is characteristic of the next generation of LSI using MOS technology. Each 70 by 100 mil chip contains 1250 transistors. Dr. Clare G. Thornton of Philco-Ford predicts 5000 bits on a chip.

The LSI computers in your future

Wide variance in opinions marked spirited discussions at the Solid-State Circuits Conference of the role that large-scale integration (LSI) will play in future computers.

IBM's view was spelled out at an afternoon technical session through a description of "Computer X," a general-purpose LSI machine of the 1970s. Max Paley, director of advanced computing systems for the IBM Research Laboratory in San Jose, Calif., envisioned a processor capable of operating at 1000 times the instruction execution rate of the 7090 computer. To manage this extremely fast computation, he predicted that machines would be built with a hierarchy of memory types, each with different speed, capacity and access capabilities.

Dr. Gene M. Amdahl, IBM Fellow, who is generally known as the architect of the IBM 360, echoed this view at an evening panel session on future memory systems.

The emergence of memory as a key design element was also emphasized at another panel session on the impact of LSI on computer design. This panel, including a programer, system designers and device designers, came up with other startling. observations.

Total semiconductor-industry sales of logic for general-purpose computers might total only about $30 million in the mid-'70s, despite a marked rise in central processing units (CPUs) to 50,000 a year, according to Charles Hobbs, president of Hobbs Associates, Del Mar, Calif., a consulting firm. His estimate was 20,000 gates in each CPU, with an average projected cost of 3 cents a gate.

He expressed surprise, in view of these projections, that the semiconductor industry has been pushing the cause of LSI for central-processor logic.

Other chip markets

But he and other panelists suggested that other markets would prove much more lucrative for the chip suppliers. LSI memories, time-sharing terminals, small-scale computers, control computers for instrumentation systems, and other special-purpose machines — all were cited.

The data-terminal business, where a remote user is tied by a communications link to a distant central processor, looks promising, most panelists agreed. Since many similar terminals are expected, repetitive manufacturing was deemed practicable. And, explained Dr. David Evans, director of computer sciences at the University of Utah, the terminals will, of necessity, be fairly complex for two main reasons:

- Memory and logic at the terminal will reduce communications requirements, and the cost tradeoff will be in favor of this choice.
- Central processors will be so loaded, it will be necessary to do as much of the auxiliary work as possible at the terminals.

Small consumer computers may become an important market also, both panelists and audience members speculated. Computers for the home, the car, the gasoline station, and the student were mentioned.

Machine organization and the role of the programer in design were topics that brought the widest divergence of opinions. Some thought that many of the steps now taken in programing could be built into LSI machines. Dr. Mel Conway, director of advanced systems research for Univac, disagreed. He said that if industry knew how to build programing into the machines, it would do it now.

Several ideas for machine organization based on programing concepts were suggested, but the panelists did not appear very

"Every home, every car may have a computer," commented a Westinghouse device designer at the computer LSI session, as he tried to defend the great promise foreseen by semiconductor manufacturers for LSI logic.

"Everybody talks about associative memories, but nobody sells them," complained panelist Ivan Flores.

Super Zener

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Who would be mad enough to come into the market with a four-dollar-and-fifty-cent Zener when you can buy some cheaper than aspirin.

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Our new LM-103, Super Zener, has the sharpest low-current knee there is. It's a monolith, packaged in a two-lead TO-46 header.

Impressively, breakdown voltage changes less than 150 mV when the current is varied between 10 μA and 10 mA or only 15 mV between 100 μA and 1 mA. This is true for any of the 10 voltages available from 5.6V down to 2.4V.

The only way to get our $4.50 Zener any cheaper is to buy them at $3.00 for 100 or more. O.K. now, let's hear from the big spenders. National Semiconductor Corporation, 2975 San Ysidro Way, Santa Clara, California 95051 (408) 245-4320.

National Semiconductor

INFORMATION RETRIEVAL NUMBER 17

optimistic about most.

"There are about 60,000 computers in place today," Dr. Conway said, "and right now IBM is delivering about 15,000 a year—about 70 per cent of the market. In a matter of years, at this rate, three-fourths of all computers will be 360 models. This is enough of the total to force standardization."

Thus IBM's plans become a critical factor in all future computer design. And that is why attention was focused on the "Computer X" discussion.

In projecting the rate of computer technology advanced in the next decade, IBM's Paley explained the prediction of a machine with an instruction execution rate 1000 times that of a 7090 computer.

This extrapolation depends on a circuit speed of about 1 ns — about 20 times better than the 7090 and about five times better than even 1969's fastest expected circuits. Paley did not foresee the ability to achieve such speeds on a single wafer containing thousands of circuits. Thus multiple chips will be needed. But to keep path lengths small, the packing density will have to stay within 200 circuits per square inch.

The designer will then face some new problems. At these densities cooling will then be a serious problem. Decoupling and noise elimination will also be difficult.

System level problems may be even more serious. Paley estimated that the peripheral gear would improve less than 50 times over that available for the 7090. "Computer X" will have to handle about 130 million instructions a second at a 10-to-20-ns clock rate. This implies a memory with under 50-ns cycle time. If tapes are used, this instruction rate would require 65 tape machines running continuously! On the average, 230,000 instructions would be expected between input-output requests. To meet these needs, Paley predicted, many peripheral functions will have to be built into the machine.

The hierarchal memory structure was proposed as a solution to this difficulty.

Dr. Amdahl elaborated at the memory panel session on this structure. He foresaw three general access-speed ranges for these various memories:

- High-speed storage with less than 50-ns access time. These will probably be integrated circuits.
- Medium-speed stores—of less than 500 ns. All major memory types are competitive in this speed range.
- Slower main memories—of less than 5 μs. Ferrite cores, magnetic films and plated wire seem the most likely contenders here.

The 360-computer architect preferred faster small, "window" memories to ultra-high-speed main memories. These would be 8-to-16-word groups put together. Dr. Amdahl contended that on a statistical basis, the words used most recently were much more likely to be referred to than others.

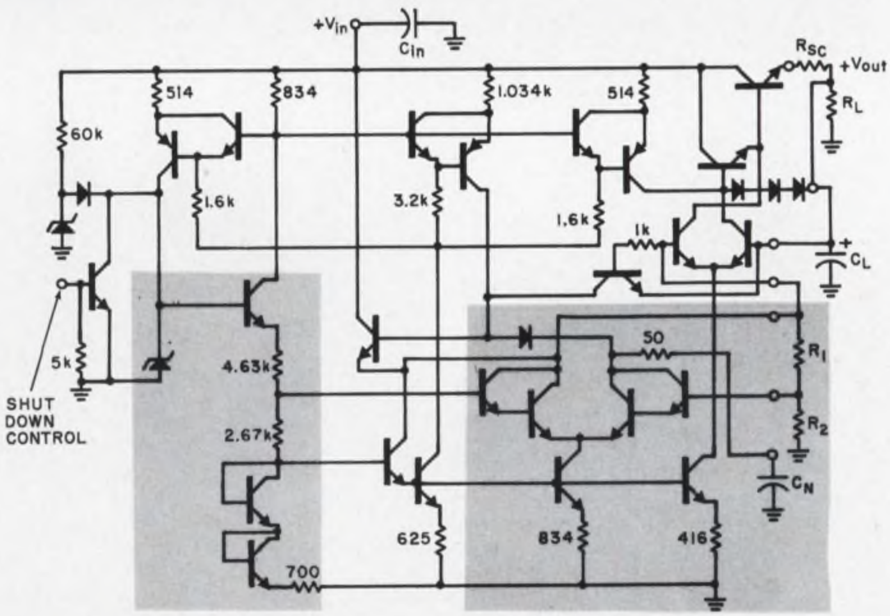
Associative memories are not suitable for this window storage, he said. The speed is slower and the cost twice or three times higher per bit. *—R.H.*

Half-amp voltage regulator fits on a chip

Down-to-earth devices and techniques, even in these days of LSI, still stir the greatest interest among designers at electronic conferences. Thus when T. M. Frederiksen of Motorola Semiconductor Products, Inc., Phoenix, described a simple, practical IC voltage regulator at a circuit-techniques session, the audience was enthusiastic. No wonder. Here are some of its characteristics:

Max current output: 750 mA
Minimum input voltage: 8 Vdc
Output voltage: 2-30 Vdc
Output Z (dc to 100 kHz): 0.015 ohm
Transient recovery time: 2 μs
V_{out}: 30 ppm/°C

The temperature stability of the regulator is largely attributable to the stable bias reference circuit (see left shaded area in the schematic). Here the temperature drift of the zener diode and the transistor is compensated for by the two transistors in the emitter leg, connected as diodes. — *P.N.B.*



500-mA, 2-to-30-Vdc voltage regulator on a 60-by-60-mil chip. The dc reference shifting circuit (right shaded area) receives its reference voltage from the bias reference circuit (left shaded area). This bias circuit also supplies reference voltage to three single-transistor current sources (bottom). Output voltage is adjusted by selecting the ratio of R1 and R2. The supply can be turned on and off by applying a signal to the shutdown terminal. The company expects the unit to be on the market in two or three months in nine-pin TO-66 packages, selling for $7 or $8 in small lots.

The follower leader.

The great thing about our new LM102 voltage follower is that it's the first monolithic amplifier that has combined low input current with high speed. A slew rate of 10V/μs means fast operation. Yet, the maximum input current is an incredible 10 nA.

The circuit is designed so that leakage isn't a problem. Input currents better than 10 nA at 125°C can be guaranteed. Considering high temperatures, it even gives better performance than FET amplifiers.

The LM102 has an offset voltage less than 5 mV, a guaranteed accuracy of 0.1%, needs no external compensation and is short circuit protected. Plus, it's a plug-in replacement for both the LM101 and the 709 in voltage follower applications.

Although it's really not a complete operational amplifier, it's a dream in low drift sample and hold circuits. And it's a wonder as a buffer amplifier for high speed analog commutators, in active filters or as an impedance buffer in analog computation circuits.

The LM102 will cost you $30.00 each for 100 or more pieces. For $12.00 we'll give you an LM202, which works from −25°C to +85°C. If you're really pinched, the LM302 does it on a 0°C to 70°C temperature range for $5.50. And you can get them all today.

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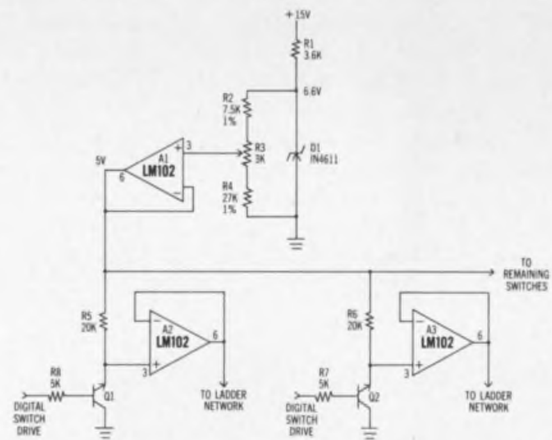

Voltage Reference and Ladder Driver for a Digital to Analog Converter uses Simple Switch Circuitry which can be driven directly from RTL, DTL or TTL Integrated Circuits.

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INFORMATION RETRIEVAL NUMBER 18

Microwave ICs: Gains, but no revolution

While the microwave engineer attending the conference found no surprises, he did see a pattern of evolution, especially in microwave integrated circuits and solid-state power sources.

Dr. Rudolf S. Engelbrecht of Bell Telephone Laboratories, Murray Hill, N.J., outlined promising applications of solid-state bulk negative resistance effects in n-type gallium arsenide and cadmium sulfide. He cited pulse generators, voltage tunable oscillators and fixed and controlled waveform generators. These functions, he indicated in a technical paper, will depend on the formation of narrow traveling high electric fields or domains in the semiconductors when they are biased beyond a critical threshold.

Dr. Engelbrecht explained how functions could be performed with bulk semiconductors that are difficult, if not impossible, to obtain with pn junctions. He said, for example, that minute blocks of material could be tapered to form a voltage-tunable solid-state oscillator. The electric field, he said, decreases from the narrow, tapered cathode end to the wide anode end. Studies at Bell Laboratories show that as the bias is increased, the frequency decreases — a necessary feature for a tunable oscillator.

Dr. Engelbrecht said that octave-wide tuning has been obtained at uhf with a 1-mm-long device and that experiments had shown the feasibility of 8-GHz operation.

Pulse current trains can be generated in uniform blocks of materials by maintaining the bias above threshold, he pointed out. A single negative output pulse is generated with a short trigger pulse. Complex current waveforms can be generated by shaping the device (see figure). The spikes occur when the domains reach the anode.

Controllable waveforms can be produced by using external resistive circuits, to allow additional current to flow through the device, Dr. Engelbrecht said. This occurs when the domain passes a region shunted by an external path. By variation of the switch positions, the current waveform can be altered.

According to Dr. Engelbrecht, this property can be used to make time-division multiplexers and two dimensional memory arrays, as well as to form circuits that perform AND, OR and inhibit logic.

Progress in integrated circuits was reported by Texas Instruments, Inc., Dallas; Sylvania Electric Products, Inc., Waltham, Mass.; Microwave Associates, Inc., Burlington, Mass.; and RCA, Camden, N.J. The work shows a trend toward more complex circuits and higher operating frequencies.

George Vendelin of Texas Instruments told of a thin-film hybrid integrated receiver operating at Ku band. It consists of a balanced mixer and a Gunn-effect local oscillator. Two versions were built: one with a rectangular cavity and the other with a circular cavity to form the Gunn oscillator.

The noise performance and operating frequency of the receivers showed minimum noise figures of 11.3 dB at 12.9 GHz for the rectangular cavity, and 14.5 dB at 13.7 GHz for the oscillator with the circular cavity. Power was about 6 mW, with efficiencies of about 1.5 per cent.

Arnold Kramer of Sylvania discussed an experimental X band doppler radar transceiver that makes use of beam-leaded silicon Schottky diodes, direct microwave power generation and integral ferrite components.

The circuit uses a silicon avalanche diode oscillator within a miniature reentrant cavity to produce 30 mW of cw power.

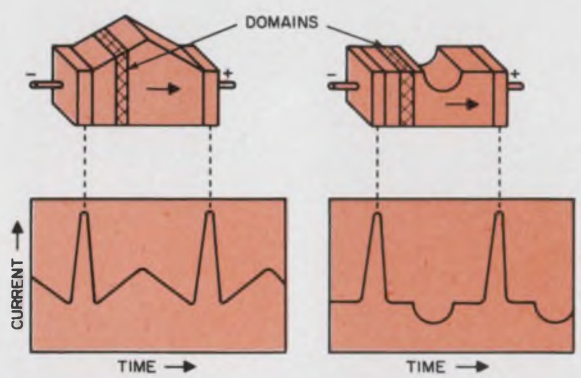
Researchers at Texas Instruments showed that varactor-tuned integrated Gunn oscillators could be integrated in microstrip.

Gailon E. Brehm, now at Stanford University, said that the simple, electronically tuned oscillators use microstrip transmission lines to form the resonant circuits for mounting the Gunn oscillator and varactor diode. He said the TI team had obtained a tuning range of more than 10 per cent at 7.5 GHz.

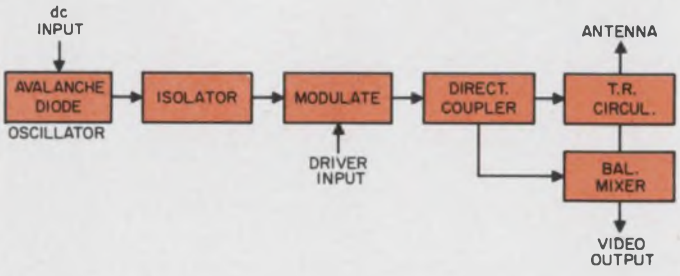
Bell Telephone Laboratories, Murray Hill, N.J., achieved higher power gain by connecting impact avalanche transit time (IMPATT) diodes in series. Dr. Wolfgang Schlosser said that the series connection of the diodes increased the output level to the sum of the individual devices, without decreasing the impedance level.

Three 4.5-GHz IMPATT diodes biased in series were operated in a coaxial cavity. Each device was capable of 250 mW of cw power, and the series produced 750 mW.

—*N.S.*



Domains in transit through shaped blocks of GaAs and CdS produce complex current waveforms.



Sylvania X-band radar transceiver built of hybrid microcircuitry occupies less than 3 cubic inches.

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The climate. Often it's compared with the Riviera's. In truth, Southern California's is better. Dryer in summer: no mosquitos, little mugginess. Balmy in winter: seven hours of sunshine a day. You'll *save* on galoshes!

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IC use in radio-tv market hinges on cost

Lower cost—not performance gains, not size reduction, not reliability improvement—is by far the dominant attraction ICs must offer the mass consumer electronic market.

This conclusion was offered by two panelists representing users at the Solid-State Circuits Conference—Donald Ruby of Zenith Corp., Chicago, and E. Q. Carr of General Electric, Utica, N.Y.

IC suppliers face considerable competition from the steady downward trend in discrete-device pricing, Ruby and Carr added.

Now that RCA's sound i-f audio IC chip in a tv set is no longer novel, Ruby argued, set manufacturers can no longer rely on ICs to glamorize sales—price and performance dictate the application.

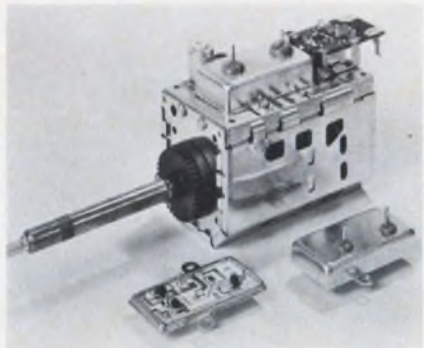
Despite extensive efforts in the last two years, IC supplies are still limited to low-frequency, low-power chips for their cost-conscious customers, the two panelists noted. No gains have been reported for the high-power deflection circuits, high-level video amplifiers, high-level color demodulator sections or low-noise rf/i-f stages.

IC manufacturers, said Howard Bonner of Texas Instruments, Dallas, are turning to color TV set designers and picture-tube suppliers in hopes that signal-processing levels can be reduced below the present 175-200-V demands; otherwise they will not be able to supply IC devices for luminance and chrominance output stages. Set and picture-tube designers are not rushing to alter their present approaches, the panelists agreed, since tubes and discrete devices are available to achieve their designs.

Circuit instability is another problem facing tv set designers, according to another panelist, J. J. Rangen of N. V. Philips, Nimwegen, the Netherlands. Single-chip, 40-MHz i-f blocks with 100-dB gain for tv sets have been successfully fabricated, Rangen explained, but troublesome oscillation effects have developed when the chips are assembled on printed-circuit boards housing other circuits. He added further that cost reduction in i-f section design did not appear overly attractive with ICs, since only 30 per cent of the cost depends on the active devices; 70 per cent for tuned circuits.

Present efforts to use R-C selective filter designs to displace L-C circuits require high-tolerance, temperature-stable elements, and these are incompatible with monolithic processing, Derek Bray of Fairchild Semiconductor told the panel at the Sheraton. Present monolithic ICs cannot satisfy TV tuner demands for low-noise, high-frequency operation, he said; hybrid thick-film approaches have been developed to meet this need.

A third factor in the use of ICs involves the highly secretive nature of the consumer industry. Zenith's Ruby explained that each set manufacturer must maintain his proprietary designs, and thus cannot allow his IC chip design to be sold off-the-shelf to competitive set manufacturers. One approach to solve this problem, he suggested, might be a master slice approach, with interconnections left to the choice of each customer. Finally, he added, a set manufacturer would require several sources of supply for each IC subsystem in his design. Not only would several IC manufacturers have to agree to fabricate those chips; they also would have to agree on a standard processing approach. *—H.B.*



Thick-film vhf tuner module developed by Oak Mfg. Co., plugs into printed inductance selector switch.

Right-side-up flip chip eliminates flying leads

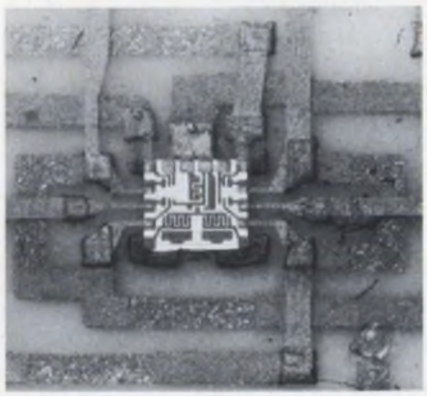
A new technique has been developed for interconnecting IC chips right-side-up, without using flying leads. The face-up chips can be tested after assembly, and the cost and reliability problems of flying leads are avoided. This process permits the interconnection, at the chip level, of otherwise incompatible devices.

A thermoplastic, Teflon FEP, is employed as the dielectric and as bonding medium between chips, substrate and interconnection patterns. Two or more levels of interconnection arc possible.

The incorporation of a variety of substrate materials, including alumina and beryllia, is permitted by the new process, which was developed by General Electric, Syracuse, N.Y. Resistors and conductors are formed by selective etching on a Xerox substrate. A 2.5-mil layer of FEP is then applied over the entire substrate, and active devices are bonded, face-up, into it.

Connections to the chips are provided by a gold conductor pattern, which is deposited on the surface of the plastic film. Copper "mesas" serve as feed-throughs between the layers of conductor pattern.

The process is intended for use in both linear and digital circuits, and for frequencies from dc to microwave. *—R.S.*



A plastic film attaches this circuit chip and its interconnections to the substrate material. The face-up configuration permits complete circuit testing. Deposited copper "mesas" serve as feed-throughs.

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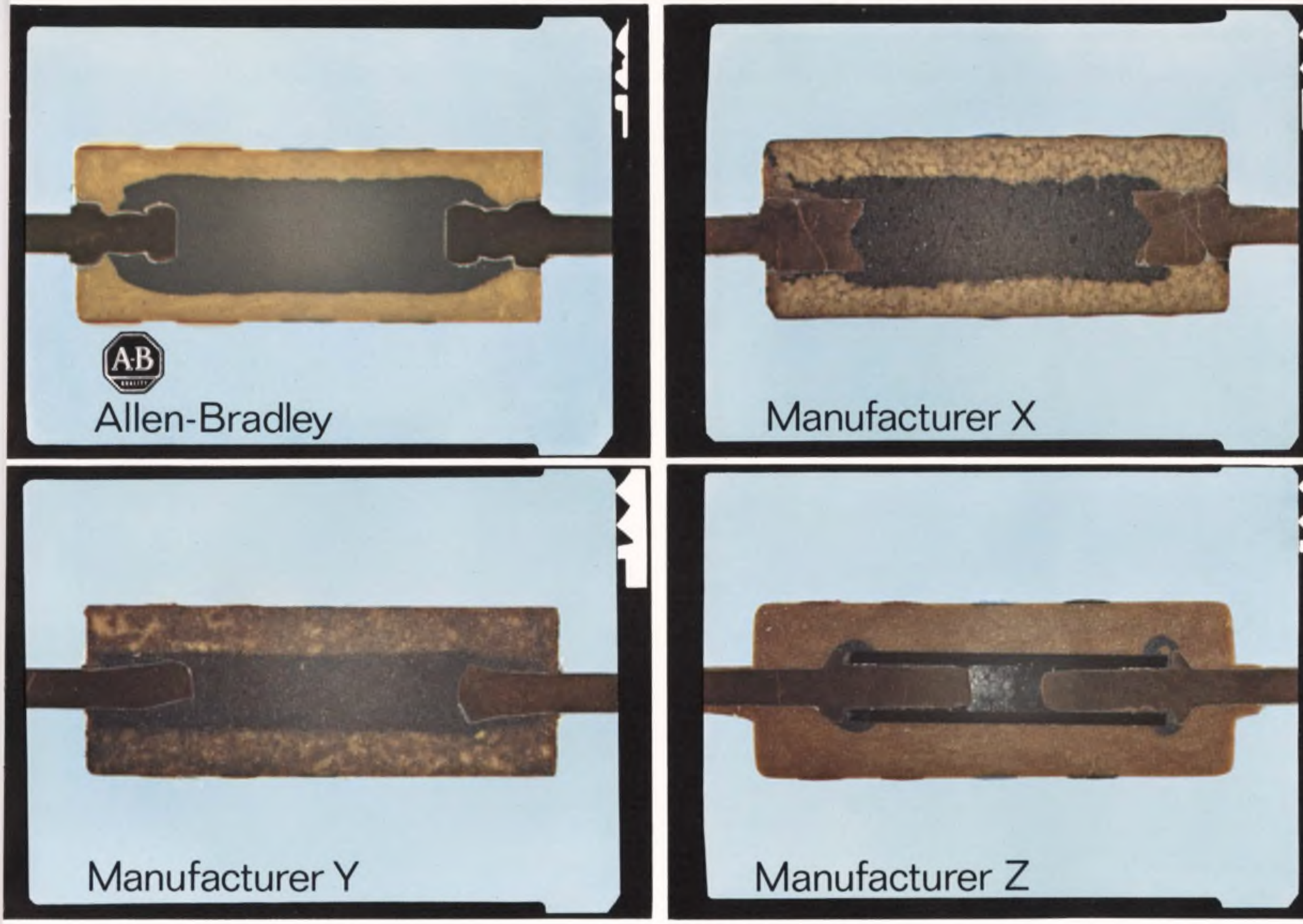

The above illustrations are from unretouched photomicrographs taken of four ½-watt fixed resistors. Compare the anchoring of the leads, the seal provided by the insulating jacket at the ends, the homogeneity of the resistance material, the sharp color code bands—and decide for yourself.

For more details on Allen-Bradley hot-molded resistors, please write for Technical Bulletin 5000: Allen-Bradley Co., 222 W. Greenfield Ave., Milwaukee, Wis. 53204. In Canada: Allen-Bradley Canada Ltd., Export Office: 630 Third Avenue, New York, N. Y., U.S.A. 10017.

1067E-4

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

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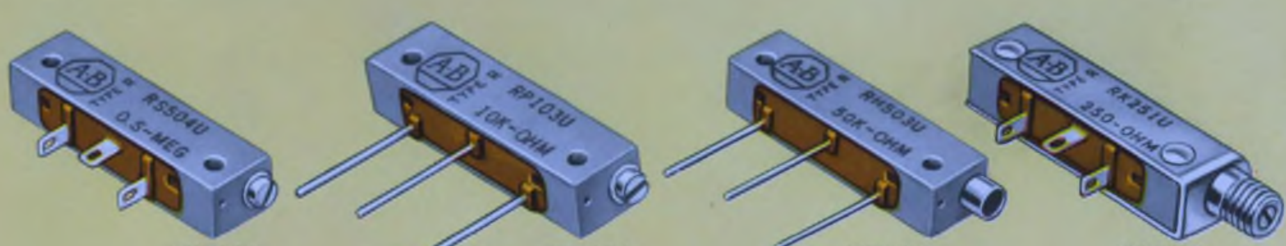
Allen-Bradley Type R Adjustable Fixed Resistors—Shown actual size



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INFORMATION RETRIEVAL NUMBER 20

1969 U. S. budget: Further electronic growth

$186-billion document contains opportunities for industry to fill defense, NASA and FAA needs

Charles D. LaFond
Chief, Washington News Bureau

President Johnson has described his record $186-billion Federal budget request for fiscal 1969 as "austere" and as one that will still provide for both butter and guns. To some observers in the capital, it would appear that some guns will have to be cast from melted butter.

For the electronics industry, the bulk of planned expenditures for product purchases and contracted research and development will be generated by national defense needs. Most of the remaining major government electronics requirements will be accounted for by the National Aeronautics and Space Administration and the Federal Aviation Administration.

Other agencies such as the Commerce Department's Environmental Science Services Administration, the National Bureau of Standards and the Maritime Administration, have R&D funding but they perform nearly all in-house. Procurement for each is relatively low.

At present, the budget is a request to Congress for approval. It will be studied, spoken over, damned and possibly praised in spots—but in the end it is doubtful that severe reductions will be made. National security, fixed obligations and self-interest will prevail, as they do every year. The principal targets for budget cuts will be repeats from last year—the Defense Dept., NASA and FAA.

$3-billion rise for defense

Defense spending requested for the new year—$76.7 billion—is up about $3 billion over last year, with the majority of the rise accounted for by increased Vietnam War costs, certain fixed expenses and a nominal inflationary rise. Reportedly, the original requests to the President by the various services exceeded $100 billion, and thus, while this represented the largest initial request in history, so did the Presidential cutbacks.

In general, there are few new programs and surprises in the defense request. Major new projects that will move to the contract-definition stage include the Convair F-106X interceptor plane (instead of the highly advanced experimental Lockheed YF-12). Development of Minuteman III will also be pressed, as will a new super-hardened Minuteman silo concept. No procurement money is included for the Air Force's long-sought advanced strategic bomber.

Money is being requested all down the line for long-leadtime procurement, systems development and nuclear warhead development and testing for the Sentinel anti-ballistic missile program. The total requested is $1.1 billion.

The Navy will receive limited, but probably adequate, financing for its advanced-ships program. Considerable sums are being sought for procurement of the massive C-5A transport plane, due to start coming out of production in the second quarter of this year. Heavy spending is requested for both the fighter and bomber versions of the controversial F-111, particularly for the Air Force.

Air Force, the big spender

The Air Force, as usual, heads the military budget list with a request for nearly $13 billion for procurement and for research, development, testing and evaluation. Nearly $10 billion of this is destined for procurement expenditures and about $1.8 billion for electronic hardware.

Over half the Air Force procurement request will be for 919 aircraft. A considerable portion of this sum is earmarked for fighter and bomber versions of the F-111 swing-wing aircraft: $1.1 billion for 163 F-111A's and $550 million

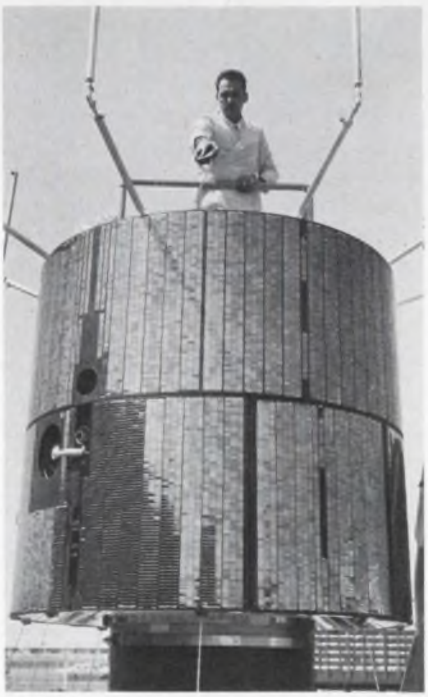
The Army budget request calls for some $700 million to be spent on communications and electronics. Rugged communications equipment for field use is expected to receive the bulk of the funds.

for 75 FB-111A's.

Just over $1.5 billion will be spent by the Air Force for strategic and tactical missiles and spares and for associated ground-support systems. In addition to Minuteman III and Titan II missiles, the Air Force will make heavy purchases of Shrike and Standard ARM, both antiradiation missiles, and SRAM, the air-to-ground short-range attack missile. It will also replenish its air-to-air missile assortment.

One surprise is the indication in the budget of the intended procurement of the AGM-79A/80A air-to-ground missile, believed to be a highly improved version of the Bullpup. Both Martin-Marietta and Chrysler Corp. are known to have been working on the development of an improved Bullpup, but it was not known that production was so close at hand. Conventional Bullpups are electro-optically guided by the pilot, whereas in the new systems it is believed that an inertial capability has been added by Chrysler and that Martin has improved the electro-optical guidance. Both will permit the launching aircraft to fire and run.

One large unknown quantity in the Air Force request for procurement under missile systems is labeled "other support." Tabbed for $728 million, this activity is described as providing for classified projects, maintenance, Government-owned production facilities and support of operational space activities. It can be presumed that much of this effort is associated with the handling of data from the Air Force's orbital surveillance satellites and probably involves both optical and electronic data-handling and interpretation.



Space applications programs, as represented by the ATS-B above, will get a modest boost in funds.

Other Air Force procurement includes over $1.8 billion for munitions and associated equipment and $296 million for electronics and telecommunications. The latter includes both tactical and strategic equipment and support items.

The Air Force research, development, testing and evaluation budget is set at $3.5 billion, with principal expenditures for space and missile programs. A total of $47 million is tabbed for use only for the Advanced Manned Strategic Aircraft program. Apparently the Air Force Manned Orbiting Laboratory program will be kept on schedule, with a significant increase ($600 million) requested. Other major R&D efforts will be for the Minuteman III program, new fighter aircraft concepts and subsystems, and a continued strong effort to improve all-weather surveillance and weapons delivery.

The Air Force will stress development of military communications satellites and satellite-tracking capabilities. Final development will be sought for the long needed Airborne Warning and Control System, scheduled for operational status by late 1969 or early 1970.

The Air Force is requesting nearly $425 million for construction, the bulk of which will probably go for the hardening of siloed ICBMs.

Ammunition heads Army costs

Army expenditures exceeding $7.3 billion are being projected for procurement and for military research and development. This is about $800 million over the previous year's budget estimate. Of this total, $269 million is requested for use only for Sentinel missile procurement.

The largest single Army outlay is for ammunition. Nevertheless, in the electronic category, subsystems required for the Sentinel and other missiles, for aircraft and spares, and for communications and electronics call for spending $1.3 billion.

The Army will continue to buy Redeye and Chaparral surface-to-air missiles for defense of the foot soldier against low-altitude aircraft. Improved Hawk missile systems will also be purchased, and the Nike-Hercules surface-to-air missile system will be improved for both U.S. and overseas air defense. Both Shillelagh and TOW anti-armored vehicle missiles will be procured in quantity. Finally, the Pershing missile system will be considerably modified to improve its ground-transport and mobile electronic-support systems.

For communications and electronics, some $700 million is being sought for the Army, with emphasis on rugged tactical communications equipment to improve field-command control over dispersed forces and weapons systems. Additional funds are included for further updating of long-haul circuits in the global defense communications system.

Over $500 million will be required to continue purchases of small Army aircraft, including the new AH-56 Cheyenne armed helicopter, a high-speed, highly mobile, flying gun platform that will be provided with a very sophisticated, automatic electro-optical fire-support system. In requesting funds to buy 1626 helicopters of all combat types, the Army is seeking to regain those craft cut from last year's budget.

A total of $1.6 billion is being requested for Army research, development, testing and evaluation. The major emphasis will be on accelerating development of both the missile and ground electronic-support systems for the Sentinel anti-ballistic missile system. Continued efforts will be pressed to improve the accuracy of Army air-defense missiles. Nearly half of the total Army research expenditures will be for missile systems. Other emphasis will be placed on the development of improved tactical data-processing systems, communications and electronic warfare equipment, and for ground systems for use with a tactical communications satellite system.

(**budget,** *continued*)

Finally, the Army will seek nearly $600 million for the construction of major facilities and for land acquisition. Nearly half this amount will be required for the Sentinel system.

High Navy electronic spending

The Navy budget for procurement and for research, development, testing and evaluation tops $9.6 billion and includes relatively high spending for electronic hardware. Current estimates indicate that electronic procurement expenditures for aircraft, missiles, ships and communications will reach roughly $2 billion. Closer estimates are difficult to obtain by examining the Navy budget, since the service includes all of its onboard electronics as a part of its ship and ship-conversion costs.

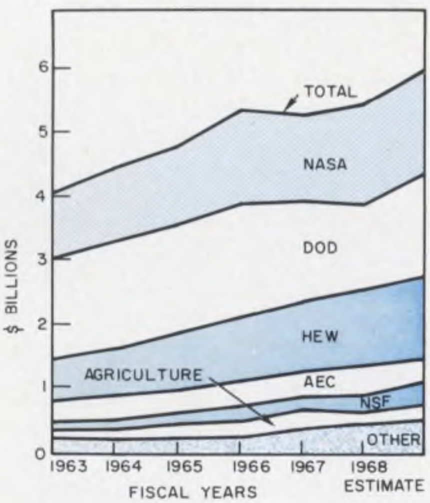
Heavy Navy expenditures are being requested for 720 tactical aircraft of all types, including patrol planes and helicopters for Marine assault missions. Included in the more than $2.7 billion requested are items limited to the purchase only of F-111B fighters ($350 million for 30 aircraft) and EA-6A electronic search and interceptor-control aircraft. Procurement will continue for fleet ballistic missiles and for all types of air- and surface-launched missiles. The latter include the new Standard missile, which ultimately will replace the existing Tartar and Terrier air-defense missiles.

Six Polaris-armed nuclear submarines will be modified to permit installation of the new, longer-range Poseidon fleet ballistic missile, now in development. The Navy will also purchase seven new antisubmarine warfare ships that have a "long-range detection and weapon capability." Also, two nuclear-powered attack submarines will be built, and additional funds are being requested for long-leadtime items for two other submarines. Funds are being asked to begin construction of five high-speed DX destroyers. Long-leadtime items will be purchased for what will be the third U.S. nuclear attack carrier and for two nuclear guided-missile destroyers. The first four fast-deployment logistics ships will go into construction to improve the flexibility of military cargo forces.

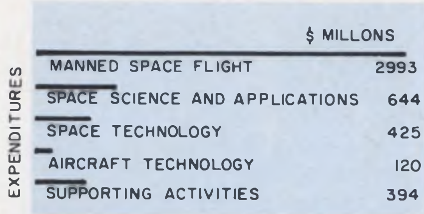
Finally, and in addition to procurement of many smaller military vessels, the Navy will begin to construct a new general-purpose amphibious assault ship—believed to be the largest of its kind in the world. It is called an LHA (for Landing Helicopter Assault), and money is being sought to buy one ship plus long-leadtime items for three more. Each ship is estimated to cost $123 million.

For communications and electronic systems not specifically destined for shipboard use, the Navy has requested $390 million. In addition, the Marine Corps has requested $149 million for communications and electronics, principally for tactical communications systems.

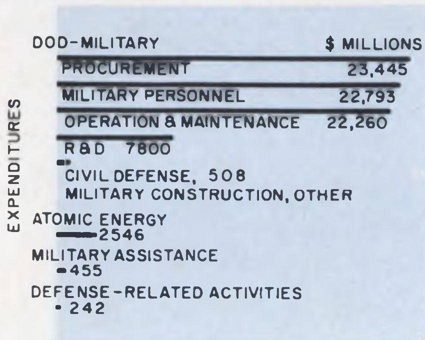
Naval expenditures of $2.1 billion for research, development, testing and evaluation are being requested. Navy efforts will center on the new VSX carrier-based antisubmarine aircraft, with continued emphasis on advanced avionic subsystems. The Poseidon fleet ballistic missile continues as a high-priority developmental system. Also, the Navy's perennial search for improved antisubmarine detection systems and improved navigational systems will be continued. The Navy's oceanographic program, now centered on the deep submergence project for underwater search and rescue, will be well financed. Night vision and imaging devices for aerial reconnaissance are also considered high-priority projects.



1. **Funds for basic and applied research** will increase from an estimated $5.5 billion in 1968 to $6 billion in 1969.



2. **Manned space flight** will continue to get most of the $4.57 billion requested by NASA. The Apollo Applications program was cut drastically.



3. **Outlays for national defense** in 1969 will increase an estimated $3.3 billion over fiscal 1968 and $9.7 billion over 1967.

Defense agencies do with less

Additional defense-oriented funds will be required by the various agencies and the Atomic Energy Commission. For the defense agencies, some $50 million will be spent, a large portion of it for equipment purchases for the Defense Communications Agency and for several military security agencies. These purchasers are, in general, for automatic data-processing equipment and electronic communications equipment.

Over $500 million is being requested for research, development, testing and evaluation within these agencies. No breakdown for either agency or equipment type is provided in the President's budget, but it can be presumed that a heavy percentage of these funds will be applied to advanced missile detection and discrimination techniques and for advanced electronic systems, principally in the computer and cryptographic fields. Electronic warfare is expected

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(**budget,** *continued*)

also to receive a fair share of the budgeting.

Construction funds totaling $85 million are being sought by the defense agencies, primarily to support activities related to intelligence and security.

Nearly half—$1.28 billion—of the Atomic Energy Commission's total expenditures for 1969 will be for military applications. Of this total, $841 million will be for the nuclear-weapons program, the rest largely for detection and measurement of nuclear detonations and radiation. While part of the weapons funds will be for nuclear stockpiling, the larger amount will be applied in direct support of the Sentinel antiballistic-missile system for the development and full-scale testing of nuclear warheads for both the Sprint and Spartan missiles.

The majority of funds requested for new AEC facilities and capital equipment also will go directly to the Sentinel program. About $285 million will be spent for new facilities for advanced weapons production.

Downward further for NASA

NASA's budget trend continues downward. While the President is requesting $4.57 billion to sustain programs under a relatively austere budget, Congress is expected to demand further cuts, probably from $200 million to $300 million.

R&D expenditures of $3.85 billion have been requested, along with only nominal construction costs of $76 million. The remainder of the budget will go for administrative operations.

As expected, manned space flight carries the bulk of the requested appropriation, with $2.1 billion being sought for the Apollo program and less than $500 million for the follow-on Apollo Applications Program. The first manned Apollo/Saturn V flight is planned for late this year, and five more flights are planned during calendar 1969. The target still is, according to the President's budget request, to make the first manned lunar landing late in 1969.

The biggest reduction of all was suffered by the Apollo Applications Program. Expenditures for this year are less than half those originally planned by the space agency for fiscal 1969. The entire Apollo Applications Program has been revamped and stretched out, with the initial launching of an orbital workshop or space laboratory planned for 1970. The hope now is that the same vehicle will be periodically reused, and there is no firm time schedule for the launching of a second orbital laboratory by NASA.

A second major NASA program appears to have been more violently slashed. The planned $2.4-billion Voyager program, which was to have explored comprehensively the Martian atmosphere and the planet surface, has been eliminated and is being replaced by a drastically reduced new program. Under a program expected to cost only $500 million during the next five years, Mariner spacecraft will be flown in 1969 to Mars to perform high-resolution topographic data collection and atmospheric profile measurements. The program also includes a Mars orbital probe planned for 1971.

Also, to begin in 1969 is development of a new Mars spacecraft, modestly instrumented and planned for launching in 1973 aboard a Titan III vehicle. One indication of the limited hardware to be installed in the small Mars landing capsule is the lack of instrumentation designed to detect life on that planet.

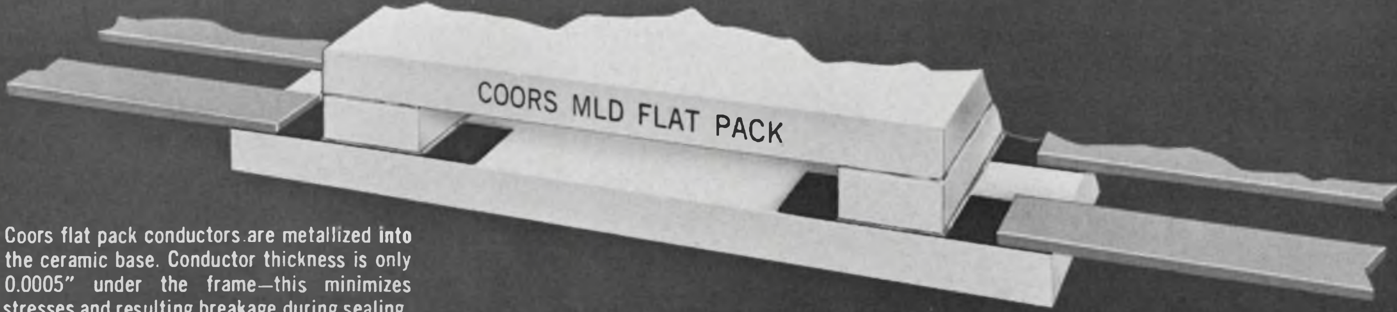
A modest increase has been given to NASA for its space applications programs. A limited effort will be conducted, looking ahead to a future Earth resources satellite. The 1969 effort will be confined essentially to the development of instrumentation and techniques, not to satellites. Aircraft will be used during 1968 and 1969 to test advanced sensors and data-acquisition systems. Funds will be included to perform studies leading to a definition of an Earth Resources Observation Satellite program.

The President is also seeking a modest increase in funds for development of a limited-thrust NERVA I nuclear engine, designed to provide propulsion augmentation for the massive Saturn V vehicle. This is a joint development program with the Atomic Energy Commission.

Other NASA expenditures will be to improve electronic systems for control, data acquisition and communications. Funds for tracking and data-acquisition support activities will be at approximately the same level as last year—a little over $300 million.

Construction expenditures are relatively low and will be spread among NASA field centers and its global tracking network. Included in the plans is a special-purpose antenna for the deep space instrumentation station at the Goldstone complex in California. Also, 210-foot-diameter anten-

The first manned Apollo/Saturn-V flight is planned for late this year with five more flights called for in 1969. The first lunar landing, according to the budget request, is scheduled for the same year.



Coors flat pack conductors are metallized into the ceramic base. Conductor thickness is only 0.0005″ under the frame—this minimizes stresses and resulting breakage during sealing.

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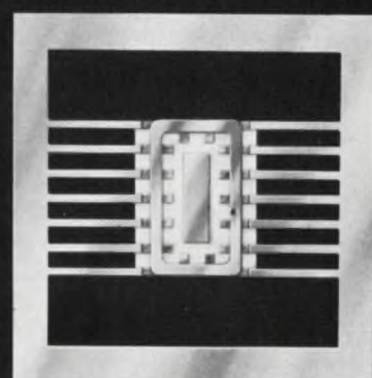
*Micro Lead Design



STANDARD COORS MLD FLAT PACKS ARE AVAILABLE FOR IMMEDIATE SHIPMENT

Coors CERAMICS

ALUMINAS • BERYLLIAS • MAGNESIAS • SPECIAL OXIDES

Coors Porcelain Company, Golden, Colorado

(**budget,** *continued*)

na systems will be installed at deep-space tracking facilities in Canberra, Australia, and Madrid.

Since the establishment of a national program to develop a civil supersonic transport plane, the Federal Aviation Administration's annual budget has produced some strange expenditure ratios. For example, one-half the fiscal 1969 budget of $1.2 billion for the FAA will be for the agency's operating expenses. One-fourth will be for the SST program, to keep it on schedule.

The President has requested $223 million more for SST development, and expenditures for the year, if approved by Congress, will be $351 million—more than three times last year's estimated outlays. The goal, under the present program, is to produce two prototype aircraft for flight testing and evaluation in early 1970.

Huge C-5A military transport will get a considerable share of the Air Force's budget request. The plane is due to start coming out of production in the second quarter of this year.

Of more immediate effect on the electronics industry are expenditures of just over $130 million for new FAA facilities and equipment and for R&D. Plans are to spend better than $100 million for all types of air-traffic-control electronic hardware, with emphasis on automation equipment ($62 million). Other major buys will include long-range radars, terminal-area radars, terminal-area computers and displays, and air navigation instrumentation, including VORTAC, lf and mf radio facilities, instrument-landing systems and visual aids.

FAA research and development will center the improvement of air-traffic control, navigation and safety. The third area of major importance will be an attempt to advance weather-forecasting techniques and sensors and to improve techniques for the communication and display of weather data. ■■

Computer-TV-phone link teaches teachers

International Business Machines Corp. has fostered a marriage of the computer, closed-circuit television and public telephone lines to provide teacher training for a parochial school system in Brooklyn, New York.

The setup, described as an experiment by Brother Austin David, technical consultant to the Roman Catholic Diocese in Brooklyn, is said to be the first embodying nearly all of the available educational electronic devices. Only the programed teaching machine has been left out.

Once a week, the teachers watch a half-hour lecture on classroom TV monitors. They then place a phone call to a digital computer at IBM's laboratory in Yorktown Heights, N. Y., some 50 miles away. The computer, which stores prerecorded voice material in digital form, asks multiple-choice questions that a teacher answers by entering coded messages on the 12 buttons of a touch-tone telephone. After each response, the computer announces whether the answer was correct or incorrect.

The computer stores more than just the immediate content of the lecture. It can automatically select pictures stored in a slide projector at the educational TV studio operated by the diocese. The pictures are transmitted over four television channels with carrier frequencies between 2500 and 2900 MHz.

Since several teachers will be viewing the TV monitors at the same time, a number of pictures must be transmitted to serve individual needs. Thus it is necessary to equip each monitor with a device that captures and holds single images. The unit, called a keyed buffer, lies between the receiving antenna and the monitor. It records each new picture and retains it on the screen until the station transmits another picture. Norman Vogel of IBM's advanced development laboratory says that the keyed buffer makes it possible to transmit up to 30 pictures a second.

Preceding transmission, the transmitter applies a coded address to the buffer. As soon as the address is decoded, the video signal is gated in and recorded. Now the gate is closed and the logic turned around to feed the signal back.

Vogel says the chief problem with any such device is the storage technique. IBM has tried endless tape loops, disks and image tubes. Since the images must be stored at the terminal—in this case, the Mater Christi High School in Queens, N.Y., where a demonstration was given—cost is crucial. An educational system like this cannot afford much.

Another IBM engineer, W. J. Levine, says that with magnetic tape, there is a problem in getting high enough bandwidth to accommodate 525 lines. Therefore, he says, it is necessary to maintain close spacing between the recording head and the recorded material—in fact, there is sometimes direct contact. This leads to head wear. If the gap is increased, the frequency response falls off. ■■

MOS flat pack converts A to D

An eight-channel analog-to-digital converter, believed to be the first such device using MOS technology, is being developed in prototype form by TRW Systems, Redondo Beach, Calif.

According to Norman Grannis, a section head in the TRW Systems microelectronics center, a single flat pack converts inputs on eight lines sequentially to a digitized single-line output. Serial binary data are taken from each channel in turn. Any number of bits from 1 to 7 can be programed (actually, 8 including zero).

The converter consists of MOS capacitors, switches and amplifiers.

The device is said to be different from other linear semiconductor devices in that it does not require precision resistors, precision current devices, or such storage elements as flip-flops. Nor does it have to be used in conjunction with expensive adder-ladder devices.

The converter has been breadboarded and its feasibility demonstrated, but it is not yet in marketable form. One of the outstanding problems in the development program is how to assimilate it into LSI devices.

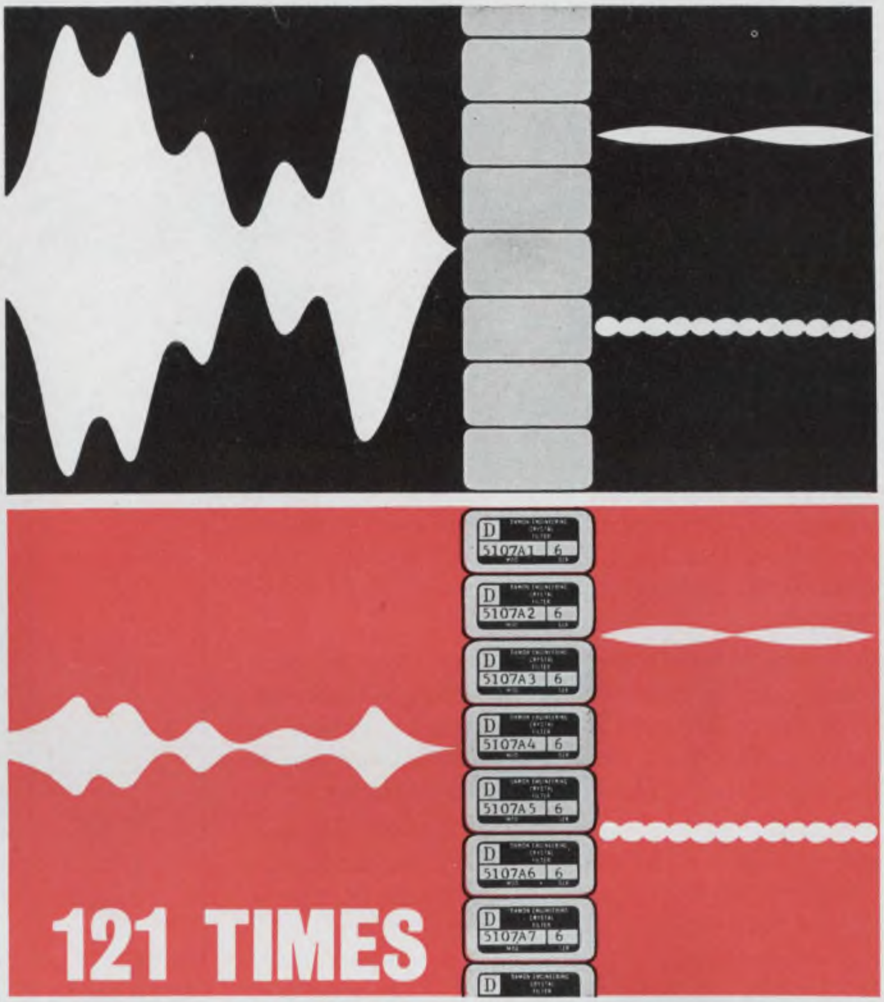
In its existing form, inputs can be cascaded in increments of eight. Or alternatively, converter outputs can be tied together to provide greater reliability. In essence, then, either the converters or the inputs to the converters can be paralleled.

Since the converter is not limited by the number of inputs, by iteration it can be expanded for larger system use, Grannis says.

Bud Johnson, applications manager at the microelectronics center, points out that transducer measurements from many remote points are transmitted in analog form along long lines. By using this converter, he says, the signal could be digitized and amplified.

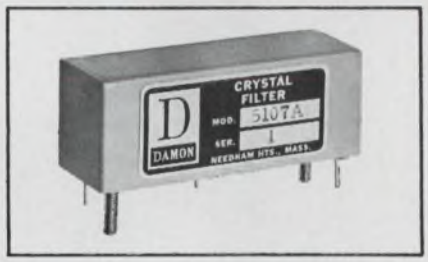
Johnson claims that the converter dissipates less than half a watt of power. Therefore, it could easily operate on battery power.

Potential applications include process control, computer control, precision voltage measurement, medical instrumentation oceanography and deep-space technology. ■■



121 TIMES LESS DRIVE POWER

with Contiguous Comb Filter Sets by Damon



Typical Contiguous Comb Crystal Filter, Model 5107A is 1 1/16" L x 9/16" W x 7/8" H.

Damon has produced a bank of 200 contiguous comb crystal filters that requires a total of 6.6 watts of drive power to obtain 10 milliwatts from each of the Gaussian (non-overshoot) response filters. This is only 1/121 of the 800 watts of drive power normally required to achieve the same output using conventional resistive padding techniques.

This significant achievement is the result of two advances in crystal filter technology: high efficiency contiguous comb crystal filters combined with new synthesis techniques. These advances permit the adherence to both frequency and time response specifications and offer a new concept in the design of radar and other spectrum-based systems. Contiguous comb crystal filter banks are also the most reliable, efficient, compact and economical precision systems available for multichannel signal processing of all kinds.

Write for data on Gaussian Response Contiguous Comb Crystal Filters to Damon Engineering, Inc., Needham Heights, Mass. 02194, Tel. (617) 449-0800.

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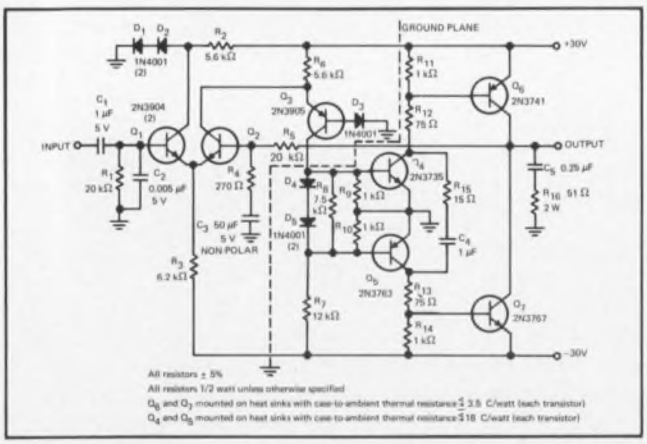

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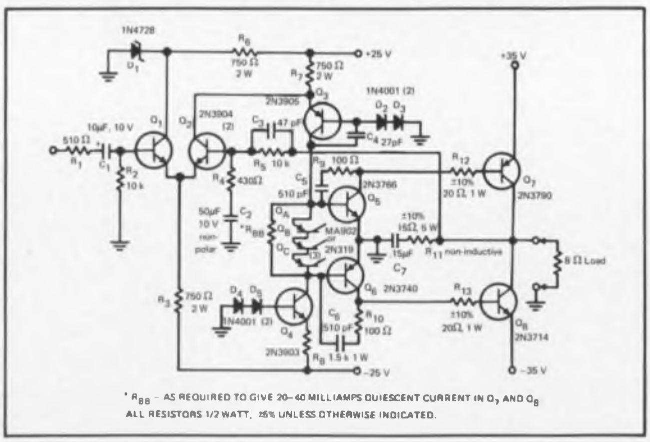

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I_C Max. Amps	V_{CEO} Volts (sus)	Package	Type NPN	Type PNP	h_{FE} @ I_C	P_D Watts	$V_{CE(sat)}$ @ I_C Volts (max)	f_T MHz	NPN/PNP Regular Combination Price (1-99)
3	40 60 80	Case 77	2N4921 2N4922 2N4923	2N4918 2N4919 2N4920	20/100 @ 500 mA	30	0.6 @ 1 A	3 3 3	$ 2.98 3.38 4.05
	40 40 60 60 80	TO-5	2N3506 2N4237 2N3507 2N4238 2N4239	2N3867 2N4234 2N3868 2N4235 2N4236	40/200 @ 1.5 A 30/150 @ 0.25 A 40/200 @ 1.5 A 30/150 @ 0.25 A 30/150 @ 0.25 A	6	0.75 @ 1.5 A 0.6 @ 1 A 0.75 @ 1.5 A 0.6 @ 1 A 0.6 @ 1 A	60 3 60 3 3	26.50 5.25 29.95 6.35 7.05
4	40 60 80	Case 77	2N5190 2N5191 2N5192	2N5193 2N5194 2N5195	25/100 @ 1.5 A	30	0.6 @ 1.5 A	4	3.58 4.00 5.95
	40 60 80	TO-66	2N4910 2N4911 2N4912	2N4898 2N4899 2N4900	20/100 @ 0.5 A	25	0.6 @ 1 A	3 3 3	3.50 4.40 5.00
5	40 40 60 60 80 80	TO-3	2N4913 2N5067 2N4914 2N5068 2N4915 2N5069	2N4904 2N4901 2N4905 2N4902 2N4906 2N4903	25/100 @ 2.5 A 20/80 @ 1 A 25/100 @ 2.5 A 20/80 @ 1 A 25/100 @ 2.5 A 20/80 @ 1 A	87.5	1.0 @ 2.5 A 0.4 @ 1 A 1.0 @ 2.5 A 0.4 @ 1 A 1.0 @ 2.5 A 0.4 @ 1 A	4	5.75 4.55 7.05 5.55 9.80 7.10
10	60 60 80 80	TO-3	2N3713 2N3715 2N3714 2N3716	2N3789 2N3791 2N3790 2N3792	25/90 @ 1 A 50/150 @ 1 A 25/90 @ 1 A 50/150 @ 1 A	150	1.0 @ 4 A 1.0 @ 5 A 1.0 @ 4 A 1.0 @ 5 A	4 4 4 4	13.30 17.20 15.35 21.60
15	60	TO-3	2N3055	2N4908	20/70 @ 4 A	115	1.1 @ 4 A	1	11.15
30	40 60	TO-3	2N5301 2N5302	2N4398 2N4399	15/60 @ 15 A	200	1.0 @ 15 A	4	18.10 21.10

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__10 A, 80 V 2N3714/3790 Kit . . . Special "3-30" kit price $10.75
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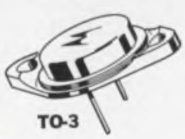
TO-3


TO-66


Case 77


TO-5

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(Be sure to include check for appropriate kit ordered payable to Motorola Inc. Mail to Motorola Semiconductors, Box 955, Phoenix, Arizona, 85001. Offer void after June 1, 1968.)

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MOTOROLA Semiconductors

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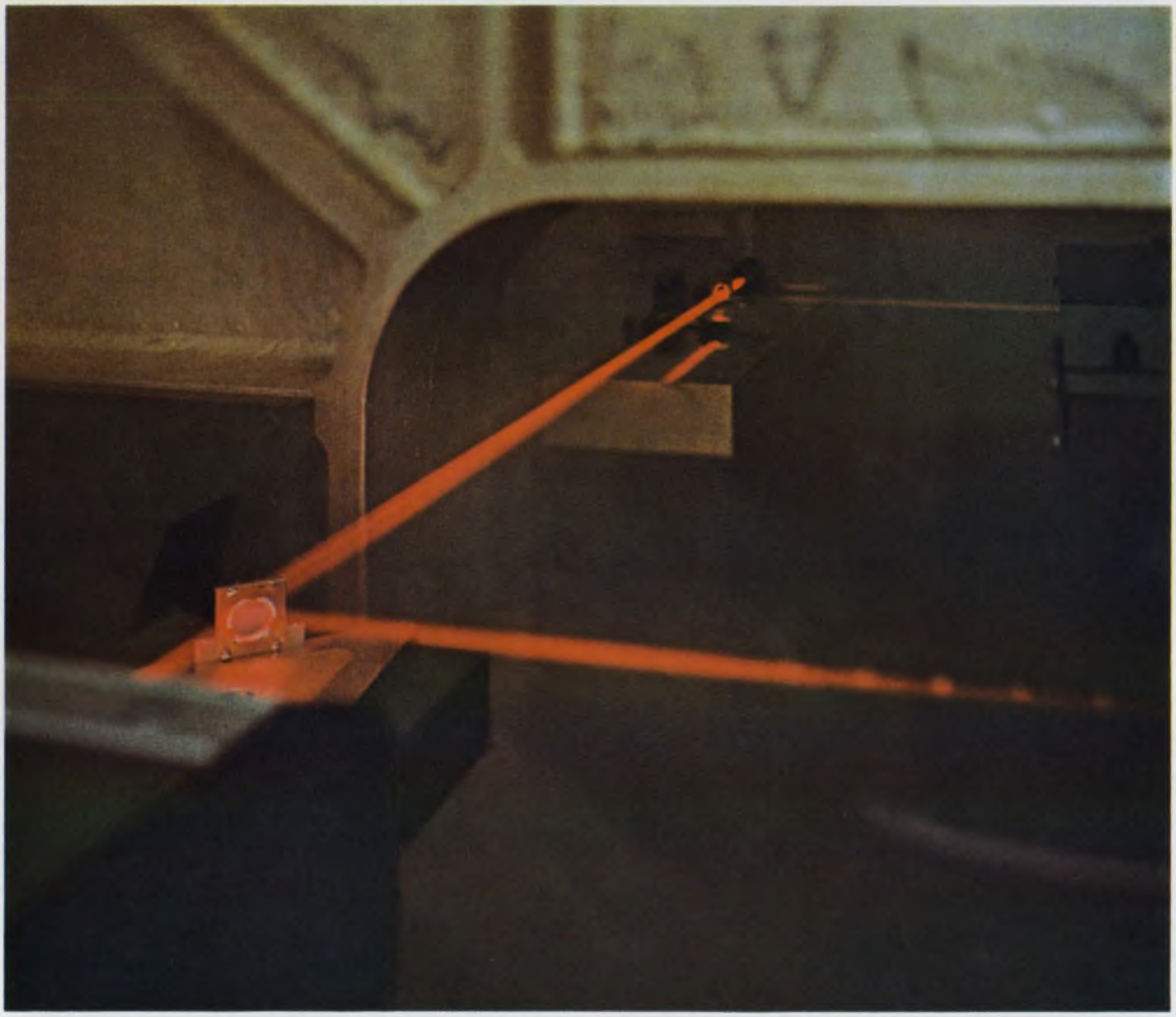

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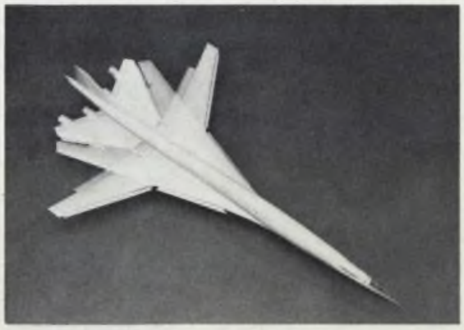
Supersonic transport back on course



Washington Report

CHARLES D. LAFOND
WASHINGTON BUREAU

SST pace up to Congress

Despite delays in the development of the Boeing 2707 supersonic transport, the program is back on course—for the time being anyway. The rate of future advances will depend largely on the mood of Congress. Last year Boeing was dissatisfied with the SST design and stepped back to take another look. It instituted significant design changes, and as of November, 1967, it accepted and essentially froze the over-all system design. The result of this delay will probably extend the time to the first prototype flight by about six months, or into 1971, according to Federal Aviation Administration officials.

The FAA is requesting $223 million in new money for SST developments. Opposition surely can be expected in Congress, but informants here believe that sufficient support exists to continue the program. A steady increase in delivery-position reservations by U.S. and foreign airlines may strengthen the FAA/Boeing position. At present 122 SSTs have been reserved by potential buyers.

The falcon, the hawk and the eagle

Once upon a time a lord and his two huntsmen had an argument. One huntsman, Usaf, begged for a new falcon; the other, Usnavy, earnestly believed he could be more effective with a new hawk. But the lord decided that both needs could be satisfied with commonality. He chose an eagle for each, to simplify problems of care and feeding. Immediately there was great consternation in the land, and both huntsmen openly expressed their dissatisfaction. They even carried their arguments to the elders in the castle. Nevertheless, it was ordered that each be given an eagle.

Later the lord, tired of squabbling, retired to his counting house, and a new master took over. He found that Usaf had become fond of the eagle but that Usnavy was quietly attempting to breed a new winged hunter—a hawgle; it would have the innards of an eagle but the plumage of a hawk.

The new lord, who had already expressed indifference to ornithology in general, readily gave his permission. The long conflict ended, and there was great rejoicing by the huntsmen and their families.

The outcome might find a modern parallel. As is well known, the Navy is far from happy with its F-111B variable-geometery fighter, despite its request for $350 million to buy 30 aircraft in fiscal 1969. And it has obtained strong support for its position in Congress.

Last October Grumman submitted a design proposal for a new Navy fighter, and additional proposals followed shortly thereafter, with competitive designs by McDonnell-Douglas, North American Rockwell and LTV, Inc. The new designs would employ essentially the same power plant and avionics now used in the F-111B, but the aircraft would have a newly designed, lighter, swing-wing airframe. Reportedly the Navy would like to settle on the final design by April and then move ahead with contract definition. It is doubtful that Congress would offer any resistance, but approval hinges on the new Secretary of Defense, Clark Clifford.

The betting in Washington is that the F-111B is dead and should be buried sometime this year.

Profiteering opposition grows

There appears to be an increasing number of Congressional leaders in both houses who are exasperated with the high war profits consistently rung up by some segments of U.S. industry. Several bills recently have been introduced in the House of

Representatives, for example, to strengthen and make permanent the Renegotiation Board. To many in Congress, the time appears right to strengthen this watchdog body—what with the national budget soaring to new heights and the President pushing for a 10% income tax surcharge. On top of this, recent evidence has been uncovered by the General Accounting Office of industrial overcharges and apparent misuses of Government-furnished equipment.

A leader in the fight to strengthen the Renegotiation Board is Rep. Henry Gonzalez (D-Tex.). The board was created during the Korean conflict to watch over Defense Dept. purchasing and to recover overcharges. It is presently far under strength, with total personnel of less than 180. The Gonzales bill would greatly enlarge the staff and the scope of the board's reviewing powers. The Representative has pointed out that in the 14-year-period through June, 1966, the board spent $47.7 million while regaining $861 million in excess profits. Without Congressional action, the Renegotiation Board will pass into oblivion at the end of June.

X-radiation bugging color TVs

In a preliminary report to a Congressional subcommittee, James G. Terrill Jr., director of the National Center for Radiological Health, stated that many of the 1200 home color television sets recently surveyed by the U.S. Public Health Service had emitted X-radiation in excess of the recommended limit of 0.5 mR per hour. Speaking before the House Commerce Committee's public health and welfare subcommittee, Terrill said that the survey of equipment, representing 27 brand names, should be completed this month. The study teams are from the Public Health Service and TV manufacturers (see this column ED No. 3, Feb. 1, 1968, page 37).

The survey began in December, and in a few cases, Terrill noted, there have been very high levels of measured radiation. He expressed satisfaction with the progress of the tests and asserted that, even at this stage of the project, it is apparent that X-radiation by TV color receivers is a problem of concern to all manufacturers. In cooperation with the Electronic Industries Association and the television industry, a conference on the detection and measurement of TV-receiver radiation will be held here this month.

The Pueblo: Questions, questions

Amid thunderous queries by everyone from Congress to the local trash collector, the Pueblo incident has the Pentagon and the State Department backed to the wall. So strong has been the national anger at the audacity of North Korea in seizing the American intelligence vessel, that Secretary of State Dean Rusk and Defense Secretary Robert S. McNamara took to the television podium to attempt clarification. They succeeded, at least in part, in explaining the U.S. position, but not to the satisfaction of most Congressmen. Demands are being made for a thorough airing before the Senate Foreign Relations Committee.

Secretary McNamara has stated three reasons for the lack of armament and other external protection on the Pueblo: (1) It would be a provocation act to arm such a spy vessel near the territorial waters of another nation; (2) The use of escort ships or aircraft might compromise the ship's mission, and (3) Protection of such a vessel automatically tends to lend itself to military escalation. What many inquirers want to know, though, is why it is less provocative to send out a partially armed spy ship than a fully armed one. Is not the act of spying near territorial waters provocative in itself?

Very shortly after the Pueblo seizure, the chairman of the Foreign Relations Committee, Sen. J. William Fulbright (D-Ark.), sent a four-page list of questions to Secretary Rusk concerning close-in surveillance by U.S. vessels in Asiatic waters.

U.S. crime net to be expanded

The Justice Dept. announced last month an allocation of just under $300,000 to expand the national crime data network. The new funds will allow 36 state and local law-enforcement agencies to link up with the National Crime Information Center.

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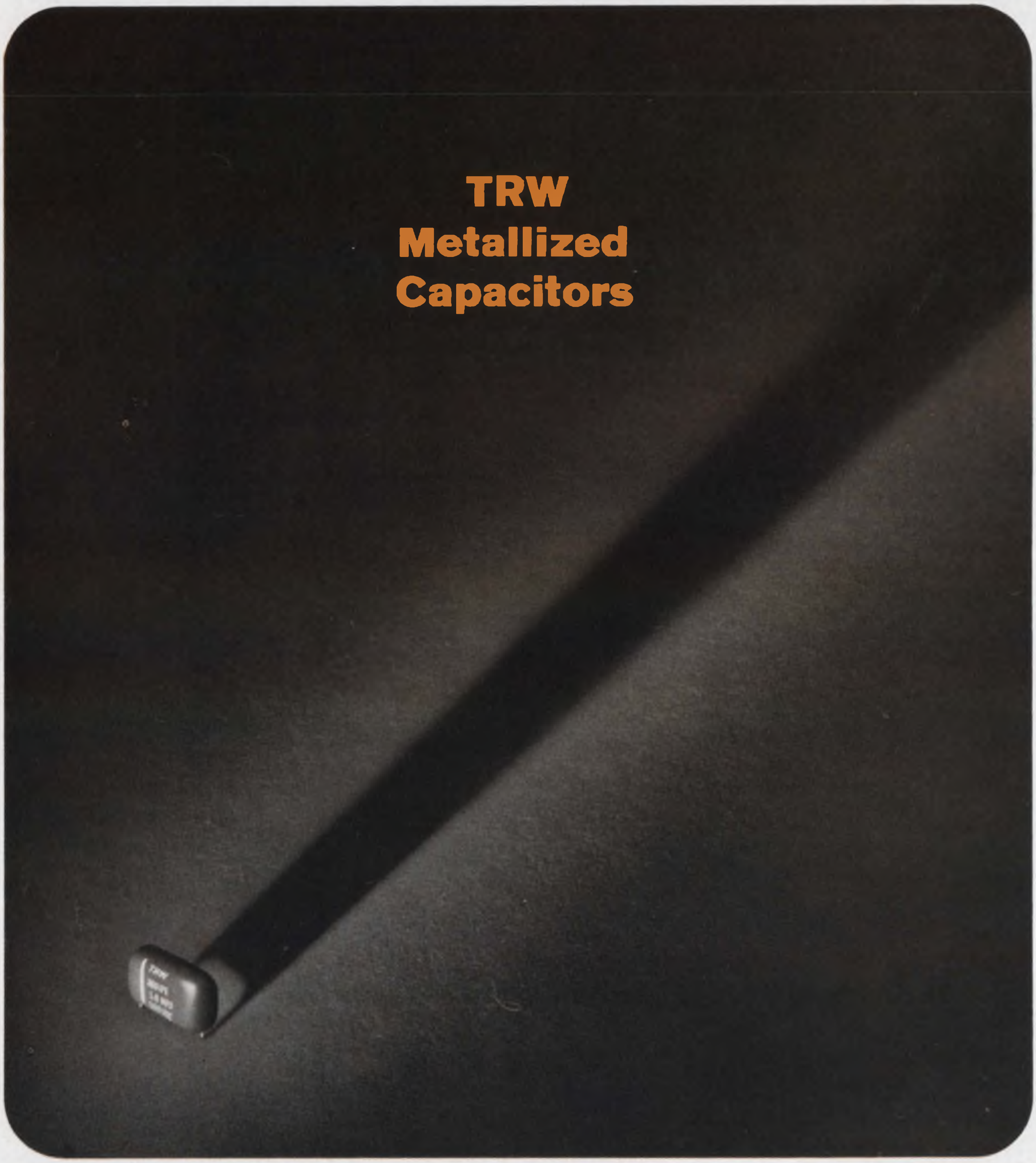

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EDITORIAL

We need innovators, not stubborn 'changers'

A company engineering department is responsible for creating profitable products. It needs innovators rather than "changers."

What's the difference?

Innovators examine existing products—their own and competitors'—with exhaustive care in a constant search for improvement. But a clever innovator doesn't just invent a better mousetrap, period. He tailors his design to allow for a profit.

"Changers" are the people in engineering departments who provide the steady, unending flow of engineering orders—some justifiable, many not—that change things with little regard for the effect on the profit picture. The most common change orders stem from poor engineering practices: (1) Improper documentation of specifications; (2) Inadequate purchasing instructions; (3) Poorly prepared test procedures; (4) Parts substitutions for the sake of "newness" but with minor improvement; (5) Parts replacements because the original design relied on a single source, incapable of delivering quantity supplies.

At a recent IC conference on Long Island the innovators were in obvious attendance. They cross-examined semiconductor engineers who gave papers on ICs, MSI and LSI: "What will it cost?", "When can we get delivery?", "How expensive will tooling be?", "Have you any field reliability figures?"

The "changers" were in evidence also. At lunch about a dozen systems engineers and an authoritative engineer from a leading semiconductor company gathered at one table. The authority warned the changers in the group that their "routine" changes in system designs would have to go once subsystems are made available as low-cost, large-scale arrays. He explained the prohibitive costs of altering mask designs and interconnection patterns. The changers were unconvinced (because if there is one thing a changer doesn't like to do, it's to change himself). They argued that the semiconductor supplier would have to accommodate the customer and learn to live with changes. Otherwise, they hinted, they just wouldn't rush to large-scale arrays and risk their careers. As one of the group put it: "An engineering change order a day keeps the unemployment away."

With enough heads like this stuck in the sand, it seems obvious that the companies with innovators to apply semiconductor and other advances profitably will dominate the companies staffed with changers.

Innovators, onward. Changers, outward.

HOWARD BIERMAN

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INFORMATION RETRIEVAL NUMBER 27

Neural hearing tested privately

Sir:

The report of Army tests of inducing hearing by coupling a-m–rf signals to the head ["Army tests hearing aids that bypass the ears," ED 26, Dec. 20, 1967, pp. 30-32] covers ground similar to that of some tests we made here in Pasadena over a year ago. We made these after reading an abstract of a government constractor report.

The principle worked, but:

- You could hear the sound quite clearly emanating from the head of the guy with the electrodes on—almost as well as he could hear it.
- You couldn't induce a subjective sound level high enough without using rf current levels so high as to cause discomfort.
- The effect would die away in a few seconds if you held the electrodes still in one place.

To keep it working, you had to keep massaging the electrodes against your head. Furthermore, any asymmetry in the amplitude modulation of the carrier would generate audio-frequency currents large enough to be felt as electric shocks.

We concluded that human tissue is electrostrictive under certain rather unknown conditions of stress gradients, and that the subjective sensation of hearing sound was produced by nothing but sound itself—generated by the electrostrictive vibration of the tissue.

It did not seem worth while pursuing the idea further, although it is intriguing and suggests many avenues for research, such as the polarity question. A great many substances are electrostrictive or piezoelectric. It is a much more common property than we are apt to think, because most of these substances are also good conductors, and so short out any dc or low-frequency attempts to measure this property. It has been suggested, for example that the propagation of detonation in TNT is due to its piezoelectric properties, which generate extremely high-voltages during the explosion process.

Lawrence Fleming
President
Innes Instruments
Pasadena, Calif.

Antenna matching can be improved

Sir:

In the Ideas for Design section of your magazine of Jan. 4, 1968, [ED 1,] p. 138, Ronald Finger describes the use of series quarter-wave feed lines for antenna matching purposes ["Match antenna impedance with series Q-sections"].

An alternative, advantageous variation involves the use of parallel quarter-wave sections. Thus two 50-ohm quarter-wave lines in parallel would approximately match the assumed 22.5 ohms. This technique is more advantageous in the matching of still lower impedances where resistive losses in the series connection might be intolerable. For example, seven 50-ohm sections in parallel would match from 50 ohms down to 1 ohm with one-seventh in resistive line loss.

If n sections of line with a characteristic impedance equal to Z_i are paralleled, the expression for n is:

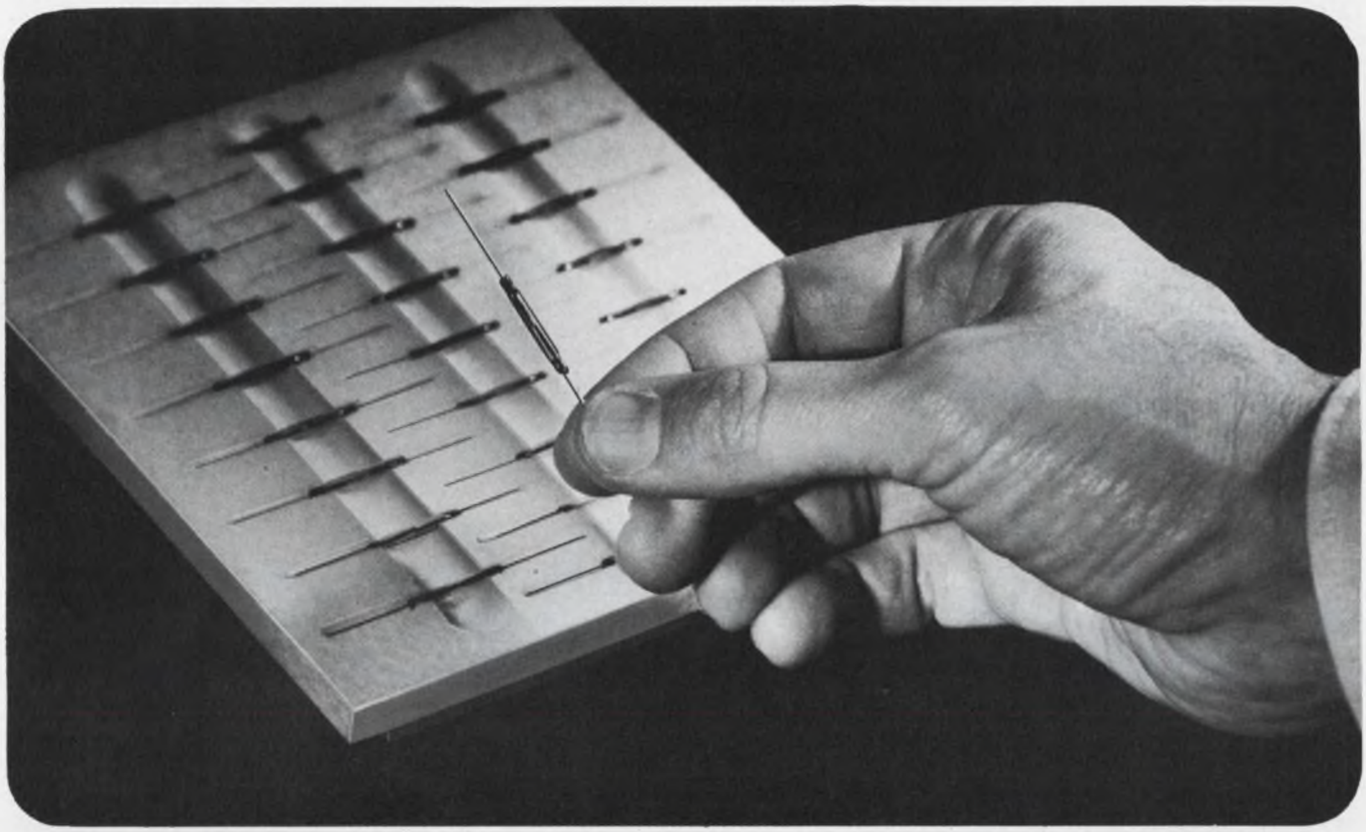
$$n = Z_i/Z_0.$$

James E. Taylor
Physicist-Engineer
Xerox Corp.
New York

Accuracy is our policy

In "Capacitor leakage tester checks production units," ED 2, Jan. 18, 1968, p. 132, diodes *CR7* through *CR12* in the schematic are shown the wrong way around. All six should be reversed.

All the dry reeds for your needs...with consistent high quality



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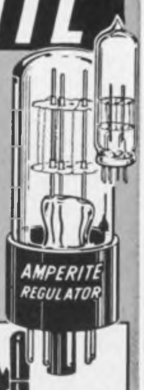

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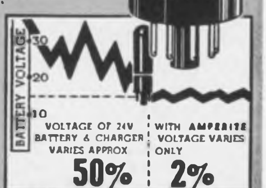

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INFORMATION RETRIEVAL NUMBER 29

Someone up there likes us

A Jesse H. Neal Award is to the technical-magazine field what a Pulitzer Prize is to a general-circulation publication.

For the second year in a row, ELECTRONIC DESIGN has garnered a Neal Award for the best staff-written feature article in a technical magazine with a circulation of more than 50,000. Richard N. Einhorn, News Editor, won the award for his article "Probing the Mind's 'Computer'." His report on electrical stimulation of the brain appeared in the May 24, 1967 issue.

The article stirred great reader interest and was praised by such pioneering scientists as Dr. Blaine S. Nashold of Duke University, Dr. Robert Doty of the University of Rochester and Dr. José M. R. Delgado of Yale University.

Last year Managing Editor Robert C. Haavind won the same Neal Award for an article on guerrilla-warfare electronics in Vietnam.

Nanosecond reporting (well, almost)

Approaching the print-out stage after the Solid-State Circuits Conference: (From the lef) Einhorn, Budzilovich, Speer and Haavind. Sclater arrived, puffing, minutes later.

The emphasis was on speed at this year's International Solid-State Circuits Conference: subnanosecond ICs . . . discretes . . . hybrids . . . LSI. And emerging trends: fourth-generation computers, for instance, with over 200 circuits per square inch.

ELECTRONIC DESIGN's five-man reporting team found it hard to descend from such giddy heights. Working jointly after the close of the three-day Philadelphia conference, Richard (Doc) Einhorn, Pete Budzilovich, Ray Speer, Bob Haavind and Neil Sclater searched their own solid-state memories (and notebooks) and printed out all the highlights in roughly 19.6 trillion nanoseconds. For details of the significant—from the Sheraton Hotel's small, smoke-fogged rooms to the spacious Irvine Auditorium at the University of Pennsylvania—start reading on page 25.

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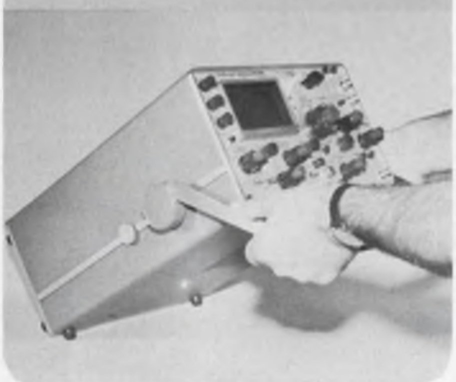

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Take the Type 453 through tight places easily . . . the vertical carrying position increases portability.

Take it anywhere. The rain/dust cover is a standard accessory and carries the complete manual and optional viewing hood.

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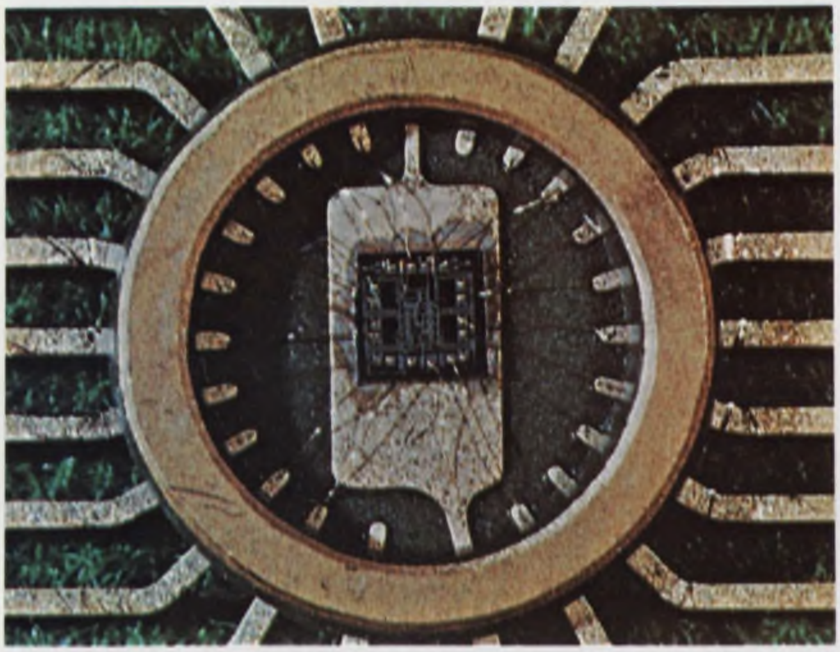
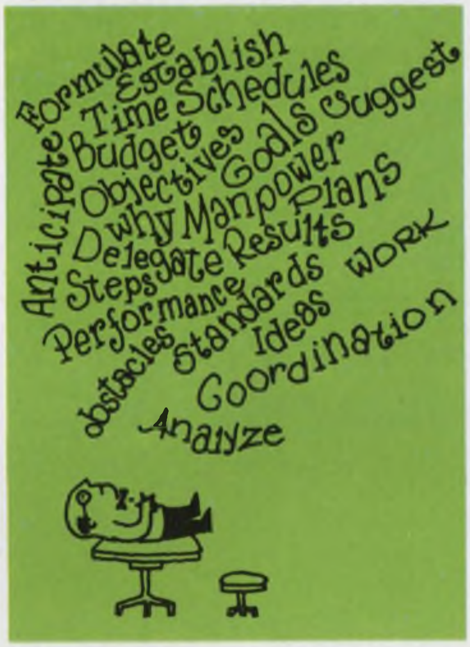
INFORMATION RETRIEVAL NUMBER 32

Technology



Selecting a microelectronic package is easy: Just follow a step-by-step "critical path" of materials decisions. Page 56



Making decisions? Think clear-ly, avoid the traps. Page 82

Fourth-order equations often appear in circuit analyses. A new, simple method of solution gives exact answers and is particularly suited to a solution by computer. Page 72

Also in this section:

You can design an inductive circuit without inductors. Page 66

Test your IC IQ. Page 78 . . . **Ideas for Design.** Page 90

Set your own IC package standards.

Follow the 'critical path' of material decisions and simplify your package selection.

At present, there are no standards for integrated circuit packages. But that doesn't mean that the selection, design or specification of an IC package cannot be treated in a logical way with a set of standardized decisions.

Whether an off-the-shelf package is being bought, a package designed or a custom package specified, the same decisions have to be made. Hermetic or nonhermetic? Metal, glass, or ceramic? Braze, solder or weld? Tackle each decision in the proper sequence and you've got your package specified. The "road map" on the opposite page can serve as your guide.

Is hermeticity a must?

The actual selection begins with deciding whether the device must be hermetically sealed or not. If this is a requirement, as in military devices, then there is no question. If, however, there is some latitude, then it becomes a matter of economics to consider resin embedment or plastic encapsulation. Where a hermetic package may cost as much as four dollars, a plastic package such as those on the right can go as low as 20 cents. And a plastic package allows almost any material to be chosen for the device leads, since there are few compatibility problems. Plastic packaging is generally not considered hermetic. Since all resin systems in use have diffusion rates, the standard definition of hermeticity (leak rate not to exceed 1×10^{-8} cm^3/s of helium) does not apply. Many claims are made for the "comparable" density of plastic to that leak rate, but opinions appear to be about equally divided.[1] There is no question, however, that plastic encapsulation is acceptable for devices meeting wider long-term electrical tolerances than called for under military requirements for operation under temperature and humidity extremes. Acceptable plastics would be those that tend to be free of impurities, or where, if impurities are present, they tend not to migrate to the chip. Bipolar devices are more adaptable to plastic than are MOS devices because of the higher surface sensitivity of MOS. So, first consider the device, and then the plastic since available plastics have widely different characteristics.[2,3]

Presently, the best way to protect a chip to be packaged in plastic is to use a passivation layer. This is a barrier applied to the surface of the device to protect the sensitive areas of the die

David Nixen, Chief, Prototype Assembly, Microelectronics Pilot Line, Autonetics Div. of North American-Rockwell Corp., Anaheim, Calif.

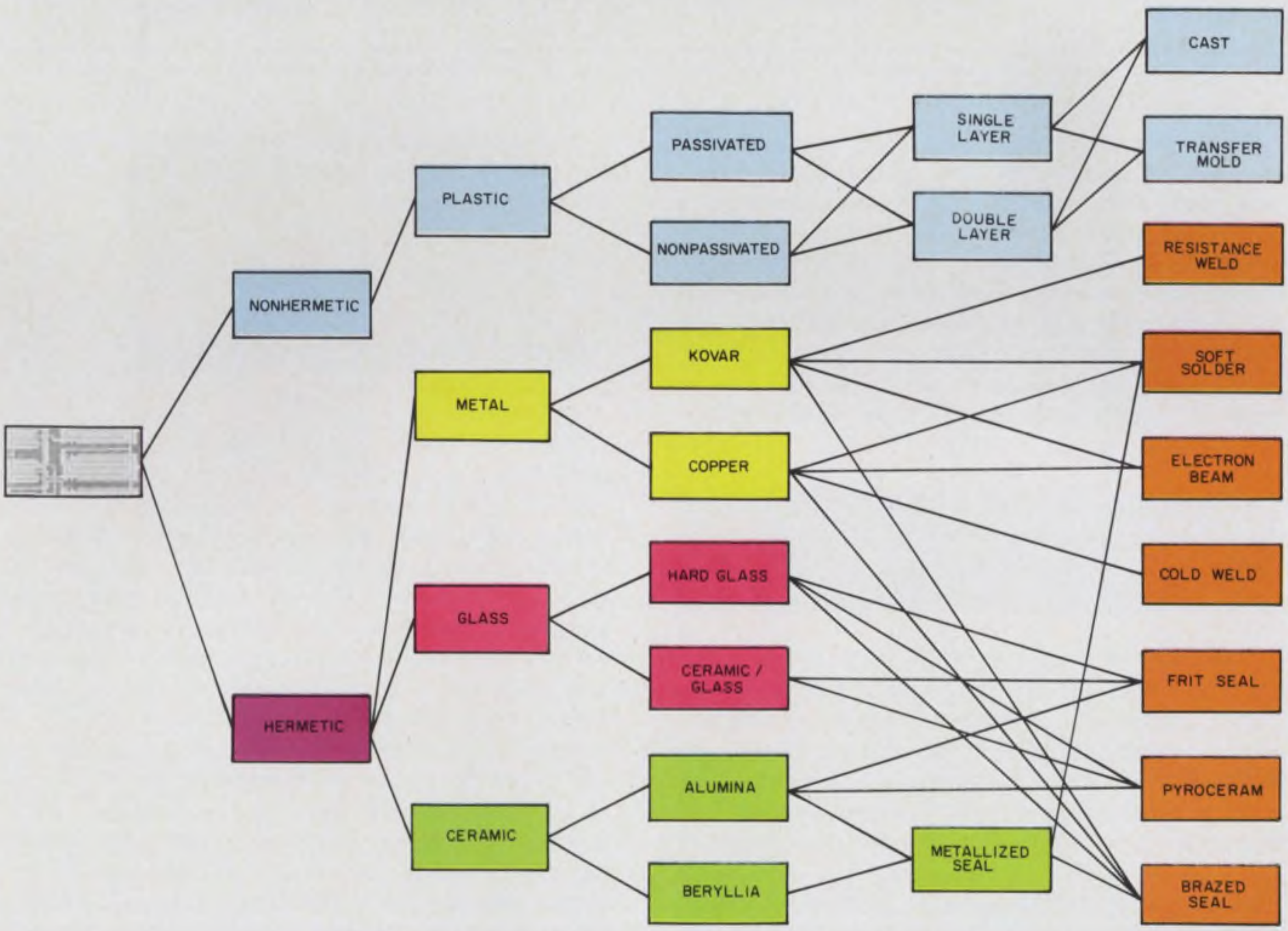
When hermeticity isn't critical, use plastic. These RCA ICs are packaged in a Dow Corning silicone material.

from chemical impurities. Such impurities may lie dormant in the encapsulant itself and diffuse through the body. It is only a matter of time before they ultimately reach the surface of the die and cause degradation of the unit. The passivation layer is an impervious, stable barrier that will not be affected by either time or subsequent processing. Some of the more popular passivation systems are borosilicate glass, thick, pure silica, silicon nitride and aluminum oxide. When evaluating a passivation material, bear in mind the density of the surface passivation material itself (it must be free of pin holes), the ease of application (the method of application should not be detrimental to the device) and whether the passivation material is chemically compatible with the device over a period of time. The methods of application of these systems range from the comparatively simple method of centrifuging fine glass frit onto the wafer, to the much more expensive vacuum-deposition process of silicon nitride or aluminum oxide. While one method may be inexpensive and simple to apply, the other may be far more impervious to impurities.

A nonpassivated surface has no externally applied materials to protect the surface of the active device from the effects of an embedment material. The plastic is applied directly onto the surface of the die. The only protective barrier that may exist between the device and the plastic is an incidental layer of silicon monoxide or dioxide formed during fabrication of the device.

Single-layer application is simply a plastic encapsulant applied over the die. Since the flying leads interconnecting the die and the lead frame are exposed, however, stresses on the wire bonds are set up by the different coefficients of thermal expansion (Table 1, p. 58). Therefore many manufacturers apply another layer of encapsulant first. It is usually an organic material that does not cure a rigid mass but remains pliable. The inner layer is generally a silicone gel; the outer layer is usually an epoxy. The gel tends to damp out potentially harmful stresses on delicate wires and bonds.

The final step in fabricating a plastic package can be a simple inexpensive casting process. The packages are placed in molds or housings, the resin is applied, oven- or air-cured, and the mold is removed. Although casting requires little outlay on equipment, it does require time for curing and mold removal.



A series of step-by-step decisions is the key to the selection of a microelectronic package. The colored sections correspond to colored section headlines in the text where all of the trade-offs involved are discussed.

Table 1. Thermal expansions and conductivities

Material	Thermal expansion (10^{-7}/°C)	Thermal conductivity (cal/cm²/cm/s/°C)
Dumet	92 (radial) 65 (axial)	0.4
1010 steel*	135 (25—300°)	0.12
No. 52 alloy*	95 (20–500°)	0.04
Sylvania No. 4*	85 (25–300°)	0.032
Kovar	57-62 (30–500°)	0.0395
Molybdenum	55 (25–500°)	0.32
Tungsten	46 (0–500°)	0.476
7052 glass (borosilicate)	46 (0–300°)	0.0028
0120 glass (potash-soda lead)	89 (0–300°)	0.0018
Silica	8 (0–300°)	0.004
96% Al_2O_3	64 (25–300°)	0.084 (25°C) 0.041 (300°C) 0.026 (500°C)
99.5% BeO	60 (25–300°)	0.55 (25°C) 0.28 (300°C) 0.17 (500°C)
Epoxy (alumina-filled)	120-150	0.0009-0.0011
Epoxy (beryllia-filled)	250	0.021-0.073
Epoxy (unfilled)	180-600	0.0003-0.0006
Teflon	800-1000	0.0006
Polyethylene	1600-1800	0.0008
Sapphire	95	0.0061 (105°C)

*1010 steel, No. 52 alloy and Sylvania No. 4 are basically nickel-iron mild steels. They are considered as acceptable hermetic standards.

The same resins used for casting can generally be used for transfer-molding as the final fabrication step. This process requires investment in a press and mold, however. The transfer-molding press is an accurately controlled low-pressure, low-temperature unit. It takes a steel mold which has been machined to accept the package lead frames. An individual mold can accept as many as 40 packs, depending on size, and requires an over-all process cycle of only about four minutes.

When hermeticity is a must

The hermetic approach offers a much wider set of choices and is far more complex. Where plastic encapsulation gives a certain amount of leeway—nearly any material can be chosen for package leads, for instance—the hermetic approach involves rigid laws to meet the level of hermeticity required. For example, an engineer can choose, at best, from among five acceptable lead materials. Of these five, perhaps only two satisfy other requirements of his design. And the physical structure of the package may dictate the use of a single material. Three basic families are in common use for hermetic packages—metals, glasses and ceramics.

Metal doubles as conductor

The most commonly used hermetic packaging materials are metals. They serve as a current carrier, a heat sink and an enclosure body—an option not offered by glass or ceramic. Bonding the die directly to the floor of the package by means of a braze material such as gold, gold-germanium, or gold-silicon enables a direct ohmic contact to be made between the bulk silicon body and the outside world through the metal package. In this manner it is possible to achieve a common interconnection between the bodies of the silicon devices on a PC board without the use of internally bonded leads in the package. With a glass or ceramic package, a fine wire would have to be bonded between the silicon and an external package lead. This would necessitate another bond, an additional lead on the package and subsequent PC board interconnections.

Table 2. Characteristics of package materials

Material	Density (g/cm³)	Thermal expansion (10^{-7}/°C)	Compressive strength (lb /in²)	Thermal conductivity (cal/cm²/cm/s/°C)	Dielectric Strength (V/mil at 60 Hz)
94% alumina	3.6	(25-300°) 62 (25-700°) 76 (25-900°) 80	315,000	(25°)0.073 (300°)0.035 (500°)0.024	230
96% alumina	3.7	(25-300°) 64 (25-700°) 75 (25-900°) 79	375,000	(25°)0.084 (300°)0.041 (500°)0.026	230
98% alumina	3.7	(25-300°) 60 (25-700°) 78 (25-900°) 80	325,000	(25°)0.084 (300°)0.036 (500°)0.026	230
98% beryllia	2.8	(25-200°) 58 (200-500°) 86 (500-800°) 105	225,000	(20°)0.49 (100°)0.37 (400°)0.17	250
99.5% beryllia	2.9	(25-300°) 60 (25-700°) 78 (25-900°) 85	185,000	(25°)0.55 (300°)0.28 (500°)0.17	240
7052 glass	2.3	(0-300°) 46	—	(0-300°)0.003	—
Kovar	8.4	(20-500°) 57-62	—	(30-500°)0.039	—
Copper	9.0	(0-100°) 166	—	(18°)0.918 (100°)1.04 (200°)0.969	—

*As metals, kovar and copper are conductors thereby negating the importance of dielectric capabilities. Where compressive strength is concerned, the values for kovar and copper are so high as to be insignificant in their use in electronic packages. The compressive strength of glass, on the other hand, is infinity. The theoretical aspects of glass state that it cannot be broken in compression.

The commonest metal used in hermetic packages is a Kovar type of alloy. It is a low-cost, low-thermal-expansion material compatible with glass to achieve a hermetic seal. The usual mating glass is Corning Glass 7052.

Although Kovar gives a good hermetic seal, it also has certain disadvantages. When Kovar parts are prepared,[1] they must be carefully cleaned before an oxide layer can be grown. The cleaning is usually done in a sulphuric and chromic acid bath. This process must be precisely controlled, for too long immersion will result in a preferential etch of the parts. Once Kovar parts have been preferentially etched, they are write-offs. Another drawback is Kovar's hardness compared with other mild steels. Other steels may be machined and stamped fairly easily but Kovar wears tools down fast. Finally, Kovar's coefficients of electrical and thermal conductivity are low (Table 2).

Copper packages are growing in popularity because they can be lid-sealed by a cold-welding process. The entire package may be copper or the lid-sealing edge may have a copper flange. Another advantage of copper is its high thermal conductivity, which gives high thermal dissipation to the packaged device. Copper's disadvantages are in the area of thermal expansion. Where an alumina substrate is bonded to the package floor, for example, very high stresses are caused by the thermal expansion mismatch between the alumina (64×10^{-7} mm/mm/°C) and copper (160×10^{-7} mm/mm/°C). Copper cannot be hermetically sealed to glass; Kovar eyelet seals must be soldered in place. Copper also readily oxidizes, so that additional caution is called for during processing. Copper should be considered over Kovar only when excellent thermal conductivity is called for, as in power integrated circuits.

Glass halves material cost

Glass makes a package that is 50 to 75 per cent cheaper than metal or ceramic. Where a metal package requires a three-part seal (conductor/glass/metal body), the glass pack requires only a two-part seal (conductor/glass body). The basic process of assembling a glass package is also simpler than the metal one. Assembly can be performed either by hot-press molding, or through a controlled-atmosphere belt furnace in carbon fixtures.

Most glass packages are a borosilicate, hard glass such as Corning Glass 7052. This glass has good resistance to thermal and mechanical shock, and lends itself very well to hermetic-seal applications. The two components of the usual glass flat pack (7052 glass and Kovar ribbon lead material) have a long successful record. Lid-sealing the glass pack can either be done directly or by brazing to a Kovar ring. The choice between these alternatives must be made early in the design. If the choice is a direct seal between lid and glass body, the glass body is left bare. On the other hand, if a braze seal is to be made, then the glass body must have a gold-plated Kovar ring sealed onto its top edges. A disadvantage of a glass package is that it is translucent, and certain custom integrated-circuit devices are photosensitive. This is not a problem with any of the commercially available devices, however.

The other glass body material used is ceramic glass such as Pyroceram. It has great mechanical strength and high resistance to thermal shock. Pyroceram's chief disadvantage is its resistance to chemical attack. Reducing acids or a hydrogen atmosphere in a furnace operation tend to attack and deteriorate the hermeticity of Pyroceram seals. A reducing atmosphere such as hydrogen or nitric acid might be used for plating leads with gold at the end of the packaging process, or for die-bonding a chip. In such cases a Pyroceram package should be used. On the other hand, if the leads are preplated or the die-bonding is done at an earlier stage of fabrication, Pyroceram may be used.

As this header rests in a heated holder, 1-mil-diameter gold leads are bonded from the chip to the terminal post. Such thermocompression bonding requires compatible materials. Photo courtesy Teledyne.

Table 3. Joining methods

Method	Joining Time(s)	Materials	Equip. Cost ($)
Soldering	5-10	Incompatible	15
Resistance welding	ms	Compatible	650
Electron-beam	ms	Incompatible	90,000
Laser welding	ms	Incompatible	20,000
Thermocompression	2-4	Compatible	7000
Ultrasonic	2-4	Compatible	7000

Ceramic can be metalized

A ceramic package combines most of the advantages of metal and glass. It marries the strength of metal with the basic characteristics of glass, it is an excellent dielectric; it is chemically stable; it is composed of oxides formed at high temperature, and it can be selectively metalized. Metalization serves three functions:

- It acts as a base on which components or wires can be bonded.
- It acts as an electric conductor and therefore part of the circuitry.
- It permits a metal-brazing form of closure.

Two ceramics, alumina and beryilla are used.

Alumina, or aluminum oxide, Al_2O_3 probably has even more advantages than ceramics in general. Its mechanical strength is good, its resistance to thermal shock is fairly good, and its resistance to chemical or gaseous attack is excellent. Alumina is marketed for electronic applications in a range of 80 to 99.5 per cent aluminum oxide. Generally 94 to 96 per cent is used in microelectronic packages. This class of composition adds relatively good thermal conductivity (approximately that of Kovar) to its other properties.

What makes alumina so desirable is the fact that it may be metalized, usually with a molybdenum-manganese mix. When fired in a reducing atmosphere, the manganese forms a spinel type of interface* on the surface of the alumina body, leaving a pure molybdenum surface on top. This surface is then plated with gold to achieve a

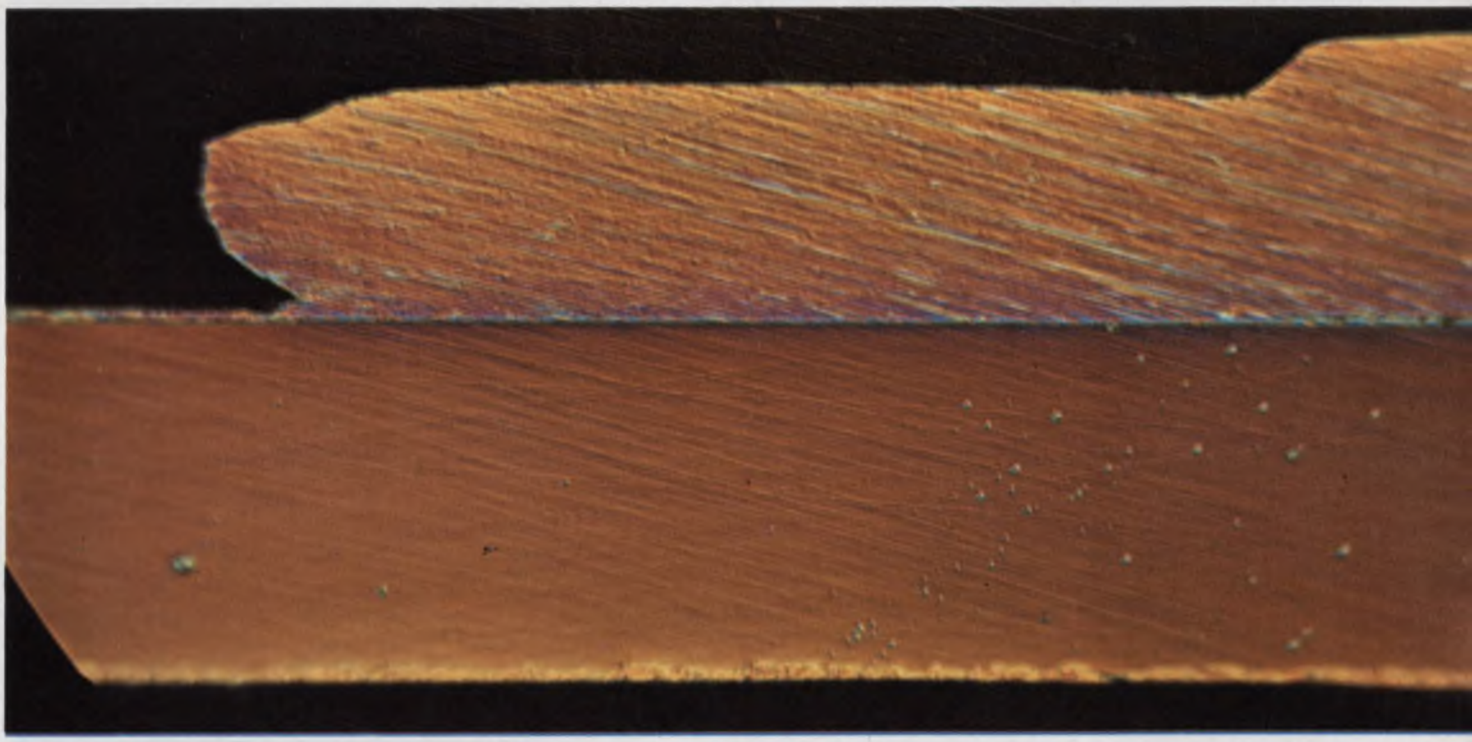
*A spinel type of interface is a manganese-alumina-silicate broad, diffused region in the alumina body, as opposed to a sharp, shallow line.

solderable or brazable area. The major advantage of this form of metalization is not only that it is mechanically very strong but it is also hermetic. A properly designed and fabricated hermetic joint made of "molymang" metalized alumina is probably the most reliable type of hermetic seal obtainable.

Alumina has another noteworthy advantage. A borosilicate glass can be hermetically sealed to the same alumina that has previously been metalized. This affords the designer the opportunity to use both means of making hermetic seals in different parts of the same package. For example, in a typical package the floor is 94% alumina on which screened "molymang" metalization is the conductor coming to the outside edge of the plate. A ring of borosilicate glass is then applied and the wall of the package is sealed to it. The metalization coming under the wall is hermetic, as are glass-to-metalization and glass-to-alumina seals.

On the negative side, alumina is about twice as expensive as glass and requires higher initial tooling charges. In addition, certain package designs preclude the use of alumina because of lack of space. Where a glass seal may be made directly to the lead, an alumina package requires a metalized hole to accept the brazed-in lead. In order to seal a lead to the alumina, there must be room for metalizing, which must be thicker than 0.03 inch to be reliable. A 0.02-inch wire thus takes 0.03 inch of space after being brazed into place. The same 0.02-inch wire needs only 0.02 inch of space in a glass seal, since it goes directly to the glass body and not through an intermediate agent.

The last material to be considered for package bodies is beryllium oxide, BeO, or more commonly, beryllia. Like alumina, beryllia can also be obtained in compositions of 80 to 99.5 per cent; 98 to 99.5 per cent BeO is best for microelectronics. Beryllia's main advantage is its extremely high thermal conductivity—about ten times that of alumina. Where high power dissipation is required for device performance, beryllia is the obvious choice. It too can be metalized with "molymang" and has the same general characteristics of strength and resistance to thermal shock and chemical attack as alumina. It is also a slightly better dielectric. The cost of beryllia, however, can be twice as high as that of alumina. Its high thermal conductivity can also be a drawback if assembly of the unit requires any hand-soldering on the beryllia floor. As the soldering iron is applied, the beryllia, due to its excellent thermal conductivity, acts as a "heat thief." It dissipates the heat across the whole floor instead of concentrating it in the desired spot. The iron thus becomes a localized heat source for the whole package and the usual result is a poor solder joint. To obviate this, it is necessary to



Aluminum lead is ultrasonically bonded to silicon which has been metalized with aluminum. This method of bonding does away with contaminants, evolves little heat or pressure, and gives a strong bond. Since ultrasonic bonding requires compatible materials, this must be borne in mind when selecting the package. See Table 3 for a comparison of five bonding techniques. Photo courtesy Fairchild Semiconductor.

preheat the whole substrate or package, and then apply the soldering iron locally. But that can be detrimental, even fatal, to heat-sensitive microcircuits. So beryllia should be chosen over alumina only when the microcircuit is to be operated beyond its rated capability. Where a device in an alumina package would fail or be on the verge of failure, the beryllia package can extend its operation past its power rating.

Lid-sealing finishes package

There are seven different methods of lid-sealing. Referring back to the "road map" it is obvious that the method chosen depends in part on the materials used in the package. Bear in mind this one axiom—use as little heat as possible.

Resistance welding uses high current (the members to be welded serve as conductors) to reach the melting point of the members while pressure is applied to them both. The electrodes may be opposing or both on one side. The weld is considered to be a true parent-to-parent weld when a "nugget" is formed of both members.

In packages specifically fabricated for resistance-welding of the lid, both the body and the lid are Kovar, or the lid may be nickel. Either metal is well suited to the process. The actual welding may be a single all-enveloping pulse, "stitch-welding," or a "rolling-electrode" process. Stitch-welding is a series of individually made weld pulses, each overlapping its predecessor. For example, there could be a series of 0.008-inch-diameter welds, each overlapping its neighbor by 0.002 inch and so forming a continuous running weld. Rolling electrodes literally roll along the materials to be joined. They remain stationary while the package travels through, and conduct the current while bearing down on the package lid. No matter which technique is used, the package body must have lip and the weld area must be as far away as possible from the glass-to-metal seal. This means a larger package than would otherwise be required. Once sealed, a resistance-welded package cannot be reopened.

Soft-solder sealing employs a lead-tin solder which melts at 190° to 225°C. The low temperature is the basic advantage of soldering. In addition, the seal is easy to reopen. Soldering is a particularly attractive method of packaging thin-film circuitry or organics. In either case, temperatures higher than 225°C could have detrimental effects on the performance of the device. Care must be taken if the seal requires to be fluxed before soldering, since flux residue could be trapped. Entrapment of impurities in hermetic electronic devices is a major failure mechanism.[5] Where resistance-welding requires weldable metals for acceptable lid-sealing, soft soldering can be performed on a metalized alumina or beryllia, Kovar, copper, or mild steel body. The steel can be bare or plated to promote wetting.

Electron-beam sealing is a relative newcomer. As in the case of resistance-welding, a peripheral lip is designed on the package so that the "nugget" forms outside the body proper. This minimizes the possibility of a leak in the glass-to-metal seal because of thermal shock. Some packages are designed without the lip, when there is a large enough distance between the lid seal and glass to ensure that thermal shock will cause no failure. Electron-beam welding has two basic advantages: since the electron beam is in vacuum, external contaminants cannot enter the package, and, the operation can be completely automated.

Although high power is unnecessary, very fine registration and power controls are required since the parts to be welded are so small. Unlike the resistance welder, where electrode-positioning can be seen before the power is applied, electron-beam welding depends completely on instrumentation for registration. Disadvantages are the high initial cost of equipment, the initial pump-down time of the chamber (approximately 15 minutes), and the fact that the metal package must withstand 15 pounds of pressure. This may cause "oil canning,"† which in turn can crack substrates cemented to the floor of the package.

Cold-weld sealing uses pressure alone; no heat is used to form the seal. Since the first axiom in lid-sealing is to use the least amount of heat necessary, this process is very attractive for ductile-metal packages. A very high pressure is applied in a single pulse to force the two members into a hermetic joint. Since the material must be ductile, copper is just about the only material that can be used. Experiments, however, are being carried out to determine whether copper-clad, and even copper-plated metals, can be used.

Care must be taken in the initial design of the package so that the forces applied under the heavy pressure are not transmitted to other parts of the package. They would crack the body or even cause seal failure.

Presently, consistent, reliable production methods of cold-welding copper seals are available for packages up to 1-1/2-inch in diameter. Cold-welding has the same disadvantage as other welding techniques—it requires a peripheral lip and once the seal has been made, it cannot be reworked or repaired.

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†"Oil canning" is that condition wherein the thin metal lid is long enough to be flexed inward on the package due to the difference of atmospheric pressure on the outside and vacuum on the inside.

Frit-sealing is used for glass and alumina. The glass frit may be of any type—low-expansion (higher temperature) or high-expansion (lower temperature). The choice depends on the thermal expansion of the body and lid materials, and the temperature that the microcircuit can withstand. The greater the dissimilarity in thermal expansions is, the greater will be the permanent strain that remains. Such residual strain determines the amount of thermal or mechanical shock needed to crack the seal. The glass frit is in the form of a sintered glass washer, which is pressed into the shape of the area to be sealed. The actual sealing operation is performed either by perimeter sealer or a belt furnace. A belt furnace requires jigging and carbon fixtures, which push up costs, because fixtures wear out. This is not so with the perimeter sealer, where jigging and heat-sinking are designed into the machine.

A Pyroceram seal is preferred to a glass frit, because of Pyroceram's lower maturing temperature. The active element can then be maintained at a lower temperature. When maturing Pyroceram, an at least slightly oxidizing atmosphere should be maintained, to avoid the problems of a reducing atmosphere. If this is done, however, then the inert atmosphere normally preferred for the inside of the package cannot be achieved. Also wetting of parts is less easy with Pyroceram than with glass or braze material.

A brazed seal probably gives the most value for the least money. Brazed metal, glass or metalized ceramic members afford good hermeticity and mechanical strength, take only moderate processing, and cost litle. The materials most commonly used are eutectic compositions of gold-tin or gold-germanium. Although gold-tin has the lower melting point (280°C vs 356°C for gold-germanium), it is comparatively fragile and tends to crack under mechanical shock. Gold-germanium, on the other hand, is ductile and resists cracking very well.[6] Where the microcircuit can take the higher temperature in sealing, gold-germanium should be used. ■■

Is the package acceptable?

Before a hermetic package can be considered acceptable, specific tests must be performed. The following are reasonably standard:

- Lead fatigue—Leads should withstand two 90° bends (45° up and 45° down) with a 4-oz weight attached.
- Lead pull—Leads should withstand an 8-oz axial pull.
- Moisture resistance—The package must pass MIL-STD-202, method 106 (omit step 7B).
- Crazing—Glass inside the header should have no crazing.
- Internal radii—All internal radii should not exceed 0.0006 in.
- Solderability—The package must pass MIL-STD-202C.
- Flatness—The top surface of the ring frame should be flat and have a minimum width of 0.005 inch at the narrowest point.
- Plating—All plating should be free of blisters and discoloration, and have no spots larger than 0.002-inch diameter after baking in nitrogen atmosphere at 310° ±10°C for 48 hours. Minimum thickness should be 100 μin. of gold.
- Island area—An expanded lead (island) should have 0.100 × 0.175 in. free of glass.
- Lead ends—The lead ends inside the ring frame should be free of glass over an area of 0.01 × 0.20 in.
- Insulation resistance—Electrical leakage from leads to ring frame should not exceed 10 nA at 100 V (10 GΩ).
- Glass splatter—There should be no glass on the top of the ring frame or the bottom plate.
- Length of meniscus—The meniscus should be no longer than 0.012 in.

Acknowledgment:
The editor wishes to thank the Semiconductor-Components Div. of Texas Instruments, Dallas, for the cover photograph and the Electronics Div. of Union Carbide for the photograph on page 55.

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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 drawback of using plastic encapsulation for MOS devices?

2. What is the main property of Kovar which suits it to making hermetic seals?

3. When would the high thermal conductivity of beryllia be a disadvantage?

4. What are the trade-offs between gold-tin and gold-germanium for brazing?


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Integrate a shunt-compensated stage

by replacing inductors with active devices to increase the gain-bandwidth product at no extra cost.

The main purpose of compensation circuits in broad-band interstage design is to improve the gain-bandwidth product. Many types of compensation circuits or coupling networks are available: one example is shown in Fig. 1.

Since inductors are, at best, very difficult to fabricate in integrated circuits, shunt compensation is usually avoided, even though the shunt-compensated interstage has a potentially higher gain-bandwidth product than other existing compensating circuits.

Here's a method for achieving the advantage of shunt compensation without using inductors. The shunt branch of series resistance, R, and inductance, L, shown in a box in Fig. 1, may be replaced by an active circuit containing no inductor but having the inductive property. Such a circuit is the common-base transistor configuration with its output ac-short-circuited. Figure 2 shows a common-emitter interstage with a common-base transistor used for shunt compensation. This circuit thus affords the advantages of shunt compensation with no sacrifice of convenience.

The inductive input impedance of the common-base stage will exhibit relatively low Qs for the transistors ordinarily used in broad-band design. For broad-band and interstage design, however, the requirement is merely for low circuit Qs. For narrow-band design, on the other hand, the requirement is for high Q, which is not directly compatible with the present configuration.

Calculate the input impedance

The input impedance (neglecting C_{ob}), of the common-base transistor with shorted collector shown in Fig. 2 is resistive-inductive (see box for symbol definitions). This is due to positive feedback, which is characteristic of the common-base configuration. The positive feedback causes the decaying current gain response, due to the device cutoff frequency, f_α, to give rise to an increasing inductive response at the input terminals. To illustrate this effect, consider the small-signal model of a common-base transistor, shown in Fig. 3a. The input impedance, ignoring C_{ob} temporarily, is:

$$Z_{in} = \frac{(1-\alpha_0)\,[1+(1-\alpha_0)\,(j\omega/\omega_t)]\,R_B + r_e'}{1+(j\omega/\omega_\alpha)} \quad (1)$$

The standard approximation has been made that the common-base short-circuit current gain is:

$$\begin{aligned}\alpha &= \alpha_0\,[\exp\,(-jm\omega/\omega_\alpha]/[1+(j\omega/\omega_\alpha)] \\ &\approx \alpha_0\,[1-(jm\omega/\omega_\alpha)]/[1+(j\omega/\omega_\alpha)],\end{aligned} \quad (2)$$

for $\omega \ll \omega_\alpha/m$.

The figure-of-merit frequency, ω_t, used in Eq. 1, is related to ω_α by:

$$\omega_t = \omega_\alpha/(1+\alpha_0 m), \quad (3)$$

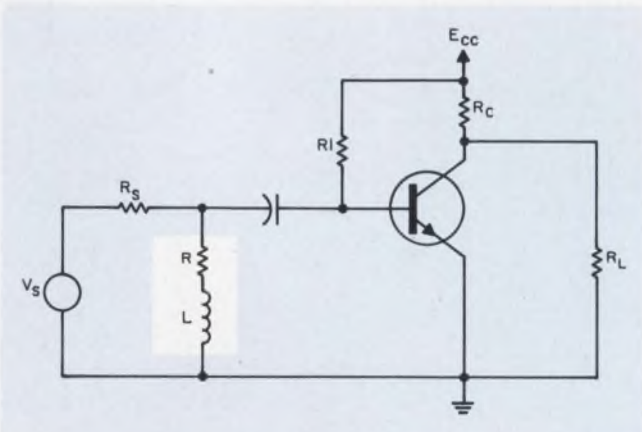
where m is an excess phase factor, defined in the box. Writing the input impedance in terms of the complex variable, $s = j\omega$, and simplifying give:

$$Z_{in} = R_{in}\,[1+(s/\omega_\beta)\,(1+\delta)]/[1+(s/\omega_\alpha)], \quad (4)$$

where:

$\omega_\beta = \omega_t/(\beta_0+1)$ (the common-emitter 3-dB frequency which neglects the emitter-transition capacitance), (5)

$$\left.\begin{aligned} R_{in} &= r_e' + [R_B/(\beta_0+1)], \\ r_e' \text{ (at } 300^\circ\text{ K)} &= 26/I_E \text{ (mA)}, \end{aligned}\right\} \quad (6)$$



1. **IC technology** cannot be used to realize this circuit since it contains an inductor. Better gain-bandwidth products are obtained, however, with this type of compensation.

Dr. Gerald T. Volpe, Senior Project Engineer, Marchand Laboratories, Greenwich, Conn.

$$\delta = (\beta_0 + 1)\, r_e'/R_B. \quad (7)$$

The input impedance of the circuit of Fig. 3a, which is represented by Eq. 4 can be exactly realized by the RL circuit of Fig. 3b. The component values are:

$$R1 = R_B\,(1+\delta)\,(1+\alpha_0 m)/[\beta_0\,(1+m)-\delta], \quad (8)$$
$$R2 = R_B\,(1+\alpha_0 m), \quad (9)$$
$$L1 = R_B\,(1+\alpha_0 m)/\{\,\omega_\beta[\beta_0\,(1+m)-\delta]\,\}. \quad (10)$$

These expressions can be obtained by formal RL network synthesis.

The common-base transistor can thus be used in place of the series RL circuit, provided that there is sufficient Q available and that $R2$ can be lumped in with the base resistance of the common-emitter interstage. The Q of the equivalent series RL branch for the common-base stage is:

$$Q_1 = \omega L1/R1 = \omega/[\omega_\beta\,(1+\delta)], \quad (11)$$

which can be made appreciably large (about 1) if sufficient R_B padding is used, say, 1 or 2 kΩ.

Consider the effect of C_{ob}

The effect of the collector-to-base capacitance, C_{ob}, in the common-base stage can be obtained by recognizing that it is in parallel with R_B in Fig. 3. In Eq. 4, R_B is then replaced by:

$$R_B/(1 + s\,R_B\,C_{ob}),$$

so that the input impedance becomes:

$$Z_{in} = \{\,[R_B + (\beta_0+1)\,r_e']/(\beta_0+1)\,\}$$
$$\times \{\,1 + [s(1+\omega_\beta\,R_B\,C_{ob}\,\delta)/\omega_\beta\,(1+\delta)]\,\} \quad (12)$$
$$\div\,(1 + s\,R_B\,C_{ob})\,[1 + (s/\omega_\alpha)].$$

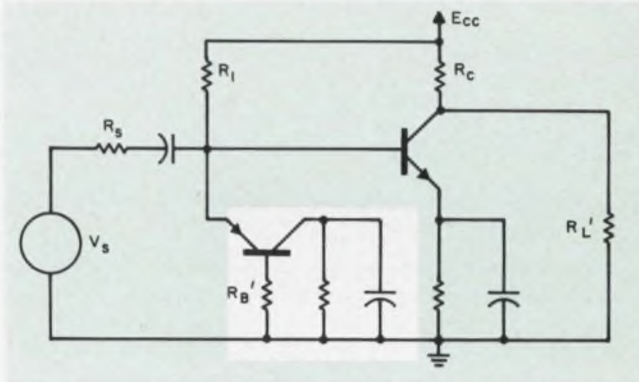
Equation 12 represents the driving-point impedance shown in Fig. 3c. The component values can be found by setting Eq. 12 equal to the input impedance of Fig. 3c, which is:

$$Z_{in}' = [R1'\,R2'/(R1'+R2')]\,(1 + s\,L1')$$
$$\div \{\,1 + s[(L1 + R1'R2'C)/(R1'+R2')] \quad (13)$$
$$+ [s^2\,L1'\,C\,R2'/(R1'+R2')]\,\}.$$

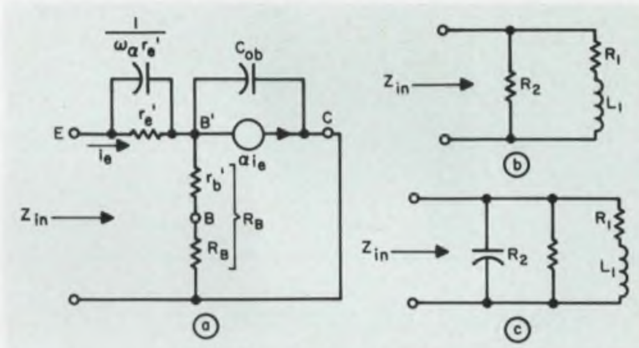
The results are:

$$\left.\begin{aligned} R1' &= R_B\,(1+\delta)\,(1+\alpha_0 m)\,(1+\gamma) \\ &\quad \div \{\,[\beta_0(m+1)-\delta] - \gamma\,[\beta_0\,(1+m)\,\delta - 1]\,\}, \\ R2' &= R_B\,(1+\alpha_0 m)\,(1+\gamma)/ \\ &\quad [1+\gamma\beta_0\,(1+m)], \\ L1' &= R_B\,(1+\alpha_0 m)\,(1+\gamma)^2/ \\ &\quad \{\,\omega_\beta\,[(\beta_0\,(m+1)-\delta] \\ &\quad - \gamma\,[\beta_0\,(1+m)\,\delta - 1]\,\}, \\ C &= C_{ob}/[(1+\gamma)\,(1+\alpha_0 m)], \end{aligned}\right\} \quad (14)$$

where the quantity $\gamma = \omega_t\,r_e'\,C_{ob}$ accounts for the effect of C_{ob} and is much less than unity.



2. **Common-base transistor circuit** can be designed to replace the series RL shunt compensating network of Fig. 1a (in a box).



3. **Inductive property** of the common-base transistor connection is demonstrated by going from its small-signal model (a) to an approximate one (b) and an exact one (c). The effect of C_{ob} is neglected in (b).

From these values two major effects can be noted. The first is that the series-branch Q increases slightly from its value (Eq. 11) to:

$$Q1' = \omega\,L1'/R1' = \omega\,(1+\gamma)/\omega_\beta\,(1+\delta). \quad (15)$$

The second effect is due to the parallel combination of $R2'$ and C, and is deleterious. The effect, however, is not serious, because the characteristic bandwidth of $R2'$ and C is usually much larger than the 3-dB bandwidth. Within the required ω_0. Furthermore, it is found that the loading effect produced by $R2'$ can be offset by increasing R_B, which fortunately increases Q_1'.

Developing the design equations

A set of design equations can be derived for the circuit parameters of Fig. 1 directly in terms of midband current gain $(A_i\,(0))$, 3-dB bandwidth (ω_3), the hybrid-pi device parameters, and a maximally flat-magnitude response. The results are:

$$\left.\begin{aligned} R_i &= (\beta_0+1)\,(r_e' + R_e) \\ &= r_b'\{\,[(\omega_3^2\,D/\omega_\beta)\,(1+1/\nu^2)^{1/2}] \\ &\quad - [\omega_d + \omega_3\,(1+{}^2\nu)^{1/2}]\,\}/\omega_d, \\ \nu &= r_b'/\omega_d, \\ R &= [r_b'\,\omega_3\,(1+\nu^2)^{1/2}]/\omega_d, \end{aligned}\right\} \quad (16)$$

$$\left.\begin{aligned} &\omega_d - \omega_3\{[2(1+1/\nu^2)^{1/2} + 1/\nu^2]^{1/2} - [1+\nu^2]^{1/2}\} = \omega_\beta/D,\\ &\nu = G/(\omega_t/D) = A_i(0)\,\omega_3/(\omega_t/D),\\ &D = 1 + \omega_t R_L C_{ob}. \end{aligned}\right\} \quad (17)$$

R_e is an external unbypassed resistor in series with the emitter and is not shown in Fig. 1.

Equations 16 and 17 are obtained by consideration of the current-gain transfer function:

$$A_i(s) = [b\,A_i(0)/z]\,[s+z]/[s^2 + as + b], \quad (18)$$

where:

$$\left.\begin{aligned} &z = R/L,\\ &a = (\omega_\beta/D) + [(R + r_b')/L],\\ &b = [(R_i + r_b' + R)/L]\,[\omega_3/D], \end{aligned}\right\} \quad (19)$$

$$A_i(0) = \beta_0 R/(R_i + r_b' + R). \quad (20)$$

The 3-dB bandwidth, subject to the maximally flat-magnitude, MFM, condition:

$$a^2 - 2b = (b/z)^2, \quad (21)$$

is:

$$\omega_3 = (b/z)\{(1/2)\,[1 + (2z/b)^2]^{1/2} - 1\}^{1/2}. \quad (22)$$

The coefficients a, b and z may then be expressed in terms of A_i (0) and normalized bandwidth ν, by means of Eqs. 20, 21 and 22, as:

$$\left.\begin{aligned} &a = \omega_3\{2\,[1 + (1/\nu^2)]^{1/2} + (1/\nu^2)\}^{1/2},\\ &b = \omega_3^2\,[1 + (1/\nu^2)]^{1/2},\\ &z = \omega_3\,(1+\nu^2)^{1/2}, \end{aligned}\right\} \quad (23)$$

so that when Eqs. 23 are equated with Eqs. 19 the results given by Eqs. 16 are obtained.

Designing an actual circuit

The following specifications are given:

$A_i(0) = 10,$

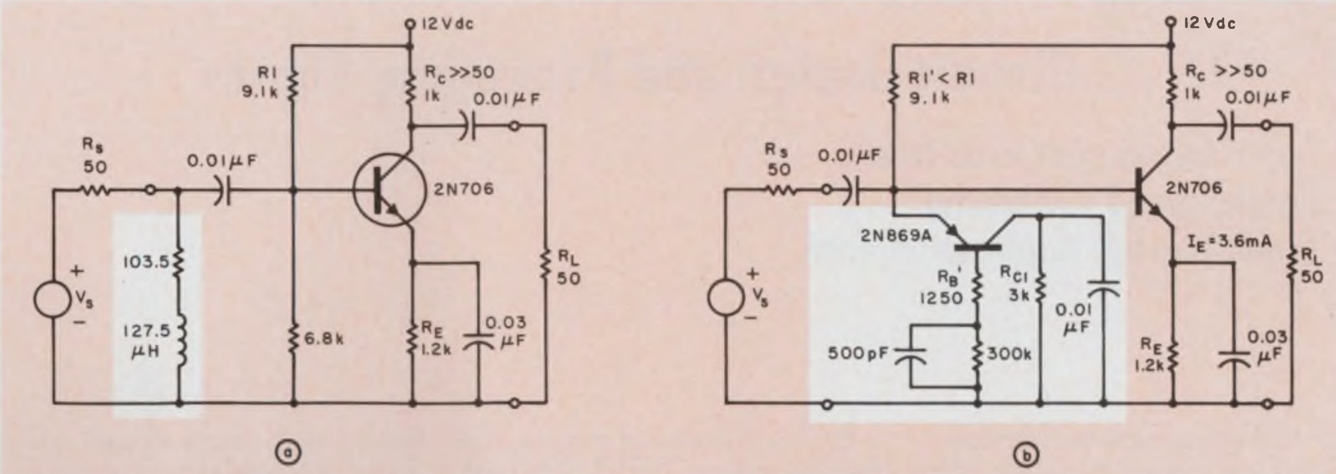
$\omega_3 = 2\pi\, 10$ MHz,

MFM response with $R_L = 50\ \Omega$.

These specifications are to be realized with a

Glossary of symbols

Z_{in}	= circuit input impedance
α_0	= short-circuit, low-frequency, common-base current gain
α	= short-circuit common-base current gain
ω_t	= intrinsic short-circuit radian bandwidth for common-base or figure-of-merit frequency (taken as equal to the transistor short-circuit radian gain-bandwidth.
ω_α	= short-circuit common-base radian bandwidth
ω_β	= short-circuit common-emitter radian bandwidth
f_α	= transistor cutoff frequency
R_B'	= external series base resistance
R_B	= total series base resistance
r_e'	= transistor emitter resistance
R_e	= external emitter ac biasing resistor
m	= excess phase factor—,that is, additional phase lag in radians that must be added to $-45°$ at ω_α to account for the distributed effect.
R_{in}	= input resistance of common-base stage
δ,γ	= design factors
β_0	= low-frequency, short-circuit common-emitter current gain
$R1, R2$	= equivalent network resistors, neglecting C_{ob}
$R1', R2'$	= equivalent network resistors, including C_{ob}
$L1$	= equivalent input inductance, neglecting C_{ob}
$L1'$	= equivalent input inductance, with C_{ob}
C_{ob}	= collector-to-internal-base reverse-bias capacitance with the emitter open
Q_1	= series circuit quality factor, neglecting C_{ob}
Q_1'	= series circuit quality factor, including C_{ob}
r_b'	= transistor series base-widening resistance
R, L	= resistance and inductance of shunt compensating network
ω_d	= design frequency parameter
G	= circuit current gain-bandwidth
ν	= μ normalized gain-bandwidth
$A_i(0)$	= low-frequency current gain
C	= equivalent input capacitance of common-base stage.
R_i	= transistor input resistance
D	= bandwidth degradation factor
ω_3	= current-gain 3-dB bandwidth



4. **Shunt-compensated network values** computed in the text result in a discrete circuit (a) and its active-device equivalent (b). The latter can be readily integrated, since the inductor has been replaced by a transistor, resistor and capacitor. The computed component values can be rounded off to the nearest standard values. The base width of the common-base transistor should correspond to a cutoff frequency about 4 MHz.

device that has these characteristic parameters:

$\beta_0 = 49$, $r_b' = 50\ \Omega$,
$\omega_t = 2\pi\ 200$ MHz, $C_{ob} = 5$ pF.
$\omega_\beta = 2\pi\ 4$ MHz,

From Eqs. 17:

$$D = 1 + 2\pi\ (2\times 10^8)\ (50)\ (5\times 10^{-12}) = 1.628;$$
$$\nu = 0.814;$$
$$\omega_d = 3.93 \times 10^7.$$

From Eqs. 16 the values for the conventional shunt network of Fig. 1 are:

$$L = 50/(3.93 \times 10^7) = 1.275\ \mu\text{H};$$
$$R = [(50)\ (10)\ (1 + 0.66)^{1/2}]/6.24 = 103.5\ \Omega;$$
$$R_i = 362\ \Omega.$$

Since $R_i = 50\ (r_e' + R_e)$, when $R_e = 0$, $r_e' = 7.24$ ohms, which correspond to an emitter current of $I_E = 3.6$ mA (see Eqs. 6). This completes the design of an ordinary shunt-compensated network as shown in Fig. 4a.

To proceed with the common-base design (Fig. 4b), form the ratio:

$$R1/L1 = R/L = 103.5/(1.275\times 10^{-6})$$
$$= (1 + \delta)\ \omega_\beta = (1 + \delta)\ (4 \times 10^6)\ 2\pi,$$

so that:

$$\theta = 3.23 - 1 = 2.23.$$

For an excess phase factor of $m = 0.22$ and the calculated value of $L = L1$, Eq. 11 gives:

$$R_B = [1.275\ (2\pi)\ (4)\ (57.6)]/1.2 = 1540\ \Omega.$$

As a design check, this value of R_B may be substituted into the expression for R_1 in Eq. 8 to yield $R_1 = 103.5$ ohms. The value of R_2 is found from Eq. 9 to be:

$$R_2 = 1540\ (1.2) = 1848\ \Omega.$$

The value of Q_1 at the 3-dB frequency is computed with Eq. 11 to be:

$$Q_1 = 2\pi \times 10^7\ (1.275 \times 10^{-6})/103.5 = 0.774.$$

The effect of C_{ob} has been neglected up to this point. To correct that fact, simply compute $\gamma = 0.0455$ (see Eq. 14) and substitute that value into Eq. 14. The results are:

$$R1' = 103.5\ \Omega \text{ and } L1' = 1.275\ \mu\text{H}$$

$$R_B' = 1250\ \Omega, \quad R2' = 426\ \Omega,$$
$$\delta' = 2.37, \quad C = 4\text{pF}.$$

The bandwidth due to $R2'$ and C is 93.4 MHz. The parallel combination of R_i, $R1'$ and $R2'$ is 67.6 ohms. This resistance is larger, as required, than 50 ohms for an iterative design.

The complete schematics for the conventional and the active shunt-compensated circuits appear in Figs. 4a and 4b, respectively. The calculated component values shown were not rounded off. ■ ■

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 property of a common-base transistor network contributes to its inductive behavior?

2. What is the advantage of replacing a series RL shunt compensating network with an active device?

3. Why is low Q not a disadvantage?

4. How is the effect of C_{ob} accounted for?

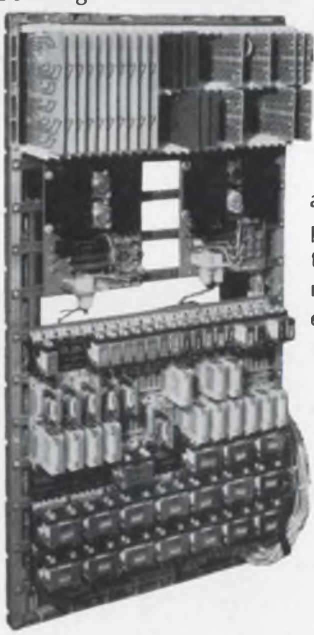
IBM Circuit Design and Packaging Topics

- ☐ packaging cost reductions
- ☐ high-speed switching
- ☐ reed switch application data

☐ packaging cost reductions

Performance Measurements Co., Detroit, Michigan, reports significant savings in packaging their new electronic recording system. The packaging method previously employed required two gates to mount the components in the main console. Now, with IBM's modular packaging as pictured below, only one gate is needed. That's because the IBM technique makes the most efficient use of console space with compactly mounted and connected circuit boards, relays and hardware.

Mounting time has been saved too. Pluggable components, low-cost card receptacles and interlocking card guides have so simplified the packaging job, that Performance Measurements now saves 70% on the cost of mounting hardware. Fewer and shorter wires are needed in the compact console—eliminating three feet of 1½-inch cable and shortening a second cable by eight inches. The modular chassis gave designers freedom to experiment freely with various mounting configurations. It also permits easy access for servicing and diagnostic analysis.



The same design freedom, plus significant hardware and labor savings are available in many applications.

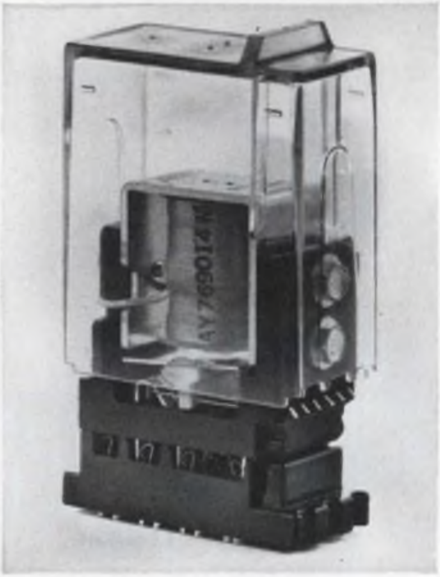
IBM components and packaging can help you in timing control, digital logic testing, telemetering, process or numerical control.

☐ high-speed switching

IBM wire contact relays were originally designed for data processing use. Now they are being used extensively in machine tool and assembly applications. One of these assembly applications is a numerically-controlled component insertion machine. It sequentially inserts random combinations of up to 24 different types of axial lead resistors and diodes into printed circuit boards. Such machines have been widely used, often on a round-the-clock, three-shift basis, in IBM's electronic assembly operations.

Insertion rates range from 3,000 to 4,500 components per hour, depending upon the type of components being inserted.

Instructions from an 8-channel punched paper tape provide the logic-input to the relay gate. The gate employs three rows of 6- and 12-pole IBM wire contact relays. These relays control the movement of each printed circuit board through the X and Y axis positioning of the board for each component insertion. They also control the component feed, component insert, and cut-and-clinch cycles for each insertion operation.



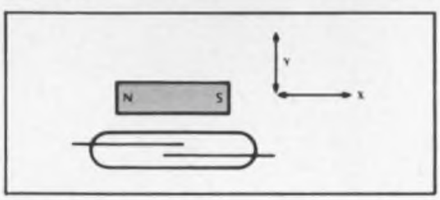
Dust covers are available for various types of IBM wire contact relays. The six-pole model above is shown with cover partially removed.

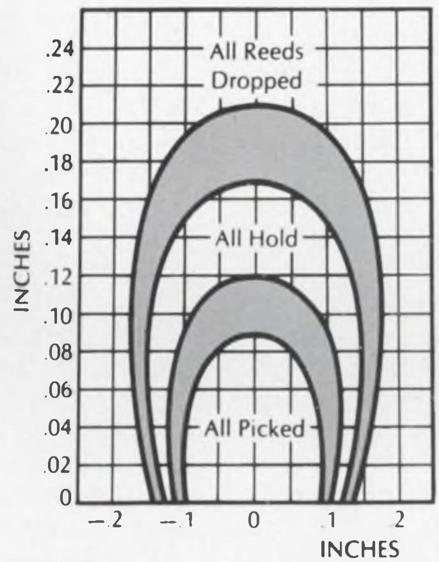
IBM wire contact relays can perform in excess of 200 million operations with an operate speed as fast as 4.5 ms, a release time of 5 ms maximum. The product line includes 4-, 6-, and 12-pole Form C relays, 4- and 6-pole latch models, all with compact, solderless, pluggable mountings—with coil-voltages up to 100 VDC.

☐ reed switch application data

Data on the magnetic switching characteristics of miniature dry reed switches is available to design engineers on request. The data was compiled from extensive tests conducted by IBM to help the design engineer use these switches most effectively. It can also help him determine the motion and position of the magnet required.

Simply described, a miniature dry reed switch operates under the influence of a permanent magnet. When the magnet is adjacent to the reed switch, the flux of the magnet flows through the cantilever beams, as illustrated. While this magnetic flux is being carried by the beams, a polarity exists across the beams. Look at the overlap area of the beams. The north pole of one beam and south pole of the other beam are in proximity. Since unlike poles of a magnet attract each other, when the magnetic force becomes great enough to overcome the physical mass of the beams, they "snap" together, thus switching.





On the graph the X axis represents the displacement (in degrees for rotary motion, inches for lateral motion) of a magnet's center with reference to the center of the reed switch. The Y axis represents displacement (in inches) of the magnet from the outer edge of the dry reed switch glass envelope. Dimensions shown along both axes represent displacement from the center of the magnet in alignment with the center of the reed switch.

There are some "gray areas" where performance varies due to minor differences in the characteristics of each switch.

Assume the zero point on the X axis is the magnetic center of an IBM reed switch. The magnet is positioned with its center at +.5 on the X axis, and .04 inches above the glass envelope. If the magnet is set in motion along the X axis toward the center of the switch, some reeds will pick when the center of the magnet reaches the point +.12 on the X axis. (The magnet has then reached the "gray area"). If motion is continued toward the center of the switch, *all* reeds will pick when the center of the magnet reaches the point +.09 on the X axis.

IBM Industrial Products Marketing Dept. T1R
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IBM INDUSTRIAL PRODUCTS

☐ **packaging cost reductions**
☐ **high-speed switching**
☐ **reed switch application data**

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INFORMATION RETRIEVAL NUMBER 34

Solve quartic equations quickly

with a new closed-form method of finding their roots to help speed circuit and system design.

One of the oldest problems in mathematics and engineering is that of determining the roots of equations in circuit and system analysis. Many methods have been developed, most of them either approximate or graphical (see box). There are, however, also some closed-form (exact) solutions for quadratic, cubic and quartic equations, though the commonly used Farrari method[1,2] is time-consuming, especially for manual calculation.

Now a new, extremely simple closed-form solution has been evolved for the quartic equation. It makes use of the cubic-equation solution developed more than 400 years ago by Tartaglia and Cardan[3]. A feature of the new method is that it can be used for both cubic and quartic equations and requires very little more numerical work than solution of a cubic equation. Another feature of this solution is that the problem may be solved by an alternate approximation method which is especially attractive for computer calculations. Many circuits involve quartic equations, particularly filters, so an example of filter design will be given after the method has been explained. Finally the computer solution will be described.

Shift the roots for symmetry

The method of obtaining a closed-form solution to the quartic polynomial, $F(s) = 0$, may be best understood by using a graphical representation of the roots of the quartic (Fig. 1a).

The roots of the polynomial are first shifted (Eq. 2) in a direction parallel to the real axis to a point where the arithmetic sum of the roots is equal to zero (Fig. 1b). This transformation introduces symmetry into the problem and simplifies the solution that follows.

Figure 2a shows that if the roots are shifted again by any distance A to a position halfway between any two roots, and two roots z_5 and z_6 are added, the resulting equation will be symmetrical about the origin (Fig. 2b). All odd-term coefficients will then go to zero and the equation can be solved as a cubic equation.

Richard L. Phares and **Robert D. Darroch**, Project Engineers, SPACO, Inc., Huntsville, Ala.

The solution to this cubic equation, however, is not necessary. From the odd-term coefficients that go to zero it is possible to solve for A and for the two added roots z_5 and z_6. Since the equation describing A is also a symmetrical cubic equation in A^2 and since z_5 and z_6 are now equal to $-z_3$ and $-z_4$ respectively, it is sufficient to solve the cubic equation in A^2 for only one real positive value of A^2. From this value all four roots of the original polynomial, $F(s) = 0$, are derived.

The cubic equation in A^2 may be solved by any convenient method. Because a cubic equation always has one real root, the Newton-Raphson method (see box) is particularly attractive for computer calculation. In order to complete the closed-form solution of the quartic equation, however, Tartaglia and Cardan's closed-form solution of the cubic equation will be used in part.

The general case solution

Let:

(1) $$F(s) = s + a_4s^3 + a_3s^2 + a_2s + a_1 = 0.$$

The arithmetic sum of the roots will be equal to zero if:

(2) $$s = w - a_4/4.$$

Then:

(3) $$f(w) = w^4 + b_3w^2 + b_2w + b_1 = 0,$$

where:

(4) $$b_3 = 6\,(a_4/4)^2 - 3a_4\,(a_4/4) + a_3,$$

(5) $$b_2 = -\,4\,(a_4/4)^3 + 3a_4\,(a_4/4)^2 - 2a_3\,(a_4/4) + a_2,$$

(6) $$b_1 = (a_4/4)^4 - a_4\,(a_4/4)^3 + a_3\,(a_4/4)^2 - a_2\,(a_4/4) + a_1,$$

If $b_2 = 0$, the roots of $f(w) = 0$ are symmetrical about the origin and may be found by application of the quadratic formula if desired. If the quadratic solution results in complex roots, w^2_n applying the quadratic formula would mean taking square roots of complex numbers. The following solution will obviate the need to take square roots of complex numbers. The roots of Eq. 3 are shifted by an undetermined amount, A, and two as yet unknown roots, z_5 and z_6, are added, so that the resulting root pattern is symmetrical about the origin (Fig. 2b).

This may be done by making the substitution:

(7) $$w = z + A,$$

and multiplying the resultant equation by:

(8) $$z^2 + Bz + C = 0,$$

where Eq. 8 contains two roots which may be either real or complex. Simplifying the results obtained yields:

(9) $$z^6 + d_6 z^6 + d_5 z^4 + d_4 z^3 + d_3 z^2 + d_2 z + d_1 = 0,$$

where:

(10) $$d_6 = 4A + B = 0,$$

(11) $$d_5 = 6A^2 + b_3 + 4AB + C,$$

(12) $$d_4 = 4A^3 + 2b_3 A + b_2 + B\ (6A^2 + b_3) + 4AC = 0,$$

(13) $$d_3 = A^4 + b_3 A^2 + b_2 A + b_1 + B\ (4A^3 + 2b_3 A + b_2) + C\ (6A^2 + b_3),$$

(14) $$d_2 = B\ (A^4 + b_3 A^2 + b_2 A + b_1) + (4A^3 + 2b_3 A + b_2)\ C = 0,$$

(15) $$d_1 = C\ (A^4 + b_3 A^2 + b_2 A + b_1).$$

Since it has been specified that Eq. 9 was to be symmetrical, the odd-term coefficients, d_6, d_4 and d_2, must be equal to zero. From these equations, the following formulas are obtained:

(16) $$A^6 + (b_3/2)\ A^4 + [(b_3^2 - 4b_1)/16]A^2 - b_2^2/64 = 0.$$

(17) $$B = -4A.$$

(18) $$C = 5A^2 + b_3/2 + b_2/B.$$

The nature of the roots of Eq. 16 is interesting (Fig. 3). First of all, since the constant term is always negative in Eq. 16, A^2 must have either one or three positive real values. If $b^2 = 0$ and $(b_3^2 - 4b_1) \leq 0$, A^2 will have one positive and one negative value. If $b_2 = 0$ and $(b_3^2 - 4b_1) > 0$, A^2 may have 0, 1 or 2 positive real values. The complete solution requires a positive real value of A^2, zero excluded and the first two cases meet this requirement. The third case, however, contains some examples for which zero is the only non-negative value of A^2 and therefore will always be solved by quadratic formula to obtain real roots. w_n^2. There are six real solutions for A or three positive values of A^2 when the original equation has all real roots (Fig. 3a). When the original equation contains complex roots (Fig. 3b, c), however, A^2 has only one positive real value.

There are three special cases when the maximum value of A will be zero:

- Where all four roots $w_n = 0$
- Where all four roots w_n are pure imaginary
- Where a pair of imaginary and a pair of real roots are symmetrical about the origin. With the positive value of A two of the roots may be found, while the other two may be obtained with the negative value of A. Only one positive real value

The Newton-Raphson method

The Newton-Raphson method is a numerical solution for polynomial equations. The procedure is to guess at a root, then to use this guess to obtain a closer approximation to the actual root, and so on until the actual root is obtained to whatever accuracy is desired. The method is thus one of successive approximation. Suppose that for the given function $f(x) = 0$, x_0 is a guess at the root $x = \alpha$ (see figure). Then the tangent to $f(x) = 0$ at $x = x_0$ gives a closer approximation at the intersection of the tangent with the x axis, x_1. This is used to find x_2, x_3 and so forth, until a sufficiently close approximation to $x = \alpha$ is found.

The equation for the first tangent is:

$$y = mx + c,$$

where $m = f'(x_0)$ and $c = f(x_0) - x_0 f'(x_0)$. Thus:

$$y = xf'(x_0) + f(x) - x_0 f'(x_0),$$

where $y = 0$ at $x = x_1$. Therefore:

$$0 = x_1 f'(x_0) + f(x_0) - x_0 f'(x_0)$$

$$x_1 = x_0 - f(x_0)/f'(x_0);$$

or in general:

$$x_{n+1} = x_n - f(x_n)/f'(x_n),$$

which is the classic form of the Newton-Raphson iterative method.

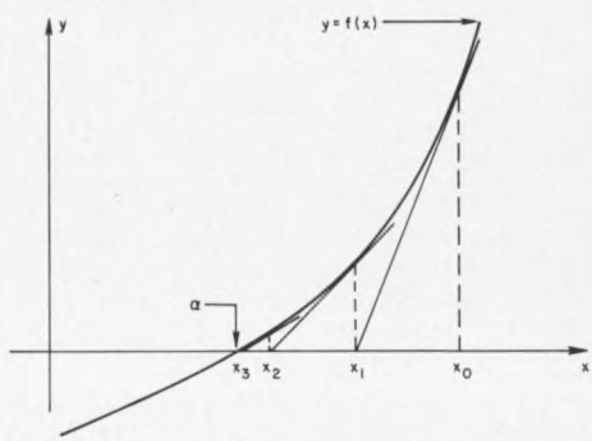
As a working example, calculate $3^{1/2}$ to three decimal places:

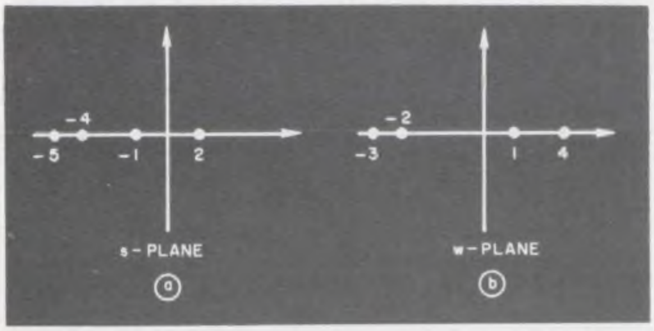
Let $f(x) = x^2 - 3 = 0$, since the roots of the equation will be $3^{1/2}$. Then $f'(x) = 2x$.

As an initial guess, let $x_0 = 1$

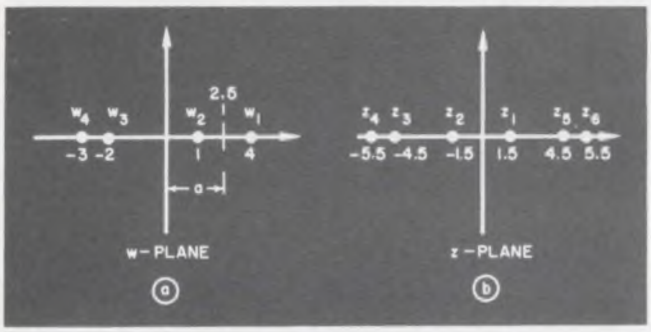
n	x	$f(x_n)$	$f'(x_n)$	$f(x_n)/f'(x_n)$	x_{n+1}
0	1	−2	2	−1	2
1	2	1	4	0.25	1.75
2	1.75	0.0625	3.5	0.0179	1.732
3	1.732	0.0002			

$3^{1/2} = 1.732$ (to three decimal places)

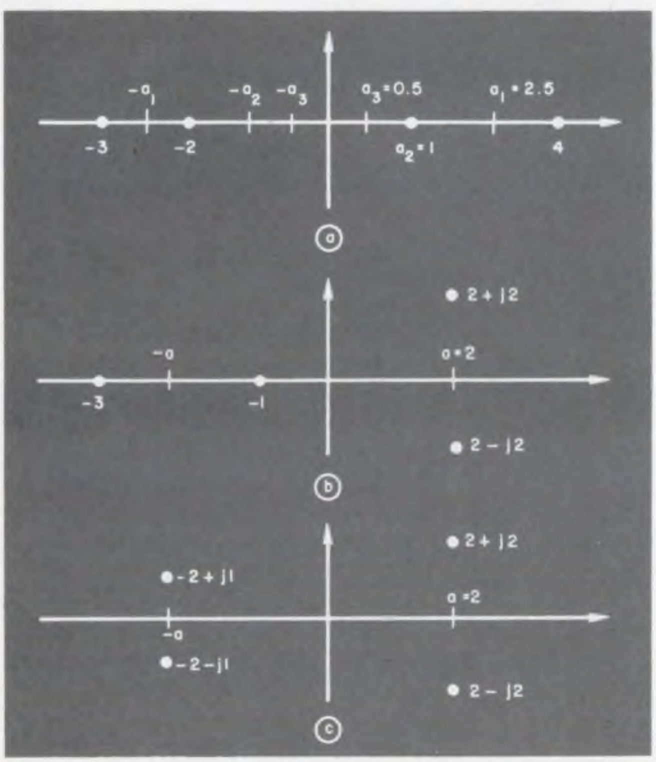




1. **The roots of a quartic equation** (a) are shifted parallel to the real axis until the sum of the roots is zero (b). This transformation from the s to the w plane is accomplished by $s = w - a_4/4$.



2. **For symmetry about the origin,** the quartic roots (a) are shifted so that the origin is halfway between any two roots. Two further roots are then added to make the set completely symmetrical about the origin (b).



3. **When the quartic has all real roots,** there are six solutions for the transformation constant, A, (a). If the quartic has complex roots, there are only two real solutions for A, so only one real value of A is needed to obtain all four roots.

of A^2 is therefore required.

Equation 16 may be solved by any method. Here Tartaglia and Cardan's method will be used to find the maximum positive value of A^2 so that the closed-form solution can be completed. In order to solve Eq. 16 for A^2, Eqs. 19 through 25 are arranged to use Eq. 16's coefficients; they apply generally to any solution of this equation:

(19) $D = b_1/12 + b_3^2/144.$

(20) $E = b_1 b_3/48 - b_2^2/128 - b_3^3/1728.$

(21) $F = (E^2 - D^3)^{1/2}.$

If $E^2 - D^3 \geq 0$, then:

(22) $G = (F - E)^{1/3} - (F + E)^{1/3};$

(23) $A^2 = G - b_3/6.$

If $E^2 - D^3 < 0$, then:

(24) $3\theta = \cos^{-1}[- E/D^{3/2}] \quad (0 \leq 3\theta \leq \pi)$

(25) $A^2 = 2\,(D)^{1/2} \cos\theta - b_3/6.$

The square root of A^2 is taken to find:

(26) $A_1 = +A \qquad A_2 = -A;$

then Eqs. 17 and 18 are used to calculate:

(27) $B_1 = -4A_1 \qquad B_2 = -4A_2,$

(28) $$C_1 = 5A_1^2 + b_3/2 + b_2/B_1,$$
$$C_{R2} = 5A_2^2 + b_3/2 + b_2/B_2;$$

Finding the added roots

The roots that were added earlier for the sake of symmetry may be found from Eq. 8 (where the coefficient of z^2 is unity) and the quadratic formula:

(29) $$z_{1,\,2} = [- B_1 \pm (B_1^2 - 4C_1)^{1/2}]/2,$$
$$z_{3,\,4} = [- B_2 \pm (B_2^2 - 4C_2)^{1/2}]/2.$$

These roots are the negative of the desired roots, z_n. From Eq. 7 then:

(30) $w_{1,\,2} = A_1 - z_{1,\,2} \qquad w_{3,\,4} = A_2 - z_{3,\,4},$

and from Eq. 2:

(31) $s_n = w_n - a_4/4.$

This completes the solution. Substituting Eqs. 26 through 30 into Eq. 31 and simplifying, the following four equations are obtained, where only the positive value of A is used:

(32) $s_1 = -A - a_4/4 + [b_2/4A - (b_3/2 + A^2)]^{1/2},$

(33) $s_2 = -A - a_4/4 - [b_2/4A - (b_3/2 + A^2)]^{1/2},$

(34) $s_3 = A - a_4/4 + [-b_2/4A - (b_3/2 + A^2)]^{1/2},$

(35) $s_4 = A - a_4/4 - [-b_2/4A - (b_3/2 + A^2)]^{1/2}.$

Applying the method to filter design

An example of the use of the exact-solution method is found in the transformation of a four-pole band-pass filter with coupling between the poles (Fig. 4a) to a configuration that has no coupling between the poles (Fig. 4b). This might be desirable where amplifier input and output capacity are both large. One such example is given by the complex Bessel Polynomial for a linear phase low-pass filter. This polynomial is used also for linear phase band-pass filters with some phase distortion depending on the bandwidth.

The Bessel polynomial is given by:

$$\frac{V_p}{\mathbf{V}} = \frac{n!}{(2n)!} \sum_{r=0}^{n} \frac{2^r}{r!} \left(\frac{jk_n f}{f_3}\right)^r,$$

where:

$\mathbf{V}$ = complex output voltage at f,
V_p = peak output voltage in the pass band,
n = total number of resonant circuits,
f = frequency variable = $(f/f_o - f_o/f)$ = f/f_o for band-pass filter
f_3 = f_{3dB}/f_o
j = $(-1)^{1/2}$
k_n: = a constant such that $f/f^3 = 1$ when $[V_p/\mathbf{V}] = 2^{1/2}$.

Letting $s = jf/f_3$ and expanding the series for $n = 4$ and solving for k_4 gives:

$$F(s) = 0.1899\,(s^4 + 4.7318\,s^3 + 10.0769\,s^2 + 11.1277\,s + 5.2655),$$

$$a_4 = 4.7318,\ a_3 = 10.0769,\ a_2 = 11.1277,\ a_1 = 5.2655,$$
$$a_4/4 = 1.1830,\ (a_4/4)^2 = 1.3994,\ (a_4/4)^3 = 1.6554,\ (a_4/4)^4 = 1.9582.$$

From Eqs. 4, 5 and 6:

$$b_1 = 1.9582 - 4.7318 \times 1.6554 + 10.0769 \times 1.3994 - 11.1277 \times 1.1830 + 5.2655$$
$$= 0.3286;$$
$$b_2 = -4. \times 1.6554 + 3 \times 4.7318 \times 1.3994 - 2 \times 10.0769 \times 1.1830 + 11.1277$$
$$= 0.5298;$$
$$b_3 = 6 \times 1.3994 - 3 \times 4.7318 \times 1.1830 + 10.0769$$
$$= 1.6807.$$

From Eqs. 19 and 20:

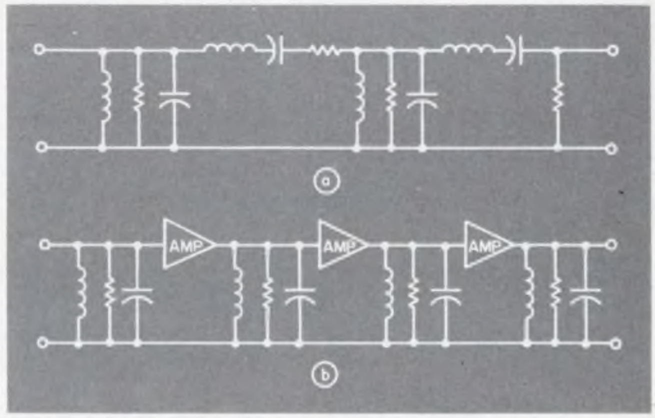
$$D = 0.3286/12 + 1.6807^2/144$$
$$= 0.0470;$$
$$E = 0.3286 \times 1.6807/48 - 0.5298^2/128 - 1.6807^3/1728$$
$$= 0.0066.$$

Since $E^2 - D^3 < 0$, Eqs. 24 and 25, and 32 through 35 give:

$$3\theta = \cos^{-1}[-0.0066/(0.0470^3)^{1/2}]$$
$$= \cos^{-1} 0.6443$$
$$= 130^\circ\ 6.8'$$
$$\therefore \theta = 43^\circ\ 22.27'$$

and $\cos\theta = 0.72692$;

$$A^2 = 2(0.470)^{1/2}(0.72692) - 1.6807/6$$
$$= 0.0351$$
$$\therefore A = 0.1873;$$
$$s_{1,2} = 0.1873 - 1.1830 \pm [0.5298/(4 \times 0.1873) - (0.0351 + 1.6807/2)]^{1/2}$$
$$= -1.3703 \pm j0.4102;$$
$$s_{3,4} = 0.1873 - 1.1830 \pm [-0.5298/(4 \times 0.1873) - (0.0351 + 1.6807/2)]^{1/2}$$
$$= -0.9956 \pm j1.2580.$$



4. **Band pass filters** with identical transfer characteristics may be synthesized directly from the transfer function (a) or its roots (b).

Completing the solution by computer

Programing the solution of a fourth-degree equation by the foregoing method is fairly straightforward provided care is taken at certain points. Examination of Eqs. 22, 24 and 25 reveals that they contain cube roots, inverse cosine and cosine functions which all require approximations in the computer. Use of an approximate method to find the root takes less computer time and is easier to program than the closed-form method. The Newton-Raphson iteration method is better than other approximation methods because it converges faster. Since only one approximation is required, as opposed to two for the closed-form method, accuracy will not be sacrificed and may actually be enhanced by the Newton-Raphson method.

The minimum input data to the program are the coefficients of Eq. 1. If desired, the error limit and the initial testing interval for determining the guessed root for the Newton-Raphson method can both be included in the input data.

Several subroutines are desirable:

- *Function evaluation* — This subprogram computes the value of a function when an array of coefficients of the function and a value for the variable are given.
- *First derivative* — This subprogram computes the coefficients of the first derivative of a function when an array of coefficients of the function is given. The resultant coefficients are stored in another array.
- *Quadratic formula* — This subprogram uses the coefficients of a quadratic expression to determine its roots. The output consists of two arrays: one contains the roots, the other contains zeros if the roots are real or the imaginary part of complex roots.

After the input data and subroutines are entered, the main program begins. Equations 4, 5 and 6 are used to compute the coefficients of Eq. 3 after the change in variable. The resulting coefficients are stored in an array. The coefficients of w^3 and

w^4, namely 0 and 1 respectively, should be stored in the array in their proper locations.

b_2 and $b_3^2 - 4b_1$ are tested. If b_2 is zero and $b_3^2 - 4b_1$ is not negative, Eq. 3 can be solved with the following equation:

$$(36) \qquad w^2 = [-b_3 \pm (b_3^2 - 4b_1)^{1/2}]/2.$$

If b_2 is zero and $b_3^2 - 4b_1$ is negative, the equation is solved as though b_2 were not zero, since solving Eq. 36 would involve taking square roots of complex numbers, and so would complicate the program further.

To determine the roots of Eq. 1, $a_4/4$ must be subtracted from the real part of the roots of Eq. 3. The roots are printed out.

At any point in the program where a number's square root must be taken, the number must first be tested to see if it is negative. If it is negative, the sign is changed before the square root is taken, and the result is stored separately from other numbers in the expression. Upon printout, it is printed as the imaginary part of a complex number.

If b_2 in Eq. 3 is not zero or if $b_3^2 - 4b_1$ is negative, the EQ16 is used. Rewritten in terms of A^2 Eq. 16 becomes:

$$(37) \qquad G(A) = (A^2)^3 + e_3(A^2)^2 + e_2(A^2) + e_1 = 0.$$

The coefficients are computed with:

$$(38) \qquad e_1 = -b_2^2/64,$$
$$(39) \qquad e_2 = (b_2^2 - 4b_1)/16,$$
$$(40) \qquad e_3 = b_3/2.$$

The coefficients of the first derivative of Eq. 37 are also calculated and stored. Equation 37 will have either one positive real root or three. If it has only one, Eq. 3 has at least one pair of complex roots. If Eq. 37 has three positive real roots, Eq. 3 has all real roots. It should be stressed that Eq. 37 always has at least one positive real root $b_2 \neq 0$ or if $b_2 \neq 0$ and $b_3^2 - 4b_1 < 0$.

Finding one root by the Newton-Raphson method

The problem is now to find a single positive real root that satisfies Eq. 37. The closed-form method, outlined in Eqs. 19 through 25, can be used. The Newton-Raphson iteration method was chosen for the program for the reasons already stated.

After the positive root is found, the roots of Eq. 1 are found by solving Eqs. 32, 33, 34 and 35 using only the positive value of A. These are printed out. The program must test the term under the radical and, if it is negative, handle it as an imaginary.

The analysis given here represents what is believed to be the simplest known general solution of the quartic polynomial. It has been programmed in FORTRAN II and converted to FORTRAN IV and has so far solved all equations with no trouble. The approximate running time including read-in and print-out time for a solution is one second once the program has been loaded and compiled. This program is available to interested parties on request from the authors.*

This analysis tends to corroborate the findings of the Norwegian mathematician, Niels Abel, who determined that a closed-form solution to equations of any degree higher than the fourth is impossible. The number of possible values for A, for instance, for a fifth-degree equation would be $4 + 3 + 2 + 1 = 10$. With a symmetrical tenth-degree equation a fifth-degree equation must still be solved. With a cubic equation the number of solutions is $2 + 1 = 3$, so no advantage is gained. It therefore appears that only a fourth-degree equation can be solved to advantage by this method. ■ ■

Acknowledgment: This work was performed for the Quality and Assurance Laboratory Marshall Space Flight Center, Huntsville, Ala.

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1. C. R. Seliger, "General Quartic Formula," *Instruments and Control Systems*, XL, No. 8 (August 1967), 113-114.
2. C. R. Seliger, "Techniques for Finding Roots of Polynominal Equations of Degree Seven or Lower," *Instruments and Control Systems*, XL, No. 2 (Feb. 1967) 120-124.
3. *Ibid.*
4. S. Deutsch, "Maximally Flat-Time-Delay Filters," *IRE Trans. on Circuit Theory*, Vol. CT-6, June, 1959, 214-218.

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*Space, Inc., 3022, University Drive, M.S. 29, Huntsville, Ala. 35805.

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.

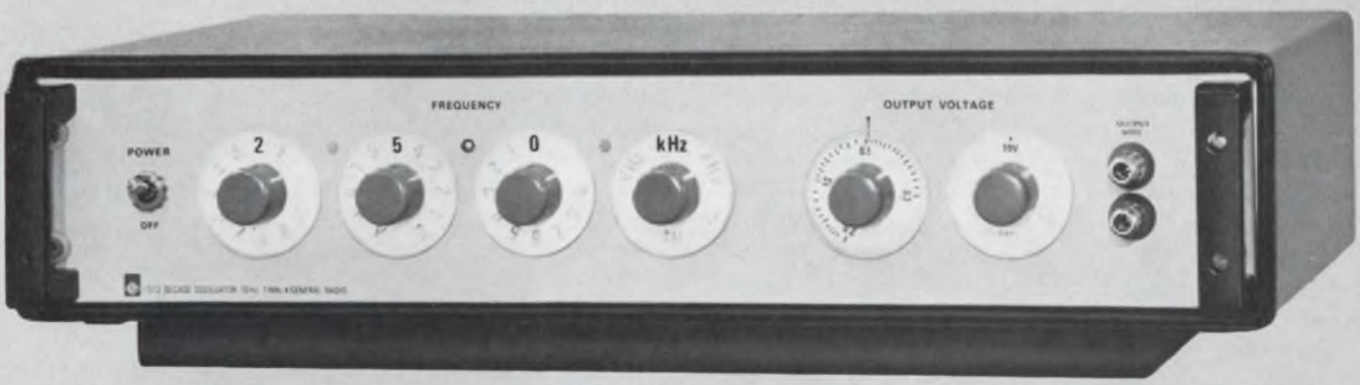
1. What is the effect of the two transformations needed for the closed-form solution?

2. Why is only one positive value of A^2 needed to obtain a solution of the quartic?

3. Solve the equation:
$$x^4 - 3x^3 + 7x^2 + 21x - 26 = 0.$$

4. Why is the method described in the article not suitable for equations of higher order than four?

(The solution to question 3 is given on p. 135.)



Simple to set ... impossible to misread

For people who must constantly change and repeat oscillator-frequency settings, quick and accurate resettability is one of the most important features of an oscillator. With GR's new general-purpose 1312 Decade Oscillator, you can reset in a jiffy any frequency in the oscillator's 10 Hz-to-1 MHz range. Resettability is better than 0.005%, and it's virtually impossible to misread the in-line readout. The first two frequency digits are set with step decades; the third, with a detented continuously adjustable dial. One more control sets the decimal point and indicates the frequency unit, also in-line. Basic accuracy is ±1% of the setting.

Up to 20 volts is available both at the front-panel OUTPUT terminals and at a rear-panel connector. Output is flat within ±2% from 10 Hz to 100 kHz, and you can even short the output without clipping the waveform. The 1312 has a 100-dB output range, provided by a 20-dB continuously adjustable attenuator and an 80-dB step attenuator calibrated in 20-dB steps.

Output impedance is 600 ohms at all voltage levels, including the four intermediate zero-volt positions of the attenuator that allow you to reduce output to zero without touching the adjustable attenuator.

A sync jack at the rear provides an isolated signal to trigger a counter or scope. Through this sync jack, the frequency of the 1312 can also be phase-locked to an external signal for extreme stability.

With excellent performance characteristics, ease of use even by unskilled operators, and a price of only $415, the 1312 Decade Oscillator is ideal for any lab or production test station. Ask to see one in your own plant. Call your nearest GR Sales Office or write General Radio Company, W. Concord, Massachusetts 01781.

GENERAL RADIO

INFORMATION RETRIEVAL NUMBER 35

Can bipolars and tunnel diodes or SCRs be put on the same chip?

The processing of tunnel diodes requires low material resistivities and high doping levels that can be obtained, as far as is known, only by the alloying process. These requirements are incompatible with the types of active devices normally used in integrated-circuit form. At present then, the possibility of including both tunnel diodes and bipolar devices in a single integrated-circuit monolithic is remote. Both types of devices can be provided in a single package, however, by multichip assembly techniques.

Four-layer npnps or SCRs and bipolar npn transistors normally require different diffusion schedules, but they are not completely incompatible. Combining npn and pnp transistors within a monolithic structure can be done if the circuit can tolerate the less-than-optimum characteristics that result.

What are the temperature effects on diode capacitors in integrated circuits?

There is no first-order temperature effect on the capacitance of a junction-type unit in integrated circuits. There is, however, a second-order effect that involves generation of additional carriers, which affect the change of capacity per unit area. Normally, the second-order effect is small enough not to require consideration in circuit design.

Is it possible to fabricate both field-effect and bipolar transistors on the same integrated circuit?

Yes. It is impossible, however, to optimize the characteristics of both the FET and the bipolar device. The FETs require high-resistivity channel material, while the bipolar devices require additional diffusion steps. Furthermore, the operational characteristics of the FET and bipolar devices dictate different voltage and current bias levels. Impedance matching is poor.

Test your IC IQ is a collaboration between the staff of ICE (Integrated Circuit Engineering Corp.) Phoenix, Ariz., and the editors of ELECTRONIC DESIGN. Readers are invited to submit questions to Test your IC IQ, Microelectronics Editor, Electronic Design Magazine, 850 Third Ave., New York, N.Y. 10022.

Although circuit designs that tolerate large parameter spreads and relatively inferior device characteristics can employ such devices, the necessary combination of design requirements is rare. These devices are therefore not generally available.

Are integrated circuits breadboarded for prototype work?

Experienced designers do not generally need to breadboard integrated circuits. Most manufacturers and suppliers of integrated circuits have sufficient experience in translating circuit schematics into mask layouts for an average of two out of three attempts to be successful. Integrated circuits are, however, designed where the components are left unconnected on a die, so that a custom circuit may be produced by wiring them together in a suitable monolithic design. This is a quick and economical way of breadboarding a monolithic, although the component parameters are somewhat limited.

How can process-control procedures be used to provide early indications of reliability degradation?

If a process-control pattern is fabricated at the same time, and in the same batch, as the desired circuits, life tests can be made on different suspected areas where reliability problems might occur. Since there is the possibility of accelerating the life tests on a special pattern, it is possible to get early indications of reliability degradation.

What are the highest values of diffused resistors available in monolithic integrated circuits? How can they be made?

There is no upper limit to the value of diffused resistors that may be used in silicon monolithic integrated circuits. There are, however, practical limitations on the line widths that can be used and the area of die occupied. In practice, few manufacturers attempt by straight diffusion techniques to design circuits with individual resistor values of over 30 kΩ. There are other techniques, such as squeeze resistors, for increasing the value by a factor of at least 10. However, a resistor made in this way has a poor temperature coefficient and poor tolerances in terms of absolute value, and has therefore not been used in any commercial circuit.

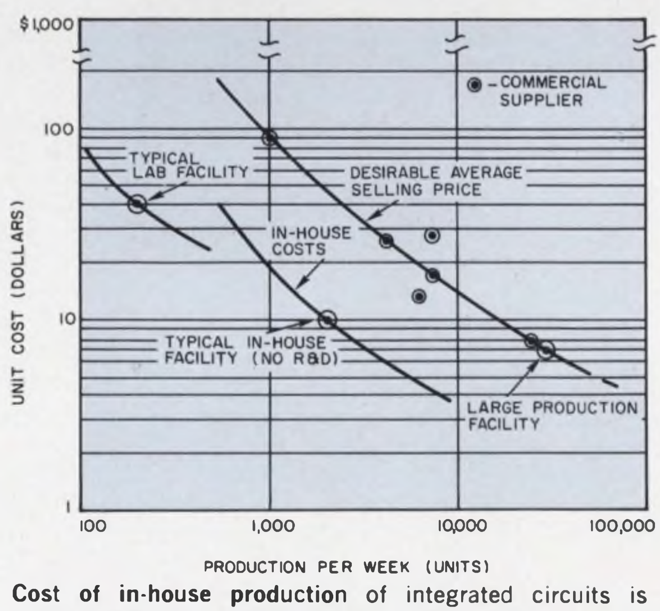
With the advent of integrated circuits, what is going to happen to the circuit designer's job?

The circuit designer's job will ultimately demand familiarity with integrated circuits. In order to optimize designs using integrated circuits, the designer will need to know the materials and the fabrication and assembly processes involved in their making. If he is presently designing with discrete components, he will be under increasing pressure to learn "building-block" techniques.

Component manufacturers will become increasingly involved in the manufacture of entire circuits. Perhaps this area will afford temporary refuge for those designers who do not acquire an IC capability.

Is there a cost-versus-quantity crossover of thick-film versus monolithic silicon integrated circuits (including all tooling)?

There is no definite crossover point in terms of dollars versus quantities. With present improved techniques, it is possible to tool up and build a custom monolithic circuit for as little as $10,000. If circuit requirements can be met by both techniques, and if quantities are in the range of 1000 to 5000 pieces, it is probably more economical to go to silicon monolithic processes.

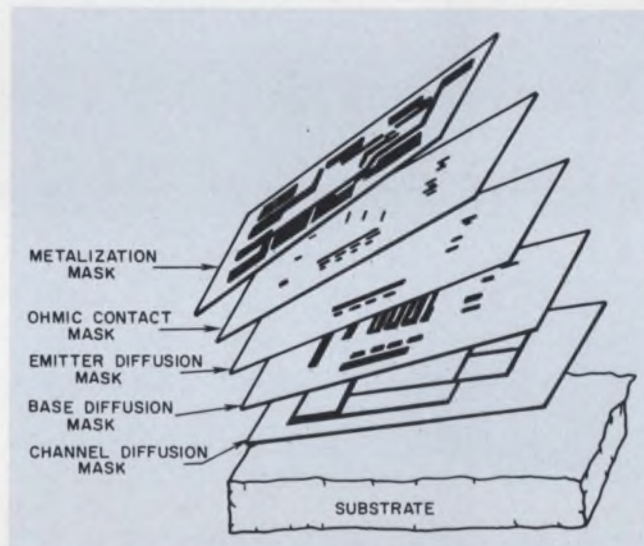


Cost of in-house production of integrated circuits is much lower than a commercial supplier's profitable selling price at the same volume. The primary reasons for this are absence of research and development costs and absence of allowance for profit in the in-house curve.

What are photo masks and what is their significance?

Photo masks are the fundamental tooling in integrated-circuit fabrication. They are used to transfer the geometric patterns that control component location, diffusion, metalization pattern, etc., to the surface of the silicon slice. Each such process step is controlled by a separate photo mask. A set of masks for integrated-circuit fabrication may number as few as five or as many as a dozen. They afford complete freedom of design with respect to the surface geometry of the components.

Producing these sets of precision microphotographic masks is now an essential part of circuit development, and of the manufacturing process. At present, because of its great versatility, photolithography is universally used as the mask making method.



A series of patterned masks, each produced photographically, is employed to control process steps in integrated circuit fabrication.

Which type of integrated circuit, TTL or DTL, has the potential for longer technological popularity?

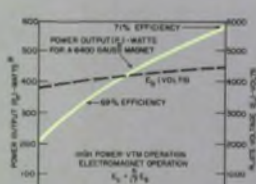
At present, it appears that the industry is turning toward the TTL logic series. For the last few years, DTL logic has been the most popular logic form for a typical digital system. This was a result of the long familiarity, on the part of the designers, with this form of circuit, and the fact that at least 11 different suppliers offer the basic DTL logic line. However, during the last year, the TTL logic line has shown a gain in popularity. This is primarily due to its higher speed operation, which results from the active turnoff characteristic caused by the multiple emitter input. The TTL line probably will receive the greatest emphasis in the next few years.

COMPONENT CAPSULES

General Electric VTM's develop over 500 watts to give you a better ECM device

No other electronically tuned device on the market today can match GE Voltage Tunable Magnetrons for power output (over 500W) and conversion efficiency (to over 70%).

Magnetic shielding virtually ends degaussing effects in GE VTM's. Tube/equipment inter-



face problems are minimal—each VTM can have an integral isolator designed for your system.

Airborne application features are: linear electronic tuning, rapid modulation, minimal power variation over the band, temperature compensation, and light, compact packaging.

GE VTM's are offered in low-, intermediate-, and high-power configurations for other microwave applications. Circle **Number 231** for more details.

* Recent developmental model

Highest volumetric efficiency at half the size—with GE wet slug capacitors

GE 69F900 wet slugs meet high-density application needs with highest volumetric efficiency of any capacitor. We halved the military (CL64) wet slug size, and essentially kept its electrical and performance traits.

The 69F900 has excellent capacitance retention at low temps . . . can be

Actual size

stored to —65C. Operating range is —55C to +85C. It's tough too—withstands vibration to 2000Hz; 15G acceleration!

GE's new capacitor is fully insulated; has low, stable leakage current. Ratings are available from 6 to 60 volts; capacitance ranges from 0.5 to 450 μf.

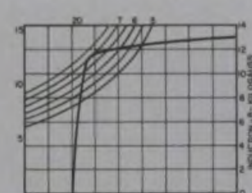
RATING	CASE SIZE	VOLUME
50V, 30μf		
solid (CS12)	.341X.750	100%
wet slug (CL64)	.281X.681	58%
69F900	.145X.600	15%
15V, 80μf		
solid (CS12)	.341X.750	100%
wet slug (CL64)	.281X.681	58%
69F900	.145X.600	15%
6V, 180μf		
solid (CS12)	.279X.650	100%
wet slug (CL64)	.281X.641	100%
69F900	.145X.600	25%

Circle **Number 232** for more data.

Alnico 5-7 magnetic material—a great improvement over Alnico 5

GE Alnico 5-7 improves or equals performance of conventional Alnico-5 —with reduced magnet length, smaller cross-section.

Alnico 5-7 has great advantage where space and weight must be minimal, and high demagnetization resistance is required.



Demagnetization vs energy output, Alnico 5-7

Typical applications for Alnico 5-7 are high-density meter movements; electron tube devices; compact loud speakers; motors and generators.

Let our engineers work with you to design a Cast Alnico 5-7 magnet for your application. Circle **Number 233** for technical and ordering information.

Specify Volt-Pac® variable transformers for maximum life, minimum maintenance

Construction is the key to Volt-Pac's optimum performance. Here's why.

A spring-loaded, grain-oriented carbon brush means even contact, reduced wear. Self-lubricating nylon bearing lessens voltage selector friction.

Here are more features—Polyesterimide in-

Manual
uncased unit, exposed terminals

sulation of coil windings gives extra reliability. Aluminum radiator and base evenly dissipate heat, extend life. Gold-plated track reduces possible heat build-up at brush contact, minimizes burn-out risks.

A-c voltage range of these autotransformers is zero to 100%, or 117% of fixed-input voltage without waveform distortion.

Manual or motor-operated Volt-Pacs can be ordered with or without enclosures, and with exposed or covered terminals. For more Volt-Pac facts, Circle **Number 234.**

Bonded heater version of popular 7077/7486 tube now available

The new GE16411 may solve your most perplexing oscillator problem.

This small planar triode provides low levels of oscillator side-band noise. A bonded heater addition makes the GE16411 useful under high shock, vibration conditions.

GE16411 recently made possible significant im-

Actual size

provement in short-term, long-term stability characteristics in a spectrum-analyzer design.

It also provides direct retrofit fast warm-up capability for the 7077/7468 family—about 3 seconds to 90% of steady-state plate current.

The new triode is another example of how GE product improvements can aid you in designing reliable, top performing equipment. Circle **Number 235** for more information.

A TECHNICAL DIGEST FOR INNOVATORS OF ELECTRONIC EQUIPMENT

High performance d-c motors for computer and peripheral jobs

New Hyper-Servo* d-c motors meet needs of single-capstan tape transports, disc packs, high-speed printers, card sorters and similar equipment.

Hyper-Servo motors offer **instant response**—to one millisecond!; up to 50 times more **frequency response** (band width) than standard d-c industrial motors.

Fast, repeatable acceleration is easy with: **low** rotor inertia, armature circuit inductance, resistance; **high** torque-to-inertia ratio, constant torque-per-ampere relationship, voltage constant. Circle **Number 236.**

*Trademark of General Electric Co.

Model 5BLG32HA1 (3.4" dia, 4.28" long)

Model 5BLG32HA1

Rated Armature	
Voltage	12 volts
Current	8 amps
Rated Torque	32 oz-in.
Rated Speed	2700 rpm
Rated Output	64 watts
Shunt Field	PM shunt
Arm. Circuit	
Inductance	82 μH
Resistance	.43 ohms
V Constant	.0291 V Sec/Rad
Torque Constant	4.0 oz-in./amp
Arm. Inertia	.0028 oz-in. Sec^2
50 Milliseconds	
Pulse Torque	320 oz-in.
Pulse Current	80 amps
Time Constant	
Inertial	9.0 ms
Inductive	.19 ms
Torque/Inertia	
@ Rated V	40,000 Rad/ Sec^2
Continuous RMS	
Current Rating	8 amps

Don't miss this one—smallest 50 mW, 2-amp relay on the market

It just takes 50 milliwatts to operate this extra small, 2-pole, 2-amp relay.

Size-wise, this newest GE 150-grid relay is only 0.32" high, 0.31" wide, 0.61" long. And, it meets or exceeds MIL SPEC environmental, electrical requirements.

Micro-electronic circuit applications are ideal for this relay because of its low operate power and compatible size.

Like all GE 150-grid relays, this 50 mW version is available with options. You can choose coil ratings for a wide range of system voltages, plus popular mounting forms and header types.

Want more facts? Circle **Number 237.**

Actual size

Check these Darlington amplifiers for high gain

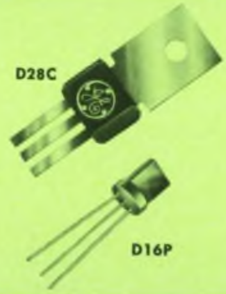
GE D16P monolithic Darlington amplifiers (D16P1, 2, 2N5305-8) with current gains as high as 70,000 are available in 2 housings. They offer dissipation capability of 400 mW or (with heatsink package) 900 mW.

D16P's high gain is ideal for preamplifier input stages requiring input impedances of several megohms.

GE's D28C monolithic power Darlington also offers very high gain (60,000 typical at 200 mA) with higher power and current ratings. Dissipation is 1.2W in free air and 4.0W at 70C case. Continuous IC is 500 mA.

The high gain affords virtually unlimited applications including: power transistor drivers, touch switches, oscillators, amplifiers and buffers, plus audio output stages for TV, radio, and other audio equipment. Circle **Number 238.**

D28C



D16P

Nickel-cadmium batteries are rechargeable—last hundreds of times longer

Get lasting battery power and versatility suitable for many commercial and consumer applications. Types include sealed, pressure-relieved, and vented cells. Custom designs to your specifications are also available.

Nominal ratings range from 0.1 amp-hours to 4.0 amp-hours in sealed cells and up to 160 amp-hours in vented types at the one-hour rate.

GE nickel-cadmium cells feature unique construction providing a very high discharge rate capability. To find out more, Circle **Number 239.**

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What's your special requirement for panel instruments? Taut band suspension, special scales or colors, one percent accuracy?

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FOR THE NEW IDEAS IN ELECTRONICS, look to General Electric—your best single source for electronic components

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285-38

Elude the traps to sound decisions,

and you're on your way to successful managing. But be prepared to shed some common biases first.

Important decisions are harder to make than less important decisions.

Or are they?

Many people believe that they are, but in fact there is no direct correlation between magnitude and difficulty. The man making major decisions may have more going for him: in addition to his own qualifications that have put him where he is, he has greater access to information and the skills of others to help him make the "right" decision.

All decision-making leans on the same foundation—fact plus theory. All decision-makers face similar fundamental traps to success.

Decisions are choices made by interpreting things observed (fact) in the light of things believed (theory).

As a decision-maker, you start first with facts—the incontrovertible, irrefutable and unarguable. But keep in mind that not all facts are immutable. With progress and change, today's fact may be out of date tomorrow.

In the absence of fact, you must fall back on the best available information, which is often well laced with opinion. This is not necessarily bad, if your sources of information are reliable and if the opinions are well founded. But in accumulating data, all successful decision-makers must learn to avoid the traps for the unwary. These may involve the information itself or the way it is collected.

Trap 1: Misdirection

Your real problem here is to ask the right questions. The questions must pinpoint the problem and properly focus the attention of the expert on it. The expert must know clearly what information is wanted from him. One of the easiest ways to misdirect him is to try to find out something from him without revealing anything significant to him. This will certainly be a case of the blind leading the blind. Solution: Explain the problem to him clearly.

Trap 2: Amateur sampling

Sampling is a legitimate and useful research tool—but only when it is handled by a qualified person. In sampling, you hope to learn about the thinking of the many by questioning the few. You can be successful if you ask the right questions of the right people.

Since a sample generally is kept as small as possible for economic reasons, the difficulty is in securing a sample that is both adequate and representative. There are usually so many human factors involved that it is extremely difficult to find individuals who can faithfully mirror the thinking of thousands. Thus you—the amateur poll taker—should be dissuaded from placing too firm a reliance on your own inexpert collection of data. A sample that is adequate in the hands of an expert may be woefully inadequate in the hands of an amateur. An error of 10 per cent may be disastrous to your findings.

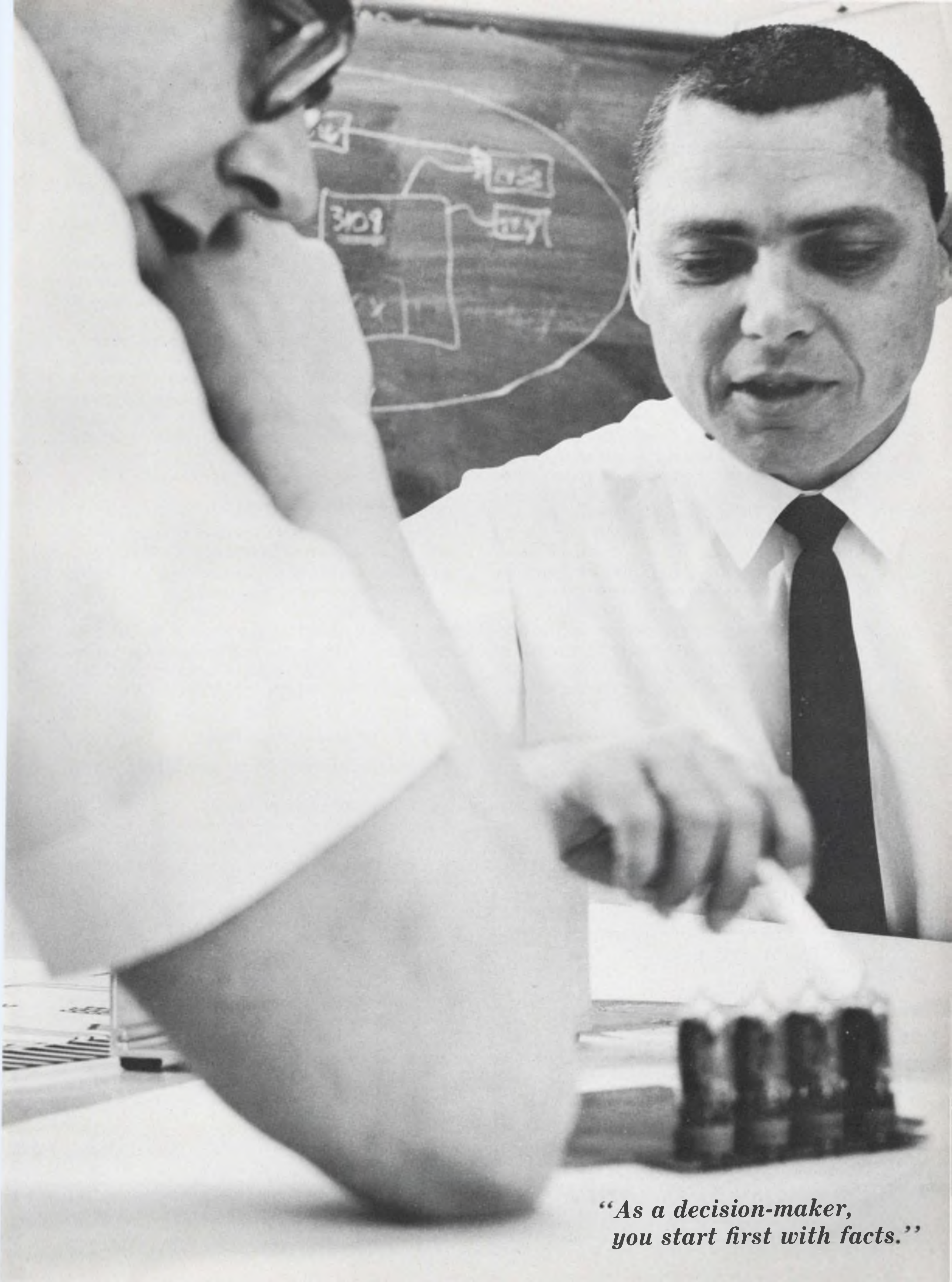
Trap 3: The ubiquitous average

The word average has several legitimate meanings, which may vary widely when applied to a particular item. If the number of units involved is small, the mean average may be far from the median or the mode.

Suppose you had to estimate the engineering manpower needs for a project, based on the figures for the year as shown in the table on p. 84. It would be misleading to use the median and to conclude that if the work load remains the same, you would need 75 engineers each month. In this illustration, 300 government engineers might have been on special assignment in the plant for the month of October to work on one phase of the project. The mode or mean

Don Fuller, Director, Engineering Div., Industrial Education Institute, New York.

Analyzing data that will lead to a decision is Perry A. Diederich, Engineering Manager, Fullerton Group, Electronics Instruments Div., Beckman Instruments, Inc., Fullerton, Calif.



*"As a decision-maker,
you start first with facts."*

(both 50) would be a more accurate guideline for your usual monthly engineering needs.

Averages bury extremes. A man can drown in a river that is on the average two inches deep if he falls into the one spot that happens to be 50 feet deep.

Trap 4: Selecting only the favorable

If you hope to reach the right decisions, you must learn to recognize and curb your personal biases. Otherwise, in evaluating the facts, you may reject the unfavorable ones and accept only the favorable. Guard against selectivity by getting all the facts, including the figures swept under the rug.

Another case of selectivity is to correlate the general with the particular. If a general study of children indicates that the average age at which a child sits up is x months, don't necessarily conclude that your child is retarded if he falls short of the average. Before you make a frantic call to the child expert, find out how many children did not sit up after x months but still managed to win a Nobel Prize or sit on the Supreme Court.

Nor must you correlate the frequent with the normal and then quickly conclude, "What is normal must be right and therefore good." Cannibalism is frequent among cannibals. Anthropologists can tell you this is normal; theologians or lawmakers can say if it is right; whether it is good will depend on whether you are the eater or the eaten.

Trap 5: Interpreting it my way

The same set of data may be open to several interpretations. Unless you have special qualifications, you would be rash to dispute the interpretations of qualified experts. Remember that in accepting their interpretations and weaving them into your decision, they become your interpretations when they go up to your superior.

Thus be wary of the interpretation that distorts the data. The distortion is not always deliberate; one man's distortion may be another's straightforward presentation. Your interpretation may be distorted only because you were misled. If your R&D budget has risen from 3 per cent to 6 per cent of the company's total budget, should you say it has gone up 3 per cent or 100 per cent? It may be best to avoid a percentage altogether and say it has doubled.

The mere physical layout of a graph, chart or table may distort. For example, if you are accustomed to thinking of something in terms of months, the reporting may be distorted by graphing it in weeks to slow down the movement of the curves, or in quarters to accelerate it (see figure).

Table. Monthly manpower needs

Month	Number of engineers
January	50
February	48
March	46
April	50
May	52
June	54
July	50
August	50
September	50
October	350
November	48
December	52

Trap 6: Biased connotation

This bias is the implied emotional content you add to an explicit literal meaning. While it is natural to draw out all the meaning there is in a remark, don't draw out meanings that aren't there. Your boss says, "If it doesn't work as you expect, we'll have to make some changes." This may mean nothing more than a change of approach to the secure engineer, but it may imply a change of personnel to the insecure one.

Trap 7: The jumped-at-conclusion

This is a trap you set up and fall into all by yourself.

Consider these two premises:

Premise 1: More plane accidents occur during clear weather than during foggy weather.

What you can conclude from this information is simply that more plane accidents occur during clear weather than during foggy weather.

What you *cannot* conclude from this information is that it is safer to fly in foggy weather.

Premise 2: More plane accidents occur during clear weather than during foggy weather; however, the mortality rate is higher for flights made in foggy weather.

What you can conclude from this information is that it is safer to fly in clear weather.

Consider and interpret all the factors before making a decision. Don't take mere words and statistics at face value.

Trap 8: The meaningless difference

The meaningless difference and its twin, the meaningless similarity, are cases where a lot is hoped to be done with practically nothing. You cannot create a difference where none exists nor make the insignificant seem significant.

Don't inflate minor differences to increase their importance or the validity of your decision.

Trap 9: The status syndrome

The status barrier between superior and subordinate limits communication in either direction, because of fear of disapproval on the one hand and of a loss of prestige on the other.

The boss may fear to ask a question. To do so, he thinks, may suggest that he does not know his business. So he acts as though he already knew the answer.

The subordinate may fear to ask the boss a question. "Maybe I should know the answer," he thinks, "and if he finds out I don't, I may be in trouble."

Trap 10: Ignoring failures

It's human nature to want to forget about past failures, but they do have a great value—as a warning. Assume that these failures occurred when intelligent men made the wrong decisions. If not reminded or warned, equally intelligent men in like circumstances might go astray again. Profit from past mistakes. Find out how and why past failures—whose initial circumstances resemble your present problem—came to pass.

Guidelines for decision-makers

Good decisions—which mean good programs—accomplish five things:

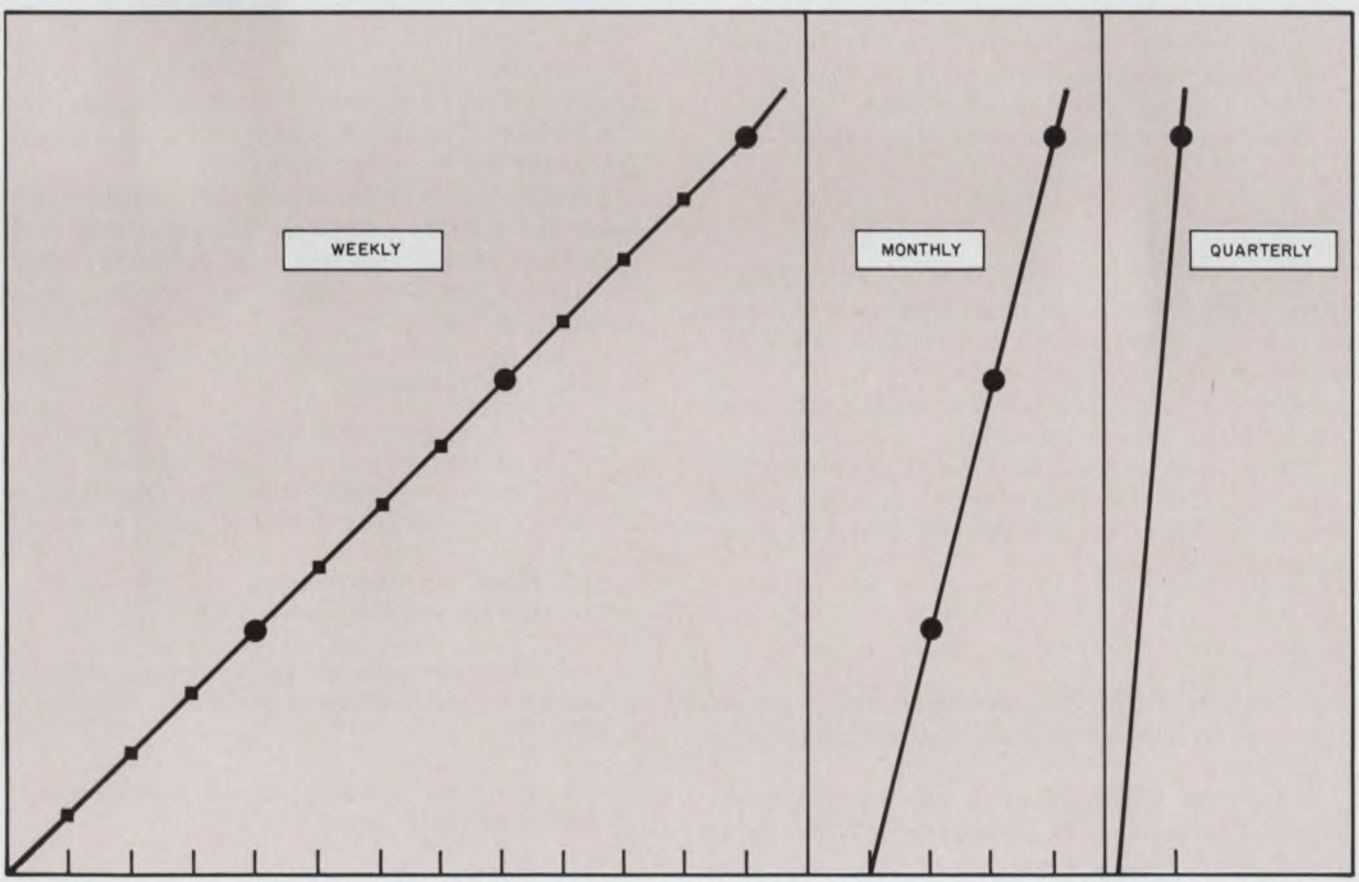
- Solve problems.
- Develop people.
- Improve the company's position.
- Encourage progress, in thinking as well as acting.
- Create opportunities.

The solving of problems is the first goal of decision-making and planning, but the degree to which the four other points are included distinguishes the pedestrian manager from the superior one.

The better you can answer the following questions, the better your final decision will probably be and the better it will accomplish the five points in good managerial decisions.

Who?

Who *should* make the decision? Who *will* make the decision? Hopefully the answers are the



Distorting the interpretation: If your data are usually plotted monthly (center), the graph may be distorted by plotting it weekly (left) to slow down the movement, or in quarters (right) to accelerate it.

same. If not, adjustments should be made.

Who should advise on the decision? Identify the specialized areas and consult the proper specialists.

Who should participate in the decision? Determine what other activities will be involved or affected.

Who should be informed of the decision? Never allow yourself to be accused of failing to keep people informed.

Who should implement the decision? In other words, once a decision has been made, how does it "get into the works?"

Who will be responsible for results? Responsibility must be fixed early, so that the man made responsible can be in on all phases of planning and performance.

What?

What *should* be decided? What *must* be decided? What *can* be decided? "Should" is a maximum, the most you can wish for; "must" is a minimum, the least acceptable; "can" is what is currently possible, with the hope of expanding toward the maximum.

What information is needed? What facts are now available? What information is lacking?

What orders and requests are necessary? Will normal procedures take care of them? If not, what steps must be taken?

What benefits will result from the decision? What disadvantages, if any must be considered?

What possible risks are involved?

What are the limitations of your action?

Where?

Where are the personnel to come from? This is often a key question in implementing a decision. If you cannot get certain people, your whole approach may have to be revised.

Where will you go for the facts, both those available and those missing?

Where will your decision lead? Where will it lead you? The wise decision-maker looks ahead and does not let himself get into blind alleys or untenable positions.

When?

When *can* the decision be made? When *should* the decision be made? When *must* the decision be made?

When *can* the decision be announced? When *should* the decision be announced? When *must* the decision be announced?

When *can* the decision be followed up? When *should* the decision be followed up? When *must* the decision be followed up?

In all three groups of questions, the key point is: Timing can be vital; make time work for you; try not to be too late, but at the same time be aware of the hazards of being premature.

How?

How can you get the facts?

How can you get the participation?

How can you get the support?

How can you get the personnel?

How would you implement the decision? A good decision-maker makes decisions as if he personally will have to implement them. In other words, he has a plan and at least a general idea of the methods by which the desired results can be achieved.

Some managers think they are doing their planning job when they no more than meet and solve day-to-day problems as they arise. These men manage to achieve a "passing grade"—but just barely. They make their superiors nervous by being just within the acceptable limits of performance.

Superiors are made uneasy by the thin margin by which success is achieved and worry that the next job will fail by an equally thin margin. Such "just make-it" managers are fond of saying, "But I've never let you down yet, have I?" What they do not realize is that they are like men who leap onto a train just as it is pulling out of the station, after you have been nervously pacing the platform and have finally given them up. The "just-make-it" manager can easily trip and not just make the train the next time.

Finally, the good decision-maker distinguishes between a *problem* and a *task*. You are faced with a problem when an answer must be found. When the answer has been found, then you are faced with a task. ■■

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 are the hazards of relying on personal surveys and overages?

2. How can selectivity and interpretation each lead you away from the best decision?

3. How can you best avoid making the "jumped-at conclusion"?

4. What is the great value of not forgetting past failures?

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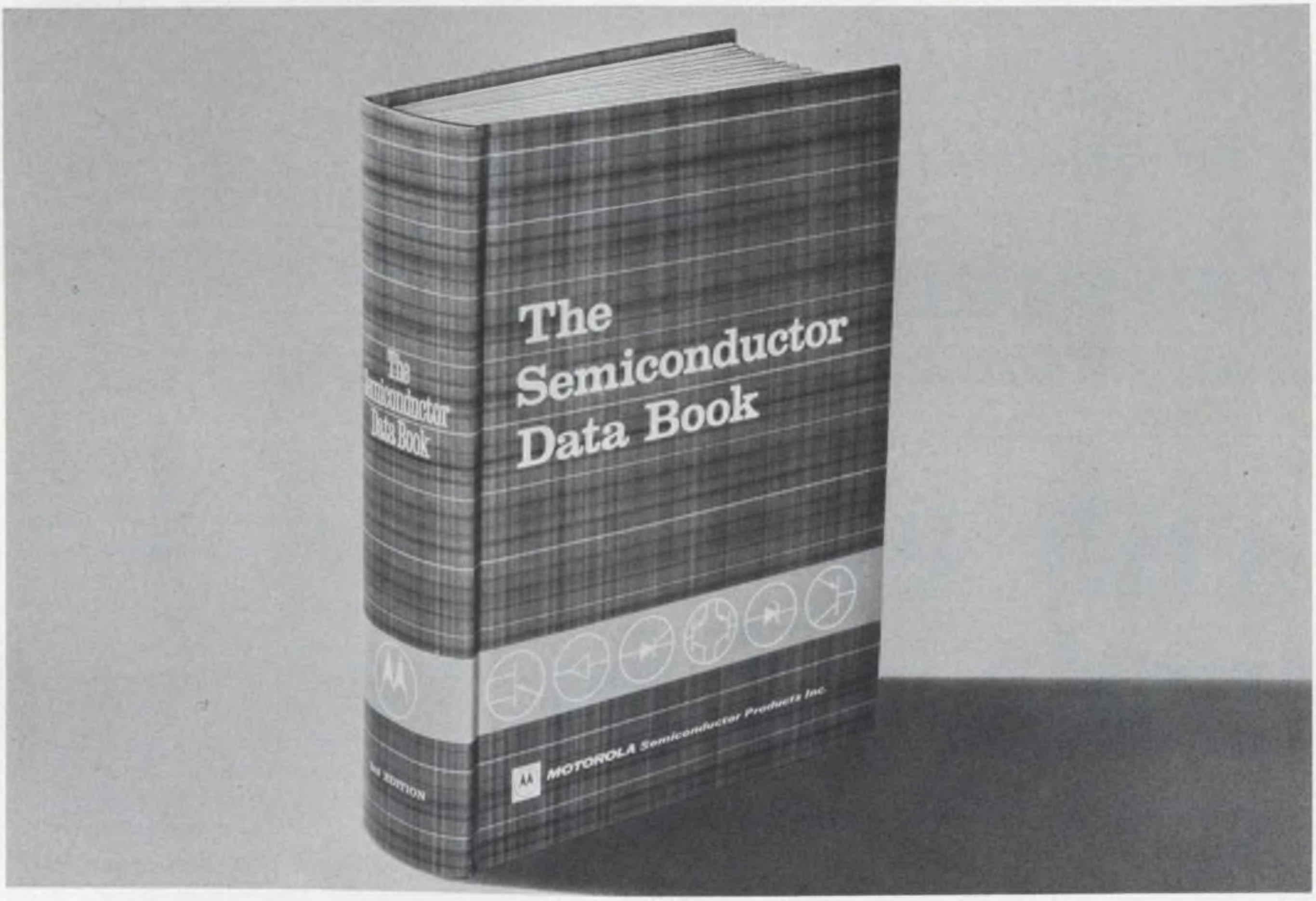

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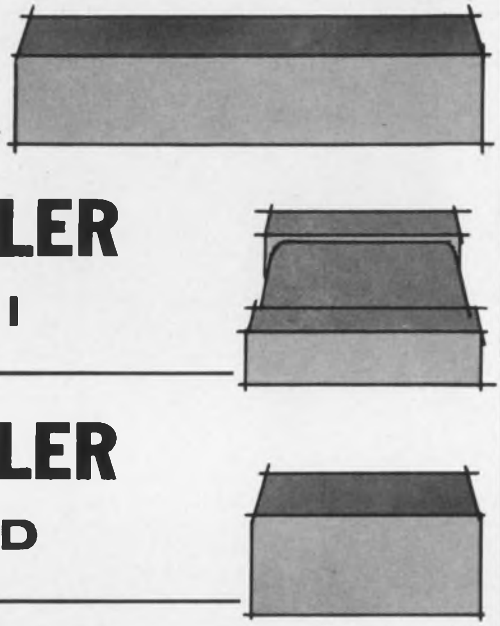

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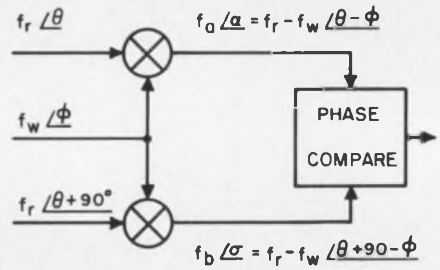
Digital approach improves frequency discrimination

Problem: Improve the stability of stable frequency discriminators. In the conventional approach, the unknown frequency is compared with a circuit tuned to the desired center frequency. The accuracy of discrimination, in such a discriminator is the stability of the discriminator itself.



Solution: Replace the conventional discriminator with a digital frequency comparator, using a very stable reference frequency. This eliminates stability problems in the discriminator and raises accuracy to that of the reference frequency.

The unknown frequency, f_w, is mixed with the reference, f_r, at 0 degrees to form f_a. The reference is also mixed at 90 degrees, to form f_b. The outputs, f_a and f_b, of the two mixers are at the same frequency but are shifted in phase by 90 degrees. The phase-comparison circuit looks at the phase of f_b when $\alpha = \theta - \phi = 0$ degrees. In this case, where $f_w < f_r$, the frequency f_b will lead f_a by 90 degrees, which will cause the output of the phase-comparison circuit to go to a "1" level.

To build a digital frequency comparator with such an operation requires a difference mixer capable of mixing two signals so that the difference frequency varies from 0 to 1.2 MHz.

Using a shift register element

as a mixer, with one signal on the shift input and the other on the steering line, we see that the maximum difference frequency is half that of the clock frequency. In this case, it is 1.6 MHz if the frequency of the clock is 3.2 MHz. Whenever the clock makes a negative transition, the shift register element transfers whatever logic condition exists on the steering line to the output.

The phase-comparison circuit is simply a shift register element with the f_a frequency on the clock and the f_b frequency on the steering line. The negative transition of f_a during the "0" level of f_b would cause a "0" level to be transferred to the output. If f_b were at a "1" level during the negative transition of f_a, a "1" would be transferred to the output. The shift register might not generate the true difference frequency at all difference frequencies in the range of the frequency discriminator. However, as the difference frequency becomes small compared with the clock frequency, the true value will be produced.

The fact that the true difference frequency is not produced does not limit the effectiveness of the frequency comparator, as both mixers will still produce the same frequency.

Inquiries about this invention may be directed to: Technology Utilization Officer, Marshall Space Flight Center, Huntsville, Ala., 35812. Reference: B67-10151.

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Mix various signals by a simple method

The problem of using a differential operational amplifier for algebraically summing several signals with a mix of gain factors and polarities and calculation of the input, feedback and junction shunt resistances can become difficult and involved. The problem is compounded by the need to keep the junction input resistances balanced.

This method of calculating the resistance values provides the solution to both parts of the problem quickly and easily. Assume the following parameters:

Signal	Gain	Polarity
A	0.5	Inverted
B	0.75	Noninverted
C	1	Inverted
D	1.25	Noninverted
E	1.5	Inverted

Step 1—Set feedback resistor at value *R*. Calculate input resistors for correct ratio to feedback resistor as if all signals were to be inverted. For example (see Fig. 1a):

$$R_A = R/A_{gain} = R/0.5 = 2R$$

Step 2.—Connect the signal input resistors to the correct-polarity amplifier terminal (Fig. 1b).

Step 3.—Calculate parallel value of resistors at each amplifier input; include feedback resistor at inverting input:

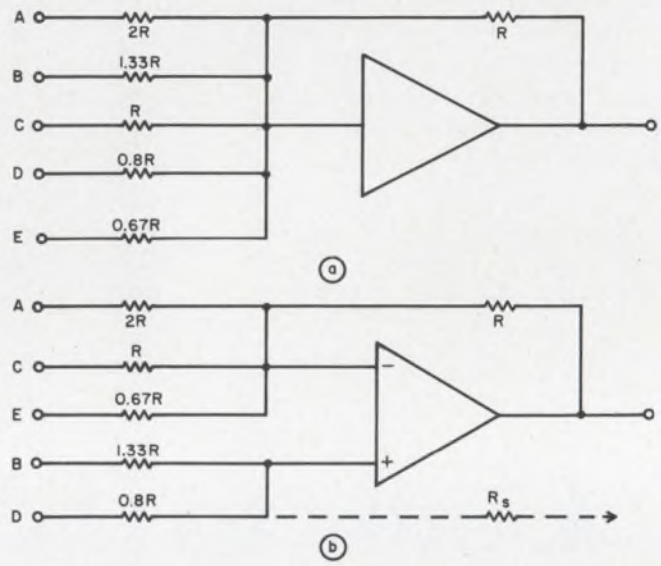
$$R_{p(-)} = 0.25R \qquad R_{p(+)} = 0.5R$$

$$\therefore R_{p(+)} > R_{p(-)}.$$

Step 4.—Calculate resistor value required to shunt the greater of the two groups, to make it equal to the lesser:

$$R_s = R_{p(+)} R_{p(-)} / (R_{p(+)} - R_{p(-)} = 0.5R.$$

Step 5.—Connect shunt resistor as calculated in Step 4 from proper junction to common. Circuit is now complete.



Signals of various gains and polarities (a) are summed as shown in (b). See text for details.

J. C. Barber, Senior Project Engineer, Systems Engineering, Leeds & Northrup Co., Sumneytown Pike, North Wales, Pa.

VOTE FOR 311

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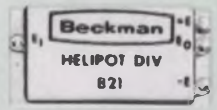
An SCR and a UJT control relay on-time

A simple circuit turns off at low-current thyristor with a unijunction transistor which at the same time can be used to give variable pulse lengths. The circuit can be used or altered in many ways but here is shown to give a variable-time relay contact closure.

When the SCR is triggered, it will first draw a heavy current surge from *C2* which will then drop to approximately $(V_S - V_F)/(R_L + R2)$. The relay contacts close and the timer goes into action. After the lapse of time $1 - 1/\exp(t/R1C1)$ the voltage at the input to the UJT will equal the intrinsic stand-off ratio of the UJT, and will fire and discharge *C1* through the common

Boost IC op amp power with Helipot's miniature hybrid amplifier.



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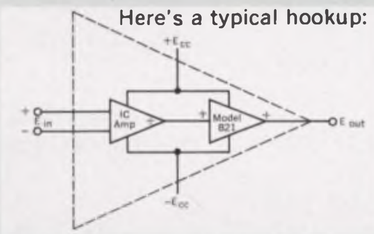

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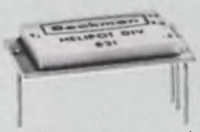

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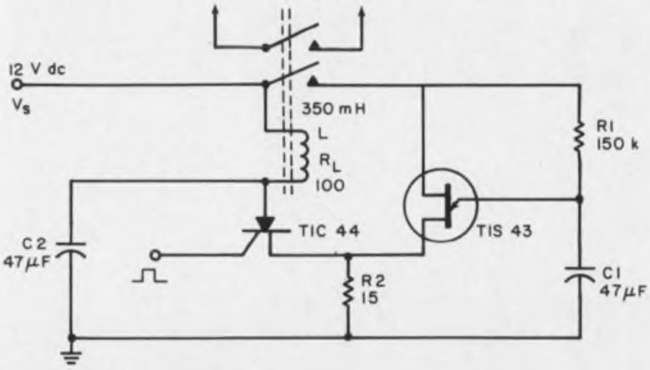


Variable relay contact closure time is obtained with an SCR and a UJT. Relay on-time depends on R1 C1 values.

resistor *R2*. Because of this rapid increase in potential at the cathode of the SCR, it will momentarily be reverse-biased and will turn off. When the cathode potential again decreases and the anode potential increases, the SCR will continue to be switched off.

C2 serves a double purpose: as a voltage memory during the short period when the SCR is being switched off, and with inductive loads as a voltage limiter or damper for the spike that occurs when the SCR is switched off.

The semiconductors are low-cost plastic-encapsulated devices.

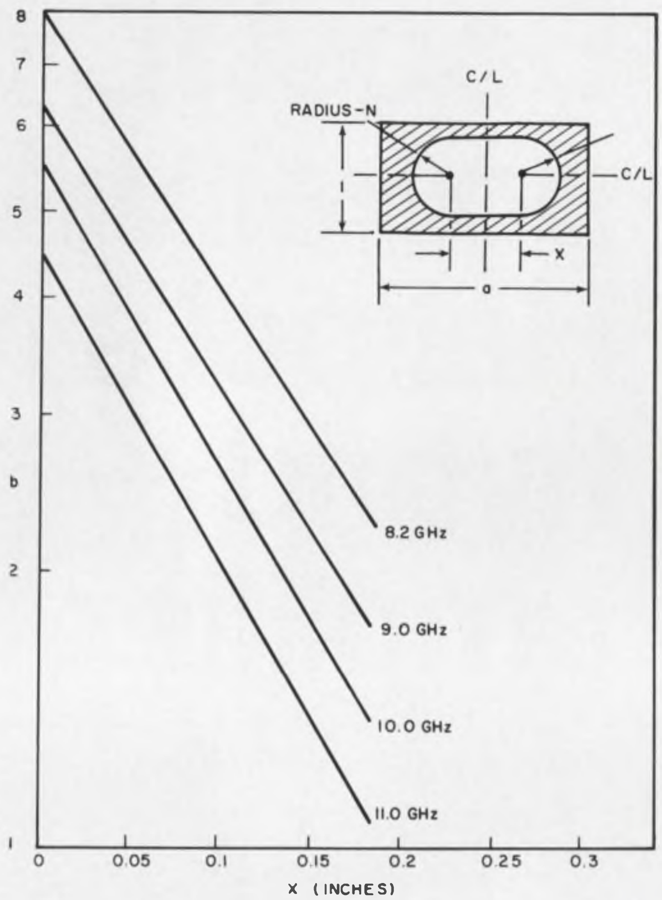
Willy Heyman, Design Engineer, Texas Instruments Sweden A.B., Stockholm, Sweden.

VOTE FOR 312

Oblong coupling apertures meet waveguide filter need

Waveguide band-pass and band-reject filters often employ apertures to realize required couplings. Circular apertures are limited in diameter to the full height of a rectangular waveguide. To obtain tighter couplings required for filters of wider bandwidths, oblong apertures can be employed.

The normalized susceptance of inductive coupling apertures is commonly used in waveguide filter design. Large susceptances provide loose couplings and small susceptances provide tight couplings. For the popular RG-52/U waveguide (width = 0.900 inch and height = 0.400 inch), measured data have been obtained for both circular and oblong apertures with an aperture thickness of 0.031 inch. For circular apertures, the normalized susceptance, *l*, for frequencies between 8.2 GHz and 11.0 GHz cannot be much below 4.0. Measured data (see plot) have also been obtained for the oblong aperture.



Low susceptance can be obtained when an oblong coupling aperture is used instead of a round one.

It can be seen that very small normalized susceptances are obtainable as the dimension x is increased. To implement a practical design, the radii, r, of the oblong shape have been fixed at 0.187 inch, so that a standard 3/8-inch end mill can be used.

Increasing x beyond a certain value can yield a normalized susceptance of zero. This is an indication of aperture resonace. Further increases in x will result in aperture susceptances that are capacitive rather than inductive.

Richard M. Kurzrok, Consulting Engineer, New York.

VOTE FOR 313

Complementary sweep circuit improves linearity and flyback

A simple sweep generator that uses complementary transistors provides a positive-going ramp voltage with minimum components. The circuit shown in Fig. 1a gives very good linearity and negligible flyback time. Its peak-to-peak output voltage is almost equal to the supply voltage.

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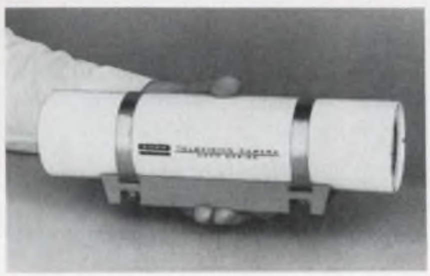
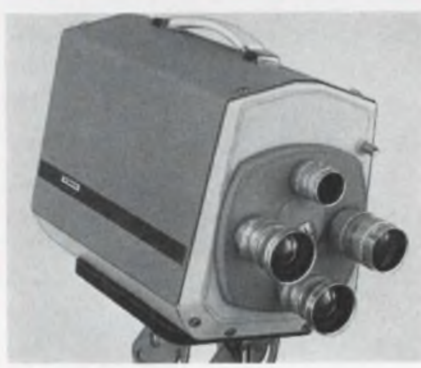


Miniaturized

Series 2000 cameras feature 3″ outside diameter cylindrical housings that will accommodate remote-controlled 4:1 zoom lens. Many lens options available, including 10:1 zoom. Operate on 10 or 20 megahertz bandwidths.

High-resolution self-contained

Modular-designed 3200 Series offers choice of plug-in sync generators for EIA 525 or 729, 873 or 945-line scan rates. Compensates for light level variations to 10,000:1. Optional viewfinder.



Industrial self-contained

Complete with all camera control circuits, Model 20/20 cameras need only video cabling and any standard TV monitor to make a complete CCTV system. Highly versatile.

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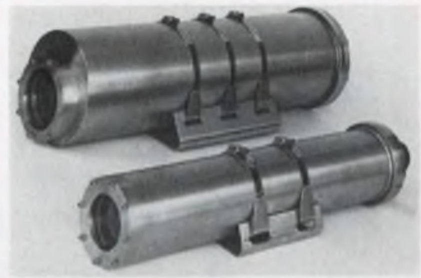

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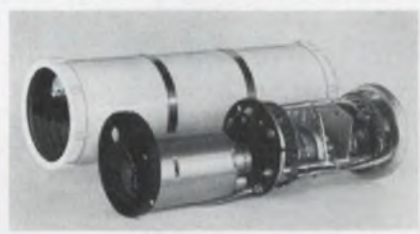
Tested to 10,000 PSI and up to 20,000 foot depth. Neutral buoyant. 70° view lens. Camera and cable independent.



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3000 Series cameras provide continuous-duty operation in up to 100% humidity, at temperatures from –20°C. to +60°C., ocean depths to 250 feet and altitudes out to deep space. Meet military explosion-proof specifications. Operate on 10 or 20 megahertz bandwidths.

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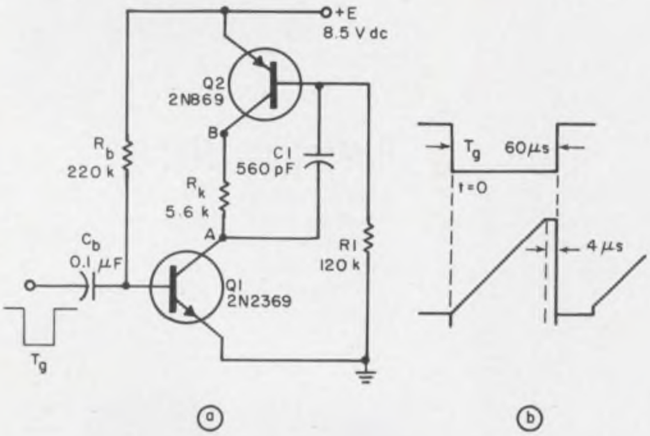


Linear sweep with small flyback time is obtained from this complementary circuit (a). The gating pulse, T_g, and the output ramp are in (b).

The waveforms obtained at point *A* (collector of *Q1*) are illustrated in Fig. 1b.

Starting from the quiescent condition when both transistors are saturated, the potential at *A* is negligibly small and the potential at *B* (Collector of *Q2*) equals supply voltage *E*. With the application of the gating waveform at $t = 0$, *Q1* is turned off. When $R_k << R1$, the capacitor *C1* is discharged at a constant current, I_c1, given by:

$$I_c1 \approx \alpha_2 E / R1,$$

where α_2 is the common base current gain of *Q2*. The potential at *A* will change by approximately *E* in time *T*, where:

$$T = R1C1/\alpha_2.$$

Q1 acts as a switch and *Q2* supplies the constant current by which capacitor *C1* is discharged during time *T*.

The excellent linearity of this ramp generator is a result of the constant discharge current through *C1*.

Thus the circuit provides linear sweep with much less flyback period than the equivalent boot-strap circuit.

Uma Shanker Singh, Electronic Engineer, Central Electronics Engineering Research Institute, Pilani, Rajasthan, India.

VOTE FOR 314

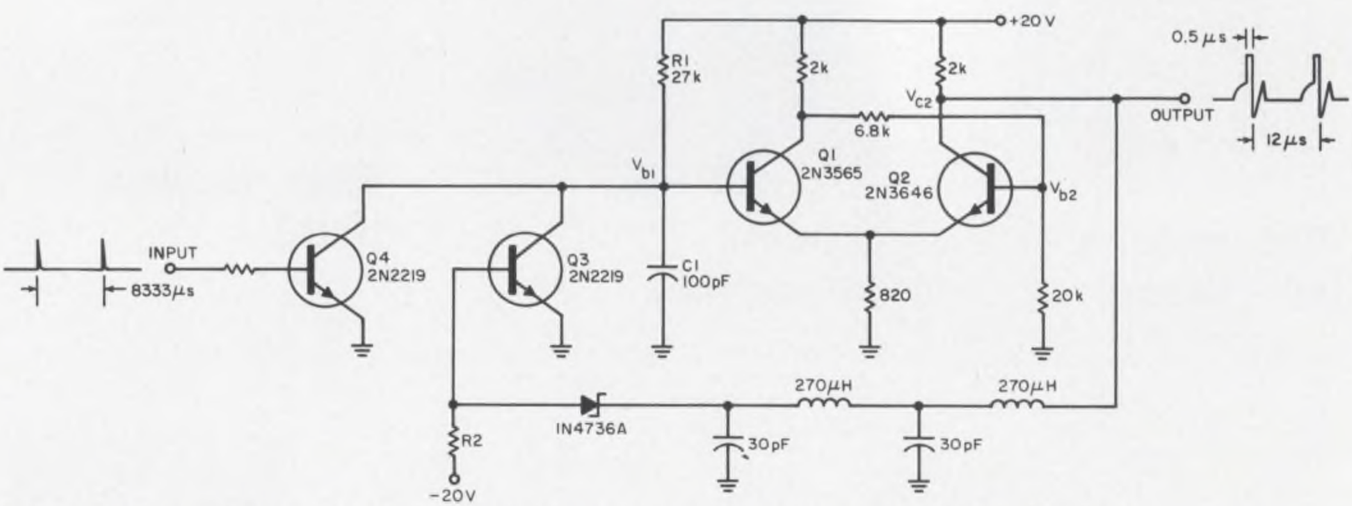
Free-running multi yields constant period after synch

In many applications where a free-running multivibrator is used, it is desirable to synchronize the device with a lower-repetition-rate pulse and maintain a constant period of oscillation from the instant the synchronization pulse is received into the free-running operation. This is useful in radar-range or time marking, where a train of equally spaced pulses must follow a main synchronization pulse.

Conventional multivibrators do not respond with constant periods until several cycles after the synchronization pulse because their timing depends on two to four varying voltages and the synchronization pulse resets only one. Thus several free-running cycles are needed to restablish a constant period after synchronization.

This circuit gets around the problem by using one varying voltage in the timing element that is reset to ground with each free-running cycle and also with each external synchronizing pulse.

In the schematic V_{b1} increases as *C1* charges



Constant-period output pulses are obtained from this circuit in response to synchronizing pulses.

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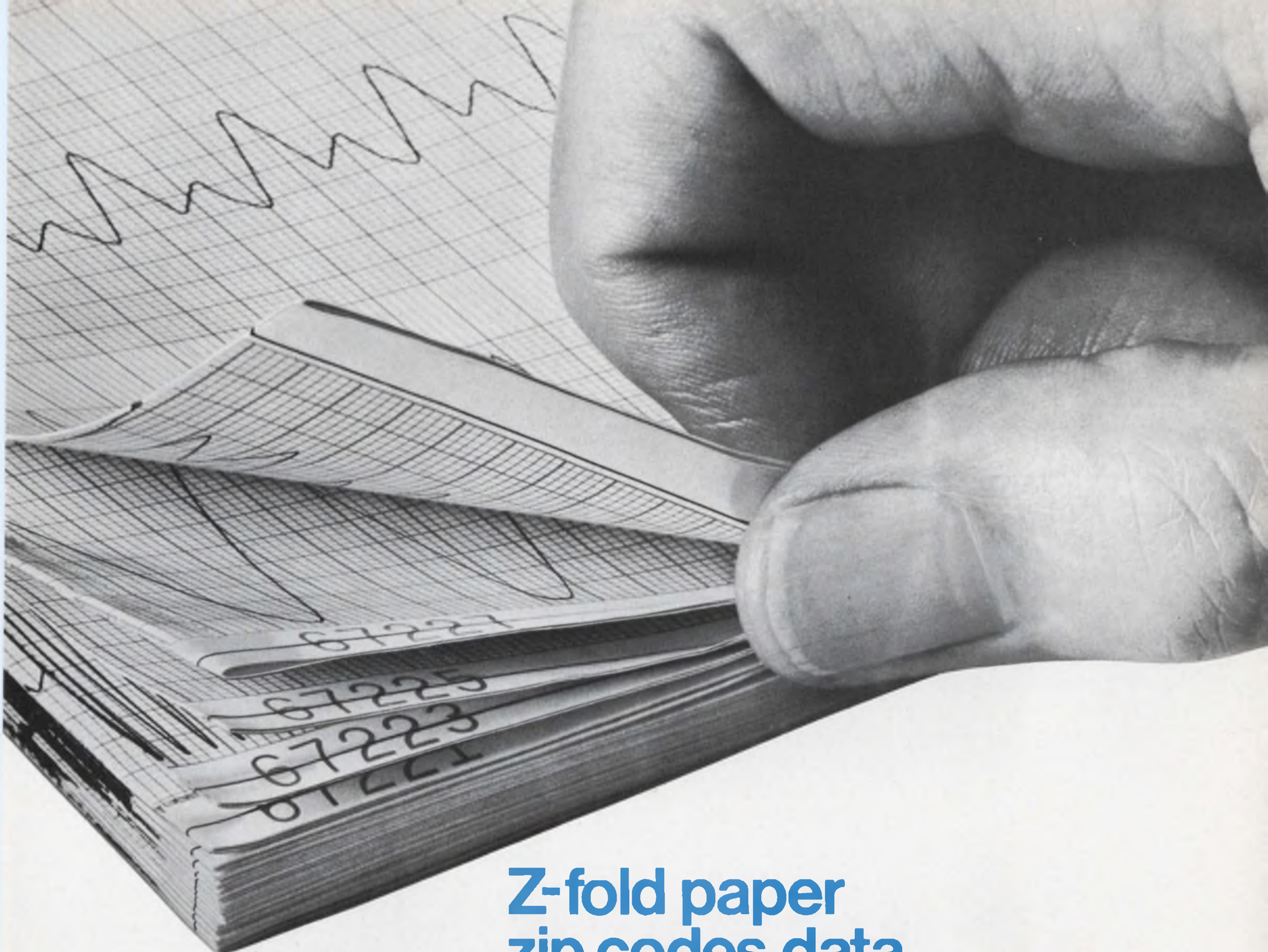

Z-fold paper zip codes data for quick retrieval

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For complete information on the 7800 system, optional and related equipment, contact your local HP Field Office or write Hewlett-Packard, Waltham Div., 175 Wyman St., Waltham, Mass. 02154.

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through *R1*. When $V_{b1} > B_{b2}$, V_{c2} rises abruptly. This positive step is delayed by the LC network and turns on *Q3*, resetting V_{b1} to ground. V_{c2} falls immediately and *Q3* shuts off after the delay, ensuring a complete discharge of *C1*. The pulse width of V_{c2} approximately equals the delay time. An external synchronizing pulse turns on *Q4*, resets *C1* to ground, and allows it to run to its normal period after sync is dropped.

This circuit has two additional benefits over a conventional multivibrator in that it is temperature-stable and will produce a ramp if *R1* is replaced with a constant-current source. If only a positive supply is available, *R2* may be replaced by an inductor to ground.

John L. Earle, Engineer, Stromberg-Carlson Data Products, San Diego, Calif.

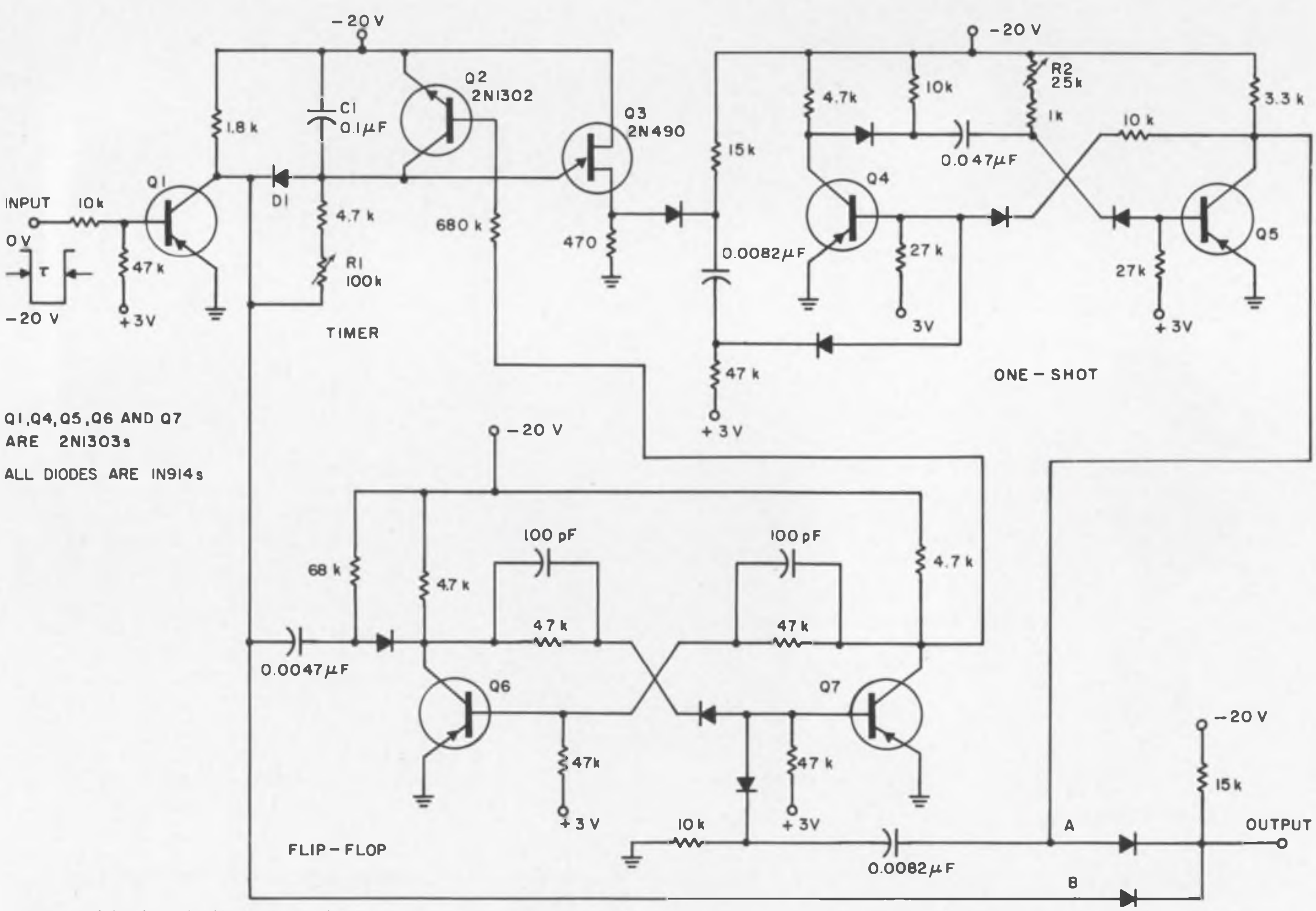
VOTE FOR 315

Pulse-width discriminator uses unijunction transistor

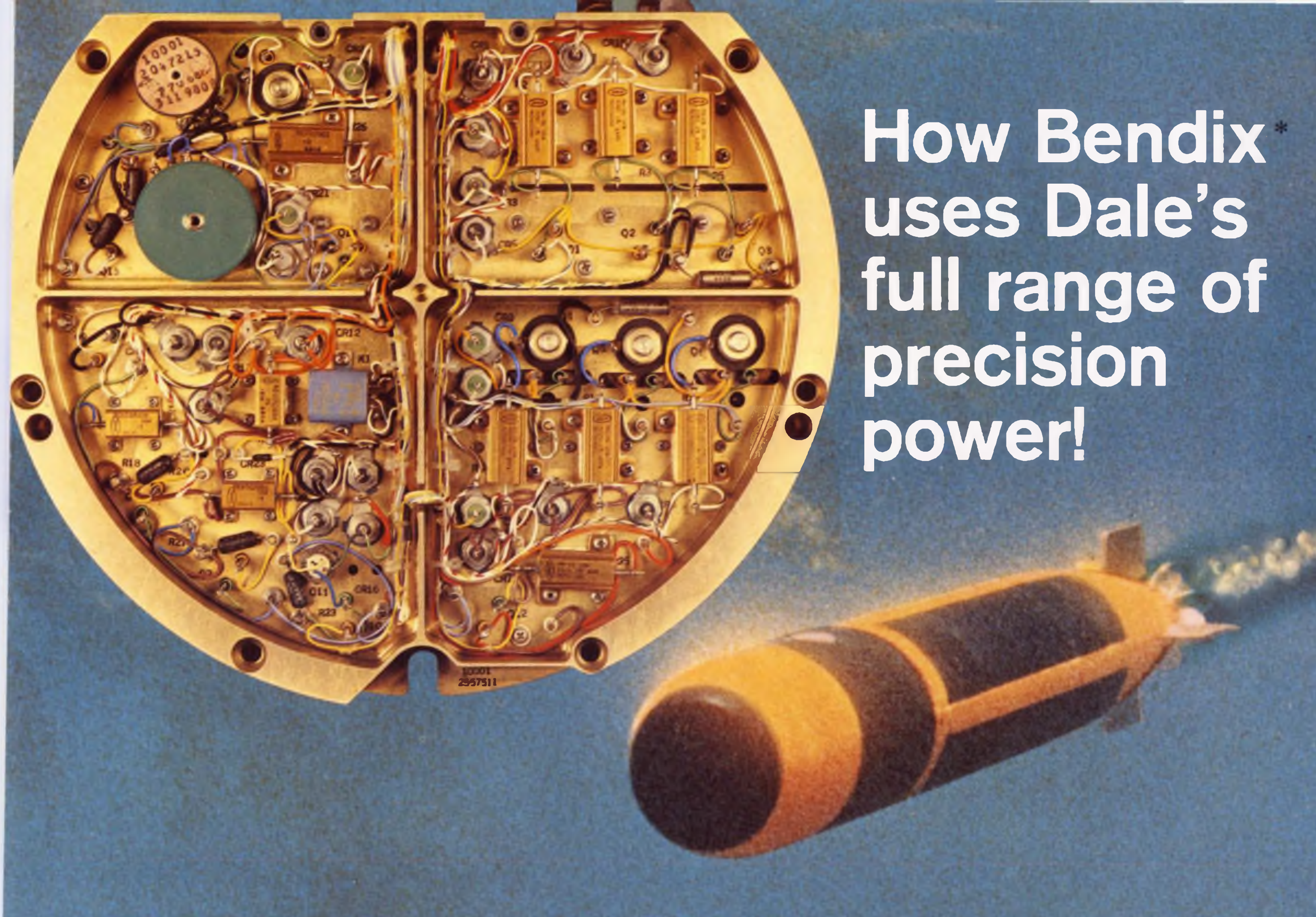
A pulse-width discriminator can be built with a slaved unijunction-transistor timer. The discriminator provides an output only when triggered by a digital input of fixed duration. The tolerance of the input pulse interval is adjustable and the timing sequence is instantly reset on rejection.

The circuit (see figure) was designed as part of the signal-processing equipment in a proximity-indicator system for underwater vehicles. Its function is to discriminate against random, spurious receptions and to pass only valid signals.

The output of inverter *Q1* allows *C1* to be charged through *R1* and the 4.7-kΩ resistor. *Q1*'s output also inhibits the AND gate (line *B*) preventing an output during time τ. The unijunction timer is set to fire when the input is 95% of the desired width. The one-shot controls the discriminator tolerance, which is set with *R2* to provide a ±5% window. The flip-flop and buffer *Q2* clamp the unijunction emitter to prevent multi-



Pulse-width discriminator produces an output only when an input pulse is ±5% of the desired width as determined by setting R1. D1 prevents the accumulation of charge on C1 in the presence of short pulses.



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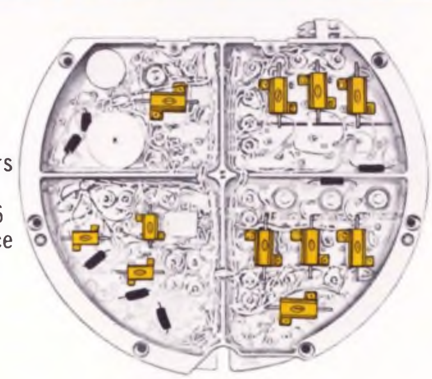
TYPE RH Exceeds MIL-R-18546. Patented chassis-mount design provides: (1) Bonus power 25% to 108% above mil rating; (2) Exceptional stability when derated to mil levels.

TYPE PH Versatile through-chassis mounting with terminals on one or both sides. Meets electrical and environmental specs. of MIL-R-18546.

Dale Resistors in Mark 46 Guidance System



When you need precision wirewounds, call Dale. No other source offers as many models, as much design freedom or a stronger foundation for reliability.

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DALE

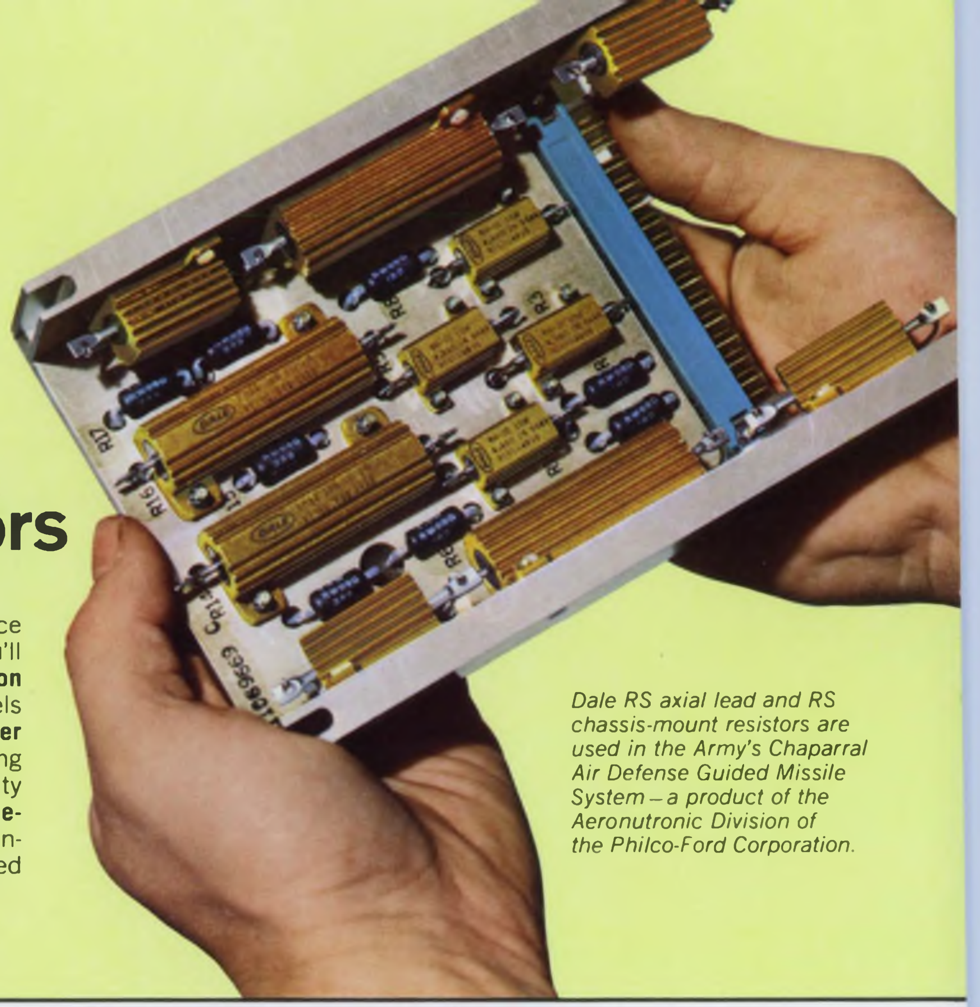
for optimum value in precision power wirewounds

DALE ELECTRONICS, INC. 1300 28th Avenue, Columbus, Nebraska 68601

In Canada: Dale Electronics Canada, Ltd.

DALE®

...a complete source for precision power resistors



Dale RS axial lead and RS chassis-mount resistors are used in the Army's Chaparral Air Defense Guided Missile System – a product of the Aeronutronic Division of the Philco-Ford Corporation.

Establish Dale as your complete source for precision power wirewounds. You'll gain added value from: **Broader Selection** ...10 different types, 64 different models ...up to 250 watts precision power. **Greater Design Versatility**...3 different mounting choices plus unmatched size/stability combinations. **Faster Reaction to your Special Needs**...more than 400 different non-standard variations are pre-engineered and ready for application in your circuit.

CHECK DALE'S COMPLETE PRECISION POWER LINEUP...

	RANGE	SIZES	WATTAGES	TOLERANCE	FEATURES
TYPE **ARS**	0.1 ohm to 40K ohms	3	2, 5, 10	1%	Established reliability, failure rate less than .00038% at 1000 hours of operation at 50% of rated power at 25° C.
TYPE **AGS**	0.1 ohm to 12.4K ohms	4	1, 2.25, 4, 7	1%	Established reliability, failure rate .00051% per 1000 hours. Estimated failure rate after GARD screening .00009% per 1000 hours. Beryllium oxide core for greater stability and hot spot elimination.
TYPE **RS & RLS**	0.1 ohm to 273K ohms	11	¼, ½, 1, 2, 2½, 3, 5, 7, 10	0.05% to 3%	Meet functional requirements of MIL-R-26D which supersedes MIL-R-26C and MIL-R-23379. Silicone coating. Weldable leads available. RS has axial leads. RLS has radial leads.
TYPE **NS & NLS**	1 ohm to 136.5K ohms	10	½, 1, 2, 2½, 3, 5, 7, 10	0.05% to 3%	Silicone coated, non-inductive winding. Type NLS has radial leads. Weldable leads available.
TYPE **G & GL** TYPE **GN & GNL**	0.1 ohm to 273K ohms 1 ohm to 136.5K ohms	10	1, 1½, 2¼, 4, 6, 7, 10, 15	0.05% to 3%	G & GL resistance units offer decreased size with increased heat dissipation. Silicone coated. Meet functional requirements of MIL-R-26D which supersedes MIL-R-26C and MIL-R-23379. GL has radial leads. GN & GNL have identical construction but are non-inductively wound. GNL has radial leads. Weldable leads available.
TYPE **HG & NHG**	HG: 0.1 ohm to 273K ohms NHG: 0.1 ohm to 136.5K ohms	4	15, 20, 35, 50	0.05% to 3%	HG features maximum heat dissipation at no increase in size. Meets or exceeds requirements of MIL-R-18546. Chassis-mounted molded radiator housing. NHG has identical construction but is non-inductively wound.
TYPE **RH & NH**	RH: 0.1 ohm to 273K ohms NH: 0.1 ohm to 136.5K ohms	6	7.5, 12.5, 25, 50, 100, 250	0.05% to 3%	RH resistance unit molded into radiator housing. Meets requirements of MIL-R-18546. Mounts on chassis. NH has identical construction but is non-inductively wound. Established reliability units (ARH) available in 5, 10, 15, 30 watt sizes. Meet MIL-R-39009.
TYPE **PH**	0.1 ohm to 95.2K ohms	4	10, 25, 50, 100	0.05% to 3%	Silicone-sealed resistance unit in radiator housing. Mounts through hole in chassis. Also available with non-inductive winding.

Circle 181 for Catalog A

SEE OUR SPECIFICATIONS IN VSMF THE MICROFILM CATALOG FILE

DALE ELECTRONICS, INC.
1300 28th Ave., Columbus, Nebraska 68601
In Canada: Dale Electronics Canada, Ltd.

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ple firing of the timer when the input exceeds the length requirement.

If the discriminator is set for 1 ms ±5%, and an input pulse of 1-ms duration is applied to the input, the circuit operates as follows.

The output of *Q1* changes from —20 to 0 volts. *D1* is reverse-biased, and the charging rate of *C1* is influenced only by *R1* and the 4.7-kΩ resistor. The leading edge of the inverted input pulse sets the flip-flop. The output of *Q1* is —20 volts which holds *Q2* cut off. *Q2* has no influence during the charging cycle.

The time constant *C1* (*R1* + 4.7 kΩ) has been set such that unijunction *Q3* will fire at 0.95 ms. This output triggers the monostable the duration of which has been set at 0.1 ms. Then line *A* of the AND gate is negated during the interval from 0.95 ms to 1.05 ms. The *B* line of the gate is negated at the end of the 1-ms input pulse (*Q1* is cut off in the absence of an input) and a 0.05-ms pulse is generated.

If the input is of insufficient length, then the unijunction will never fire and no output will be initiated.

The output of the monostable also triggers the flip-flop, causing *Q1* to change state. That in turn forces *Q2* into saturation, preventing *C1* from recharging and causing a second firing of the unijunction when the input is much longer than 1 ms. This condition is maintained until the next input resets the flip-flop.

D1 prevents the accumulation of charge on *C1* when the input consists of a series of short pulses. If a pulse of insufficient length enters the discriminator, *C1* would start to charge, but *Q3* would not fire, the flip-flop would not be triggered and the unijunction emitter would not be clamped. When the output of *Q1* reverts to —20 volts, *D1* is forward-biased and *C1* is quickly discharged.

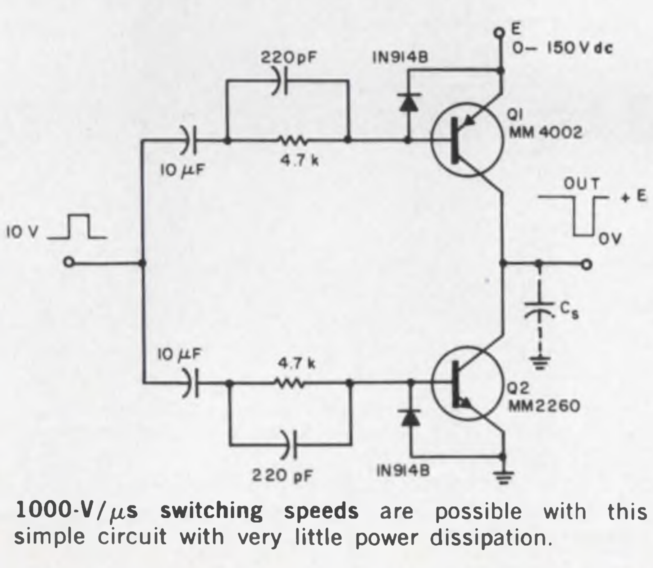
The operating range and tolerance of the discriminator can be adjusted for a particular pulse width and tolerance. The circuit could be miniaturized by fabricating the respective stages from available integrated circuits.

R. Alan Benson, Jr., and Frederick M. Cancilliere, U. S. Naval Station, Newport, R.I.

VOTE FOR 316

Complementary circuit switches high voltage

There are many applications that require a voltage pulse that switches rapidly between zero and some well-defined positive or negative dc level. One typical application involves the dc target voltage of a vidicon camera tube, which must be quickly switched from some positive operating voltage to ground during the retrace time and then rapidly back to the original voltage.



1000-V/μs switching speeds are possible with this simple circuit with very little power dissipation.

The dc load current is very small (typically 100 nA) but the stray capacitance, C_s, may well be several hundred picofarads.

The circuit shown here accomplishes this switching. At any given time, either *Q1* or *Q2* is in saturation because of the input drive pulse, and the output voltage is therefore either at ground or at the applied potential, *E*. Since collector current flows only during the charging and discharging of the stray capacitance, the power dissipation of the circuit is very small, even though large fast-rise-time output pulses are being delivered. With currently available transistors, output speeds of almost 1000 V/μs can be obtained.

John Schroeder, Design Engineer, RCA Labs, Princeton, N.J.

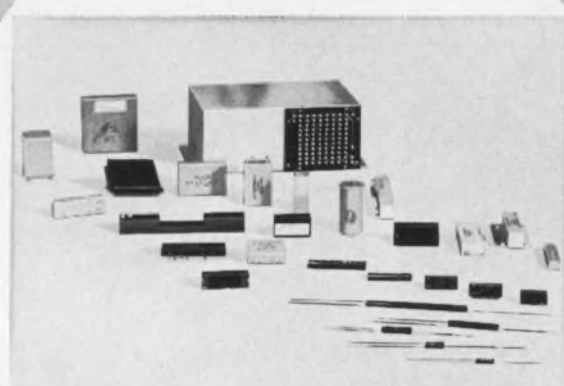
VOTE FOR 317

IFD Winner for November 22, 1967
Jerry F. Foster, Chief Engineer, Wavetek, San Diego, Calif. His Idea "Low cost op-amp integrator has range from dc to over 1 MHz," has been voted the $50 Most Valuable of Issue Award.
Cast Your Vote for Best Idea in this Issue.

JFD announces . . . NEW delay line SERIES...

*

JFD Delay Lines are top quality, ruggedly constructed, precision components of proven dependability. A variety of models, having a wide range of electrical and physical parameters, are production items. Characteristics and mounting methods available in standard JFD units meet the requirements of a wide variety of circuit applications. Delay Lines for highly specialized applications are designed in JFD laboratories. A staff of skilled engineers employ proven techniques to limit development time to a minimum.



Illustrations shown 1/15 actual size.

Distributed Constant
JFD distributed constant Delay Lines manifest minimum rise-time and distortion characteristics. Miniaturized and hermetically sealed models are available. Measured delay-time is within 5% of rating in most models.

Lumped Constant
JFD lumped constant Delay Lines are compact in size relative to delay-time. Attenuation, distortion and temperature coefficient of delay are minimized. Ratio of delay to rise time is excellent and delay tolerances may be held to within 0.2% when required.

Continuously Variable
JFD continuously variable Delay Lines are designed to withstand shock and vibration and meet military environmental requirements. Resolution is better than 1/1000th of maximum delay across the entire delay range, in most models.

For additional information, write for catalog DL-68.

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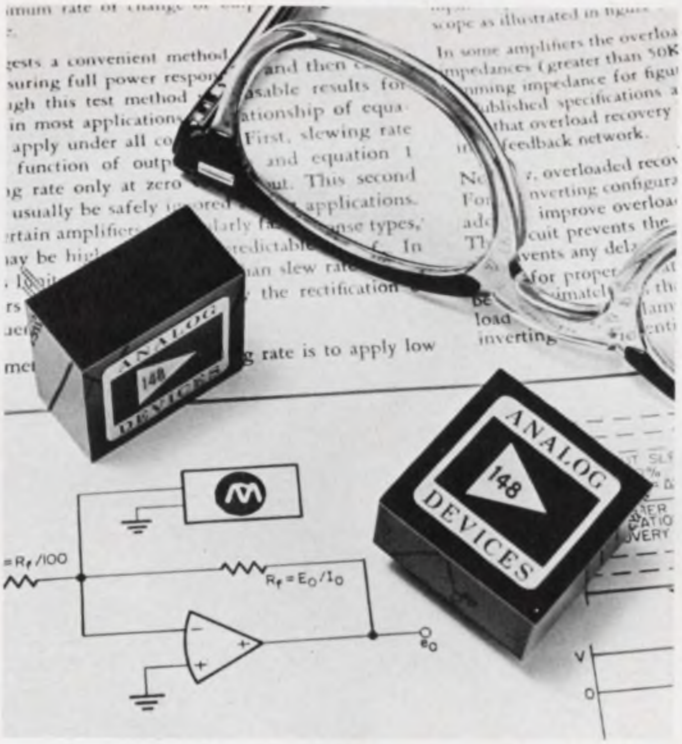
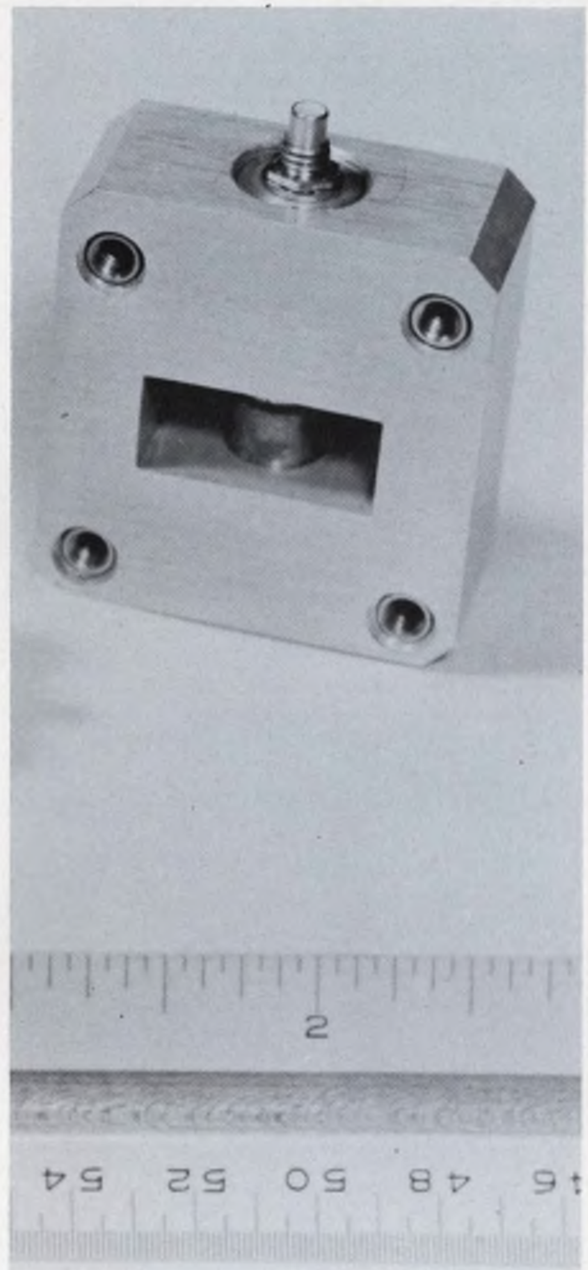
INFORMATION RETRIEVAL NUMBER 41

Products



Differential dc operational amplifier settles to 0.01% of final values in one μs. Page 100

Digital rf power meter reads out on a linear or logarithmic scale to 12.4 GHz. Page 118



Semiconductor microwave oscillators deliver 60 mW cw at X band. Page 114

Also in this section:

Electrically conductive paper tape seals out electrostatic interference. Page 126

Component-lead bending tool shapes leads to fit printed-circuit board layouts. Page 108

Application Notes, Page 128 . . . **New Literature,** Page 130

Differential dc operational amplifier settles in 1 μs to 0.01% of final value

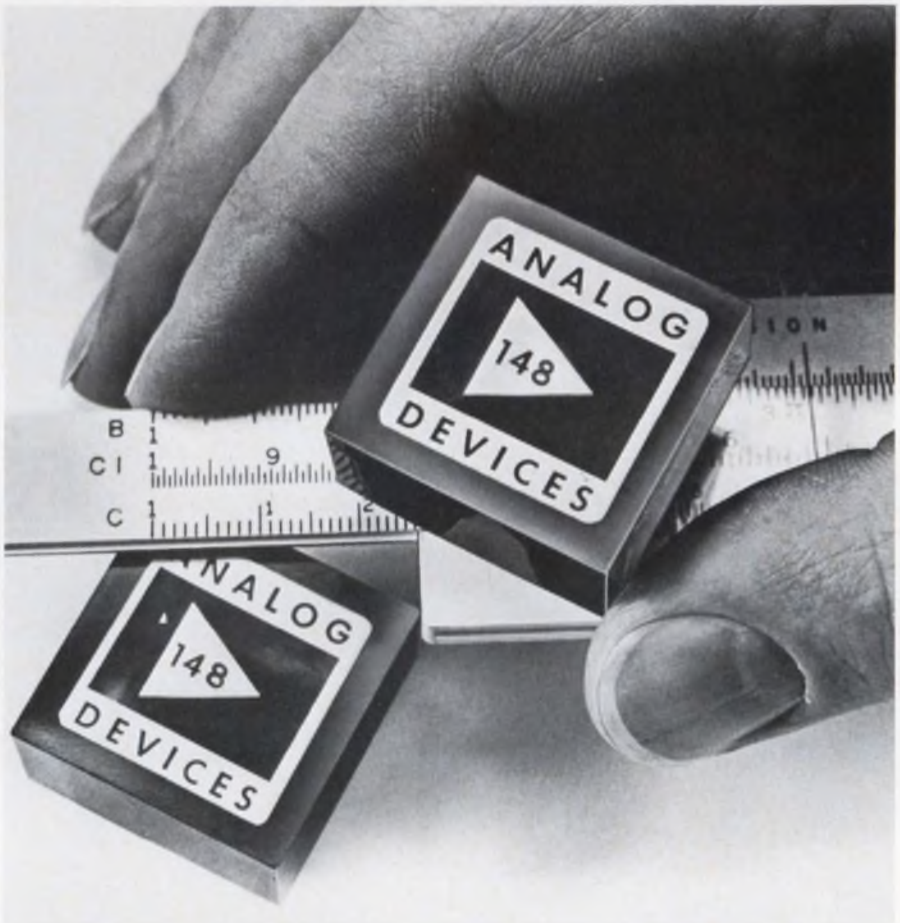
Analog Devices, 221 5th St., Cambridge, Mass. Phone: (617) 491-1650. P&A: Model 148 A, $42; 148 B, $47; 148 C, $65; Stock.

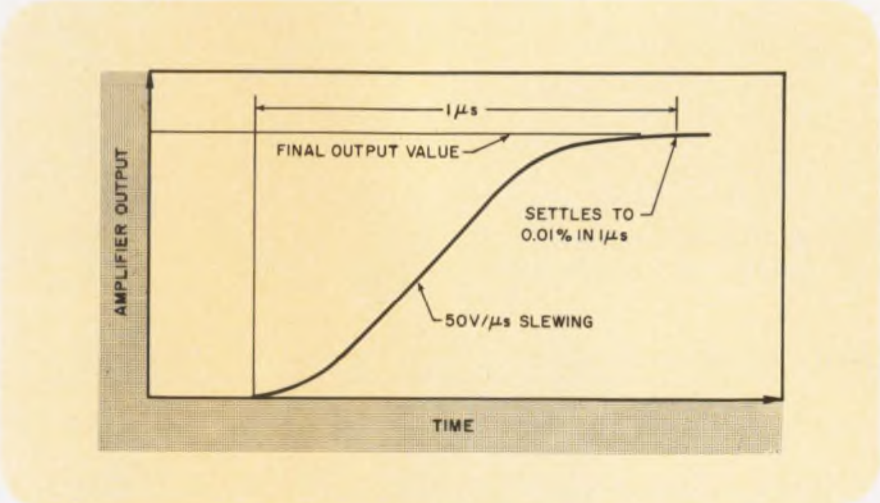
Analog Devices' new ultrafast model 148A differential dc operational amplifier gives digital circuits new levels of speed and accuracy. The unit's most noteworthy feature is its 1-μs settling time for the output level to reach within 0.01% of its final value. Additional characteristics include a 50-V/μs overload recovery time, 10-MHz small-signal bandwidth, and 500-kHz full power output. Drift specifications are 50-μV/°C max voltage drift, 30-pA max initial bias current at 25°C, and 5-pA/°C max drift averaged over the 25°C-to-35°C range. Output rating is ±10 V, 20 mA, and both the common-mode and differential input impedances are 10^{11} Ω shunted by 3.5 pF. The device also features a 30,000 open-loop dc gain.

By settling to within 1 part in 10,000 of the final ouput voltage value in less than 1 μs, this unit can form the basis for a 12-bit D/A or A/D converter capable of encoding or decoding at a rate approaching 1,000,000 conversions per second. The output attains its final 10-V value in two fairly distinct stages. It slews at a high rate to within about 17% of the final value, then takes considerably longer to settle this last 1%.

Three different models in the 148 operation-amplifier series are available. The differences lie solely in the price and drift specifications for the different models. The model 148A features a 50-μV/°C and 50-mA max voltage drift. The model 148B is identical, except maximum voltage drift and bias current are 25 μV/°C and 30 pA. Finally the model 148C's maximum voltage drift and bias current are 15 μV/°C and 30 pA.

CIRCLE NO. 321





Differential dc operational amplifier settles to within 0.01% of final value in one μs. It also features a 30,000 open-loop dc gain.

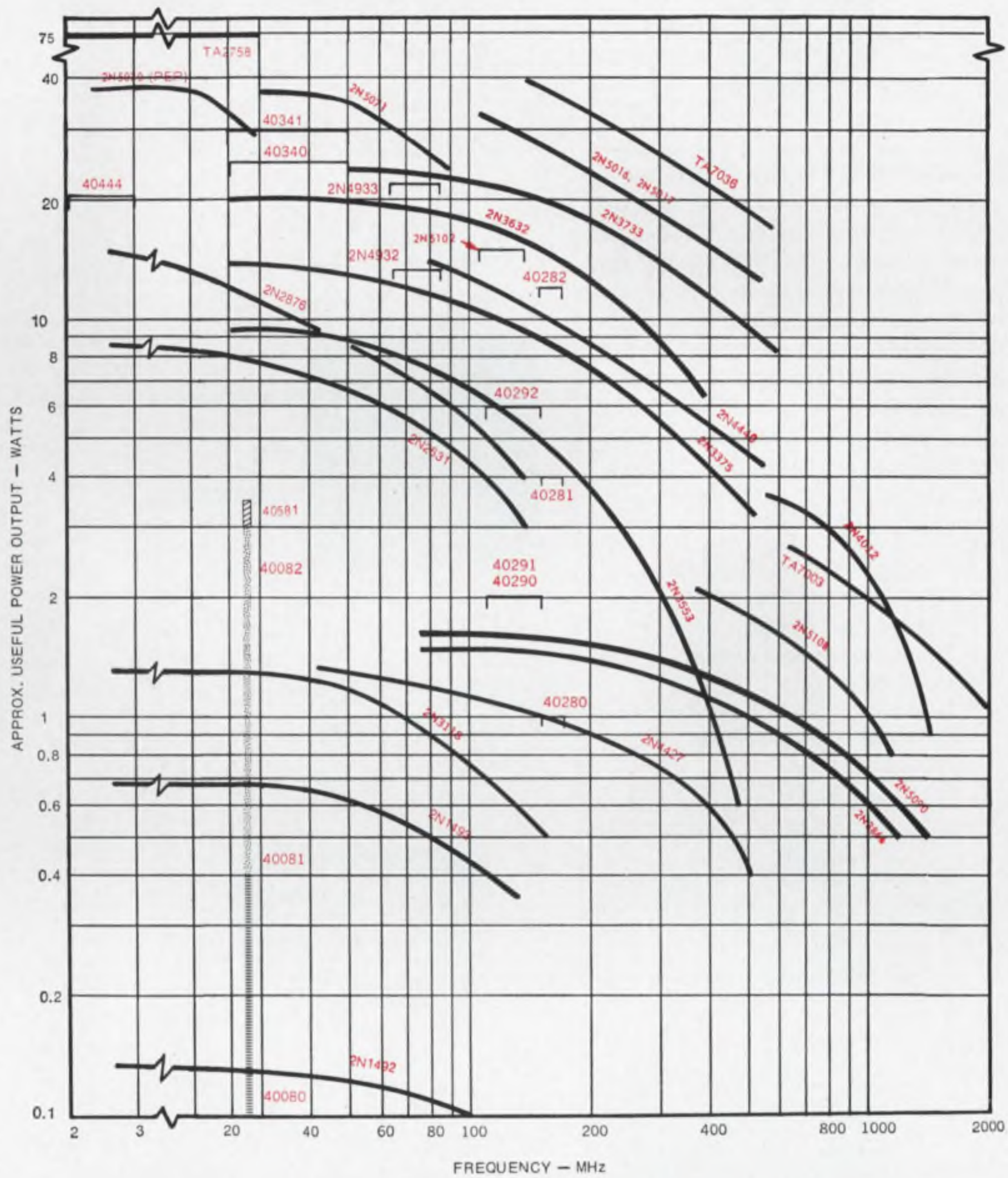
RCA "Overlay" Transistors
at home anywhere in the RF power range

TO-39
Grounded
collector

TO-60
Isolated or
grounded emitter

Molded silicone
plastic case

Microwave
coaxial package



RCA offers you the broadest line of rf-power transistors in the industry.
For more information on RCA "overlay" transistors see your RCA Representative or your RCA Distributor. For technical data on specific types, write: RCA Commercial Engineering, Section PG3-1, Harrison, N.J. 07029.

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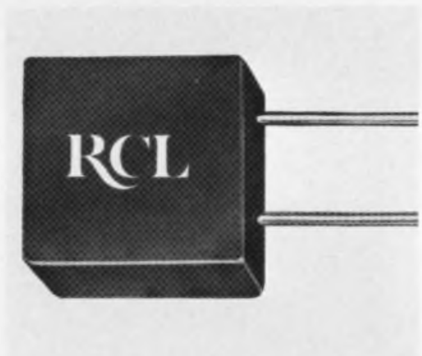
Ten-inch dia CRT resolves 2 mils

Westinghouse Electronic Tube Div., Elmira, N.Y. Phone: (607) 739-3611.

A magnetically focused CRT features a 10-in. optically flat faceplate and line width of only 2 mils. Typical applications include data handling, film scanning for graphic arts equipment in the printing industry, and flying-spot scanning. The tube is aluminized and has 50 deg magnetic deflection. It can be supplied with most of the standard JEDEC phosphors.

CIRCLE NO. 322

Miniature resistor carries 2-W rating

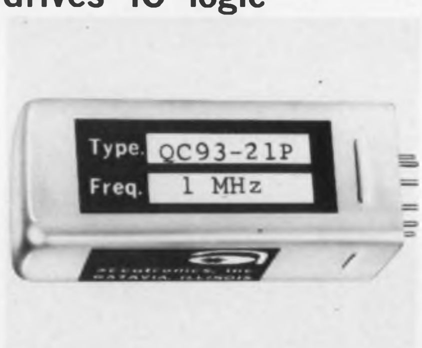


RCL Electronics, Inc., 700 S. 21st St., Irvington, N.J. Phone: (201) 374-3311.

A rectangular resistor, with dimensions of 0.295 × 0.3 in., is fully encapsulated, has all-welded construction, and features a maximum resistance of 200 kΩ. Rated at 0.20 W, it is available in tolerances ranging from 0.01% to 1% and resistance values from 0.1 Ω. Operating temperatures are from −55°C to +125°C, derated to zero at 150°C.

CIRCLE NO. 323

Crystal oscillator drives IC logic



Accutronics, Inc., 628 North St., Geneva, Ill. Phone: (312) 232-2600. Price: $37.50.

Designed to drive all types of IC logic, a crystal oscillator develops square wave output voltages of 0 ±0.5 V to between 2 and 5 V peak with rise and fall times of under 60 ns. The oscillator is available in standard frequencies of 1, 2, 5, 10 and 20 MHz with a frequency stability of ±0.01% from +15°C to +45°C.

CIRCLE NO. 324

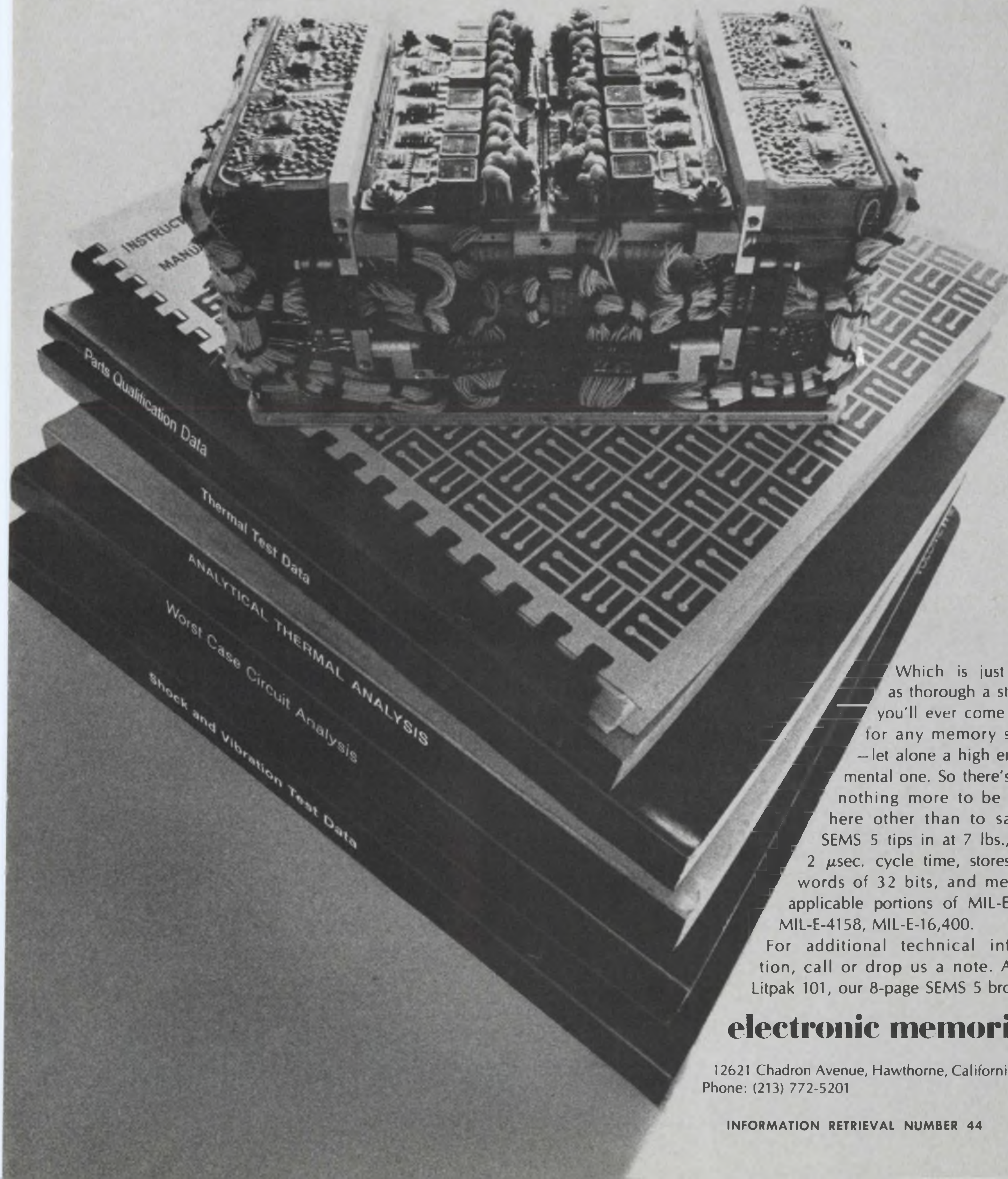
Solid-state op amp drifts less than 0.1 μV

Julie Research Laboratories, Inc., 211 W. 61st St., New York. Phone: (212) 245-2727.

All-solid-state self-contained operational amplifiers are drift-free and low in noise content. Maximum short-term noise, flicker and drift are 0.1 μV pk-pk. Designed for dc applications where accurate and linear current amplification is required, one model has an output level of up to 40 mA into a 750-Ω load.

CIRCLE NO. 325

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

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Phone: (213) 772-5201

INFORMATION RETRIEVAL NUMBER 44

At last, here's a full line of time-delay relays.

(We took our time)

True, we weren't first with commercial time-delay relays. But now we're the most complete. With a tough, versatile line that gives you full choice, whether your specifications call for precision and long life, or economy.

Our low-cost thermal-time-delay line (background) includes both panel-mount and plug-in forms rated 2 amps resistive.

Our solid-state-timer designs (foreground) include our High Performance Line (±2% accuracy) rated 10 amps resistive, with a miniature unit rated 2 amps resistive. And a Standard Line (±10% accuracy) rated 10 amps resistive, at a lower price.

Whatever your needs, your Cutler-Hammer Sales Engineer or Stocking Distributor is ready to serve you now.

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Milwaukee, Wisconsin 53201

CONTROL

INFORMATION RETRIEVAL NUMBER 45

Low-cost NIXIE tube IC compatible

Burroughs Corp., Electronic Components Div., Plainfield, N.J. Phone: (201) 757-5000. P&A: $3.95 (1000 lots).

Measuring 0.53 in. in dia by 1.5 in. high with a numeral height of 0.5 in., Burroughs new cold-cathode indicator is compatible with ICs. The tubes are being built by the Japan Radio Company to Burroughs specifications under a joint engineering program.

Designated type B-5750, they are designed for low-cost digital voltmeters, calculators and counting instruments. A design twist allows the tube to be operated in time-sharing applications where higher than normal current is needed. This time-sharing operation permits all like numerals to be driven in parallel while the tube anode is strobed. Reduction in driver costs for many applications can be achieved. In addition to the digits, two decimal points are included.

Operating from 170 V dc, the tube illuminates with a brightness of 200 ft-lamberts. This is enough illumination for the readout to be viewed from as much as 24 ft away. A pin-spacer standoff, which is used to align the tube pins for ease of printed circuit insertion, is part of the tube assembly. The standoff also allows gas to escape during soldering operations.

It is designed to withstand 250 g for 1 ms and it has a life expectancy of 200,000 hours. Leads are pre-tinned for ease of soldering.

CIRCLE NO. 326

Metal-film resistors span 1 to 4600 Ω

Angstrohm Precision Inc., 7811 Lemona Ave., Van Nuys, Calif. Phone: (213) 989-3061. P&A: $1.80; stock.

Adjustable metal-film resistors with no moving parts may be trimmed by the user before or after installation down to one-fifth their base value, with accuracies to ±0.02%. Twelve base resistance ranges cover over 350 standard 1% values from 1 to 4600 Ω. The device size is 0.085 × 0.09 × 0.02 in. Its rating is 1/20 W at 125°C.

CIRCLE NO. 327

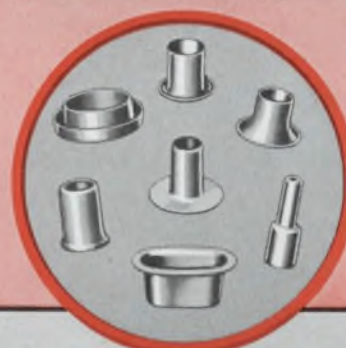
Photocell and amplifier respond to 5750Å

Vactec, Inc., 2423 Northline Industrial Blvd., Maryland Hts., Mo. Phone: (314) 432-4200. Price: $93.

A module that combines a selenium photocell detector with a matched solid-state amplifier provides high quantum efficiency and sensitivity at visible wavelengths. The radiometric response of the cell is 0.3 μA/μW at 5750 Å. The 2-in.-dia-by-1.5-in. module provides an output from 0 to 10 V dc and is linear within 1% over five decades of illumination. High available gain allows the use of inexpensive meters for readout. The unit operates in a temperature range of up to 65°C with less than 0.2%/°C change in output. Low-voltage power supplies or batteries can be used. There is no warm-up time and a response of less than 100 μs is typical of the photo-detector.

CIRCLE NO. 328

A standard fastener from the WORLD'S MOST COMPLETE LINE will save you TIME and MONEY



Instead of a special, perhaps one of our standard fasteners can meet your requirements.

We make a tremendous variety of eyelets, grommets, rivets, washers, snap fasteners, ferrules, hole plugs, terminals, and other similar fasteners. Tell us what you need and let us submit a standard fastener.

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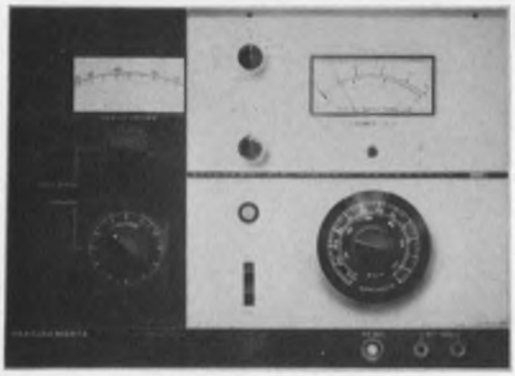
VISIT BOOTH 2D26

MEASUREMENTS



MODEL 188 STANDARD FM SIGNAL GENERATOR

- Carrier frequency: 86-108 mcs.
- Frequency accuracy: ±0.5%
- Output voltage: 0.1 to 100,000 microvolts across 50 ohms
- Deviation: 0 to 300 kcs. in 3 ranges
- Source impedance: 50 ohms; low VSWR
- Distortion: Less than 0.5% at 75 kcs. deviation
- Modulation fidelity: Within 1db to 75 kcs; less than 3db down at 200 kcs.

10

Laboratory Standards

MEASUREMENTS

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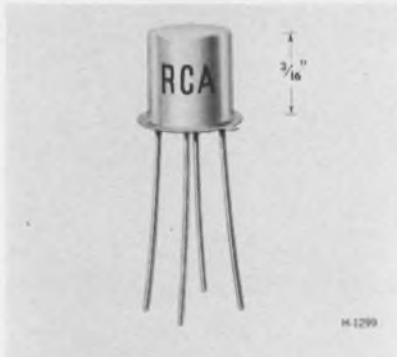
INFORMATION RETRIEVAL NUMBER 47

Silicon MOS FET chops and multiplexes



RCA Electronic Components and Devices, Harrison, N.J. Phone: (201) 485-3900. P&A: 96¢ (1000 pieces); stock.

A silicon MOS FET of the N-channel depletion types is intended for chopper and multiplex service. The MOS device features a terminal arrangement which provides maximum isolation between the output and the input terminals. Typical ratings are 200 Ω on resistance, 10^{10} Ω off resistance and 0.34 pF feedback capacitance at zero drain-to-source volts.

CIRCLE NO. 329

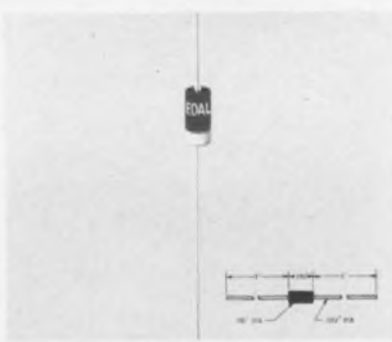
Silicon transistors carry 20 amperes

Solitron Devices, Inc., Transistor Div., Riviera Beach, Fla. Phone: (305) 848-4311.

A line of 20-A pnp silicon power transistors is packaged in a TO-61 case. These devices have breakdown voltages of up to 100 V. They offer a gain range of 30 to 90 at a collector current of 10 A. Collector saturation voltage is 1.75 V max and base saturation voltage is 2.5 V max. Similar 10-A devices are also available.

CIRCLE NO. 330

Silicon rectifiers handle 2 A at 25°C



Edal Industries, Inc., 4 Short Beach Rd., East Haven, Conn. Phone: (203) 467-2591.

Miniature silicon rectifiers offer currents to 2 A at 25°C ambient temperature and voltages to 1200 PIV. Axial lead, tubular insulated construction and small size (1/4 in. × 0.115 in. dia) facilitate circuit board and point-to-point wiring. Weight is 0.4 g. Humidity requirements of MIL standard 202A, method 106, are met.

CIRCLE NO. 331

Pnp alloy transistors packaged three ways

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

A line of small signal pnp silicon alloy amplifier and chopper transistors, available in TO-5, TO-18 and coaxial packages, exhibit high breakdown voltages, symmetrical breakdown voltages and high inverse gain. The coaxial package has a rating of 1 W in free air.

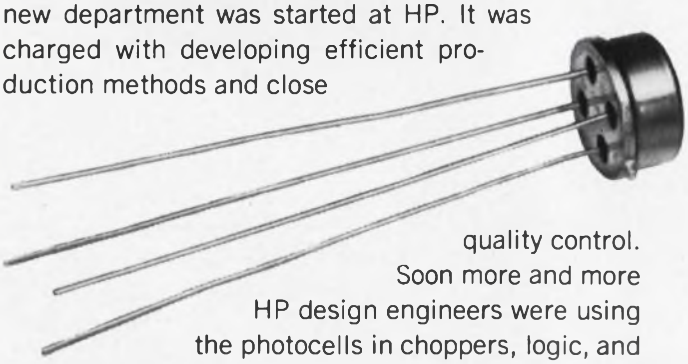
CIRCLE NO. 332

HP isn't in the photocell business by accident.

We're in it to deliver a superior line of products—and there's a lot of thought behind the current availability of photoconductors from Hewlett-Packard.

It all started ten years ago when HP found an urgent need for a reliable supplier of photocells for its instrumentation—a supplier who could deliver *and* keep the reject rate down. The decision was unavoidable—HP should produce its own photocells.

With the development by the HP engineering staff of new photoconductive materials that optimized speed and stability in early photoconductors, a whole new department was started at HP. It was charged with developing efficient production methods and close



quality control. Soon more and more HP design engineers were using the photocells in choppers, logic, and circuit control applications, requiring growth in the size and capability of the photoconductor department and its ability to bring unique R & D efforts to the photocell business. With its own plant, a separate applications group, complete production facilities and a vigorous new product program, this department no longer makes photoconductors only for HP—it's now *your* source, too.

HP's line of photocells, modulators, photo-controlled resistors and photochoppers represents the best optimization of overall photocell performance—and HP also has the engineering know-how to give you the customized "special" design attention you may require. HP experience provides the reliability you need, too.

If you're looking for a photoconductor product, check with HP before deciding on one. We can talk your own particular application language, giving appropriate performance data and specifications.

Write Bob Santos, Hewlett-Packard, 620 Page Mill Road, Palo Alto, California 94304; or call him collect at (415) 321-8510. In Europe write: 54 Route des Acacias, Geneva.

HEWLETT hp PACKARD

SOLID STATE DEVICES

INFORMATION RETRIEVAL NUMBER 48

NEW COVERAGE

tuners and receiver frequency extenders

8-12 GHz
4-8 GHz
1-4.5 GHz
2-4.5 GHz
1-2 GHz

Tunable 4-section YIG preselectors • 21.4 and 160 MHz outputs • manual and motor-driven • Call or write for specifications.

NOW by CEI — 1 kHz⇌12 GHz

CEI

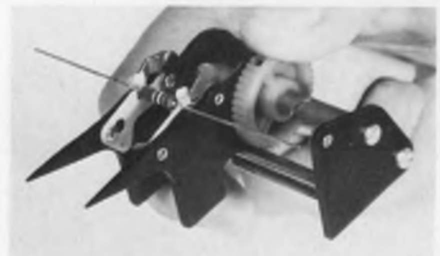
COMMUNICATION ELECTRONICS
6006 Executive Blvd., Rockville, Md. 20852
301/881-3300 • TWX 710-824-9603

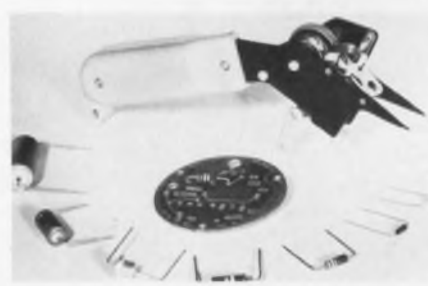
SUBSIDIARY OF WATKINS-JOHNSON

INFORMATION RETRIEVAL NUMBER 49

PRODUCTION EQUIPMENT

Assembly tool bends leads of component





Harwil Co., 1009 Montana Ave., Santa Monica, Calif. Phone: (213) 394-4710.

A hand tool, model N-300, is used for fast, accurate bending of electronic component leads for insertion into printed-circuit boards and eliminates measurement and trial-and-error methods. Spinning a knurled wheel matches a pair of pointers with the holes in a circuit board. The bends are then formed by pressing leads against the sides of the pointers with thumb and forefinger. All axial lead components up to 1/2 in. dia × 1-1/2 in. long can be accommodated.

CIRCLE NO. 333

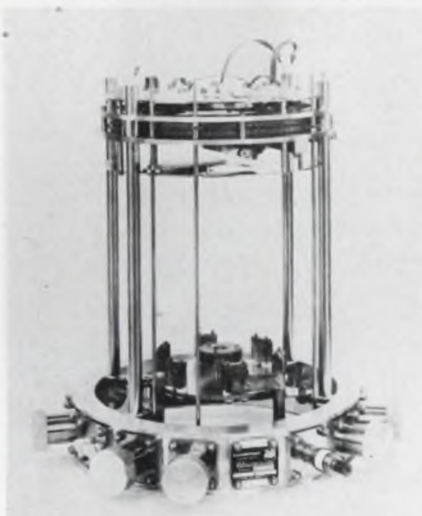
Abrasive jet process cuts, trims or etches

S. S. White Co., Industrial Div., 201 E. 42 St., New York. Phone: (212) 661-3320.

Applications include trimming trick-film resistors to thin sections of any fragile material. The work is done by a high-velocity stream of fine (27 μm) abrasive particles such as silicon carbide, aluminum oxide, sodium bicarbonate, dolomite or ground glass. The tool may also be used to etch glass or metal.

CIRCLE NO. 334

Tooling system deposits uniformly



Allen-Jones Electronics, Div. of WEMS, Inc., 17171 S. Western Ave., Gardena, Calif. Phone: (213) 321-9490.

A tooling system that offers uniform deposition for semiconductor applications permits the vertical adjustment of both evaporation source array and modulator to vary source-to-substrate distance as much as 20 in. A single planetary gear offers rotational speeds up to 100 rpm and a quartz-lamp substrate heater array provides controllable temperatures to 400°C.

CIRCLE NO. 335

CLOVERLEAF®
TEFLON* RECEPTACLES

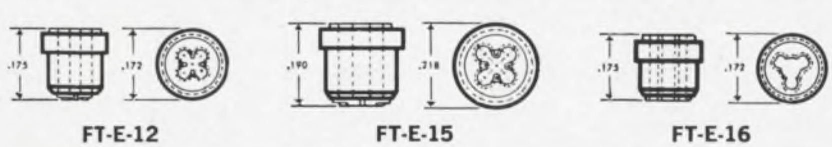
Press-Fit Cloverleaf Receptacles provide new economies in production of hand-wired, metal chassis electronic assemblies. For the first time, metal chassis may be dip or wave-soldered just as you do P.C. boards and with uniformly perfect solder joints everytime.

The unique Cloverleaf configuration permits insertion of four or more wire leads plus an optional center post for mounting additional components or external leads. This design provides an encompassing hold on the leads while allowing excellent capillary flow of solder. The Cloverleaf receptacle is manufactured of virgin Teflon and precisely machined to "Press-Fit" into the chassis for fast, positive and economical installation.

The inherent reliability of Cloverleaf/metal chassis construction makes it ideal for use in high density electronic packaging. The low unit cost of the terminal and its simple installation provides a new and economical assembly technique for quality radio and television production.

*Reg. T.M. E.I. DuPont deNemours & Co.

U.S. Patent No. 3,193,617



CIRCUIT HARDWARE DIVISION
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Sealectro Ltd., Portsmouth, Hants, England

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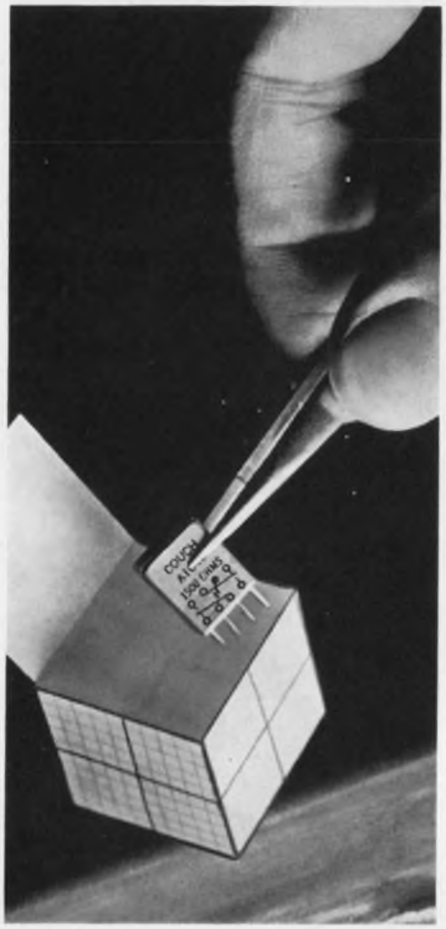
INFORMATION RETRIEVAL NUMBER 50



Couch 2X 1/7-size relays meet MIL-R-5757D/19 in 1/25th of a cubic inch

The new, third generation Couch 2X relays solve switching problems where space and weight are critical. Thoroughly field-proven in electronic and space applications. Relays are delivered *fully tested.* Additional screening tests available at your option.

	2X (DPDT)	1X (SPDT)
Size	0.2"x 0.4"x 0.5"	same
Weight	0.1 ox. max.	same
Contacts	0.5 amp @ 30 VDC	same
Coil Operating Power	100 mw 150 mw	70 mw 100 mw
Coil Resistance	60 to 4000 ohms	125 to 4000 ohms
Temperature	—65°C to 125°C	same
Vibration	20 G to 2000 Hz	same
Shock	75 G, 11 Ms	same

Broad choice of terminals, coil resistances, mounting styles. Write for detailed data sheets.

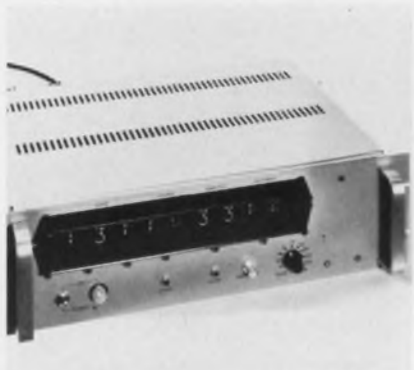
RUGGED ROTARY RELAYS *Dynamically and Statically Balanced*

Couch 1894

COUCH ORDNANCE INC.

3 Arlington St., North Quincy, Mass. 02171
Area Code 617 CYpress 8-4147
A subsidiary of S. H. COUCH COMPANY, INC.
INFORMATION RETRIEVAL NUMBER 51

Time code generator reads out at 9 rates



Flow Corp., 127 Collidge Hill Rd., Watertown, Mass. Phone: (617) 924-8505.

This time code generator generates the IRIG-B time-of-year code (days, hours, minutes and seconds) at nine selected digit rates and corresponding carrier frequencies for indexing magnetic tape at real time or at selected speed ratios up to (1/256 of real time). Used for time-indexing magnetic tape at high speed.

CIRCLE NO. 336

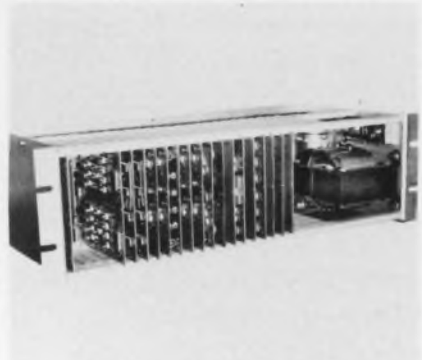
Laboratory computer cycles in 1 μ s

Spear, Inc., 335 Bear Hill Rd., Waltham, Mass. Phone: (617) 899-4800. P&A: $50,000; 90 days.

The Micro-Linc-300 offers a 1-μs cycle time and a buffered tape, which permits parallel processing while tape instructions are being carried out. A RAM (rapid access to memory) feature has been added which, in conjunction with buffered tape, permits data logging at 6000 character/s rate. Other characteristics include a 4096-word core memory (expandable to 32,000); 3 million bits of tape storage, expandable to 12 million bits; alphanumeric CRT; 9-bit A/D converter with conversion rate of 7 μs; 16 analog input channels (expandable to 32); and 12 digital sense lines and a 12-bit parallel input to the accumulator. Maximum analog sampling rate is 110,000 samples/s, continuous sampling rate is 6000 samples/s.

CIRCLE NO. 337

Magnetic-core memory cycles in 900 ns



Datacraft Corp., 776 N.E. 40th Court, Ft. Lauderdale, Fla. Phone: (305) 565-9441. P&A: $1210; 30 days.

The Model DC-31 magnetic-core memory is a compact, two-dimensional, high-speed, memory that features random-access operation with a full-cycle time of less than 900 ns. Memory access time is less than 450 ns. Maximum capacity of the unit is 1024 × 12 in one-bit-per-word increments.

CIRCLE NO. 338

Digital logger records analog data

Control Equipment Corp., 19 Kearney Rd., Needham Hts., Mass. Phone: (617) 444-7550. P&A: $7500-$15,000; 60 days.

A portable digital-data logger automatically measures and records signals from multiple installations of transducers or electrical pickups. The data are recorded in digital form for later computer entry or manual study. Complete in one package,the data logger scans, digitizes and records analog information. It can be used to measure and record any combination of physical parameters that is convertible by transducers to voltage, current, or resistance. Some examples are temperatures, pressures, velocities, accelerations, weights, displacements and positions. It also records digital data from keyboards, shaft encoders, counters and digital transducers, and generates time and identification information.

CIRCLE NO. 339

ERA LC COMPACT MODULES

Output Voltage (DC)	Current (71°C)	Model	Price
4-32	0-750 ma	LC32P7	$ 89.00
4-32	0-2 amps	LC322	$115.00
4-32	0-5 amps	LC325	$179.00
4-32	0-10 amps	LC3210	$215.00
30-60	0-1 amp	LC601	$145.00

SPECIFICATIONS

Input: 105-125 VAC, 50-400 cps
Ripple: Less than 800 microvolts RMS
Line Regulation: Better than ±0.01%
Load Regulation: Better than 0.05% for 0-100% load change
Transient Response: Less than 50 microseconds
Operating Temperature: −20°C to +71°C free air, full ratings
Temperature Coefficient: Less than 0.01% per degree C

Write Today for Catalog #147A

ERA WR ULTRA-COMPACT MODULES

Output Voltage (DC)	Current (71°C)	Model	Price
1-33	0-500 ma	WR33P5	$120.00
1-33	0-1 amp	WR331	$155.00
1-33	0-2 amps	WR332	$185.00
1-33	0-4 amps	WR334	$255.00
1-33	0-8 amps	WR338	$305.00

SPECIFICATIONS

Input: 105-125 VAC, 50-400 cps
Ripple: Less than 800 microvolts RMS
Line Regulation: Better than ±0.01%
Load Regulation: Better than 0.05%
Transient Response: Less than 50 microseconds
Operating Temperature: −20°C to +71°C free air, full ratings
Temperature Coefficient: Less than 0.01% per degree C

Write Today for Catalog #148A

ERA ST SLIM PROFILE MODULES

Output* Voltage (DC)	Current* (71°C)	Model	Price
1-63	0-1 amp	ST1000	$155.00
1-33 Dual	0-1 amp Dual	ST1000-2	$195.00
1-33	0-2 amps	ST2000	$175.00

SPECIFICATIONS

Input: 105-125 VAC, 50-400 cps
Ripple: Less than 800 microvolts RMS
Line Regulation: Less than 0.01%
Load Regulation: Less than 0.05%
Transient Response: Less than 50 microseconds
Operating Temperature: −20°C to +71°C free air, full ratings
Temperature Coefficient: Less than 0.01% per degree C

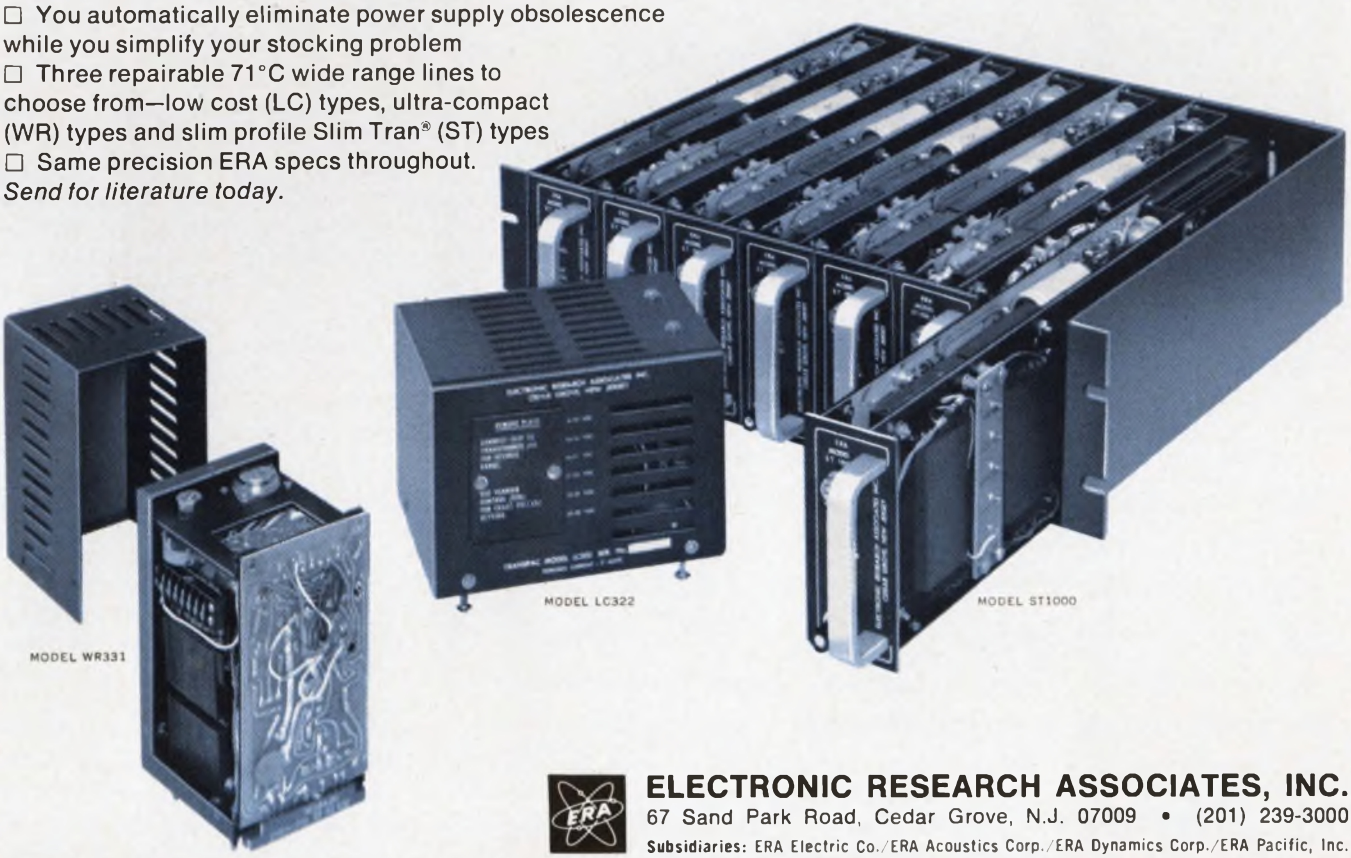
Write for Catalog #149

With these power modules you get wide VDC ranges— and set your own slot!

Frustrated by the narrow voltage ranges of conventional power modules? Now you can specify *wide range* ERA Transpac® modules and *set any module to any voltage slot* within its range!

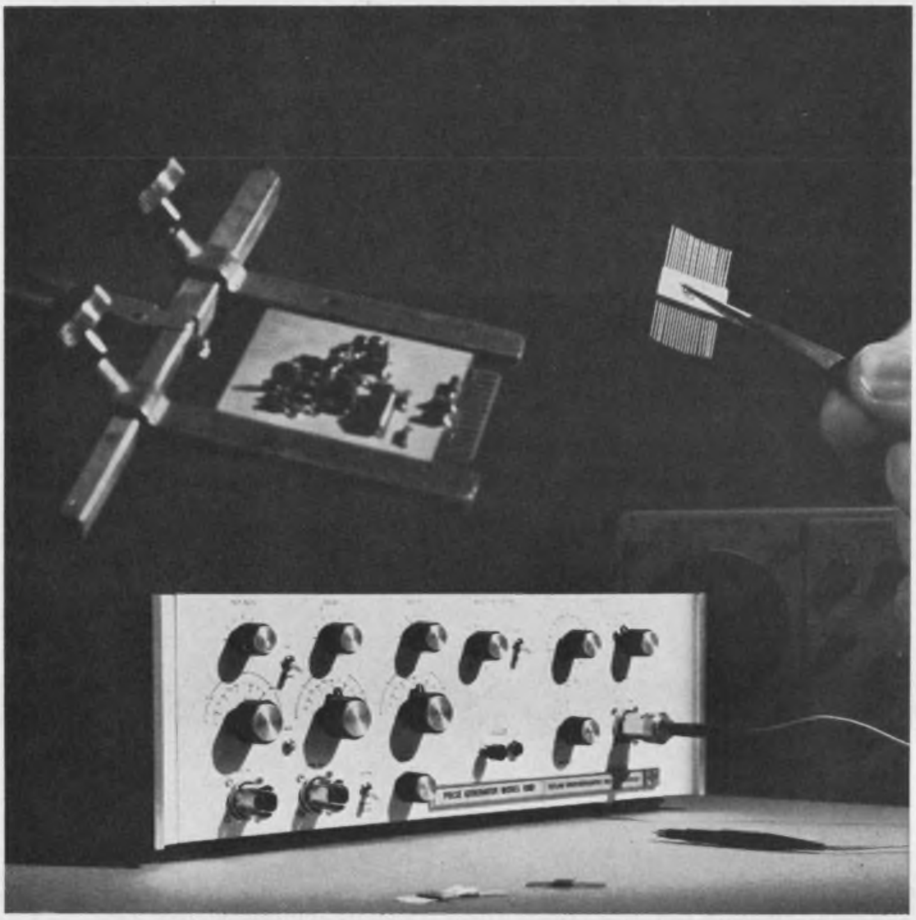
☐ You automatically eliminate power supply obsolescence while you simplify your stocking problem
☐ Three repairable 71°C wide range lines to choose from—low cost (LC) types, ultra-compact (WR) types and slim profile Slim Tran® (ST) types
☐ Same precision ERA specs throughout.

Send for literature today.



ELECTRONIC RESEARCH ASSOCIATES, INC.
67 Sand Park Road, Cedar Grove, N.J. 07009 • (201) 239-3000
Subsidiaries: ERA Electric Co./ERA Acoustics Corp./ERA Dynamics Corp./ERA Pacific, Inc.

INFORMATION RETRIEVAL NUMBER 52



Why You Need a Special Pulse Generator for State of the Art Circuit Design

With high speeds and critical design parameters, you need the best test instruments to be sure your designs will be optimum. The TI Model 6901 Pulse Generator gives outputs from 1 KHz to 0.1 GHz; independent amplitude and baseline controls; jitter less than 0.1% of period + 50 psec; and countdown synchronization output.

The 6901 makes your designing simpler, too. Because the pulse amplitude of the generator can be changed without affecting DC offset, you can use the offset instead of an external bias supply for your circuit.

For additional information, contact your TI Field Office, or the Industrial Products Division, Texas Instruments Incorporated, P. O. Box 66027, Houston, Texas 77006.

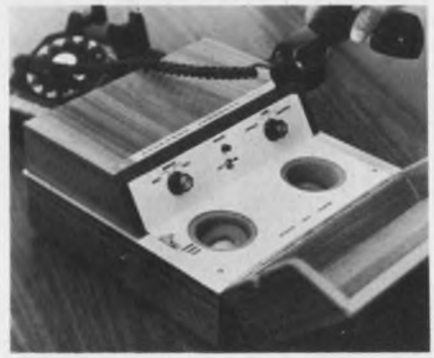
TEXAS INSTRUMENTS
INCORPORATED

INFORMATION RETRIEVAL NUMBER 53

827A

SYSTEMS

Portable data coupler for telephone use

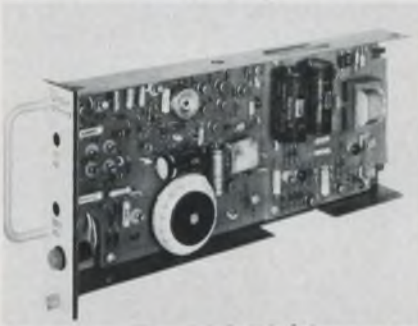


Anderson Jacobson, Inc., 2235 Mora Dr., Mountain View, Calif. Phone: (415) 968-2400. Price: $570.

For sending and receiving data between a remote terminal and a time-shared computer, the Acoustic Data Coupler uses any telephone. It is used typically with a model 33 or 35 Teletype but can be used interchangeably with EIA RS-232 specification interface teleprinters that can operate with a 103A Dataphone. This includes the Friden 7100, Datel Thirty-10, IBM 2741 and various card readers. The teleprinter-coupler combination provides a remote computer terminal which can be moved from one place to another wherever a telephone is available. Coupling with the telephone system is acoustic both into and out of the telephone system, assuring compatibility with telephone handsets of various magnetic-field configurations. Operation is independent of signal level, above a required minimum, and no adjustment is required. A "carrier on" indicator is provided to help with system diagnostics. The ADC 260 is designed to handle a bit rate of approximately 300 Baud. It is used at a 110-Baud rate when used with a Model 33 or 35 Teletype. Transmission characteristics are fully compatible with using a 103A Dataphone at the computer end of the telephone line, with switches provided for both upright and inverted codes and full and half duplex. No special interface in the Teletype is required except to install a connection cable which is included. EIA Specification terminals plug in directly.

CIRCLE NO. 340

Telemetry receiver powered by 12 V dc



Quindar Electronics, Inc., 60 Fadem Rd., Springfield, N.J. Phone: (201) 379-7400.

An analog telemetering receiver has been developed for use where ac power is not available. Normal operation is from a 12-V dc power source, but higher voltages may be accommodated by the addition of a voltage divider accessory. Completely solid-state, the unit requires no temperature control oven and its low power requirement of 2 W contributes to cool operation.

CIRCLE NO. 341

Data switch makes 512 contact closures

3M Co., Instrument Products, 300 S. Lewis Rd., Camarillo, Calif. Phone: (805) 482-1911.

A data switch offers up to 512 contact closures with no closure excluding the possibility of another. Programing format consists of an address signal followed by BCD characters to generate a three-decimal digit-interconnection number and a command number. The command column allows the data switch to be zeroed or interconnections to be made or opened.

CIRCLE NO. 342

Only the best panel meters have dual slope integration

actual size

API's new digital panel meter

has it—which means the meter maintains its ±0.1% accuracy (DC voltage) over long periods of time. Erroneous signal transients are eliminated also.

There are other digital panel meters, but this one has an exceptional combination of attributes. It doesn't flicker annoyingly. It counts fast and it reads fast, so that you are always seeing an up-to-the-split-second signal.

API's digital meter not only looks pretty, but its required panel space is only 3 inches high and 4½ inches wide. It has no "iceberg" configuration behind the panel. Standard ranges begin at 0 to 20 microamperes DC and 0 to 200 millivolts DC.

Bulletin 61 has full details

List price: $320.00

See it at Booth No. 2G-34 and 36, IEEE Show.

api
INSTRUMENTS CO.
CHESTERLAND, OHIO 44026 • (CLEVELAND-216) 729-1611 • TWX: 810-427-9230
In Canada: Oshawa, Ontario • (416) 576-1541

INFORMATION RETRIEVAL NUMBER 54

Wedge-Action* Relays

Hermetically-sealed, electromagnetic relays that provide high performance and reliability under the most difficult operating conditions in dry-circuit to 2 amp applications.

2 PDT
MARK II, SERIES 500
MIL-R-5757/9

2 PDT
MARK II, SERIES 400
(1.35" high)
SERIES 410 (1" high)
MIL-R-5757/8

6 PDT 4 PDT
(1" x 1")
MARK II, SERIES 300
(6 PDT).
SERIES 350 (4 PDT).
MIL-R-5757/1 and
MIL-R-5757/7

6 PDT
MARK II, SERIES 085
(−55°C to +85°C)
SERIES 100
(−65°C to +125°C),
SERIES 200
(−65°C to +200°C).
MIL-R-5757/1.

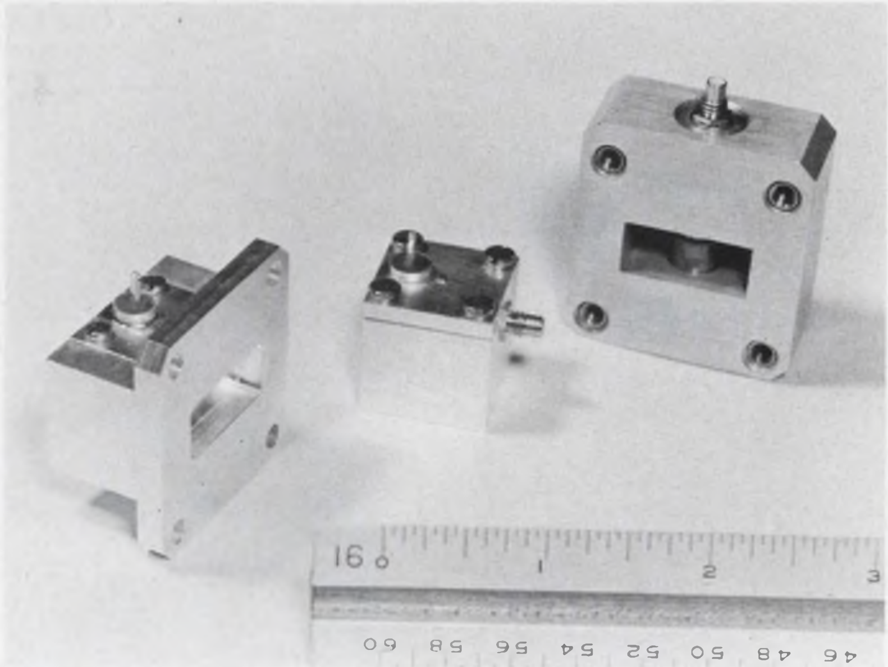
***Wedge-Action**

The moving contacts are mounted between two stationary contacts. On actuation, they drive into the stationary contacts, creating high pressures and low contact resistance at all current levels. In addition, wedge-action contact wipe provides self-cleaning of the precious-metal contacts.
*Patent No. 2,866,046 and others pending.

For complete data write Relay Sales and Engineering Office, P. O. Box 667, Ormond Beach, Fla. 32074, Phone 904-677-1771, TWX 810-857-0305.

Electro-Tec Corp.
SLIP RINGS • RELAYS • SWITCHES

INFORMATION RETRIEVAL NUMBER 55



Oscillators use diodes to generate at 10.525 GHz

Varian, Bomac Div., 8 Salem Rd., Beverly, Mass. Phone: (617) 922-6000. P&A: $450; 60 days.

Semiconductor oscillators utilizing the (IMPATT) impact avalanche transit time principle deliver 60 mW cw at 10.525 GHz in the public service radio location band. Typical applications include use as local oscillators and in low-power railroad monitoring and police Doppler radar systems.

Earlier versions of IMPATT oscillators gained a reputation for being inherently noisy; avalanche breakdown gave rise to noise which took the form of amplitude and frequency modulation. In these devices a-m noise has been reduced enough to satisfy most system requirements. Although fm noise close to the carrier is still marginal, it falls off more rapidly with increasing displacement from the carrier than does the a-m noise. The noise figure of an X-band receiver that used the IMPATT oscillator has been compared with that of the same receiver using a low-noise tube oscillator. When a balanced mixer was used, the figures were within 0.2 dB of each other, although use of a single-ended mixer yielded an IMPATT noise figure that was 10 dB greater. The explanation of the discrepancy is that single-ended mixers respond to a-m as well as fm components of the local oscillator output.

The IMPATT diodes incorporated in these oscillators are constructed much like varactor diodes in terms of starting material, diffusion and packaging. The most notable difference is in the IMPATT diode's better thermal conduction. The surface of the active region of the silicon directly contacts the heat sink of the diode and the surface of the mesa, rather than the substrate, is bonded to the inner portion of the diode stud.

In operation, the diode of the X-band IMPATT oscillator is reverse-biased into breakdown by approximately 70 V, drawing a reverse current of about 40 mA. Under these conditions, the nominal 60-mW output is produced at a typical efficiency of 2%.

Weighing 4 oz, the oscillator can be mounted in any position. Dimensions are 1-5/8 × 1 in. deep—a volume less than 2-3/4 in.^{3}. The output flange mates with UG-39/U and positive bias connection is made to a solder terminal. The oscillator case itself is negative.

CIRCLE NO. 343

When reliability is the rule

...specify Johanson

HIGH Q, HIGH FREQUENCY VARIABLE AIR CAPACITORS

An **extra margin** of reliability is built into Johanson Miniature Variable Air Capacitors.

This versatile series provides, in miniature size, exceptionally high Q, superior ruggedness for protection against shock and vibration, −55°C to +125°C operating temperature range, protection against fungus, salt spray and humidity . . . plus all the other construction and performance features that have made Johanson capacitors the industry standard for excellence.

No compromise is made in materials, design or workmanship assuring, in all cases, the finest performance available for the price.

Test Johanson capacitors yourself — under your worst-case test conditions.

Write Today for Complete Catalog, Prices.

Features 570° Solder
Prevents distortion. Not affected by conventional soldering temperatures.

THE JOHANSON 2950 SERIES VARIABLE AIR CAPACITORS (ILLUSTRATED)

SPECIFICATIONS:

CAPACITANCE RANGE:	0.8 — 10.0 pf.
DIELECTRIC WITHSTANDING VOLTAGE:	Rating 250 vdc Breakdown > 500 vdc
Q:	> 2000 @ 100 mc
TEMPERATURE COEFFICIENT:	0 ± 20 ppm/°C
INSULATION RESISTANCE:	> 10^6 megohms @ 500 vdc
ROTATIONAL LIFE:	> 800 revolutions rotor screw
THERMAL SHOCK:	65°C to +125°C
SHOCK:	50 g's 11 millisec.
VIBRATION:	15 g's 10-2000 cps

Complete data available on request.

The Complete Johanson line includes variable air capacitors ranging from .1-1 pf to 6.0 — 325 pf. also high-reliability and non-magnetic types.

Johanson **MANUFACTURING CORPORATION**
400 Rockaway Valley Road, Boonton, N. J. 07005
Phone (201) 334-2676

Coaxial breakaway stretches 7 in.

Prodelin, Inc., Hightstown, N.J. Phone: (609) 448-2800.

A coaxial line stretcher or breakaway maintains constant impedance over 7-in. travel with no adverse effects from high power. A VSWR not exceeding 1.02 at any frequency is maintained throughout the operating range. This design, featuring complete pressurization capability, makes it possible to break into a rigid transmission line system at any point.

CIRCLE NO. 344

Black-body radiator measures 3/8 × 1/2 in.

Electro Optical Industries, Inc., P.O. Box 3770, Santa Barbara, Calif. Phone: (805) 968-2591.

This black-body radiation source measures only 3/8 in. dia by 1/2 in. long. Designated the model 111, the unit operates from 50°C to 600°C. It is available with either the temperature controller shown or as a conventional linear, proportional laboratory model. Long-term control stability is better than 0.1°C.

CIRCLE NO. 345

Microwave stabilizer doubles as receiver

Micro-Now Instrument Co., Inc., 6124 N. Pulaski Rd., Chicago. Phone: (312) 282-0846.

Combining a high-gain 60-MHz i-f amplifier, limiter, discriminator, dc amplifier and a-m detector, this klystron-stabilizer/receiver is basically a stabilizer for microwave oscillators, but added features permit its use as a sensitive and versatile microwave receiver. Frequency range is limited by the external oscillator and mixer.

CIRCLE NO. 346

MAGNETIC SHIELD REFERENCE GUIDE

SHEET STOCK

TO STOCKED NETIC & CO-NETIC MAGNETIC SHIELDING FOIL AND SHEETS FOR YOUR FABRICATION

THICKNESS	NETIC S3-6 SHEET WIDTH	CO-NETIC AA SHEET WIDTH
.014″	30″	30″
.020″	30″	30″
.025″	24″	30″
.031″	26″	30″
.049″	26″	30″
.050″	26″	30″
.062″	26″	30″
.095″	26″	30″

Maximum length is 120″.
Also sold in 15″, 30″ and 60″ lengths.
After fabrication, shields made from sheet must be heat treated for maximum shielding. No further annealing required.
Pre-annealed stock also available.

CO-NETIC AA FOIL IN COILS: (Specify length desired)	BLUE NETIC FOIL* IN COILS: (Specify length desired)
.010″ thick x 15″ wide	.004″ thick x 19⅜″ wide
.006″ thick x 15″ wide	.004″ thick x 4″ wide
.004″ thick x 15″ wide	*BLUE NETIC foil not available in .002″ thick
.002″ thick x 4″ wide	

All foil also available adhesive backed.
Other widths available to maximum above.

Both BLUE NETIC and CO-NETIC AA foils, plain and adhesive backed, can be furnished slit to any desired width, at additional cost—Ask for prices.

- Non-shock sensitive; requires no periodic annealing
- DELIVERY TIME—normal delivery time on stock widths is 1 to 2 days after receipt of order. For adhesive backed foils, approximately one week, and for foils slit to desired width, approximately 1 to 2 weeks.

Request Catalog SG-1

Co-Netic MAGNETIC SHIELD DIV. Netic

MAGNETIC SHIELD DIVISION

Perfection Mica Company

1322 N. ELSTON AVENUE • CHICAGO, ILLINOIS 60622

Phone: 312, EV 4-2122 • TWX 910 221-0105

INFORMATION RETRIEVAL NUMBER 57

Double balanced mixers range up to 2.4 GHz

Vari-L Co., Inc., 207 Greenwich Ave., Stamford, Conn. Phone: (203) 323-2176. Price: $45 to $350.

Double balanced mixers with frequency ranges from 0.05 MHz to 2.4 GHz are packaged in metal enclosures with coaxial connectors, or in miniature modules with pin terminals spaced for strip-line connections. The broad-band and hybrid transformers are used for input and output coupling. Carefully matched by Schottky barrier diodes comprise the mixer, or ring modulator portion.

CIRCLE NO. 347

S-band noise source fires at —450 V

Signalite Inc., 1933 Heck Ave., Neptune, N.J. Phone: (201) 775-2490.

A gas-discharge noise source for use at frequencies from 2900 to 3100 MHz has a firing voltage of —450 V max applied to the cathode and rapidly attains its operating voltage level of 35±4 V dc. Designed for 90° E-plane mounting in a RG-75/U circuit, it incorporates an integrally mounted gas-discharge tube and features a built-in protective cell, to prevent firing by a stray high-energy rf signal.

CIRCLE NO. 348

CYCLIC
A/D CONVERTER

For more than a decade, engineers have attempted to design a workable CYCLIC A/D converter. Bunker-Ramo has engineered and manufactured the first practical Cyclic A/D converter, the B-R 850.

- CYCLIC! — Within the B-R 850, the signal is synthesized rather than successively approximated. Input data conversion is continuous, eliminating requirement for sample and hold. Output can be sampled continuously or on command.
- FAST! — Worst-case conversion time: 1 μsec. for 8-bit word. 1-bit changes as short as 60-nsec. When following a multiplexer, conversion time will add less than 1 μsec.
- ECONOMICAL! — $1,348 (single unit price); POWER: max 7½ watts; SIZE: 3¾" x 4⅜" x 7½"; WEIGHT: less than 2-lbs.

SPECIAL PROBLEMS? NEED HIGHER SPEED—GREATER RESOLUTION—LOWER POWER—SMALLER SIZE? TRY US FOR THE SOLUTIONS!

For more information on the BR-850 and on our upcoming line of components, (i.e.: 12-bit, 300 KHz; 8-bit, 3 MHz converter; 16-channel multiplexer and others) please contact Mr. W. G. Garner. Phone (213) 346-6000 or write:

See You at the IEEE Show, Booth 4E39-41

THE BUNKER-RAMO CORPORATION
DEFENSE SYSTEMS DIVISION
8433 FALLBROOK AVENUE • CANOGA PARK CALIFORNIA 91304

INFORMATION RETRIEVAL NUMBER 58

New Dual-Tracking Power Modules from ERA

Ultra-Compact, High Temperature

Drive operational amplifiers, IC's and other devices requiring dual-tracking DC with ERA's fully repairable DV series Transpacs®. Two independent power sources provide continuously adjustable and proportional outputs, ± 12 VDC through ± 15 VDC, reducing variations in operational amplifier performance resulting from power supply changes.

SPECIFICATIONS

Input: 105-125 VAC, 50-400 cps
Voltage output: ±12 through 15 VDC, Dual
Current rating: See table
Ripple: Less than 800 microvolts, RMS
Line, load regulation: Less than 0.05%, full line or load change
Transient response: Less than 50 microseconds
Operating temperature: —20°C to +71°C
Temperature coefficient: 0.02% per degree C
Heat sinking: Internal, convection cooled

STANDARD MODELS

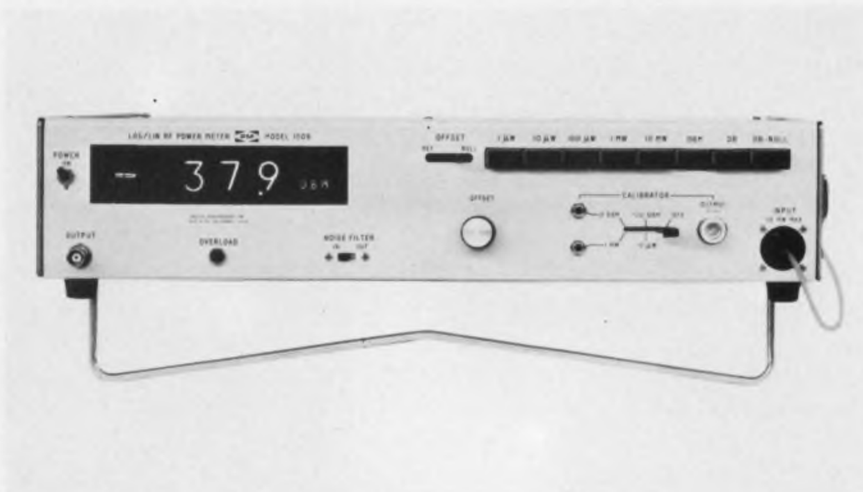
Output Voltage VDC	Current 71°C	Model	Price
+(12-15) −(12-15)	0-60 ma 0-60 ma	DV60	$96.00
+(12-15) −(12-15)	0-500 ma 0-500 ma	DV500	$149.00
+(12-15) −(12-15)	0-1 amp 0-1 amp	DV1000	$189.00

Write for Catalog #151

ELECTRONIC RESEARCH ASSOCIATES, INC.
67 Sand Park Road, Cedar Grove, N. J. 07009
(201) 239-3000

Subsidiaries: ERA Electric Co. • ERA Acoustics Corp. ERA Dynamics Corp. • ERA Pacific, Inc.

INFORMATION RETRIEVAL NUMBER 59



Digital rf power meter has BCD, analog outputs

Pacific Measurements Inc., 940 Industrial Ave., Palo Alto, Calif. Phone: (415) 528-0300. Price: $1850.

Offering an instantaneous digital display of rf power on either a logarithmic or linear scale, this rf power meter will make both swept and single frequency measurements from 10 MHz to 12.4 GHz. In addition to digital readout, the instrument offers BCD output for data acquisition systems and computers. BCD (digital) outputs are available on the rear panel, as an option. For computer use, the digital display rate may be triggered from an external source over a range of zero to 100 readings/s. An analog output is available to drive an oscilloscope or an X-Y recorder.

The high-gain direct-coupled input amplifier is chopper-stabilized, and temperature sensitive components are oven-mounted to minimize dc drift. Auxiliary inputs are provided on the back panel to allow the addition of frequency markers to a swept frequency display and to permit the connection of two instruments for ratio measurement.

Crystal-diode response in the rf detector is adequate for swept frequency measurements. The detector is compensated to permit accurate measurement (0.1-dB resolution) from −40 to +10 dBm between 15°C and 45°C. An over-range numeral, a unit annunciator and a decimal point augment the three-digit standard readout to minimize the possibility of operator error.

Linear modes of 1, 10, 100, 10,000 and 100,000 μW as well as logarithmic modes of dBm, dB and dB-null may be selected by pushbutton. In the dB and dB-null modes, an offset control permits zero adjustment of the analog output for any input level. The db-null mode is used for swept frequency measurements when a dc-coupled oscilloscope is used to display a response curve. Digital readout can indicate the difference between reference and null offset. If these two offsets are used to bracket noise on a swept display, the digital display will indicate their magnitude in dB.

Precise power levels of 1 mW and 10 W at 30 MHz are internally generated for calibration of the instrument. Temperature compensation from 15°C to 45°C is provided by a thermistor in the detector mount. A nonlinear noise filter may be thrown in ahead of the DVM input by a front-panel switch, ensuring a clean display of noisy signals while allowing quick response to large changes in signal level.

The combination of wide dynamic range and digital display permits accurate microwave power measurement and eliminates the possibility of error in reading an analog meter.

CIRCLE NO. 349

FET analyzer tests and classifies

Siliconix Inc., 1140 W. Evelyn Ave., Sunnyvale, Calif. Phone: (408) 245-1000.

A high speed go no-go tester sequentially makes up to 15 tests, at 33 ms per test, and classifies devices into five categories according to preset priorities. Counters on the front panel total each category. Using prepunched Mylar film and a pinboard-programing concept, the tester allows selection of junction or MOS FET dc parameters, at specific test conditions, and the establishment of limits on each.

CIRCLE NO. 350

Laboratory amplifiers boost signals to 60 dB

AGAC-Derritron, Inc., 600 N. Henry St., Alexandria, Va. Phone: (703) 836-4641. P&A: $295; 30 days.

Laboratory amplifiers that have a frequency response of 1 Hz to 100 kHz and offer a voltage gain of up to 60 dB feature small size and battery operation for portability. Good low-noise characteristics are due to a noise-canceling circuit that attenuates low-frequency semiconductor noise. Input impedance is 500 MΩ and dynamic range is 80 dBV at 40 dBV gain.

CIRCLE NO. 351

Ballantine Solid State AC Voltmeter

2 Hz to 6 MHz, with 1% Accuracy at Midband -- Operates from Built-in Rechargeable Battery or Power Line

FEATURES:

- ★ **Frequency range of 2 Hz to 6 MHz**
- ★ **Voltage range of 300 μV to 350 V (100 μV sensitivity, 10 Hz to 1 MHz)**
- ★ **Optional models with probe for voltage range 1 mV to 1000 V**
- ★ **1% accuracy, 30 Hz to 1 MHz**
- ★ **Built-in rechargeable battery or power line operation (Optional version for power line only)**
- ★ **Logarithmic indicator for uniform accuracy and resolution over entire scale**
- ★ **Floating signal ground**
- ★ **10 MΩ input resistance**
- ★ **Model 800 kit available for rack mounting without modifications**

Prices:

Model 303: Rechargeable battery/line, $360
Model 303-50: Rechargeable battery/line, with 1 kV 20 dB Probe, $410
Model 303-01: Line powered only, $305
Model 303-51: Line powered only, with 1 kV 20 dB Probe, $355

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Boonton, New Jersey

CHECK WITH BALLANTINE FIRST FOR DC AND AC ELECTRONIC VOLTMETERS/AMMETERS/OHMMETERS, REGARDLESS OF YOUR REQUIREMENTS. WE HAVE A LARGE LINE, WITH ADDITIONS EACH YEAR. ALSO AC/DC LINEAR CONVERTERS, AC/DC CALIBRATORS, WIDE BAND AMPLIFIERS, DIRECT-READING CAPACITANCE METERS, AND A LINE OF LABORATORY VOLTAGE STANDARDS FOR 0 TO 1,000 MHz

INFORMATION RETRIEVAL NUMBER 60

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Thermistors provide precision measurement, compensation and control of temperatures, liquid levels, the flow of liquids and gases . . . WITH INSTANT RESPONSE. VECO Thermistors are available in a wide range of sizes, shapes, resistance values and temperature coefficients. VECO's staff of experienced engineers is available to assist you in product application and circuit design. Write for Condensed Catalog MGP681.

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INFORMATION RETRIEVAL NUMBER 61

ADD AND DIVIDE

ACTUAL SIZE

0.5 — 150 MHz 0.5 — 100 MHz

WITH ASSURANCE

Obtain high isolation, low insertion loss, and excellent output balance . . . 0.5 to 150 MHz. Feed signals to common load without crosstalk. Drive isolated loads with single source . . assured load variations will not be cross coupled . . confident of coherent output signals. Ask for RELCOM hybrids isolation 45 dB; insertion loss 0.2 dB; VSWR 1.15; phase difference nominally 0°.

Space problems? The miniature H2A and H3 have all connectors on one side . . occupy only 0.5 cubic inches.

Model H2A $80; Model H3 $150 in quantities 1-4. Discounts on larger quantities. Hybrids with BNC connectors also available.

RELCOM
2329 Charleston Road Mountain View, California 94040
Telephone (415) 961-6265 TWX (910) 379-6979

INFORMATION RETRIEVAL NUMBER 62

IC multimeter displays 4 digits

Cimron Div. Lear Siegler, Inc., 1152 Morena Blvd., San Diego, Calif. Phone: (714) 276-3200.

Holding an accuracy of ±0.01% for six months, this digital multimeter features a 10% overrange on its 4-digit readout. It has an external sample rate of 1-5/s, automatic polarity, 3 manual ratio ranges of 1, 10, and 100 and 3 manual full-scale dc ranges of ±10.999, ±109.99, and ±1099.9. Optional BCD or 10-line decimal outputs of voltage state, contact closure or DTL are offered.

CIRCLE NO. 352

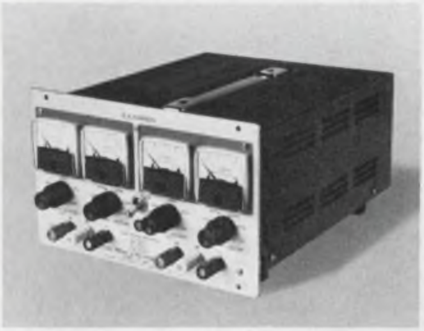
Silicon power supplies regulate to 0.01%

Kepco, Inc., 131-38 Sanford Ave., Flushing, N. Y. Phone: (212) 461-7000.

A series of programmable all-silicon power supply modules, including six models from 0-7 V to 0-2 A, to 0-100 V at 0-0.2 A, features 0.01% line and load regulation, less than 100-μV rms ripple and temperature coefficient of better than 0.01%/°C. Without external heat sinking, these supplies operate at 71°C without derating.

CIRCLE NO. 353

Dc power supply has twin outputs

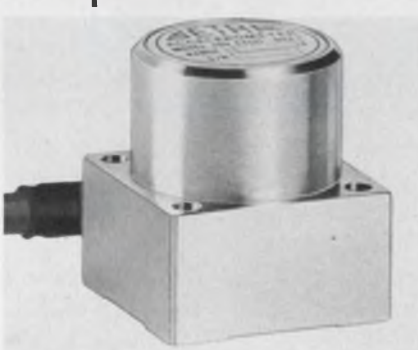


Lambda Electronics Corp., Terminal Drive, Plainview, L.I., N.Y. Phone: (516) 931-3300. Price: $260.

Two independent dc outputs double the voltage and current yield of this laboratory power supply and allow its use in dual-output applications. The 13-lb portable unit holds ripple to 1.5 mV pk-pk and regulates its output to 0.01% + 1 mV. It may be operated on a 105-132 Vac, 47-440-Hz line although its ratings are based on 60-Hz operation.

CIRCLE NO. 354

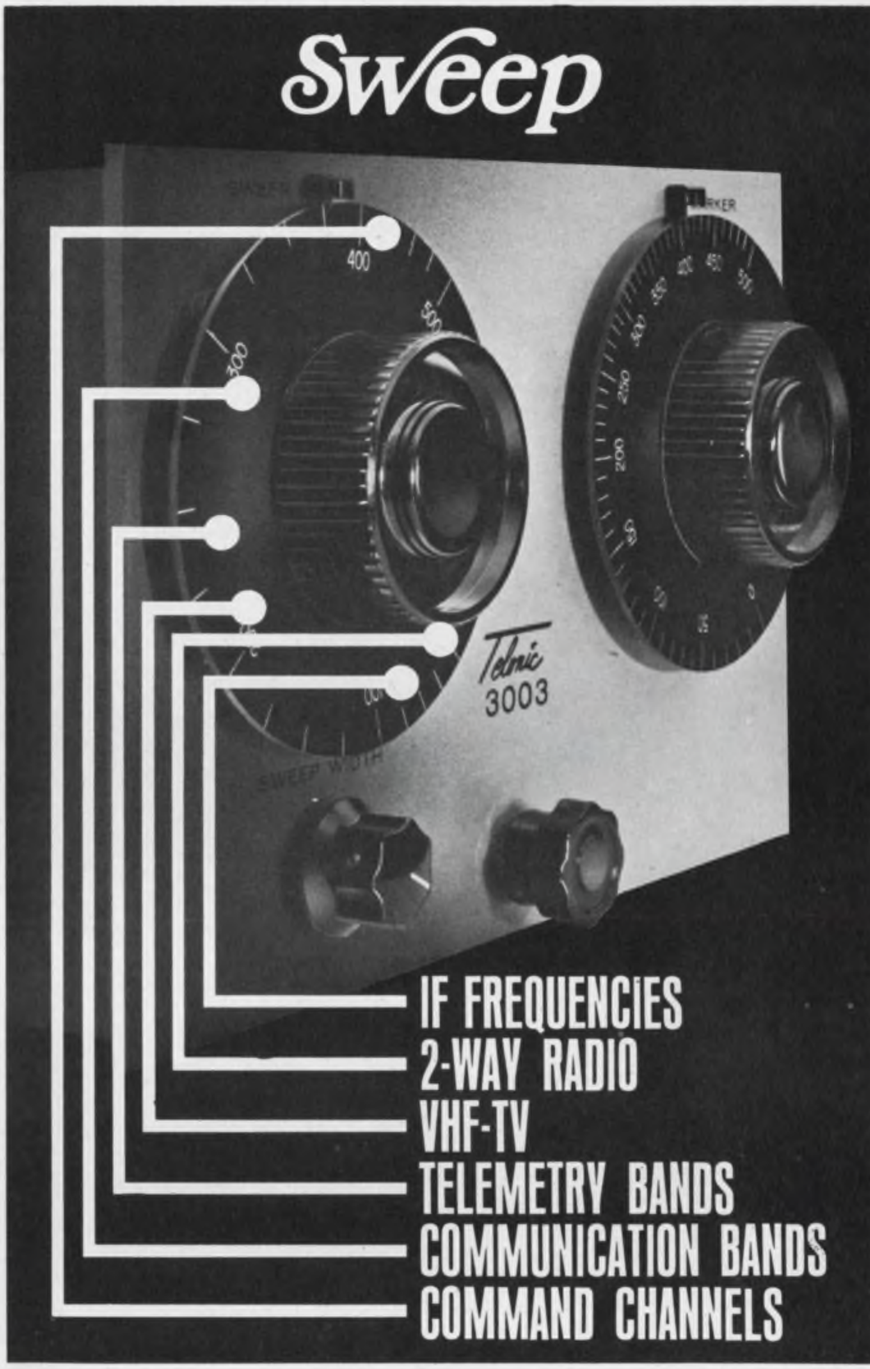
Linear accelerometer incorporates ICs



Setra Inc., 12 Huron Drive, Natick, Mass. Phone: (617) 655-4645. Price: $345.

A high-level dc output (±1.5 V) linear accelerometer, whose output is proportional to an acceleration vector in the range of ±1 g to ±250 g, is a self-contained transducer that utilizes ICs. Gas squeeze-film damping ensures constant amplitude response over the temperature range of −65 to +250°F.

CIRCLE NO. 355



Designed for Telonic's SM-2000 Sweep Generator, this new Model 3003-1 plug-in oscillator provides frequency coverage from **5 to 500 MHz,** sweeping this entire range in one pass or any portion of it down to 500 kHz wide.

Using electronic tuning and all solid state circuits, the 3003-1 virtually doubles the capabilities of the SM-2000 Sweep Generator. In addition to wide range and sweep width, it also features variable rate for permanent recording applications and a variable birdy-type marker, providing frequency identification from 5 - 500 MHz.

SPECIFICATIONS

Frequency Range	5 MHz - 500 MHz
Sweep Width	500 kHz - 500 MHz
Output	.5 v RMS
Sweep Rate	.01 to 100 Hz, variable
Vernier Attenunation Range	6 dB min.
Linearity	1.5:1
Flatness @ max. sweep	±0.75 dB
@ 10% max. sweep	±0.5 dB

Full details plus Application Data in Catalog 70-A. **Send for your copy.**

Telonic INSTRUMENTS Division of Telonic Industries, Inc.

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INFORMATION RETRIEVAL NUMBER 63

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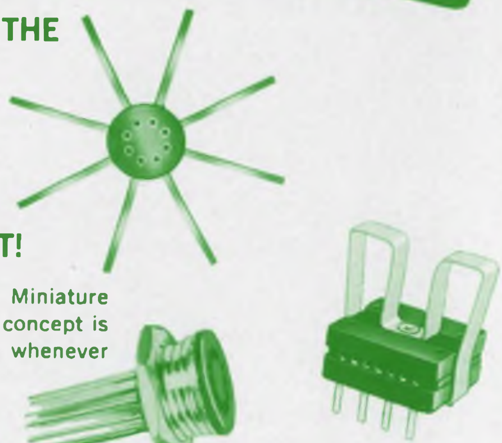

From Integrated Sockets to Miniature Sockets, our Total Capability concept is yours to use and specify whenever quality is critical.

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Write or call for complete catalogs and information

MASTERS OF MINIATURIZATION

INFORMATION RETRIEVAL NUMBER 64

TWISTING TOROIDS ISN'T NECESSARY

Instead, choose the toroid configuration to fit your circuit design: radial-lead ( ) or side-lead ( ). Saves assembly time. Halts lead breakage, during installation and when equipment is in use. Vanguard has your choice of styles with inductive values from 0.01 microhenries to 10 millihenries—all immediately available for the roughest environments, from −55°C to +125°C. And thanks to the toroid's low external magnetic field, you can package units closer than with other types of inductive devices.

While we can't say which lead type is best for your design, we do have a pair of suggestions. (1) Use side lead toroids for your prototype. They mount fast and are quickly removable. (2) Before starting on your breadboard, write for data on Vanguard's broad toroid line. You might find it necessary.

Vanguard Electronics/A Division of Wyle Laboratories/930 West Hyde Park Blvd./Inglewood, Calif. 90302/(213) 678-7161/TWX: 910 328-6126.

VANGUARD/WYLE

INFORMATION RETRIEVAL NUMBER 65

TEST EQUIPMENT

Integrating DVM exhibits 6 ranges

Vidar Corp., 77 Ortega Ave., Mountain View, Calif. Phone: (415) 961-1000.

Full scale ranges of this DVM are 10 mV, 100 mV, 1 V, 10 V, 100 V and 1000 V. The 10-mV range provides useful resolution of 1 μV at up to 40 readings/s. Readings accurate to ±0.01% full scale, ±0.004% of reading ±1 μV are visible on a six-digit front-panel display, and available for direct recording with a printer connected to the 8421-coded electrical output.

CIRCLE NO. 400

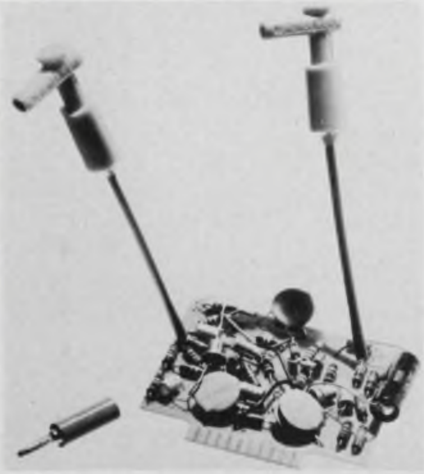
Pulse generator develops 3 outputs

Preston Scientific Inc., 805 E. Cerritos Ave., Anaheim, Calif. Phone: (714) 776-6400. P&A: $465; 90 days.

A double pulse generator develops an initial pulse upon receipt of command, a delay pulse generated when the pulse is turned on and a pulse which is generated at the end of the delay pulse. The unit provides six periods ranging from 1 μs to 100 ms. Pulse width is variable from 10 ns to 10 ms. The delay between the leading edge of pulse 1 and the leading edge of pulse 2 may be set less than 10 ns. The magnitude of the delay output ranges from 0.2 V to 10 V peak and the unit features a delay signal rise and fall time of less than 10 ns. Delay output impedance is 50 Ω.

CIRCLE NO. 401

Spring clamps aid circuit tests



Hunter Associates, 182 Clairmont Terrace, Orange, N. J. Phone: (201) 672-0423. Price: $1.50.

The Hunter universal test clamp has wide application in the entire field of electronic testing and production. It consists of a retractable spring clamp activated by light pressure on the handle. The clamp will grip the finest wire and then retract into the insulating sleeve, so that it can be used in high-density circuitry with no danger of short circuits. The head contains a standard banana plug jack which allows flexibility for rapid interconnection. It is available in red, black and green.

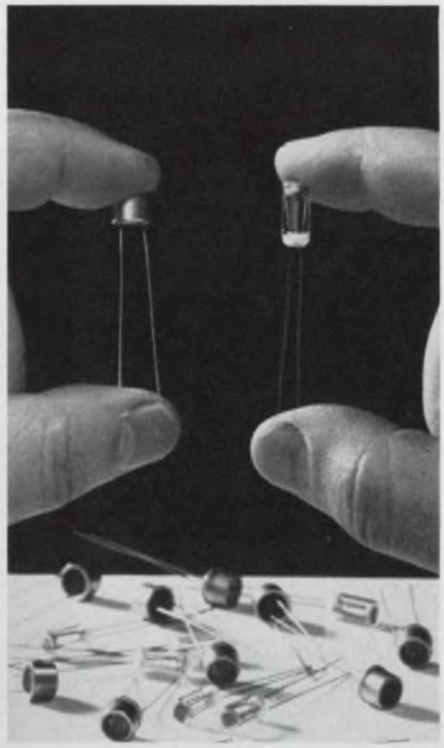
CIRCLE NO. 402

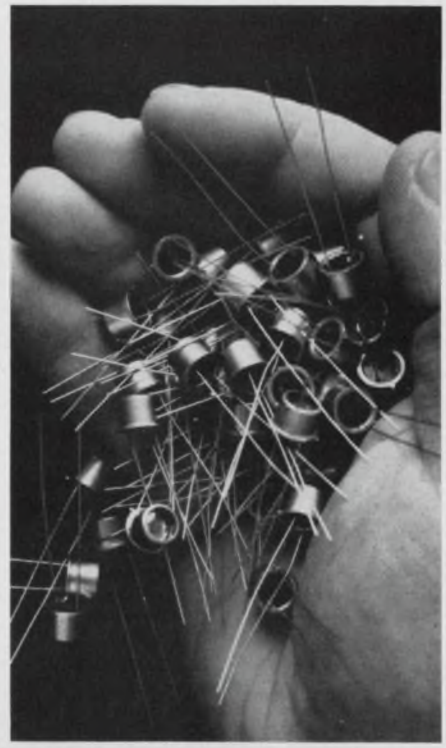
Wave analyzer goes from 10 Hz to 60 kHz

The London Company, 811 Sharon Drive, Cleveland. Phone: (216) 871-7980. P&A: $2950; stock.

A solid-state heterodyne wave analyzer provides a choice of six bandwidths through the frequency range of 10 Hz to 60 kHz. It is suited for analysis of harmonic and noise components of periodic signals, selective measurements of frequency responses and intermodulation measurements.

CIRCLE NO. 403





Need thirty different photocells? Or thousands exactly alike?

In either case, specify "Raytheon." Raytheon now offers standard and special types with cadmium sulfide or selenide sensors, TO-5 case or glass vial packaging, and a wide range of operating characteristics. These photocells are interchangeable with competitive types, available to MIL specifications, priced from 90¢ to $1.60 in production quantities.

All Raytheon photocells feature: rugged mechanical construction, small size, light weight. Low noise, completely ohmic light-dependent variable resistors, their characteristics and high voltage capabilities ensure fast switching, temperature stability and linear response to illumination.

Wide range of characteristics. Our CK1201, for example, features 150 ohms resistance at 100 ft. candles, rise-fall time of 3 and 60 ms, 75 mw power dissipation (maximum). And our CK1266 features 2500 ohms resistance at 100 ft. candles, rise-fall time of 1.5 and .6 seconds, and power dissipation of 100 mw maximum.

Send reader service card for data on the complete line of standard Raytheon photocells. Or tell us about your special requirements.
Raytheon Company, Components Division, Quincy, Mass. 02169.

RAYTHEON

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INFORMATION RETRIEVAL NUMBER 66

Need fast action on servo amplifiers?

Try Bulova first! Chances are, we can solve your problem better and faster than anyone else. Here's why:

1. We have the most complete line of Servo Amplifiers in the business—hundreds of standard designs to solve your problems! From 3.5 to 40 watts output power; 60 and 400 Hz.

2. Bulova Servo Amplifiers are engineered to reduce the number of components, producing low cost, high quality, trouble-free units. This frees you to concentrate on systems, rather than components.

3. High-density packaging—down to just 0.3 cu. in.! For example, Model S21220101: A 3.5 watt Servo Amplifier with gains of up to 5000—in the smallest package of its type on the market!

Another example:
The smallest package ever for a stable solid state servo amplifier producing 40 watts of output power! Need a unit **fast** to put into a breadboard or prototype? We can probably supply it, meeting most military specs (MIL-E-5272, MIL-E-5400, MIL-I-26600, etc.) You'll get assembly by personnel trained and certified by NASA, if desired. You'll get amplifiers built for 10,000 hours of operating life! And perhaps equally important, you'll get the unit you need **fast!**

Write today for your free copy of our 8-page Bulletin No. 10, containing complete specifications and ordering information. Also ask about our Resolver Amplifiers, Demodulators, Quadrature Reject and AGC Amplifiers. Address: Dept. ED-24.

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ELECTRONICS DIVISION
OF BULOVA WATCH COMPANY, INC.

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WOODSIDE, N.Y. 11377, (212) DE 5-6000

INFORMATION RETRIEVAL NUMBER 67

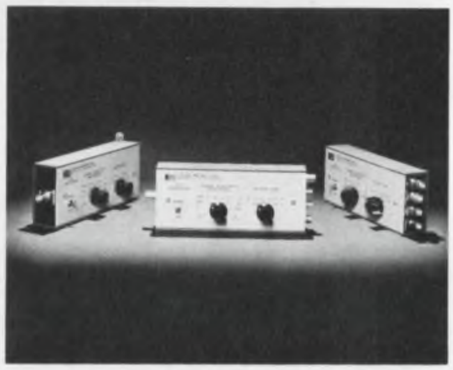
Ac line conditioner responds in 50 μs

Elgar Corp., 8046 Engineer Rd., San Diego, Calif. Phone (714) 278-0800. P& A: $925; 2 wks.

This silicon solid-state instrument is an ac line conditioner offering a response time of under 50 μs. With up to 10% distortion on the line, the unit will deliver an output of 500 VA at 60 Hz with less than 0.25% distortion. The conditioner is 3-1/2 in. high and weighs 35 lb. It is equipped with detachable rack adaptaters to permit bench operation.

CIRCLE NO. 356

Switchable preamp is charge-sensitive



Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000. Price: $300.

A charge-sensitive preamplifier can accommodate scintillation, gas proportional, geiger and semiconductor detectors without requiring soldered circuit changes. User can select charge sensitivity, voltage gain and shaped or nonshaped pulses. The high-voltage decoupling circuit can be matched to a change in detector by replacing a bias resistor that is secured by snap-in clips.

CIRCLE NO. 357

Impulse generator develops 1000 V

White Electromagnetics Inc., 670 Lofstrand Lane, Rockville, Md. Phone: (301) 424-2900. P&A: $4950; 60 days.

This broadband signal source generates a 1000-V pulse that, varying in width from 0.6 ns to 100 ns, develops a spectrum amplitude density of 160 dBμV/Hz below 5 MHz to 115 dBμV/Hz at 1 GHz. Spectral density can be controlled by selection of pulse width and level.

CIRCLE NO. 358

Noise source operates from 200 to 250 MHz

Signalite Inc., Special Products Div., 1933 Heck Ave., Neptune, N.J. Phone: (201) 775-2255.

A gas-discharge noise source for use at 200 to 250 MHz has an internally heated cathode and may be operated either pulsed or cw. Operating voltage is 200 V dc and operating current is 30±5 mA dc. The excess noise ratio is 18.5±0.5 dB and VSWR (fired or unfired) is 1.75 max. Firing voltage is −1500 V dc.

CIRCLE NO. 359

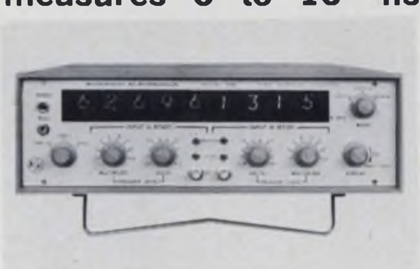
Amplifier/null meter ranges in 20 steps

Preston Scientific Inc., 805 E. Cerritos Ave., Anaheim, Calif. Phone: (714) 776-6400. Price: $295.

A floating differential amplifier/null meter, with an input range of 1 μV to 1 V full scale in 20 calibrated steps, provides three bandwidth ranges of 10, 1 and 0.1 Hz, with a bandwidth accuracy of $\pm 5\%$. Featuring low drift of less than 0.1 μV/°C, input isolation greater than 10^{12} Ω and providing common mode rejection of greater than 120 dB at 60 Hz, the unit maintains less than 0.2-μV noise with a 0.1-Hz bandwidth.

CIRCLE NO. 360

Interval counter measures 0 to 10^9 ns



Eldorado Electronics, 601 Chalomar Rd., Concord, Calif. Phone: (415) 686-4200. P&A: $6500; stock.

This time interval counter performs measurements from 0 ns min (for null measurements) to 10^9 ns. Long-term stability up to 1 part on 10^9 is provided by a variety of internal crystal oscillator options. Point of trigger is calibrated in volts from 0.1 to 128 V by combination of continuous trigger level and binary step-multiplier control.

CIRCLE NO. 361

We've got good connections in high places

Surveyor, Mariner, F-111, OGO, X-15, Apollo, LEM, and most other high flying programs rely on Cinch-Graphik printed circuitry for dependable electronic interconnections. The lunar surface, or 6000 miles above Mars, isn't the place to find out that circuitry doesn't perform to specs. That's why Cinch-Graphik maintains complete in-house facilities for NASA and MIL Spec testing. Cinch-Graphik's unequalled competence in producing single and multilayer printed circuits to these stringent requirements uniquely qualifies them to produce circuits for applications where "it *has* to be right."

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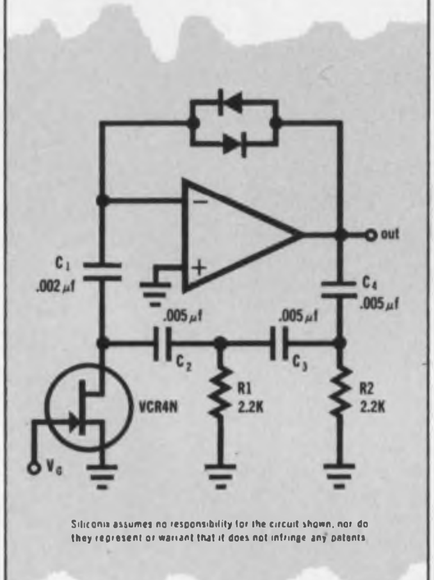
CONSISTING OF CINCH MANUFACTURING COMPANY, CINCH-GRAPHIK, CINCH-MONADNOCK, CINCH-NULINE, UCINITE (ELECTRONICS) AND PLAXIAL CABLE DEPT.

INFORMATION RETRIEVAL NUMBER 68

VCR* FET performance

in a voltage-tunable oscillator



Output frequency varies between 6 Kc and 18 Kc as V_G is varied from zero volts to pinchoff. The range can be shifted by changing C1, C2, and C3, and broadened by substituting VCR FETs for R1 and R2. The diodes maintain proper amplifier gain throughout the entire frequency range and eliminate the VCR matching problem.

Interested? Build this and other VCR circuits with the VCR FET Designer's Kit DK6. You get 6 VCR FETs ($30 value) for just $19.50 from your distributor.

More information? Write us or check the inquiry card.

*VCR: Voltage Controlled Resistor - a new family of FET devices offering variable resistance ranges on the order of 10,000 : 1.

Siliconix incorporated

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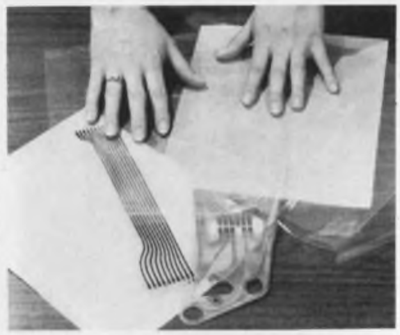
Phone (408) 245-1000 • TWX: 910-339-9216

INFORMATION RETRIEVAL NUMBER 69

Polyester film heat-sealable



3M Co., St. Paul, Minn. Phone: (612) 733-4033.

Heat-sealable polyester films are designed for such applications as protective laminations for flexible printed circuitry, flat cable, standard wire and cable insulation, transformer layer insulation, coil cover wrappings, and to form laminates, tubing and component packaging. Heat sealability is achieved by applying a polyolefin surface to one or both sides of the polyester.

CIRCLE NO. 362

Foam encapsulant will not burn

Emerson & Cuming, Inc., Canton, Mass. Phone: (617) 828-3300. Price $20/lb.

Eccofoam EFF-14FR is a one-part free-flowing powder that can be poured into a cavity, and then cured in place to a rigid foam. It is classed as nonburning according to ASTM Test Method D-1692. The material was developed as a support medium for sensitive electronic components, particulary where low weight is needed.

CIRCLE NO. 363

Paper tape is able to conduct electricity

3M Co., St. Paul, Minn. Phone: (612) 733-4033.

Electrically conductive paper tapes for electrostatic interference shielding applications are available in three forms. Tape No. X-1175A is flatback and 12 mils thick; No. X-1175B is flatback and 7 mils thick, and No. X-1175C is a creped construction and 17 mils thick. The tapes are pliable, easily handled and compatible with common impregnating resins and varnishes.

CIRCLE NO. 364

Epoxy remover a cool stripper

Possis Machine Corp., 825 Rhode Island Ave. S., Minneapolis. Phone: (612) 545-1471.

Easy-Off 253 cold stripper is a liquid preparation designed to remove epoxy resins, polymer vinyl coatings, acrylic paints, fluidized epoxy and other hard-to-strip coatings for small parts. It is used undiluted at room temperature. Parts to be stripped are soaked in it. When it reaches the base metal of the part, the coating is actually lifted off.

CIRCLE NO. 365

Molding compounds pass the flame test

B. F. Goodrich Chemical Co., 3135 Euclid Ave., Cleveland, Ohio. Phone: (216) 818-8200.

Thermoplastics rated nonburning by ASTM tests have good molding characteristics. The ratings were derived from the ASTM D635 and ASTM D568 tests, with the use of samples as thin as 0.01 in. With the Aerospace Industries Association Flame Resistance Test Method, the materials were rated self-extinguishing in zero seconds. Parts molded from these materials retain shape and perform well, even at temperatures exceeding 200°F. The heat distortion ratings for injection-molded samples are 210°F to 225°F at 264 lb/in.^{2}.

CIRCLE NO. 366

Polyvinyl chloride is glass-fortified

LNP Corp., 412 King St., Malvern, Pa. Phone (215) 644-5200. Price: 61¢ to 63¢ (lb.).

Polyvinyl chloride (PVC) is available with 15, 25 and 35% glass fiber (VF-1003, VF-1005 and VF-1007, respectively). Thoroughly dispersed glass fiber significantly increases the strength and stiffness values of PVC. VF-1007, for example, has a tensile modulus of 1.8 million lb/in.^{2} at room temperature, higher than any other nonburning, nondripping, flame-retardant thermoplastic.

The VF Series is most useful in the intermediate temperature range, where it retains good property values. The tensile modulus of VF-1007, for example, is 1.5 million lb/in.^{2} at 140°F. In terms of equivalent stiffness, the VF series is nearly half the cost of other, flame-retardant thermoplastics.

Fortified PVC is available in black or in opaque colors. It can be painted and decorated easily. The molding shrinkage is expectionally low, permitting injection molding to tight tolerances.

CIRCLE NO. 367

Resistor Adjustment Problems?

Automatic Solution...

BR-670

Now you can lease Bunker-Ramo's unique precision **Film Resistor Adjuster, Model BR-670.**

For a low monthly charge plus a penny-a-pulse, you can use our proprietary thin-film processes. The equipment and processes have been thoroughly tested in daily production of custom microcircuits. We adjust thin-film resistors to .01% and match the temperature coefficient of resistance to track within ±5ppm/°C. Our substrates are also available, providing a complete microelectronics package with no investment in capital equipment.

Call our Microelectronics Operation for a demonstration; we are sure that one demonstration will convince you that the highest in precision can only be attained with the BR-670 Resistor Adjuster. Available for immediate installation. Please call Joe Crist, Marketing Manager, Microelectronics Operation at (213) 346-6000. Or write:

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DEFENSE SYSTEMS DIVISION

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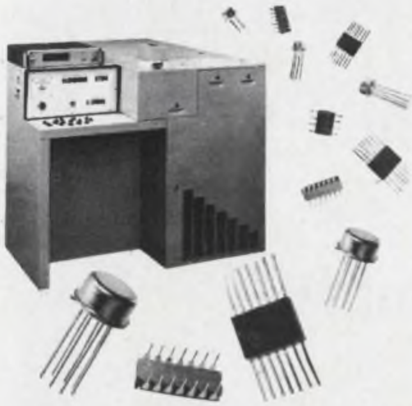
INFORMATION RETRIEVAL NUMBER 70



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No? How about an easy 3,600 parts per hour, twenty-four hours a day, day after day? DELTA's ASTEC is a unique concept in handling electronic components at extreme temperatures. The ASTEC system will even sort your parts automatically on the basis of your measurement. Would you believe that? You should, it's true.

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Telephone (714) 465-4141

INFORMATION RETRIEVAL NUMBER 71

Application Notes

Resistor articles

Technical articles from the Engineering and R&D Staff of RCL Electronics, Inc., are contained in one brochure. Among the articles are: "Faster Risetimes In Wirewounds," "How To Measure Resistor Self-Heating Effects," and "How To Measure Performance of Wirewound Resistors." In addition, the brochure includes specifications on silicone-coated radial-lead and standard precision power wirewound resistors. RCL Electronics, Inc.

CIRCLE NO. 368

Delay measurements

A paper entitled "Progress in the Technique of Group Delay Measurements" covers in depth present methods of group delay measurement and difficulties encountered. Tel-Com Instruments, Inc.

CIRCLE NO. 369

Quality-control manual

Practice problems and assignments in quality-control training are offered in a 120-page workbook. Besides the essentials of quality control, the manual also offers simplified data based on industrial applications and production. The manual is available without charge if requested on your company letterhead from: *Advertising Department, General Instrument Corp., P.O. Box 600, Hicksville, N.Y.*

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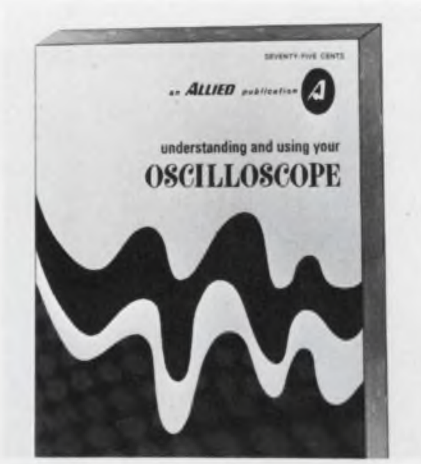

Oscilloscope use

Understanding and Using Your Oscilloscope deals with one of the most useful and versatile pieces of electronic test equipment. It covers basic theory of the oscilloscope, its many uses, interpretation of wave forms and operation with associated equipment. Chapter headings: History of the Cathode Ray Tube; Basic Oscilloscope Controls and How to Adjust Them; How to Select an Oscilloscope; Auxiliary Equipment; Oscilloscope and Test Equipment Kits. *The 128-page paperback book is priced at 75¢ from Allied Radio Corp., 100 N. Western Ave., Chicago, Ill.*

Sun-angle measuring

How accurate and reliable sun angle measurements can be obtained over a wide field of view is explained in a 20-page brochure entitled "Digital Solar Aspect Systems." Details are given of the use, operation, testing and alignment of attitude sensors. Also covered are solar gate sensors, pointing sensors, earth sensors and high resolution sensors — their design, capabilities and uses. Details are then provided on the two basic types of Digital Solar Aspect Systems: the single-axis systems (for spinning vehicles) and the two-axis types (for use on a variety of vehicles). Reticle arrangements for both types are illustrated, as are their fields of view and optimum placement. Adcole Corp.

CIRCLE NO. 370

From any angle, a wired assembly with solderless terminations by Waldom is better, stronger, neater and easier to assemble. Everyone gains . . . the pretty assembler on the line, her foreman, the company officers and stockholders and, most of all, the user of the completed product.

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INFORMATION RETRIEVAL NUMBER 72

New Literature

Fiber optics data

An information kit contains comprehensive information on fiber optics technology, products, and applications. *A Mosaic Fiber Optics Handbook* covers the theoretical aspects of fiber optics, explains various nuances of the new discipline such as optics and glass fiber properties. Also included are technical-note sheets treating various fiber optic applications such as mosaic fiber optic contact reflective readers for mark sensing in EDP; automotive applications of fiber optics; electro/fiber optic pressure transducers; and fiber optic viewfinder screens for reflex cameras.

Write on company letterhead to Mosaic Fabrications Division, The Bendix Corp., Galileo Park, Sturbridge, Mass.

Copper conductors

"Coppermetal Electrical Conductors" is a 62-page booklet, that includes a section on hollow copper conductors, information on the new B-D Cu (Boron deoxidized copper) and other information. Sections cover copper and copper alloys for electrical purposes; bus conductor shapes; high-strength copper alloys; resistance materials and damper bars; special products; and dimensions, properties and ratings of Anaconda products for electrical uses. Anaconda American Brass Company.

CIRCLE NO. 371

Finishing touch

"Total coating systems design" is the title of a brochure covering some 100 specialty coating systems. These include bonded solid dry-film lubricants, technical aerosols and adhesives. Each system is master-listed in one of 16 classes of prime environmental protection, with numerous secondary benefits also featured. The coating systems are designed to improve the old "industrial paint" functions of materials-protection against combinations of friction, heat, electricity, corrosion and weather. Products/Techniques, Inc.

CIRCLE NO. 372

Harshaw's devices

A catalog describing radiation detectors, nuclear electronic devices and crystal products is available for use by researchers and manufacturers of industrial, medical and aerospace equipment. Products and technology spotlighted in this 88-page booklet have applications in fields such as crystal growth, materials research, nuclear physics, medical research, aerospace, well logging, solid-state research, optics and oceanography. Among the different types of material and equipment included in the catalog are scintillation crystals and assemblies, gas-filled nuclear radiation detectors and instrumentation, thermoluminescence dosimetry—instruments and materials, optical crystals and Hammer electronic instrumentation. The catalog is fully illustrated with charts, drawings and photographs. The Harshaw Chemical Co.

CIRCLE NO. 373

Varactor op amps

A six-page foldout application-and-data sheet from Analog Devices gives specifications and circuits for use with varactor-bridge dc operational amplifiers, models 301, 302 and 303. All three units are able to measure low-level currents in the picoampere range. The note presents comprehensive specifications, provides graphs to illustrate gain, offset and noise performance, and charts the total output error of the varactor-bridge op amp. Circuits for improving closed-loop stability and reducing the effects of rf noise are also given, as well as a basic description of how the varactor - bridge unit works. Analog Devices.

CIRCLE NO. 374

Phenolic molding

A folder detailing phenolic compounds for compression-, plunger- and injection-molding includes general-purpose, heat-resistant, electrical-insulating, improved impact- and chemical-resistant phenolics. The brochure — a handy, 3-hole punched fold-out — contains information on 31 phenolic molding compounds. In chart form, it describes the resin type and filler, and provides data on physical, mechanical, electrical and chemical properties. Indicated uses for parts molded of these phenolics include automotive, electrical, appliance and wet-dry applications. Union Carbide Corp.

CIRCLE NO. 375

Celco

DEFLECTION COMPONENTS

for the DISPLAY INDUSTRY

YOKES

DEFLECTRONS
Ultra High Resolution Yokes
Type HD

For 40° Flat Faced Scanners, Computer Readouts, Side-Looking Radar, Mapping.

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Electromagnetic

Straight Sides to 0.1%.

Use with CELCO Micropositioner for optimum accuracy

TV CAMERA COILS
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Deflection Yoke, Focus and Alignment Coil Assemblies to meet your specs.

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for High Resolution CRT's
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For correction of CRT distortions. Consists of static and dynamic focus and astigmatic coils.

AMPLIFIERS

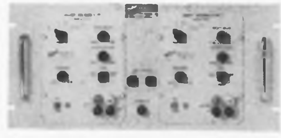
20V ALL SILICON DRIVERS
Type DA-PPN-3

3, 6, 12 amp X-Y amplifiers matched to your yoke and response requirements. Available with regulated power supplies

40 VOLT DEFLECTION DRIVER
All Silicon Type RDA-PP6N-1

With regulated Quadru-Power Supplies. 12 amp change in less than 9 μsec. 0.02% linearity.

RASTER GENERATOR
All Solid State Type 2 SG-1



Two Ramp Units in one panel. Ramps from 20 μsec to 100 msec. Adjustable dc offset. Compatible with CELCO Drivers.

INSTRUMENTS

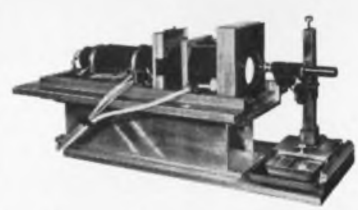
DISPLAY MEASUREMENT LAB

Two-Slit CRT Spot Analyzer on X-Y Traverse quickly ascertains spot size, line width, and X-Y coordinates. Easily determines linearity and positional accuracies as well as phosphor characteristics.

X-Y TRAVELING MICROSCOPE
Mounted on X-Y Traverse.

Line Straightness, spot positions and line positions measured with a high degree of repeatability. Use for aligning yokes, focus coils and field correctors.

CRT DEFLECTION SYSTEM



Contains all deflection, focus and corrective coils, micro-positioners for each, your CRT, complete shielding from all stray magnetic fields. Use for automating assembly lines, a reader of bubble-chamber photos.

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INFORMATION RETRIEVAL NUMBER 73

M-O V GIVES RADAR A NEW LOOK

M-O V introduces some of the most advanced P.P.I. tubes for new radar applications.
Take a new look at these brilliant features:

* narrow angle deflection
* flat face
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* aluminised screen
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	Screen dia. ins.	Deflection angle°	Final anode voltage kV	Cut-off V
F16-10	7	37	14	−44
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3000R	12	40	16	+65 cathode
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INFORMATION RETRIEVAL NUMBER 74

NEW LITERATURE

Special glasses

PYREX high temperature glass products for science and industry are displayed in a 24 page publication. Among the heat-resistant flat glass products described are infrared-reflecting glass, furnace observation blue glass, precision flat glass, sight glasses, VYCOR—96% silica glass and PYREX heat shields. Also included are fraction-to-decimal, inch-to-inch conversion charts. Complete specifications and price information accompany each entry. Kaufman Glass Company.

CIRCLE NO. 376

Power transistor data

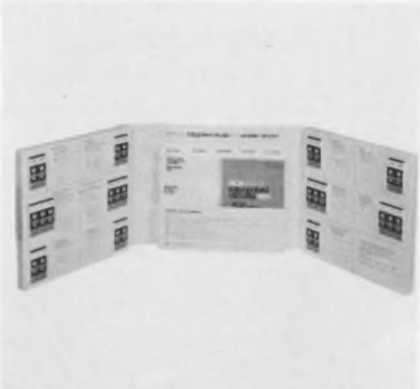
An 8-page data sheet provides detailed descriptive information on both the B-148000 and B-155000 series silicon transistors. SOAR (Safe Operating Area) charts and comprehensive specifications charts and graph are a particular feature. SOAR is defined for dc and pulsed operation, resistive, unclamped inductive and unclamped switching operation. Bendix Semiconductor Division.

CIRCLE NO. 377

Strip chart recorders

Fifty different models of miniature strip chart recorders, all of which feature a dry writing process are contained in a 20-page catalog. Included is detailed information on chart paper, drive motor specifications, accessories, optional features, dimensions and weights for each. Rustrak Instrument Division, Gulton Industries, Inc.

CIRCLE NO. 378



IC sampler

A sampler kit, containing 26 RCA linear ICs plus complete technical data and application information on each type. In addition, an RCA Linear Integrated Circuit Fundamentals manual, RCA Integrated Circuits Product Guide and IC Mounting and Assembly Instructions are included. Eleven separate linear integrated circuit types are supplied in the kit, with two or three of each type provided.

Available for $39.95 from RCA Electronic Components and Devices, Harrison, N.J.

Glass laser rods

Laser rods made of a new type of laser glass are available in five configurations. The ED - 2 laser glass was developed as a result of research into the electronic phenomena of glasses, fluorescence and the doping of glasses with rare earths. ED-2 is a silicate glass doped with 3 per cent neodymium. The booklet contains data on the physical, spectral and lasing properties of ED-2, as well as information on dimensional tolerances for the five different rod configurations. Owens-Illinois, Inc.

CIRCLE NO. 379

the last time you used a 'scope, did you really need more performance than these Heathkit® models provide?

Heathkit IO-17
. . . new 5 MHz
3" 'scope . . . only
$79.95

IO-17 SPECIFICATIONS — VERTICAL CHANNEL: Input impedance: 1 megohm shunted by 25 pf; x 50 attenuator position 1 megohm shunted by 15 pF. **Sensitivity:** 30mV P-P/div. (uncalibrated). **Frequency response:** 5Hz to 5MHz ±3 db. **HORIZONTAL CHANNEL: Input impedance:** 10 megohm shunted by 15 pF. **Sensitivity:** 300 mV P-P/div. **Frequency response:** 2Hz to 300 kHz ±3 dB. **HORIZONTAL SWEEP GENERATOR: Sweep generator:** Recurrent type. **Frequency:** 20Hz to 200 kHz in four overlapping ranges. **Retrace:** Blanked by a pulse from blanking amplifier. **Synchronization:** Automatic type. **GENERAL: Tube complement:** (1) 3RP1 cathode ray tube, medium persistance, green trace; (3) 12AU7; (1) 12AX7; (1) 6GH8; (1) 6BH6; (1) 6BQ7. **Power requirements:** 105-125 volts 50/60 Hz or 210-250 volts 50/60 Hz. **Power consumption:** 60 watts. **Overall dimensions:** 9½" H x 5½" W x 14½" L. (Dimensions include handle, knobs, etc.). **Net weight:** 12 lbs.

Heathkit IO-14
. . . DC to 8 MHz
5" 'scope . . .
triggered sweep
. . . 0.25 usec
delay line input . . .
assembled
$399.00
kit
$259.00

IO-14 SPECIFICATIONS — (VERTICAL) Sensitivity: 0.05 V/cm AC or DC. **Frequency Response:** DC to 5 MHz — 1 dB or less; DC to 8 MHz — 3 dB or less. **Rise time:** 40 nsec (0.04 microseconds) or less. **Input Impedance:** 1 megohm shunted by 15 pf. **Signal delay:** 0.25 microsecond. **Attenuator:** 9-position, compensated, calibrated in 1, 2, 5 sequence from 0.05 V/cm to 20 V/cm. **Accuracy:** ±3% on each step with continuously variable control (uncalibrated) between each step. **Maximum input voltage:** 600 volts peak-to-peak; 120 volts provides full 6 cm pattern in least sensitive position. **(HORIZONTAL) Time base:** Triggered with 18 calibrated rates in 1, 2, 5 sequences from 0.5 sec/cm to 1 microsecond/cm with ±3% accuracy or continuously variable control position (uncalibrated). **Sweep magnifier:** X5, so that fastest sweep rate becomes 0.2 microseconds/cm with magnifier on. (Overall time-base accuracy ±5% when magnifier is on.) **Triggering capability:** Internal, external, or line signals may be switch selected. Switch selection of + or — slope. Variable control on slope level. Either AC or DC coupling. "Auto" position. **Triggering requirements:** Internal; 0.5 cm to 6 cm display. External; 0.5 volts to 120 volts peak-to-peak. **Triggering frequency response:** DC to 2.5 MHz approx. **Horizontal input:** 1.0 v/cm sensitivity (uncalibrated) continuous gain control. **Bandwidth:** DC to 200 kHz ±3 db. **Power requirements:** 285 watts. 115 or 230 VAC 50-60 Hz. **Cabinet dimensions:** 15" H x 10½" W x 22" D includes clearance for handle and knobs. **Net weight:** 40 lbs.

FREE 1968 CATALOG

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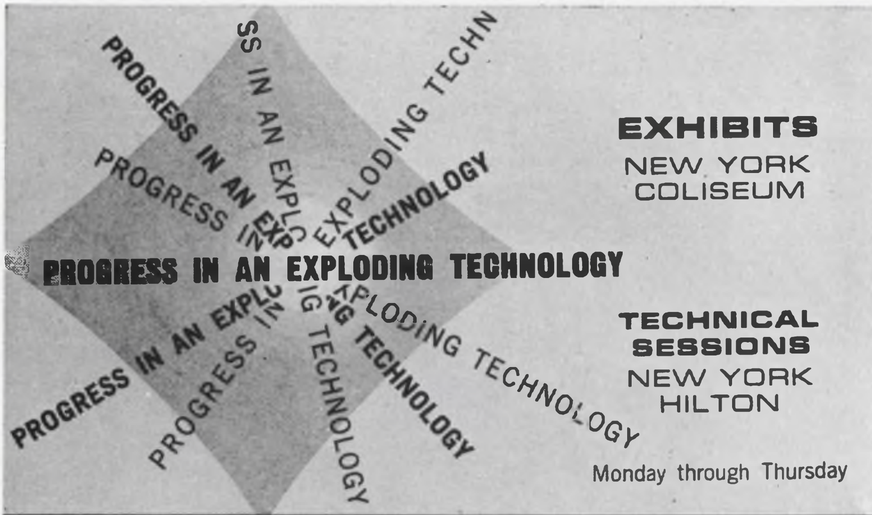

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IEEE Exhibition MARCH 18-21,1968

INFORMATION RETRIEVAL NUMBER 76

Help your children form good health habits now to reduce risk of heart attack later:
- Encourage normal weight; obesity in youth may persist throughout life;
- Build body health through regular physical activity;
- Serve them foods low in saturated fats;
- Teach them that cigarette smoking is hazardous to health;
- Make medical check-ups a family routine.

Set a good example. Follow the rules yourself and guard *your* heart, too.

GIVE... so more will live HEART FUND

Contributed by the Publisher

Fluorocarbon tapes

A 16-page brochure on "'Chemfluor' Tapes" made of "Teflon"*/"Halon"*/"Tetran"* TFE and "Teflon" FEP resins is available. The brochure describes the company's line of flourocarbon tapes that meet a range of industrial needs. There are four basic tapes: Skived TFE . . . Extruded TFE . . . Glass-Fabric Coated with TFE . . . and Extruded FEP. Each is supplied as plain tape or in modified forms to meet special requirements. "Chemfluor" FEP tapes are extruded from fluorinated ethylene propylene resins ("Teflon" FEP) and offer the features of being heat-sealable, transparent, and thermoformable. Chemplast, Inc.

CIRCLE NO. 380

Fused silica

A booklet describing Corning U. L. E. (Ultra-Low-Expansion) fused silica has been released by Corning Glass Works. The 12-page publication says the recently developed material "offers the highest degree of stability ever achieved in an optical mirror . . . making possible a system that is basically limited only by diffraction of light." Fused silica exhibits virtually no thermal expansion from −100°C to +100°C. The two-color booklet includes the development history of fused silica and detailed charts of the material's thermal, chemical, mechanical, optical and electrical properties. Corning Glass Works.

CIRCLE NO. 381

Servo assemblies

Twenty-six servo assemblies are pictured and described in a booklet by Weston-Transicoil. The assemblies shown include data converters, function generators, incremental servos, computing servos and indicating-display devices. Illustrations include photos and block diagrams and the text indicates the types of components used and their specific operation in the system. Weston Instruments, Inc.

CIRCLE NO. 382

Injection molding

A comprehensive, 28-page, four-color injection molding guide covering General Electric's four grades of Noryl thermoplastic resin is available. The bulletin is an in-depth guide for molding Noryl resins and covers such detailed information as product characteristics, typical molding conditions, effects of molding conditions on material properties, part design, mold design, as well as trouble-shooting guides and price/properties comparisons of engineering thermoplastics. General Electric Company.

CIRCLE NO. 383

Glass spheres

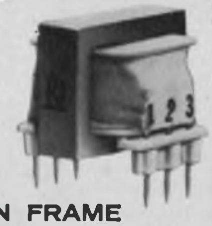
The advantages of solid-glass spheres as reinforcement filler for thermoplastics and thermosetting plastics are described in a brochure. Included are details of how the spheres may be used by molders to improve the physical properties of molded products. Potters glass spheres are used as reinforcement fillers in virtually all types of resin systems, including nylon, urethane, ABS and vinyl. A properties chart compares the physical properties of unfilled nylon with those of nylons containing various percentages of glass spheres. A properties chart shows how the addition of PBI glass spheres to a fiber glass-epoxy laminate increases flexural strength and modulus without significant loss of other properties. Potters Bros., Inc.

CIRCLE NO. 384

The solution to question 3 on p. 76 is:

$x = 1, -2, \text{ or } 2 \pm j3.$

TRANSFORMERS FOR INDUSTRIAL APPLICATIONS MILITARY QUALITY AT COMMERCIAL PRICING



OPEN FRAME
DECI-MINIATURE
INDUSTRIAL GRADE
PRINTED CIRCUIT
TRANSFORMER

Miniature Printed Circuit Transformer specially designed for transistorized control and instrumentation • Molded-in terminals provide fixed mounting centers usually found only in expensive molded transformers • Size: 3/4" x 13/16" x 19/32" — 3/16 x .042 pins. Weight: 1/2 oz. • These units can be used as input, interstage, output and isolation applications.

Part No.	Primary Impedance	Secondary Impedance	Pri. D.C. Unbalance Ma.	Operating Level DBM
DCM1-PC	25000 C.T.	1200 C.T.	2	18
DCM2-PC	15000 C.T.	15000 C.T.	3	19
DCM3-PC	15000 C.T.	600 C.T.	3	19
DCM4-PC	10000 C.T.	5000 C.T.	4	20
DCM5-PC	10000	2500/625 Split	2	20
DCM6-PC	10000 C.T.	1500 C.T.	4	20
DCM7-PC	5000 C.T.	80,000 C.T.	6	15
DCM8-PC	4000 C.T.	1200 C.T.	6	20
DCM9-PC	4000 C.T.	600 C.T.	6	20
DCM10-PC	4000	600/150 Split	3	20
DCM11-PC	2500 C.T.	2500 C.T.	8	20
DCM12-PC	2500	2500/625 Split	4	20
DCM13-PC	2500 C.T.	625 C.T.	8	20
DCM14-PC	2500 C.T.	200 C.T.	8	20
DCM18-PC	600 C.T.	50,000 C.T.	16	20
DCM19-PC	600	8000/2000 Split	8	20
DCM20-PC	600 C.T.	200 C.T.	16	20
DCM21-PC	600 C.T.	600 C.T.	16	20
DCM22-PC	250 C.T.	600 C.T.	25	20

DECI-MINIATURE — INDUSTRIAL GRADE — OPEN FRAME PRINTED CIRCUIT CHOKES

Part No.	Oma d.c.	Inductance rated current conditions	DCR
DCM51-PC	10 hy	5 hy-3 ma	300
DCM52-PC	5 hy	2 hy-5 ma	155
DCM53-PC	2.5 hy	1 hy-7 ma	75

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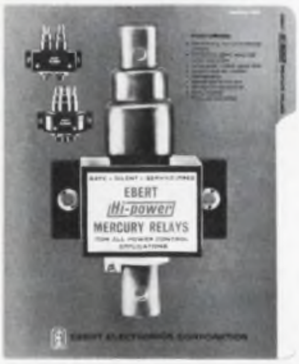

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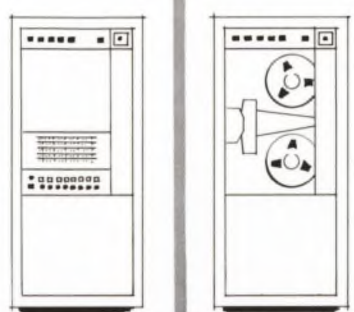

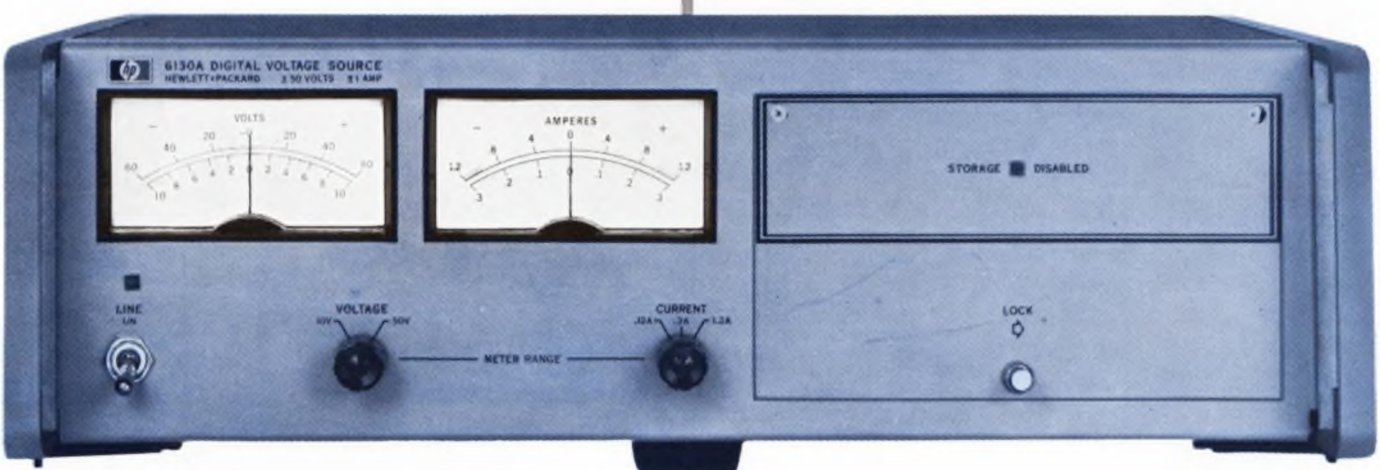

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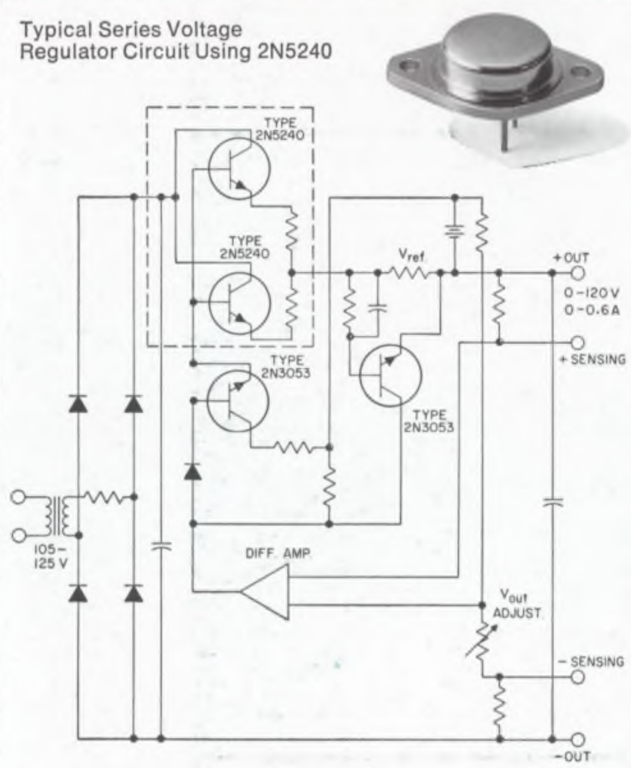

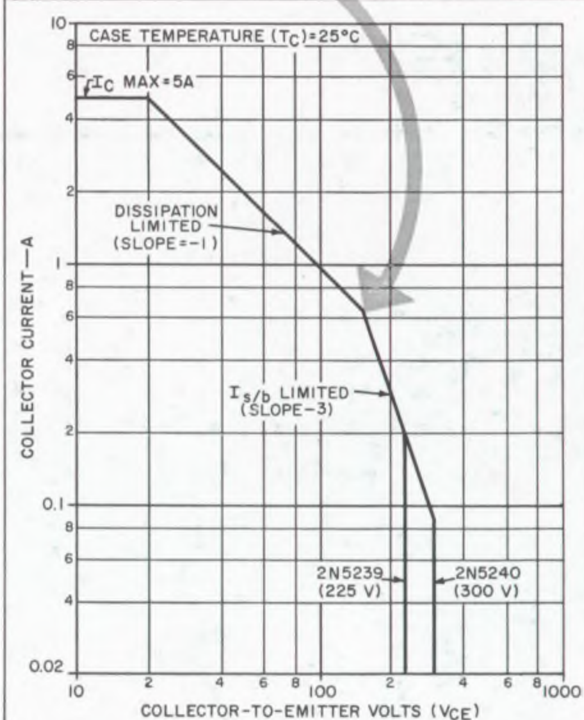

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