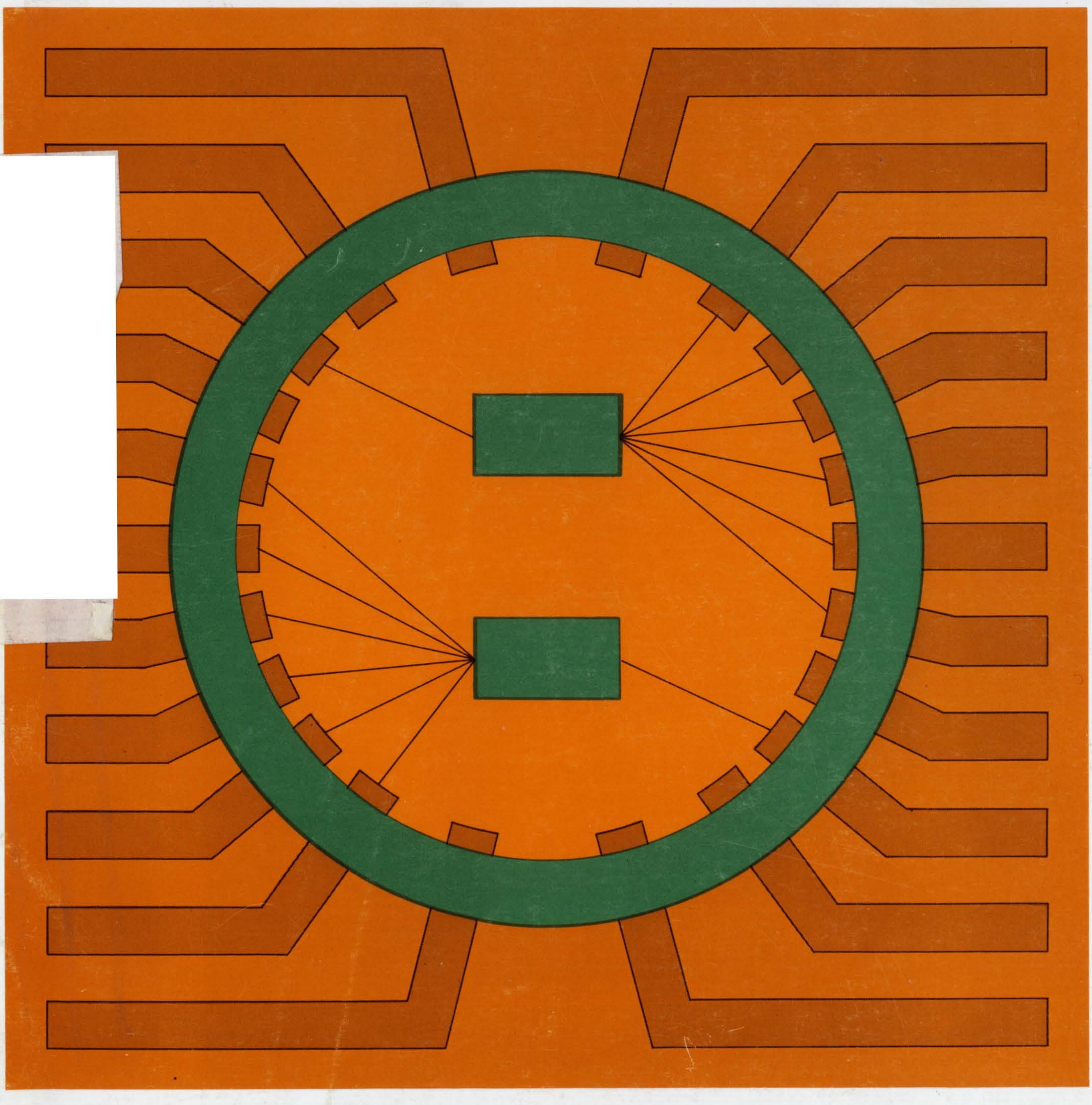
Electronic Design

VOL. 17 NO. 5

FOR ENGINEERS AND ENGINEERING MANAGERS

MARCH 1, 1969

Shift to MOS registers! They're cheaper—5 to 7 cents per bit for short delay lines—and offer small size, low dissipation and clock rates variable to system needs. They interface readily with TTL, can be paralleled for operation to 32 MHz, and are expected to compete strongly with drum memories. Page 50.



Cornucopia

Get UTC's NEW 1969 Catalog—the quick-and-easy locator for transformers and filters.

UTC's 1969 Catalog is the most comprehensive in our history. Over 1350 standard parts, including audio, power and pulse transformers, inductors, electric wave filters, high Q inductors, magnetic amplifiers, saturable reactors, and similar iron-core inductance devices. Many of these new products are listed for the first time.

Eighty-eight clear pages make it easy to locate and specify the part you need: product lines categorized, product selection guide for each line, engineering specifications and applications, new drawings, new curves, expanded charts.

Also included are: audio and power application circuitry, plus a lucid digest of the new MIL Specs (MIL-T-27C, MIL-F-18327C, MIL-T-21038B).

The "special" you need is probably a "standard" in the NEW UTC Catalog. All items are immediately available from your local distributor. For your copy of the catalog contact: United Transformer Company, Division of TRW INC., 150 Varick Street, New York, N.Y. 10013.

TRW® UNITED TRANSFORMER COMPANY

INFORMATION RETRIEVAL NUMBER 202

CROWBAR...?

The One Inside is FREE

Not so many years ago, the prudent transmitter engineer discharged a high voltage capacitor bank by dropping a shorting "crowbar" across its terminals. Today's "crowbar" is a protective overvoltage circuit found on DC power supplies — usually at extra cost. Now HP includes a crowbar as standard on its recently updated series of low-voltage rack supplies . . . at no change in price.

Long established as preferred system supplies for component aging production testing and special applications, these supplies have now been redesigned and expanded to meet the stringent demands of today's power supply user. Advantages include low ripple (peak-to-peak as well as rms), well-regulated constant voltage/constant current DC with outputs to 60 volts and 100 amps.

Where loads are critical and expensive, the extra protection — say, against inadvertent knob-twiddling — from a crowbar is invaluable. On all internal crowbars in this series, the trip voltage margin is set by screwdriver at the front-panel.

Pertinent specifications are: triggering margins are settable at 1V plus 7% of operating level; voltage ripple and noise is 200 μV rms/10mV peak-to-peak (DC to 20 MHz); current ripple is 5 mA rms or less depending on output rating; voltage regulation is 0.01%; resolution, 0.25% or better; remote programming, RFI conformance to MIL-I-6181D.

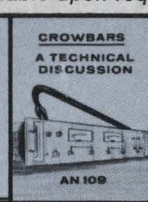
Prices start from $350. For complete specifications and prices, contact your local HP Sales Office or write: Hewlett-Packard, New Jersey Division, 100 Locust Avenue, Berkeley Heights, New Jersey 07922 or call (201) 464-1234 . . . In Europe, 1217 Meyrin, Geneva.

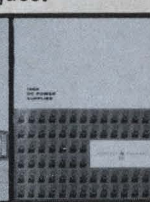
HEWLETT hp PACKARD

POWER SUPPLIES

SEE US AT IEEE SHOW—BOOTH #3K28-29, 2F25-36.

Additional data sheets available upon request



Alternative Power Supplies LAB SERIES, smaller package, lower power, optional crowbar CROWBARS A Technical Discussion

1969 Power Supply Catalog — includes total HP power supply line.

Circle # for details 326 327 328 329

Systron-Donner's Model 6316A gives you automatic final-answer frequency readings non-stop from dc through X band.

It's the perfect systems counter—a completely programmable unit that mounts in a slim 1¾ inches of panel space and costs only $4750. Before now you needed a collection of instruments totaling five times the bulk and costing half again as much to do the same job.

Model 6316A covers the full range by combining a dc-to-100 MHz counter with built-in automatic frequency extenders. Readings can be taken in milliseconds, and the extenders lock in phase with the input to preserve counter accuracy to 12.4 GHz. That accuracy depends only on time base stability—which can be an ultra-high 5 parts in 10^{10} per 24 hours.

Reliability is superb—proven by more than a year's operation in the field. For a prompt demonstration, phone or write Measurements Division, Systron-Donner Corporation, One Systron Drive, Concord, California 94520. Phone (415) 682-6161.

First counter to measure automatically from dc to 12.4 gigahertz!

Another first. One of 144 Systron-Donner instruments

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

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FOR ENGINEERS AND ENGINEERING MANAGERS

MARCH 1, 1969

NEWS

TECHNOLOGY

PRODUCTS

Departments

COVER CREDIT: Art by Clifford M. Gardiner

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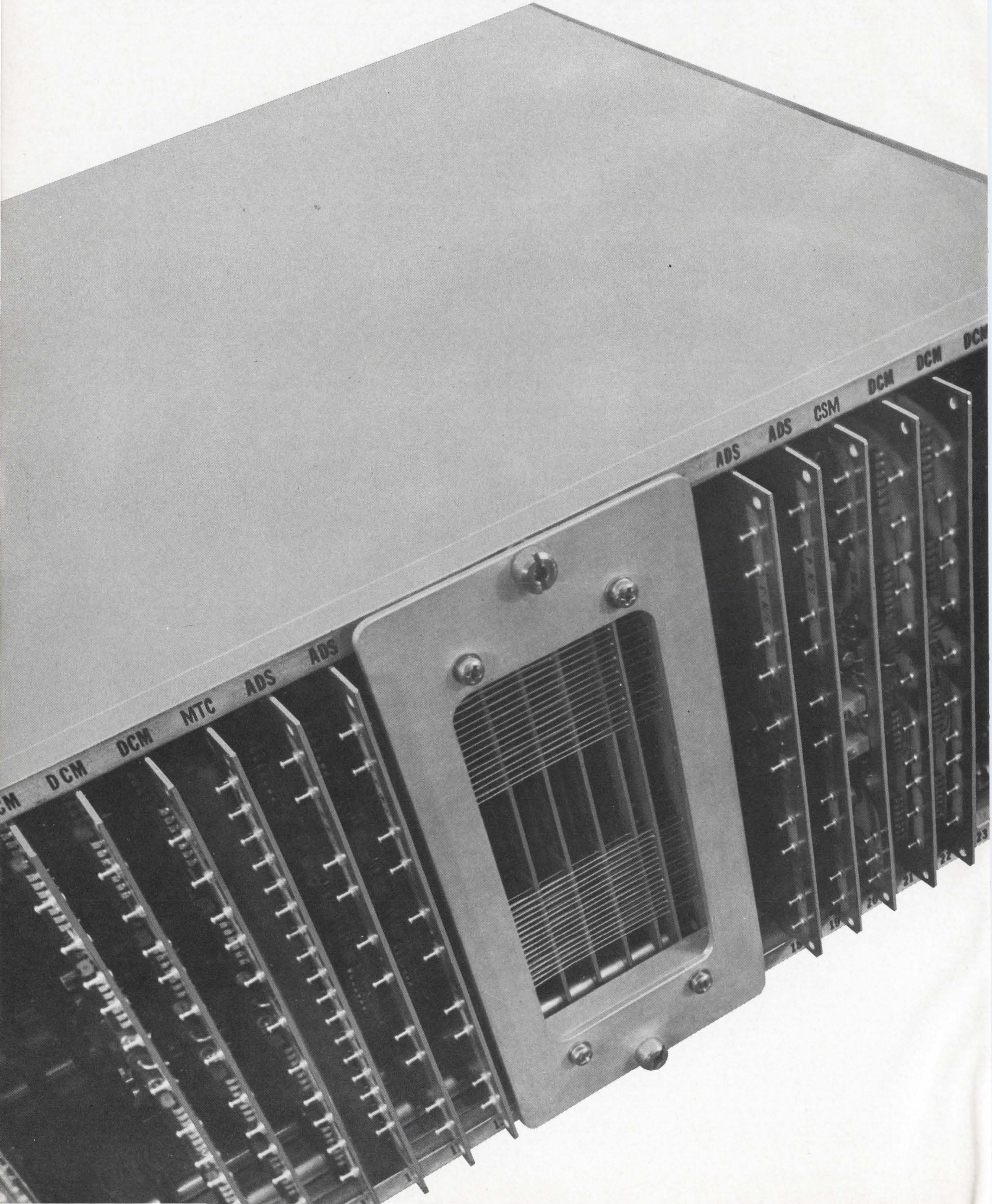
DCM
MTC
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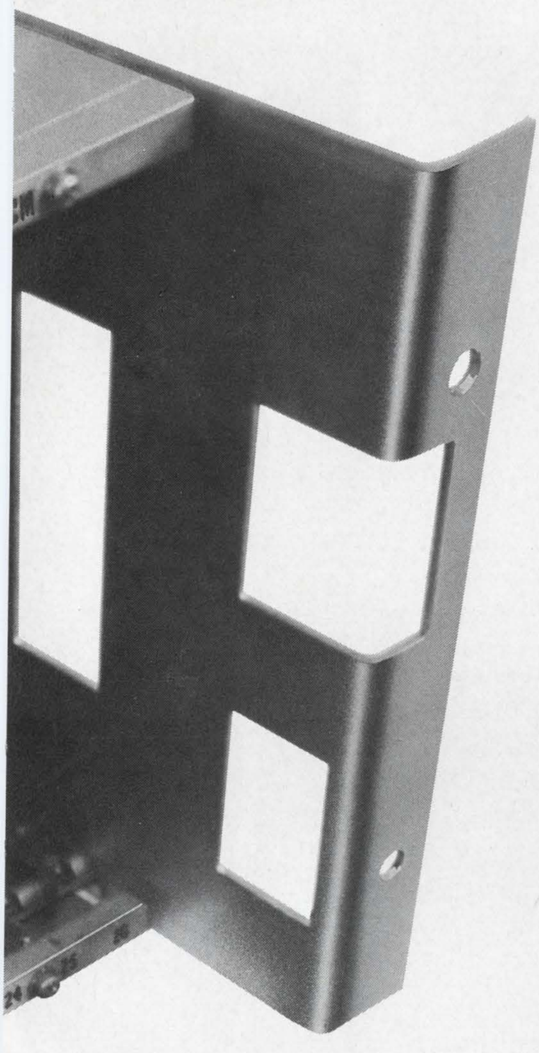
ADS
ADS
ADS
CSM
DCM
DCM

2½D cycle time at 3D cost!

Data Products' new 3-wire, 3D memory

...the STORE/33™



STORE/33 is in full production at Core Memories, Inc.* . . . now you can have 2½D speed at coincident-current prices! For example, the 4K x 16 version of STORE/33 uses 18 mil cores to give a full-cycle time of 650 nsec. The price? Under $4500** in production quantities.

What makes this price breakthrough possible without a tradeoff in speed? The key, of course, is 3-wire 3D organization in which the fourth winding normally associated with coincident-current organization is eliminated. By utilizing the same winding for both sensing during reading and inhibiting during writing, assembly costs of the magnetic planes are reduced . . . But 3D organization is only part of the story.

STORE/33 employs IC electronics throughout to increase reliability, reduce power consumption and achieve more compact packaging. The basic memory uses only four types of plug-in cards. The memory stack also plugs in. This standardization of circuit card types and modular construction reduces your inventory costs and simplifies maintenance. Word capacities to 16K, interface flexibility, plus a wide range of options . . . for the full story, write Data Products Corporation, 6219 De Soto Ave., Woodland Hills, Calif. 91364.

Los Angeles, Calif. 213/887-8000 **Melbourne,** Fla. 305/262-4773
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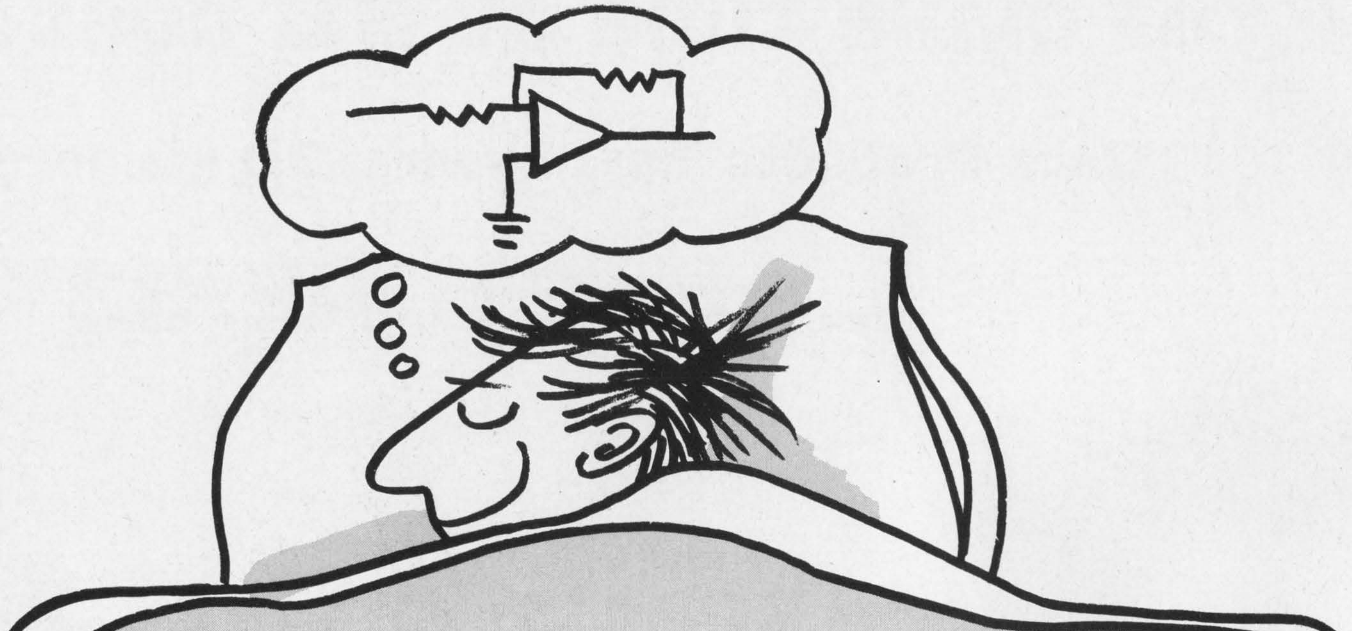
data products

"the peripheralists"

*Core Memories, Inc. is a subsidiary of Data Products Corporation.
**Price does not include optional power supply.

Data Products manufactures LINE/PRINTERS™, DISCfILES®, Core Memories, Off-Line Printer Systems, Card Readers & Punches.

Dream OP AMPS



Here are your dreams come true.

MIL hybrid FET ADO-101B
Metal can DIP
400,000 gain
20,000 CMRR
3 μV rms noise

100 V/μsec for $55.00 ADO-60
FET input
2 μsec settling time (0.01%)
1,000,000 gain
1.5 MHz full power frequency

0.5 μV/°C bipolar ADO-72A
500,000 gain
250,000 : 1 CMRR
5 μV/V supply rejection
10 μV/week drift (typ)

0.5 pA bias current ADO-32
Junction FET input
10^{12} Ω input impedance
12 μV rms noise
20,000 : 1 CMRR

2 μV/°C FET ADO-26B
100,000 gain
20,000 : 1 CMRR
100 μV/V supply rejection
5 μV p-p noise

Milliwatt power drain ADO-39
200 μA supply current
FET input
75,000 gain
±4.5 to ±20 V operation

These specifications are guaranteed. For complete details on these and other dream-fulfilling op amps, consult your local Fairchild Controls representative.

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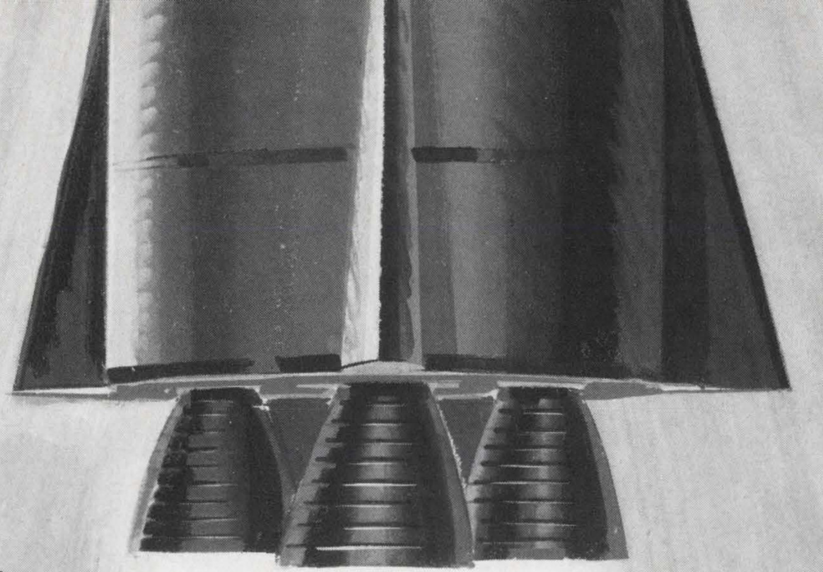


RCA Announces

The industry's <u>first</u> integrated circuits high-reliability program based on MIL-STD-883

Now you can evaluate and design across a broad range of critical applications with integrated circuits processed to the requirements of the first military standard of test procedures for microelectronics.

RCA's high-reliability program—conforming to the test methods and procedures of MIL-STD-883—covers integrated circuits for aerospace, military, and other critical applications from RCA's major integrated circuit lines: RCA Linear Integrated Circuits; RCA Digital Integrated Circuits; and shortly this program will be expanded to include RCA COS/MOS (Complementary-Symmetry MOS) Integrated Circuits.

Integrated Circuits in this program are classified in four screening levels corresponding to the three classes of MIL-STD-883. (See chart below.) A comparison of RCA's four screening levels is illustrated in the flow chart at right.

Comprehensive high-reliability-format data bulletins are now available for the following types:

- HIGH-RELIABILITY VERSIONS OF CA3000, CA3001, CA3006, CA3015A, C3020A
- 19 HIGH-RELIABILITY VERSIONS OF CD2300 Series DTL in flat pack
- 19 HIGH-RELIABILITY VERSIONS OF CD2300D Series DTL in dual-in-line ceramic package

(RCA Levels /1, /2, /3, and /4 are detailed for each type)

Add your name to our mailing list for these bulletins and subsequent high-reliability information. Contact your RCA Representative or write: RCA Electronic Components, Commercial Engineering, Section FK-2-4A, Harrison, N. J. 07029.

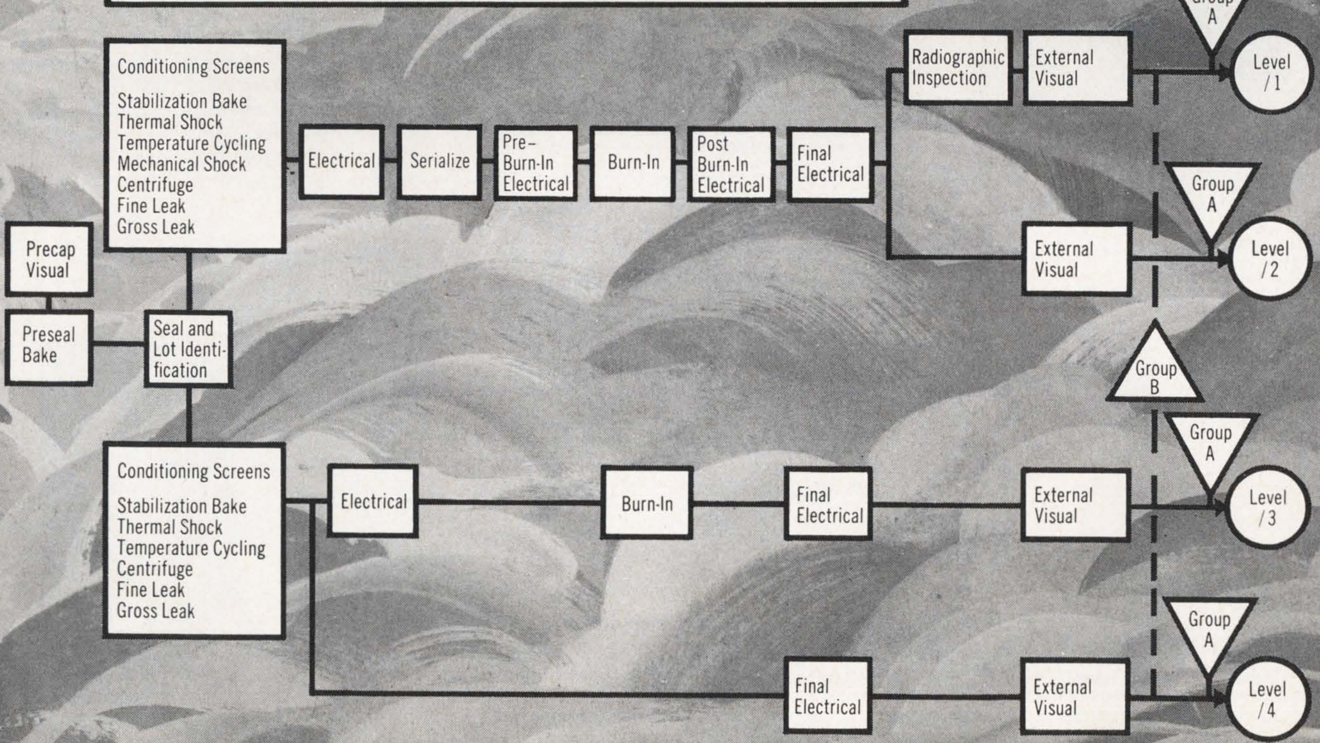
RCA Level	MIL-STD-883 Equivalent	Application	Description
Level/1 and Level/2	Class A	Aerospace and Missiles	For devices intended for use where maintenance and replacement are extremely difficult or impossible and reliability is imperative
Level/3	Class B	Military & Industrial—For example in Airborne Electronics	For devices intended for use where maintenance and replacement can be performed but are difficult and expensive
Level/4	Class C (Class B without Burn-in)	Military & Industrial—For example on Ground Based Electronics	For devices intended for use where replacement can readily be accomplished

RCA screening level/1 is equivalent to MIL-STD-883 Class A except that reverse-bias burn-in is performed only in Group B.
RCA screening level/2 is the same as level/1 but radiographic inspection is not performed.

INFORMATION RETRIEVAL NUMBER 9

RCA Integrated Circuits

RCA High-Reliability Integrated Circuits Product Flow Diagram

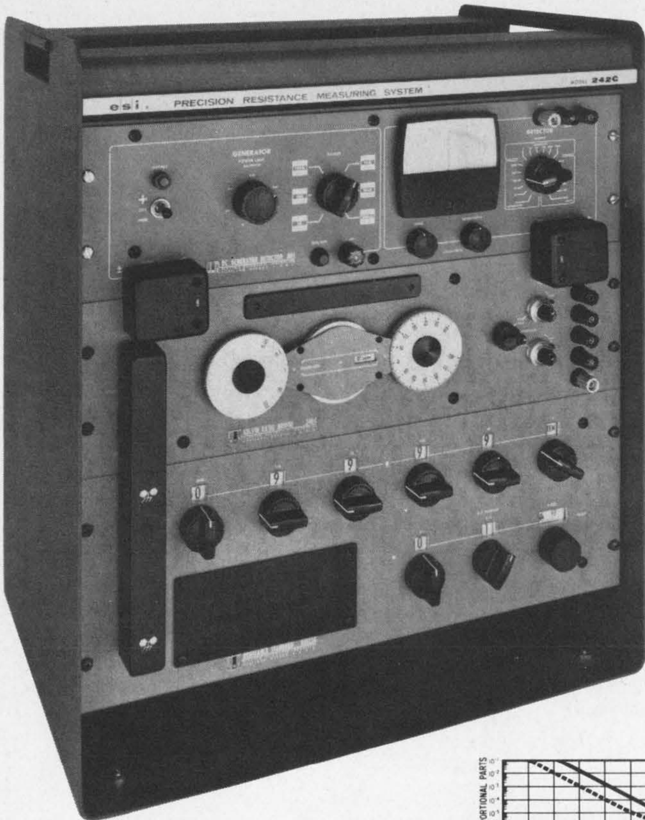


How a lab wallflower, measuring ohms at 10 ppm, has blossomed in the field:

news and innovations in metrology e|s|i

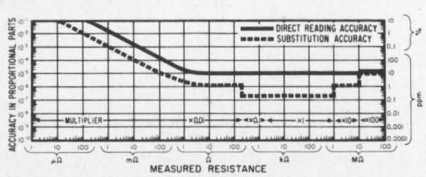
Upgrading of accuracy by resistor manufacturers has made a triple-threat star out of our newest general purpose Resistance Measuring System — the Model 242C. It's "flown the coop" (standards lab) for bigger things in the production and engineering departments or wherever resistors need to be checked to 10-ppm-or-better in batches.

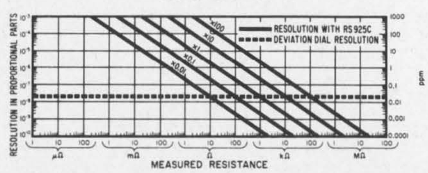
By delivering 10 ppm direct-reading accuracy over a wide range and 1-ppm *comparison* accuracy—all in an exceptionally easy-to-operate console — we apparently have discovered a flexible answer for which both makers and buyers of precision resistors have found a need.

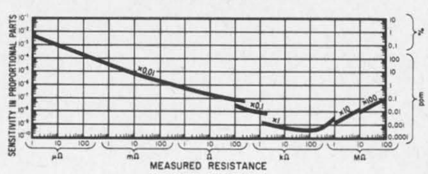


The 242C is simple enough for batch testing on a GO-NO-GO basis (meter deflection without bridge adjustment). Or if you prefer to read *percent deviation* from nominal value, you do so with a one-dial adjustment. Then when the perfectionist has a need, he can resolve actual value of a resistor to 10 places (with 8 decades plus a vernier). And when calibrated against ESI standards, comparisons can be made to 0.1 ppm with accuracy directly traceable to the National Bureau of Standards.

The 242C is the latest in a 10-year model series of general purpose Kelvin bridge systems, which owe their accuracy, dependability and wide range (10 milliohms to 120 megohms) to a unique guarding and lead compensation technique. Trimmable ratios and decades in our new "C" model simplify calibration for any production environment — even yours. Price $5500.







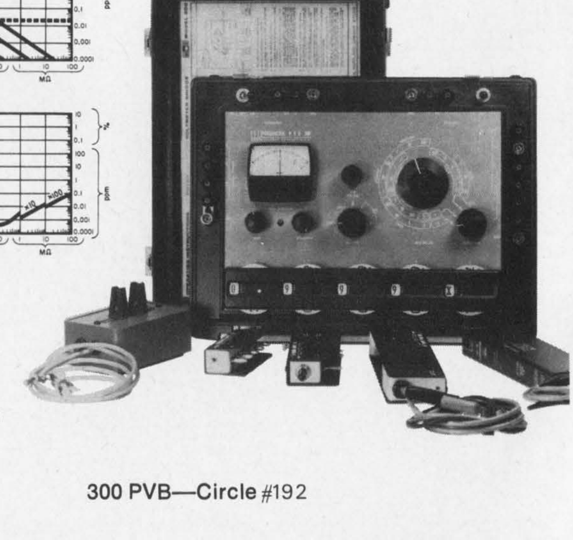
ESI's portable lab—the 300A PVB® that measures "everything"—now 0.01%

We call it our little portable lab—and indeed it's all of that with measurement capability for seven different electronic functions. It's a potentiometric voltmeter, a precision voltage source, ammeter, guarded Kelvin bridge, resistance comparison bridge, ratiometer, electronic null detector, pH indicator, temperature bridge, meter calibrator, components tester and more—with the addition of several plug-in accessories.

Our news is that accuracy on the Model 300A PVB has been improved to .01% on all functions and ranges. And yet the basic 300A PVB package sells for only $1045.

As with the proven 300 PVB, the Model 300A affords the user 5 dc-voltmeter ranges to 511.10 volts with 1 microvolt minimum steps, 8 ammeter ranges to 5.1110 amperes with 10 pA minimum steps and 10 resistance ranges to 511.10 MΩ with 10 microhm minimum steps and it's completely portable with typical one-year battery life.

Applications include potentiometric temperature measurement, calibration of recorder controllers, dc voltmeters and ammeters, X-Y recorders, analog computing elements, checking of dc power supplies, measurement of chemically generated potentials and calibration of resistance thermometers and thermocouples.



e|s|i®

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242C—Circle #191

300 PVB—Circle #192

MDS LOW-COST PAPER TAPE READERS MAKE NO COMPROMISE WITH QUALITY

These MDS Paper Tape and Card Readers come from specialists in the design and manufacture of compact, reliable Readers. Models in this MDS Series are designed to meet a multitude of needs in programming and control applications.

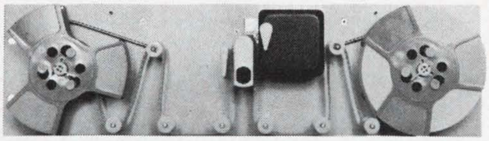
They are available in models for 5, 6, 7 or 8 channel tape . . . reading speeds from 0 to 60 characters per second . . . bi-directional or uni-directional sensing . . . panel or table mounting . . . all provide star-wheel sensing. A unique dual cross-coupled electro-magnetically actuated pawl system (patented) advances the tape bi-directionally and provides the simplest method of integrating the tape reader into a system.

The star-wheel sensing system used in MDS Readers effects minimum wear on tapes . . . tolerates wide variation in punching . . . reads any type of tape.

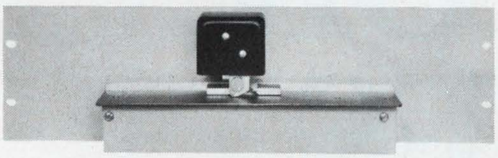
For simplicity in design . . . reliability in action . . . specify MDS low-cost Paper Tape and Card Readers.

Ask for: The MDS file-folder on Paper Tape Readers, giving general specifications and more complete information.

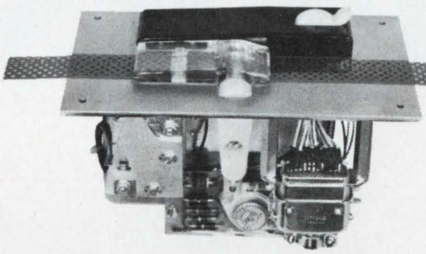
FOR MORE — MEET YOUR MAN FROM MDS



MDS 2119 Paper Tape Reader—Speed: 30 cps, bi-direct; Panel Size: 3½" x 11".



MDS 2131 Edge-Punched Card Reader.



MDS 2153 Horizontal Mount Paper Tape Reader—Speeds of 30 or 60 cps, uni-direct. Reads up to 8 channel punched paper tape.

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INFORMATION RETRIEVAL NUMBER 10

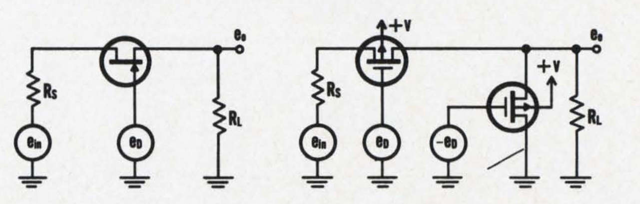
Applications Power*

29 FETS FOR SWITCHES OR CHOPPERS

What's your most important switch or chopper requirement?

ON resistance . . . low as 5 ohms
Gate-to-drain capacitance . . . little as 0.25 pF
Price . . . some low as $2.00 (100 up)
Somewhere in the 29 FETs listed here you'll find the right tradeoff for your switching or chopping application. Contact us for complete data on any or all of these devices!

TYPICAL SWITCH CONFIGURATIONS

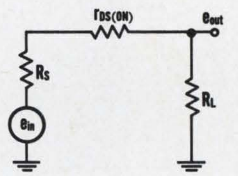


Series **Series-Shunt**

Type	$r_{DS(ON)}$ Max. (Ohms)(1)	$C_{gd(OFF)}$ (pF)(2)	$I_{D(OFF)}$ (pA)(3)	V_P Max. (Volts)(4)	BV_{GDS} Min. (Volts)(5)	Price(6)
MOS						
M105	20	9	10	—	30	$23.50
M103	200	2.7	8	—	30	5.30
M104	1200	0.25	3	—	30	4.65
JUNCTION						
2N5432	5	9.5	40	10	25	40.00
2N5433	7	9.5	40	9	25	20.00
2N5434	10	9.5	40	4	25	33.50
U240(7) (2N4445)	5	9.5	40	10	25	31.50
U241(7) (2N4446)	10	9.5	40	10	25	14.25
U242(7) (2N4447)	6	9.5	40	10	20	18.00
U243(7) (2N4448)	12	9.5	40	10	20	11.70
2N4856	25	2.9	8	10	40	4.50
2N4857	40	2.9	8	6	40	3.80
2N4858	60	2.9	8	4	40	3.15
2N4859	25	2.9	8	10	30	4.35
2N4860	40	2.9	8	6	30	3.70
2N4861	60	2.9	8	4	30	3.00
2N4391	30	2.9	8	10	40	4.70
2N4392	60	2.9	8	5	40	3.70
2N4393	100	2.9	8	3	40	3.00
2N4091	30	2.9	8	10	40	4.35
2N4092	50	2.9	8	7	40	3.70
2N4093	80	2.9	8	5	40	3.00
2N3970	30	5.5	10	10	40	3.50
2N3971	60	5.5	10	5	40	2.60
2N3972	100	5.5	10	3	40	3.00
U200	150	5.5	20	3	30	2.35
U201	75	5.5	20	5	30	2.20
U202	50	5.5	20	10	30	2.00
2N3824	250	1.2	2.5	8	50	2.70

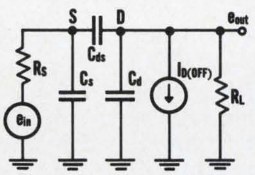
NOTES:
(1) Maximum ON Channel resistance measured at $V_{GS} = 0$, $V_{DS} = 0$, for junction FETs, and $V_{GS} = -20V$, $V_{DS} = 0$ for MOS FETs.
(2) Typical gate-to-drain OFF capacitance values measured at $V_{GS} = -10V$, $V_{DS} = 10V$ for junction FETs and $V_{GS} = 0$, $V_{DS} = -10V$ for MOS FETs. $C_{gd(ON)}$ is approximately three times $C_{gd(OFF)}$.
(3) Typical OFF drain current measured at $V_{GS} = -10V$, $V_{DS} = 10V$ for junction FETs and $V_{GS} = 0$, $V_{DS} = -10V$ for MOS FETs.
(4) V_P max. to data sheet conditions.
(5) BV_{DSS} for MOS FETs.
(6) 100-999 Prices.
(7) Identical to 2N4445 series, except for package.

ON CONDITION: ON error voltage is a function of FET $r_{DS(ON)}$ value relative to source and load resistance values of the circuit. Since, for different FET geometries, lower ON resistance means larger capacitance, a good figure of merit is the $r_{DS(ON)}\ C_{gd}$ product for a given V_P. The 2N5432 series has the lowest $r_{DS(ON)}\ C_{gd}$ product available!



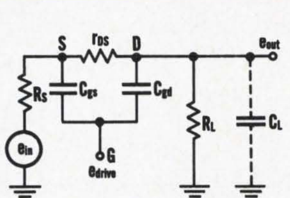
$$e_{error} = e_{in} \frac{R_s + r_{DS\ (ON)}}{R_s + R_L + r_{DS\ (ON)}}$$

OFF CONDITION: Static OFF error voltage is extremely small due to low drain leakage current, $I_{D(OFF)}$. AC feedthrough is low since drain-to-source capacitance, C_{ds}, is always less than 0.4 pF.



$e_{error} = I_{D(OFF)} R_L$
C_s = Source-gate (and body) capacitance
C_d = Drain-gate (and body) capacitance
Circuit assumes gate and body guarded (AC grounded)

SWITCHING: Going from the ON condition to the OFF condition is generally the limiting case, and the important parameters are gate-to-drain capacitance, C_{gd}, and the output load impedance R_L and C_L. Siliconix FETs offer lower C_{gd} for a given $r_{DS(ON)}$ and V_P.



CASE I:
e_{drive} rise time $< R_L\ (C_{gd} + C_L)$
$$e_{error} \cong e_{ov} \frac{C_{gd}}{C_L + C_{gd}}$$
$t = R_L\ (C_{gd} + C_L)$
where $e_{ov} = e_{drive} - V_P$
CASE II:
e_{drive} rise time $> R_L\ (C_{gd} + C_L)$
$$e_{error} \cong C_{gd} \frac{de_{ov}}{dT}$$

For further information and immediate applications assistance call the number below. Ask for Extension 19.

*** Applications Power: An ever-expanding catalog of quality devices, plus an in-depth applications team waiting to serve you!**

Siliconix incorporated
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INFORMATION RETRIEVAL NUMBER 11

Designer's Datebook

MARCH 1969						
Sun	Mon	Tue	Wed	Thu	Fri	Sat
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2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

APRIL 1969						
Sun	Mon	Tue	Wed	Thu	Fri	Sat
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

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

CIRCLE NO. 469

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

CIRCLE NO. 470

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

CIRCLE NO. 471

Apr. 22-23
Relay Conference (Stillwater, Okla.) Sponsor: NARM & Okla. State Univ.; Dr. D. D. Lingelbach, Engineering and Industrial Extension, Okla. State Univ., Stillwater, Okla. 74074

CIRCLE NO. 472

Apr. 23-25
Southwestern IEEE Conference and Exhibit (San Antonio, Texas) Sponsor: W. H. Hartwig, Univ. of Texas, EE Dept., Austin, Tex. 78712

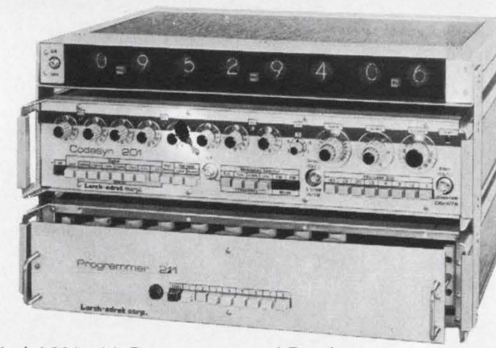
CIRCLE NO. 473

Apr. 30-May 2
Electronic Components Conference (Washington, D. C.) Sponsor: G-PMP, EIA; James O'Connell, ITT Hdqs., 320 Park Ave., New York, N.Y. 10022

CIRCLE NO. 474

Signal Generator Versatility + Synthesizer Accuracy + Programming and Sweep Flexibility + IC Economy = LORCH-ADRET SIGNAL GENERATOR-SYNTHESIZERS

Models to 100KHz, 2MHz and 60MHz



Model 201 with Programmer and Readout.

- Digital Frequency Selection .... YES
- Excellent Frequency and Amplitude Stability .... YES
- Coherent Output .... YES
- High Spectral Purity .... YES
- Built-In Digital Attenuator .... YES
- BCD Programmable Frequency and Attenuation .... YES
- Programmable Search Oscillator .... YES
- AM and FM Internal and External Modulation .... YES
- Sweep: Narrow Band and Wide Band .... YES
- IC Design using MSI Devices .... YES
- Small Size .... YES
- Attractive Price .... YES

SPECIFICATIONS

Model	301 100 KHz	201 2 MHz	202 60 MHz
Frequency Stability	3 x 10^{-5}/ week	1 x 10^{-7}/ day (2 x 10^{-9}/ day optional)	
Digital Decades	4	8	8
Resolution (with vernier)	0.1 Hz	0.001 Hz	0.001 Hz
Modulation AM	none	0 – 100%	0 – 100%
Deviation FM	100 KHz (external only)	2 MHz	10 MHz
Sweep Range	100 KHz	2 MHz	12 MHz
Output Level	+21 dbm	+13 dbm	+13 dbm
Attenuator	continuous	0 – 100 db	0 – 60 db
Spurious Output (nonharmonic)	– 60 db	– 70 db	– 80 db
Signal to Phase Noise	60 db	70 db	70 db
Rack Panel Height	3½″ (½ rack)	3½″	5¼″
Price	$2150.00	$3800.00	$6900.00

Also available: BCD Programmable DC Voltage Standard (6 digit); Remote Displays; Remote Programmers; Programmable Attenuators; IRIG Programmers and Comb Generators.

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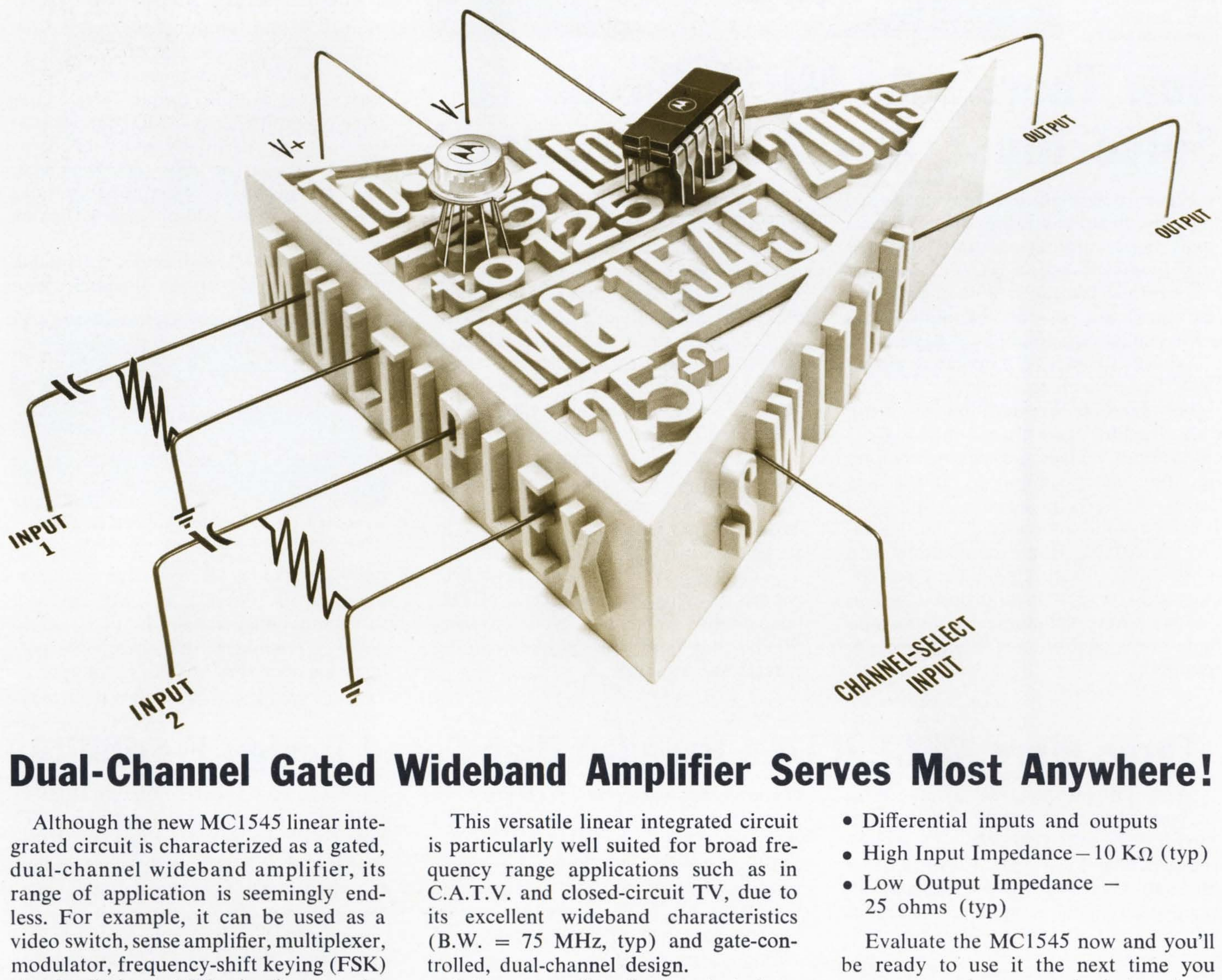
INFORMATION RETRIEVAL NUMBER 14

No. 5 — 69

SEMICONDUCTOR newsbriefs

PUBLISHED BY MOTOROLA SEMICONDUCTOR PRODUCTS INC.



Dual-Channel Gated Wideband Amplifier Serves Most Anywhere!

Although the new MC1545 linear integrated circuit is characterized as a gated, dual-channel wideband amplifier, its range of application is seemingly endless. For example, it can be used as a video switch, sense amplifier, multiplexer, modulator, frequency-shift keying (FSK) circuit, limiter, AGC circuit, or pulse amplifier . . . to name just a few!

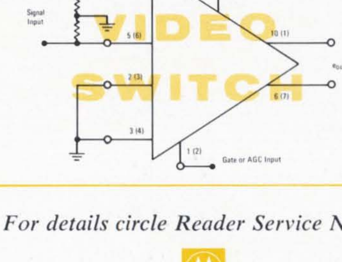
And, its low-cost further enhances its universal appeal for practically any linear application — just $5.50 for the 10-pin metal-can packaged version ("G" suffix), in 100-up quantities. The MC-1545 is also available in the TO-116 14-lead ceramic dual inline ("L" suffix) and the 14-lead TO-86 ceramic flat-pack ("F" suffix). All versions operate over the −55 to +125° temperature range.

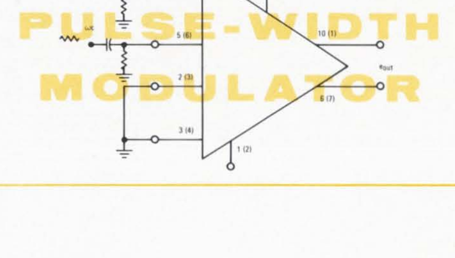
This versatile linear integrated circuit is particularly well suited for broad frequency range applications such as in C.A.T.V. and closed-circuit TV, due to its excellent wideband characteristics (B.W. = 75 MHz, typ) and gate-controlled, dual-channel design.

Other outstanding features include:

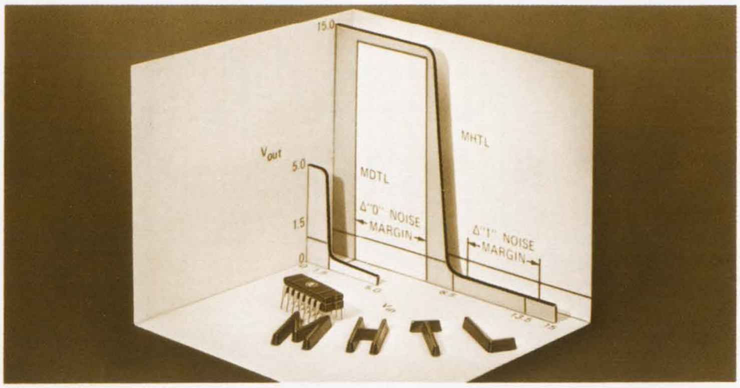
- 20 ns channel-select time (typ)
- Differential inputs and outputs
- High Input Impedance — 10 KΩ (typ)
- Low Output Impedance — 25 ohms (typ)

Evaluate the MC1545 now and you'll be ready to use it the next time you come up against a tough design situation.





For details circle Reader Service No. 211



The transfer curves on the right illustrate the large logic swing available from MHTL compared with MDTL.

Now There's An MHTL Circuit To Solve Most Any Noise Problem!

Eleven new high-threshold integrated logic circuit functions that offer 7.5-volts (typ) noise-immunity are now available in hermetically-sealed, TO-116 dual in-line ceramic packages. With these latest additions, the designer of high noise-environment equipment now has a wide choice of 15 MHTL integrated circuit types from which to select.

For example, in addition to a full complement of multiple-input gates (with both active and passive pull-up options), several flip-flops and a line driver, the series includes two triple-level translators and a monostable multivibrator. As MHTL is pin compatible with other forms of saturated logic, these circuits can be used in high-speed system designs where economical solutions to high noise environment conditions are required.

Combining a voltage swing of 13 volts with a 7.5-volt noise margin, a wide operating temperature range of -30 to $+75\,°C$, high fan-out of up to 30; and 35 mW dissipation, the MHTL family will prove an invaluable aid in industrial applications such as: numerical and supervisory control systems and computer peripheral equipment. These monolithic I/Cs can be interfaced with discrete componentry in many designs.

And, they carry the same low price tags associated with plastic encapsulated types. For example, the MC670L/671L Triple 3-Input Gates sell for as little as \$2.60 each (in 1,000-up quantities).

A comprehensive Perpetual Data Brochure, detailing the complete MHTL line, and two Application Notes covering MHTL flip-flops and noise-immunity criteria are available.

For copies circle Reader Service No. 212

New I/C Voltage Regulator Handles Up to 35-V Inputs

Now, there's a Motorola "Double-Regulated" I/C Voltage Regulator for just about any application up to 35-Volts input!

The new MC1561/1461 types are essentially the same as the recently-introduced MC1560/1460, internally-compensated voltage regulators . . . except that they have a higher input voltage capability! The new devices offer a maximum 35-Volts input, compared to 20-Volts (max) for the MC1560/1460.

The "built-in" reference-voltage regulator stage of this unique linear integrated circuit line provides characteristics that are essentially independent of output voltage (*no other I/C regulator, currently available, offers this important advantage)!* Yet, 100-up prices start as low as \$4.50 (MC1461G).

These new I/C regulators are available in both the "G" 10-pin metal-can and

The new MC1561/1461 voltage regulators can handle inputs of up to 35-volts.

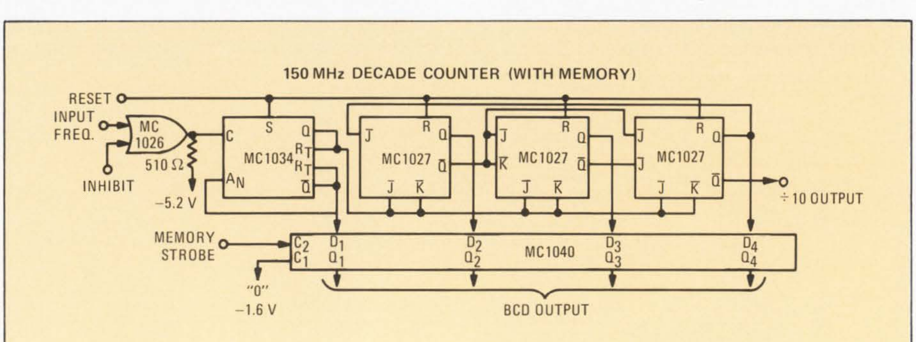
the 9-pin TO-66 "R" package (dissipating up to 17.5-Watts). The MC1561 is a full temperature range circuit (-55 to $+125\,°C$), while its MC1461 counterpart operates over the 0 to $75\,°C$ range.

For details circle Reader Service No. 213

Three More MECL II I/Cs Broaden High-Speed Design Flexibility

With the introduction of a 1.8 ns propagation delay (typ) Line/Clock Driver – the **MC1026/1226** – along with the **MC1034** Type "D" Flip-Flop and **MC1040** Quad Latch, the designer of high-speed digital equipment has 29 different MECL II circuits from which to choose. *And, he can now exclusively use fast emitter-coupled logic functions throughout his entire system!*

For example, the illustration shows how the MC1026 and MC1034 combine with three MC1027's to yield a decade counter that will operate in excess of 150 MHz. In this design, the MC1040 is used as a buffer storage for the BCD data from the counter. The MC1034, since it utilizes a true master-slave design, eliminates data "rippling-through" when the clock is in the low state.



For copies circle Reader Service No. 214

Both the MC1034 and MC1040 are available in the 0 to $+75\,°C$ temperature-range and come in the 14-pin dual in-line ceramic package. The MC1026/1226 come in either limited or full temperature versions and are packaged in both the TO-116 ceramic dual-in-line and TO-86 flat-pack.

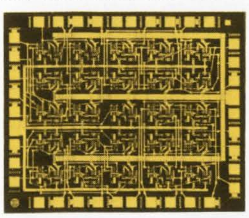
Two application notes – one called "I/C Crystal Controlled Oscillators;" the other "High Speed Monostable Multivibrators" – along with comprehensive data sheets on these new MECL II types have just been published. Add them to your high-speed design library.

XC177 Provides Ingredients For Low-Cost Custom MSI/LSI!

The recipe is really quite simple. Take the basic XC177 chip – a flexible array of 25 uncommitted TTL gates, each having 4 circuit options. *Add* your own circuit and logic layout for transition to two layers of intraconnecting metal. *And,* send to Motorola!

The result can be an inexpensive, custom, complex-circuit such as the Quad "D" Flip-Flop illustrated . . . or, any other that you can design. And, your costs can be a great deal less than for circuits of comparable complexity. For still greater complexity and functional capability, up to 100 gates may be interconnected using 4 adjacent XC177's.

Even though customizing costs normally run to $15,000 and up, development costs for your designs with the XC177 are only $2,500 per layer of metal; and, even then, unit costs will be in the $15 to $30 range, depending on the function and tests required.

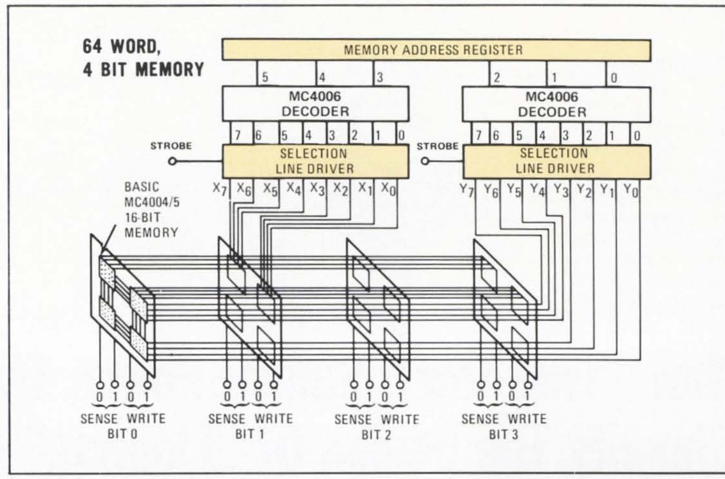


The XC177 shown formed into a universal Quad D Flip-Flop.

The "how" of it is almost as simple as the recipe: By starting with a standard chip that houses 25 bipolar gates, development time and mask-making costs are drastically reduced – because of the flexibility offered through two metalization layers. So, you get custom-designed basic gates with passive pullups, for wired OR capability and low-noise; plus, almost unlimited flexibility.

The various options of the XC177 are available in five different package configurations: 14 and 16-pin dual in-line plastic, and both 14-pin and 32-pin ceramic flat packs.

For details circle Reader Service No. 215



Only two MC4006 Decoders and 16 MC4004/5's are needed to form a complex, yet compact system such as this 64-Word, 4-Bit Memory.

Family of 23 MTTL Complex-Element I/Cs Led-Off by Two Memories and a Decoder

Improved performance, lower system costs and inter-family (MDTL, T^2L, etc.) compatibility are just three of many advantages offered by a new series of complex-element transistor-transistor logic circuits – the first introductions being two 16-bit memory circuits and a binary to one-of-eight-line decoder. *The rest of the family, consisting of twenty more types, is scheduled for release during the first half of 1969.*

The **MC4004** and **MC4005** 16-Bit Random Access Memories can serve as "building blocks" for 100 ns scratch-pad memory systems; while the **MC4006** Decoder offers greatly improved operating efficiency and a lowering of "can-count" and system costs. As shown in the illustration, these new MTTL complex-elements can be combined to form expanded memory systems.

The MC4004/05 provide 16-words of one-bit memory each, operating in the NDRO mode. Each of these units contains 16 flip-flops, arranged in a four-by-four matrix, plus two amplifiers and two "write" circuits. Eight "select" lines provide for the selection of one of the bits by applying a logic "1" level to one of the "X" and one of the "Y" select lines. After selection, information may be written into the bit by applying a logic "1" level to one of the "write" circuit inputs.

The MC4006 combines low-level, non-saturating gates with high-level gates, all on a single chip. The "enable" line provides an inhibit capability and also allows the decoder to be expanded for larger systems.

These new circuits offer the same system compatibility improvements pioneered by Motorola with its MTTL III line. That is, diode-clamped inputs and a by-pass network to improve transfer characteristics and reduce "ringing."

MC4004/05/06 are on distributor's shelves now, in the 14-lead dual in-line ceramic package and the TO-86 ceramic flat-pack. All operate over the 0 to 75°C range. 100-up prices are:

MC4004L–$11.80	MC4004F–$17.70
MC4005L– 9.05	MC4005F– 12.65
MC4006L– 7.50	MC4006F– 12.80

For details circle Reader Service No. 216

Now One MC1514 Can Do The Job Of Two Diff-Comparators

Why use two when one will do?

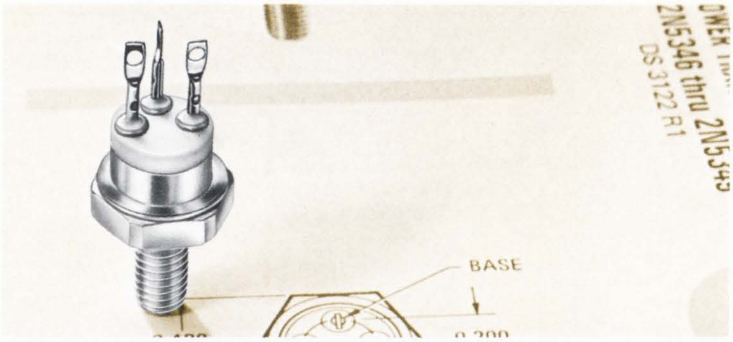
With Motorola's new **MC1514** Dual Differential Comparator I/C you can replace **two 710-types,** thus reducing package count, system-size, costs and complexity in low-level detection, sensing and memory designs.

In addition to two separate outputs, the MC1514 also offers a strobing capability as well as a high output current-sink – 2.8 mA (min) for *each comparator!* This circuit also features a propagation delay time of only 40 ns. And, its output is compatible with saturated logic forms.

It is capable of transferring differential signals directly into dc output levels – thus making it useful in a variety of applications such as variable threshold Schmitt triggers, pulse-height discriminators, memory sense amplifiers, and high-noise-immunity line receivers.

The MC1514 comes in the 14-lead, TO-116 dual inline ceramic case and operates over the –55 to +125°C temperature range. It is 100-up priced at $13.

For details circle Reader Service No. 217



"Isolated-collector" packaged silicon power transistors can be thermally-mounted to a heat-sink without using electrical insulation — making them ideal for critical high-wattage applications.

New "Isolector" Silicon Power Transistors Simplify The Design Of "Floating" Systems!

Increased system design flexibility and a decrease in hardware requirements — that's what's wrapped-up in four new NPN, TO-59 packaged, 7-Amp silicon power transistors that feature a unique isolated-collector design.

These new isolated-collector power transistors allow the designer to thermally-mount the units, but keep them electrically isolated from the heat-sink— a requirement often found in non-grounded or "floating" systems in missiles and satellites. In addition, mounting and insulating hardware are virtually eliminated.

The new 60-Watt "Isolector" series — EIA registered 2N5346-49 — has been specifically developed for power switching and wideband amplifier applications in critical industrial and military designs where reliable performance under demanding conditions is important.

The new series features a wide spectrum of advantages such as: dc current gain spec'd at three points up to 5 Amps; excellent dc safe operating area (5 Amps at 10 Volts) and saturation voltage of only 1.2 Volts @ 7 Amps . . . plus a 200°C maximum operating temperature.

TYPE NO.	V_{CEO} (sus)	h_{FE} @ I_C (min)	SWITCHING TIME		
			t_{on}	t_s	t_{off}
2N5346	80 V	30 @ 2A 20 @ 5A	200 ns	2.0 μs	200 ns
2N5347	80 V	60 @ 2A 40 @ 5A	@ V_{CC}=40V/I_C=2A (max)		
2N5348	100 V	30 @ 2A 20 @ 5A			
2N5349	100 V	60 @ 2A 40 @ 5A			

For details circle Reader Service No. 218

New Si_3N_4 Dual-Gate MOSFETs Are Low-Cost, Yet Versatile

The new dual-gate MOSFETs — types MFE3007 and 3N140 — offer RF circuit designers all the basic advantages of field-effect transistors coupled with low cross-modulation distortion, more efficient AGC action and lower feedback capacitance. Cascode operation is facilitated by the series arrangement of two channels, with a separate and independent control-gate for each, thereby maintaining separation of RF-signal and AGC voltage. They are ideal for RF amplifier and mixer applications such as required in frequency converters, TV/FM tuners, AGC amplifiers, and color demodulators.

These N-Channel, TO-72 packaged dual-gate MOSFETs exhibit excellent long-term stability under both high temperature and reverse biasing conditions — due to Motorola's Silicon-Nitride passivation process. C_{rss} values are minimal, namely 0.02 pF typical for the MFE-3007 and 0.03 pF max for the 3N140, while maximum input capacitance (C_{iss}) is 5.5 pF and 7.0 pF, respectively.

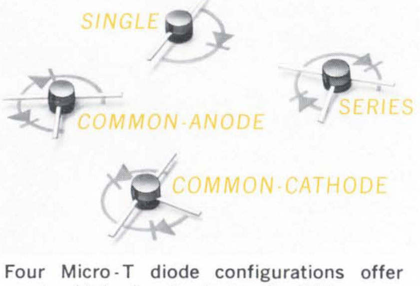
Characteristics	MFE3007	3N140
G_{ps} min @ 200 MHz	18 dB	16 dB
y_{fs} (μmhos) @ 1 kHz	10,000 min 18,000 max	6,000 min 18,000 max
NF max @ 200 MHz	4.0 dB	4.5 dB
I_{DSS} (mA)	5.0 — 20	5.0 — 30
Price: (1,000-up)	99¢	98¢

For details circle Reader Service No. 219

4 Diodes, 5 Transistors Now Join Micro-T Packaged Line

Fast-Switching Diodes Offer Assortment of Configurations

Four new Micro-T silicon epitaxial diodes with typical reverse recovery times of just 3 ns are now available for designers who have severe space limitations in computer, instrumentation, and military switching applications.



Four Micro-T diode configurations offer greater high-density design flexibility.

The MMD6050 is a single diode in a two-lead variation of the one-piece, injection-molded plastic Micro-T package. The others are dual-diodes (in the 3-leaded package). They are the MMD-6100, a common-cathode device, MMD6150 (common-anode), and the MMD7000, a series configuration.

Adding to the advantages of these fast-switching diodes are premium specs like: high breakdown voltage of 70 V (min) @ 100 μA and capacitance values as low as 2 pF (max). The power dissipation for all types is 225 mW @ 25°C; and, they operate over a wide junction temperature range of −55 to +135°C.

Ultra-Fast-Switch Heads List Of 5 New Micro-T Transistors

Take a familiar NPN silicon Annular fast-switching transistor like the 2N3960, speed it up even more, and improve its current-gain — bandwidth product, then package it in the Motorola Micro-T housing, and you have the best high-speed current-mode logic switch yet — the MMT3960A. And, you are afforded the flexibility of being able to use discrete devices while retaining the circuit shrinkage attributes of I/Cs.

Application	Polarity	Type No.	Key Parameters
Current-Mode Logic Very Fast Switch	NPN	MMT3960A	t_{on}/t_{off} = 2.1 ns (typ) f_T = 2250 MHz (typ) @ I_C = 10 mA
Low-Noise Amplifier	NPN	MMT930 MMT2484	h_{FE} = 175 (min) @ 100 μA (MMT2484) NF = 3.0 dB @ I_C = 10 μA
DC-to-VHF Amplifier High-Speed Switch	NPN	MMT2222	f_T = 200 MHz (typ) @ I_C = 10 mA t_{on} = 16 ns (typ) @ I_C = 150 mA
General Purpose Amplifier & Switch	PNP	MMT2907	h_{FE} (range) 100-300 @ I_C = 150 mA t_{on} = 20 ns (typ) @ I_C = 150 mA $V_{CE(sat)}$ = 0.4 V (max) @ I_C = 150 mA

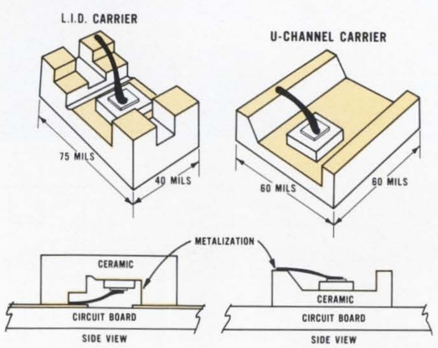
Four other additions to the Micro-T transistor line include: two NPN low-noise amplifiers, an NPN dc-to-VHF amplifier/high-speed switch, and a PNP general-purpose transistor.

For details circle Reader Service No. 220

Zener Diode Chips Now Make Internally-Regulated Hybrid I/C Designs Practical

Built-in voltage regulation has just become simple and economical to achieve in hybrid microcircuit designs!

Two new MZC series of unencapsulated, 400 mW zener diodes (both high and low current-level versions) are now available for cost-cutting, assembly-simplifying applications in virtually any type of hybrid design requirements, from



Zener diode "chips" can be supplied on metalized ceramic U-channel and L.I.D. carriers (as well as unmounted), to satisfy most any Hybrid thick or thin-film circuit mounting and fabrication requirement.

1.8 to 200 volts ... in a choice of three, compatible configurations: (1) chips only; (2) chips-on-U-channels; (3) chips-on-L.I.D.'s.

The MZC series "A" – equivalent to chips used in the popular Surmetic 1N-5221 family – has test currents which are specified at standard milliamp levels and, can be incorporated into most higher-current circuits where power drain is not a prime consideration.

For space, instrumentation and other low-current-level, battery-operated systems where power drain must be minimized, the "B" series offers test currents spec'd at only **250 μA!** These chips are closely akin to those found in the 1N4614 and 1N4099 "glass" RamRod family.

Both series are available in 5% and 10% voltage tolerances, offer anode/cathode metallization compatibility with standard wire and die-bonding techniques, and feature gold-plated bonding surfaces – to facilitate thin or thick-film assembly operations.

Chip Series No.	Voltage Range	Test Current (I_{ZT})	Leakage Current (I_R)	1N Device Equivalent
MZC "A" Series (High-Level)	2.4-200V	0.65-20 mA	0.1-100 μA	1N5221* Series
MZC "B" Series (Low-Level)	1.8-200V	250 μA	0.01-10 μA	1N4099 Series 1N4614 Series

*Also equivalent to 1N4370,A thru 1N4372,A; 1N746,A thru 1N759,A; 1N964,A,B thru 1N922,A,B.

For details circle Reader Service No. 221

Mini/Micro-T Opto-Sensor Entries Make For Maxi-Visibility Arrays!

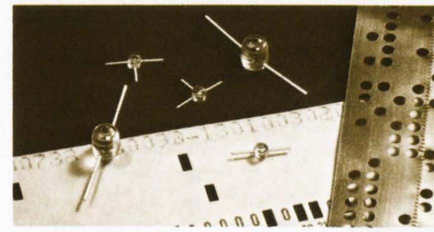
Like women's latest fashions, they're mini-sized, maxi-produced and specially-designed for optimum optical properties!

Unlike the new fashions though, they're low in cost!

We're talking about the new, clear plastic packaged, Micro-T and Mini-T optoelectronic transducers – state-of-the-art devices that clear-the-way to more economical, high-density-array punched-card and tape-readers, shaft encoders, pattern and character recognition, process inspection, counting, sorting, switching and logic circuit systems designs.

So tiny you can put more than 100 of them in a thimble without reaching the top, the Micro-T units are available with (MRD100), or without external base leads (MRD150). They can be closely spaced and mounted on the underside of PC boards, with only their active areas exposed – making it possible to design smooth, uncluttered close-contact interface configurations.

Covering the visible and near-infra-red spectral range, Micro-T's feature a sensitivity of 0.04 mA/mW/cm² (min).



New Micro-T (2 and 3-leads) and Mini-T opto-devices expand opportunities to develop low-cost high-density/high sensitivity sensors.

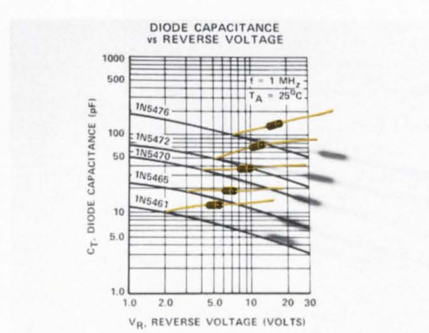
The Mini-T (MRD450) exhibits an even higher radiation sensitivity – 0.20 mA/mW/cm² – due to a unique, molded lens design which concentrates more light onto the active die surface. It is especially suitable for sensing designs in inspection, production and detection equipment as well as alarm systems, SCR triggering and optical interfacing with data processing systems.

Type No.	Package Type	Dark Current	Rise Time	Fall Time	Price (100-up)
MRD 100	Micro-T	100 nA (max)	2.5 μs (max)	4.0 μs (max)	$1.00
MRD 150	Micro-T				.80
MRD 450	Mini-T				1.50

For details circle Reader Service No. 222

Latest Premium Tuning Diode Line Increases Broad-Frequency-Control Design Flexibility

A new premium-performance EPICAP tuning diode series, types 1N-5461-76, can now serve to improve the design of tuning circuits for such exacting frequency control requirements as are found in ECM equipment, ground and aerospace radio and frequency synthesizers. The significant features of this line include: very high Q's – for sharp response at high frequencies; high tuning



The slopes of capacitance change vs.voltage are the same for all types in the 1N5461 Epicap tuning diode series.

ratios – to facilitate tuning over broad frequency ranges; and uniform linear changes in capacitance with voltage – making it a simple matter to "gang" them into matched multi-stage configurations and for continuous wide-band tuning requirements.

Their tuning ratios are closely held to indicated typical values by guaranteed min. and max. values on each type (see table). The series covers all standard nominal capacitance values from 6.8 pF to 100 pF.

These new EPICAP tuning diodes are supplied in the Motorola RamRod DO-7 "glass" case. The 100-up price for suffix A types is $4.50 each, suffix B – $5.80 and suffix C – $8.00.

Type No.	Fig. of Merit (Q) @ 4V/50 MHz	Capacitance (C_T) @ 4V/1 MHz	Tuning Ratio C_2/C_{30} @ 1 MHz
	Min.	pF*	Typ
1N5461A	600	6.8	2.8
1N5462A	600	8.2	2.9
1N5463A	550	10.0	2.9
1N5464A	550	12.0	2.9
1N5465A	550	15.0	2.9
1N5466A	500	18.0	3.0
1N5467A	500	20.0	3.0
1N5468A	500	22.0	3.0
1N5469A	500	27.0	3.0
1N5470A	500	33.0	3.1
1N5471A	450	39.0	3.1
1N5472A	400	47.0	3.1
1N5473A	300	56.0	3.1
1N5474A	250	68.0	3.1
1N5475A	225	82.0	3.1
1N5476A	200	100.0	3.1

*Nominal capacitance tolerance of ±10%, ±5%, or ±2% indicated by suffix A, B or C, respectively.

For details circle Reader Service No. 223

PRODUCT BRIEFS

NEW ULTRA-LOW-NOISE JFETs

– Feature Low-Frequency Noise-Figures Below 1.0 dB!

Three new ultra-low-noise N-Channel JFETs (2N5556-58) offer excellent noise characteristics making them exceptionally well-suited for low-signal, high impedance input circuits, such as required in electrometers and medical electronic amplifiers. For example, they exhibit a small equivalent input-noise-voltage (e_n) = 20 nV/$\sqrt{Hz}$ typ. @ 10 Hz and a noise-figure (NF) of only 1.0 dB max. @ 10 Hz.

In addition to the specs shown in the table below, these TO-72 packaged devices exhibit a minimum breakdown voltage of 30 volts and a low I_{GSS} of just 0.1 nA max. Typical figures for C_{iss} and C_{rss} are also quite low – 4.5 pF and 1.2 pF, respectively.

Type No.	I_{DSS} (mA) Min — Max	$V_{GS(off)}$ (V) Min — Max	y_{fs} (μmhos)			Price (100-up)
			Min	Typ	Max	
2N5556	0.5 — 2.5	0.2 — 4.0	1500	3500	6500	$9.50
2N5557	2.0 — 5.0	0.8 — 5.0				8.00
2N5558	4.0 — 10.0	1.5 — 6.0				7.50

For details circle Reader Service No. 224

TWO LOW-LEVEL PNP AMPLIFIER TRANSISTOR SERIES

– Provide High-Gain At Low Collector-Currents, Plus Low Noise-Figures!

With the availability from Motorola of two PNP silicon Annular transistor series – the 2N2604/05 and their premium versions, the 2N3798/99 – designers can now utilize low-level, high-gain amplifiers with noise figures that are typically less than 3 dB (even when operating over a wide frequency bandwidth of 10 Hz to 15.7 kHz).

While the 2N3798/3799 are premium devices by virtue of their lower capacitance, lower noise figures, higher gain, and higher collector-emitter breakdown voltage, the 2N2604/2605 have the advantage of being encased in the space-saving TO-46, low-silhouette, solid Kovar package and, they carry significantly lower **price-tags** (see table at right).

HIGHLIGHT CHARACTERISTICS	2N2604	2N2605	2N3798	2N3795
Low Noise: NF(max) @ I_C (B.W. = 10 Hz to 15.7 KHz)	4.0 dB @ 10 μA	3.0 dB @ 10 μA	3.5 dB @ 100 μA	2.5 dB @ 100 μA
High Voltage: BV_{CEO}(min) @ I_C BV_{EBO}(min) @ I_E	40 V @ 10 mA 6 V @ 10 μA		60 V @ 10 mA 5 V @ 10 μA	
Low Capacitance: C_{ob}(max) @ V_{CB}	6 pF @ 5 V		4 pF @ 5 V	
High Gain: H_{FE}(min) @ I_C	60 @ 500 μA	150 @ 500 μA	150 @ 500 μA	300 @ 500 μA
Package Type:	TO-46		TO-18	
Prices (100-up):	$2.30	$2.70	$4.00	$4.50

For details circle Reader Service No. 225

SIX NEW SILICON JAN TRANSISTORS

– Join Motorola's Extensive Mil-Type Availability List

Two each universal high-speed switches, general purpose medium-current high-speed switches, and high-speed switching/DC-to-VHF amplifier transistors now join over 300 Motorola semiconductors that are now available to meet MIL requirements.

Test data on the JAN/JANTX2N708 and JAN/JAN-TX2N914 NPN types is available on request. A comprehensive Designers data sheet, containing complete limit curves, covers the PNP JAN2N3467/3468 core drivers – while, the space savings provided by the low-profile TO-46 packaged PNP JAN2N3485A/3486A make them ideal for high component-density applications.

Type No.	Mil-S-19500/	Case	P_D @ 25°C	C_{ob} @ 10V	f_T @ I_C (min)	$V_{CE(sat)}$ @ I_C (max)	V_{CEO}
JAN/JAN-TX2N708	312B(USAF)	TO-18	360 mW	6 pF (max)	300 MHz @ 10 mA	0.4V @ 10 mA	15V
JAN/JAN-TX2N914	373(USAF)				300 MHz @ 20 mA	0.7V @ 200 mA	
JAN/JAN-TX2N3485A/86A	392(USAF)	TO-46	400 mW	8 pF (max)	200 MHz @ 50 mA	0.4V @ 150 mA	60V
JAN3467/68	348(NAVY)	TO-5	1.0 W	25 pF (max)	175/150 MHz @ 50 mA	0.3/0.35 V @ 150 mA	40V/50V

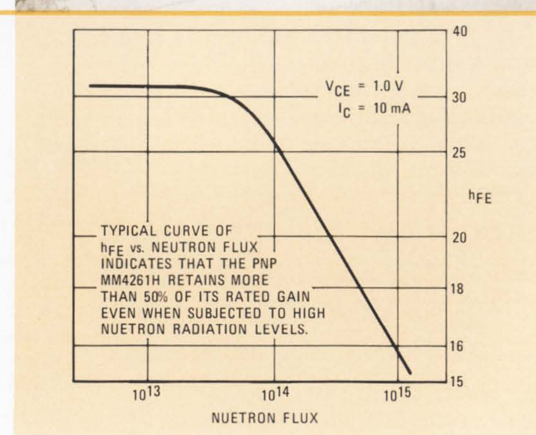
For details circle Reader Service No. 226

RADIATION-RESISTANT PNP "DIONIC" TRANSISTOR

– Especially Processed For High Neutron Tolerance Levels!

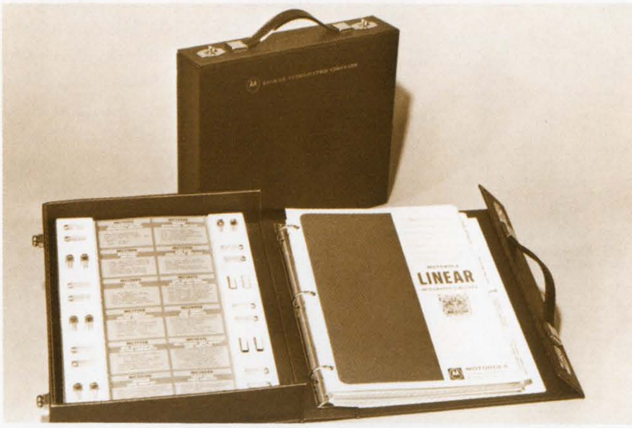
Motorola's new MM4261H PNP silicon Annular "Dionic" transistor marks the first time that a radiation-resistant device, which has also met the highest high-rel criteria, is available "off-the-shelf." Advanced processing techniques provide an exceptional tolerance to neutron radiation (h_{FE} degradation is less than 50% after exposure to 5 x 10^{14} neutrons/cm^2) and reliability is doubly assured through testing standards which are over-and-above those specified for typical JAN-TX requirements.

Applications in ordnance, space, and wherever low-level switching or low-voltage amplifier circuits require high radiation tolerance, are naturals for the MM4261H. Among its key specifications, this TO-72 four-lead metal-can packaged device features a high current-gain – bandwidth product (f_T) of 2,000 MHz (min) @ 10 mA. Input and output capacitances are both a low 2.5 pF (max), while its fast switching capability is shown by a t_r = 0.5 ns (typ) @ 10 mA.



For details circle Reader Service No. 227

New Linear I/C HANDYLab Kit Makes Prototyping Quick and Easy

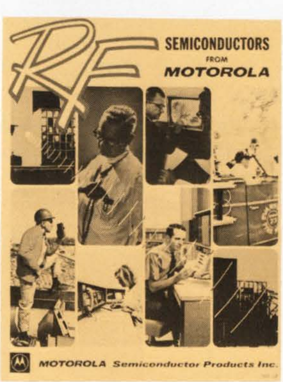


MCK1500 is the latest in a continuing series of prototype design kits, developed to give the working engineer a complete, "all-in-one" source of information and devices for evaluation and breadboarding.

This new kit contains 24 linear integrated circuits – **2 each of 12 types** – representing a cross-section of Motorola's Linear I/C line. Ten of the circuits are in TO-5 metal cans and two are in 14-pin ceramic dual in-line packages. In addition, a complete library of technical data is also included in the kit. For example, data sheets for all Motorola Linear I/Cs are included, plus Application Notes that are representative of the wide range of uses for the circuits that are in the kit. In addition, an "Applications Selector Guide" for Motorola Linear I/Cs makes it possible to tell at-a-glance which is the proper circuit for your application.

The material is all contained in a sturdy, compact vinyl-covered case that will fit in a desk drawer. The MCK1500 is available now from franchised Motorola distributors for $94.50 each. The value of the device alone, in 1-24 quantities, is $361.00!

First RF Selector Guide Provides Applications-Oriented Device Data



As an aid to the design of UHF and VHF circuitry, Motorola has just published a comprehensive selector guide that includes *all* types of RF characterized semiconductors – from 2 MHz to more than 10 GHz. The power and small-signal sections are further divided into three sequential selectivity levels. The first level being graphical representations of application areas covered by specific devices; the second is in the form of charts which list the devices by their frequency of operation as related to their most pertinent parameter; while the third is an alphanumeric listing of the devices with their abbreviated specifications.

A spectrum-chart covering major areas of applications is also included.

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NEW LITERATURE BRIEFS

Over 650 Semiconductors Covered In Motorola's New Hi-Rel Catalog!

The most complete guide to semiconductors for Hi-Rel applications ever compiled, has just been published by Motorola. This 28-page, condensed catalog and selector guide describes over 650 types, in terms of their performance criteria for Hi-Rel requirements. Over 400 discrete devices that meet NASA, JAN/JAN-TX or Motorola's MEG-A-LIFE specifications are shown cross-referenced to the specific program under which they are available. In addition, condensed specifications are given for all the listed types. Process flow charts are also shown to provide details on Motorola's Hi-Rel procedures.

The listings include: Over 300 zener diodes; more than 100 germanium and silicon transistors (in both small-signal and power categories); eight thyristors and UJT's; three silicon rectifiers; over 230 digital I/C functions covering all popular families – MDTL, MECL, MTTL and MRTL – and, 24 linear I/C types, including diff-amps, op-amps, sense-amps, power and high-frequency amplifiers.

No design engineer whose work areas and interests include the Hi-Rel field should be without this new all-inclusive semiconductor catalog and selector guide.

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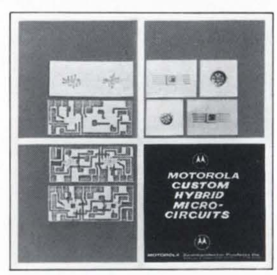
Better Ideas In Custom Hybrid Microcircuits Shown In New Brochure



The ability to combine any of 19,000 different semiconductor chips into a virtually endless variety of custom hybrid microcircuits, at economical costs, keynotes Motorola capability – detailed in this new publication.

With more and more systems designers searching for the optimum answer to bridging the gap between sometimes-costly, sometimes-cumbersome discrete device assemblies and power and performance-limited monolithic circuits, the brochure provides much starting-point impetus to new-design thinking along custom hybrid lines.

What they are, where they fit, their advantages and graphic examples of specific, finished custom designs in thick and thin-films are shown. Quality assurance considerations (including 100% stress tests) are also treated.

If you're planning to or already working in miniaturization through microelectronics . . . you'll want this new brochure!

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Published by Motorola Semiconductor Products Inc., P. O. Box 20924, Phoenix, Arizona 85036.

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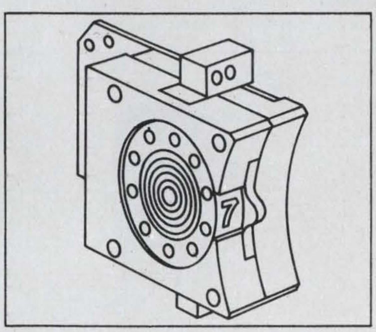
HAPPENINGS IN ELECTRONICS

Schweber salutes the Barnes Corporation.

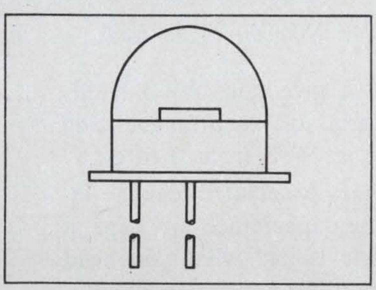
March, 1969

The mercurial growth of integrated circuits created a need for sockets that the big-name socket manufacturers did not attempt to meet. Turning a deaf ear to the exploding solid-state technology, the big names continued punching out tube sockets. A dynamic new group stepped into this vacuum, and by working closely with the leaders in the transistor and IC field developed a line of sockets that met the testing, breadboarding, and production needs of the industry. That group is the Barnes Corporation. With the emergence of MSI and LSI and 40-lead devices, some of the big names are taking another look, but the industry can't afford to wait for the results. It's an amazing fact that just as the three leaders in the semiconductor field never made a vacuum tube, the leader in semiconductor sockets never made a tube socket. As part of our salute to Barnes, we will send you the standard 46-page Barnes catalog as well as the special MSI/LSI supplement. Circle #241.



Rotary thumbwheel switch is state-of-the-art.

The EECoSWITCH,® made by Electronic Engineering Company of California, can solve most of your switching problems. The switch is operated by a rotary thumbwheel (see drawing). The switch position is indicated by a window framed readout number controlled by the thumbwheel (you don't need dials or decals). Behind-panel space requirements are significantly reduced by printed circuit board terminations. The switch can be installed without preliminary between-deck wiring. Both back-of-panel and front-of-panel assemblies are available. Contact chambers come sealed or unsealed; lighted or unlighted with a long life permanent lamp. We have a 12-page catalog and price list for you. Circle #242.



Monsanto gallium arsenide semiconductors.

Schweber now stocks GaAs semiconductors, a product of Monsanto Electronic Special Products Division. Individual light-emitting diodes in the visible range cover the green, amber, and red frequencies. Also available is an infrared emitter diode. In addition to these incoherent light emitters, Monsanto has a lineup of GaAs semiconductor injection lasers with peak power outputs of 5 to 28 watts at peak emission wavelengths of 8,600 and 9,000 angstroms. For catalog, circle #243.

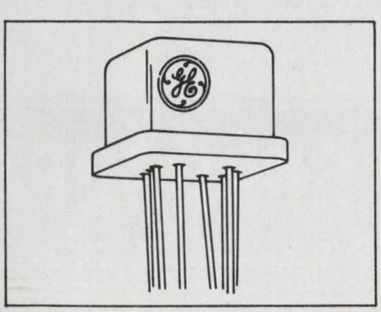
Review of new catalogs: RCA Mosfet Product Guide.

This 20-page booklet is both a catalog and a comprehensive application note for MOS Field Effect Transistors. Four pages are devoted to typical FET circuits, all components specified including coils. Three more pages discuss handling of FETs, their features and areas of applications, as well as a description of the dual-gate FET. The remaining pages list FET devices for consumer, industrial, and military equipment. Circle #244.

Fairchild MOS/LSI Brochure.

Here again we have the unusual combination of a catalog and an introductory section describing the union of MOS technology and Large Scale Integration. LSI can be described in the phrase: "A-subsystem-on-a-chip." This 40-page Fairchild brochure is divided into three parts. The first seven pages introduce the technology voted most likely to succeed in LSI, namely Metal-Oxide-Silicon (MOS). An unusual catalog of standard* MOS/LSI devices follows. (Unusual because some of the devices listed were not known to the public when the catalog was released.) The final section is devoted to Custom Arrays. Circle #245.

*Standards are always stocked by Schweber unless a later date is specified.



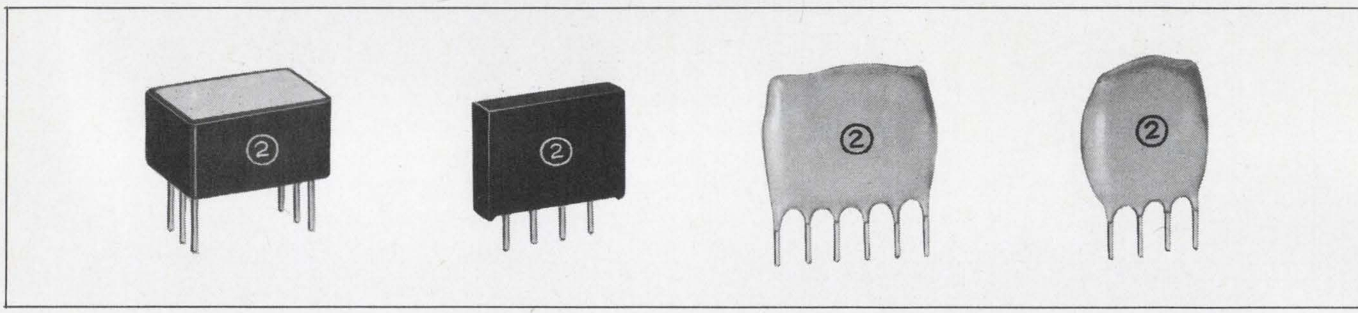
The logic of the TO-5² sealed relay.

GE squared the TO-5 can and created the TO-5² sealed relay. The logic of TO-5² is magnetic superiority. In a square enclosure, the magnet provides 2.5 times the magnetic pull achieved in a round enclosure. This results in higher contact forces, larger contact gaps, and greater contact over-travel. Extremely small relays are susceptible to mechanical shifts during environmental stress. The larger forces, gaps, and over-travel characteristic of the square design will minimize such shifts. The square design also permits greater accessibility of contacts and more precise adjustments. For data sheet, circle #246. Call Schweber for shipment from stock.

SCHWEBER ELECTRONICS

Now from Sprague Electric!

Your *custom* pulse transformer is a *standard* DST* transformer



Some of the case styles in which Sprague DST Pulse Transformers are available. Note the in-line leads.

You can select the transformer design you need from the new Sprague DST Family, a fully-characterized series of Designer Specified Transformers which Sprague Electric has pioneered. It's easy. Start with the two basic parameters dictated by your circuit requirements: primary (magnetizing) inductance and volt-second capacity.

New Sprague engineering data gives basic information from which all nominal sine wave parameters are derived. This data allows you to specify the one transformer from thousands of possibilities which will optimize performance in your application.

Design Style A minimizes magnetizing inductance change as a function of temperature. Typically it's $< \pm 10\%$ change from 0 to 60C; $< \pm 30\%$ from -55 to $+85$ C.

Design Style B and C give you broad band-pass characteristics, and still keep magnetizing inductance change $< \pm 15\%$ from 0 to 60 C.

Design Style D is *fast*. Associated leakage inductance and coupling capacitance are kept at a minimum. This style is just what you need for interstage and coupling devices in computer drive circuits.

The Sprague DST Series packs a lot of transformer into minimum volume packages — epoxy dipped for minimum cost, or pre-molded. The 100 mil in-line lead spacing is compatible with integrated circuit mounting dimensions on printed wiring boards.

To solve your pulse transformer design, start now. Write for Engineering Bulletin 40,350 to the Technical Literature Service, Sprague Electric Company, 347 Marshall St., North Adams, Massachusetts 01247.

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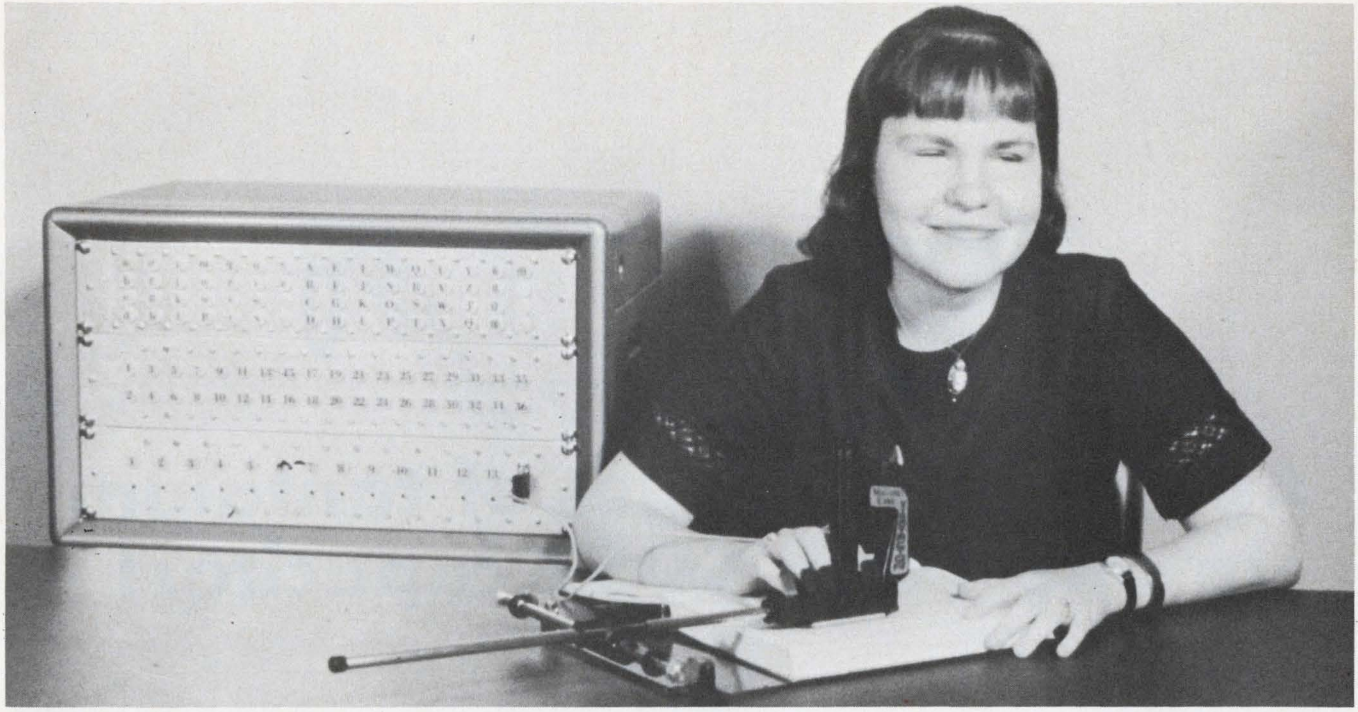
INFORMATION RETRIEVAL NUMBER 15

News



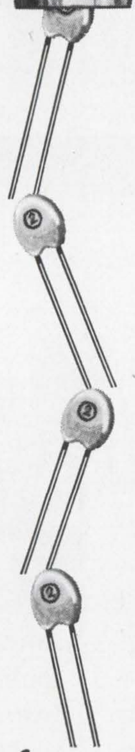
The Cognodictor, one of several reading aids under development for the blind, spells aloud the letters that appear beneath the probe in the operator's hand. Details are on page 30.

Display for Back-Up Interceptor Center (Buic III), which would replace a bombed-out Sage air defense network, shows twice as much information as its predecessor. Improvement comes from more memory and better software. Page 36.

Also in this section:

Now from Sprague!

All the advantages of tantalum in one LOW COST capacitor!



EPOXY-DIPPED TANTALEX® CAPACITORS...
For industrial, commercial, and entertainment electronic applications where tantalum capacitors were previously too expensive!

-|(- Type 196D Solid-electrolyte Tantalum Capacitors have special epoxy-dip coating which keeps costs down without sacrifice in dependability. Positively seals capacitor section while providing excellent electrical insulation. Protects against mechanical damage in handling.

-|(- Radial lead design for plug-in mounting on printed wiring boards. The .250″ lead spacing will fit standard .125″ grids.

-|(- High stability—very little capacitance change, even at outer limits of operating temperature range.

-|(- Low dissipation factor of these capacitors permits higher ripple currents.

-|(- Meet environmental test conditions of Military Specification MIL-C-26655B.

-|(- Prime capacitance and voltage ratings. Based on rating popularity of other types of solid tantalum capacitors.

-|(- Designed for continuous operation at temperatures from —55 C to +85 C.

For complete technical data, write for Engineering Bulletin 3545 to Technical Literature Service, Sprague Electric Company, 347 Marshall Street, North Adams, Massachusetts 01247.

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RESISTORS	PULSE-FORMING NETWORKS	BOBBIN and TAPE WOUND MAGNETIC CORES
INTEGRATED CIRCUITS	TOROIDAL INDUCTORS	SILICON RECTIFIER GATE CONTROLS
THIN-FILM MICROCIRCUITS	ELECTRIC WAVE FILTERS	FUNCTIONAL DIGITAL CIRCUITS

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INFORMATION RETRIEVAL NUMBER 16

Showdown on Sentinel is due this month

The battle lines are forming in Washington for a struggle over deployment of the Nike-X/Sentinel antiballistic missile system. Only early capitulation by the Nixon Administration can forestall open conflict with Congressional foes of the ABM system.

Nike-X is the program for research and development of advanced ABM techniques; Sentinel is the program to develop, build, test and deploy a "thin" operational ABM defense system. The announced goal of Sentinel is protection against possible nuclear attack by Red China. Opponents say the system is too costly (estimates range from $5.5 billion to $10 billion) and would probably be ineffective when complete.

Washington observers believe the President has three major options. He can:

- Order an indefinite halt to Sentinel deployment, revamp the entire Nike-X concept and press development of a more acceptable ABM system.
- Order a temporary halt to Sentinel deployment, continue with Nike-X development and reassess the Sentinel program with a view toward modifying it and deploying it in the near future.
- Fight to continue both R&D and deployment schedules as they now exist.

If the President selects the latter course, informants predict he probably can win continued support in both the House and Senate for ABM deployment. But this option would leave him open to critics' suggestions that his Administration has downgraded urban and social needs.

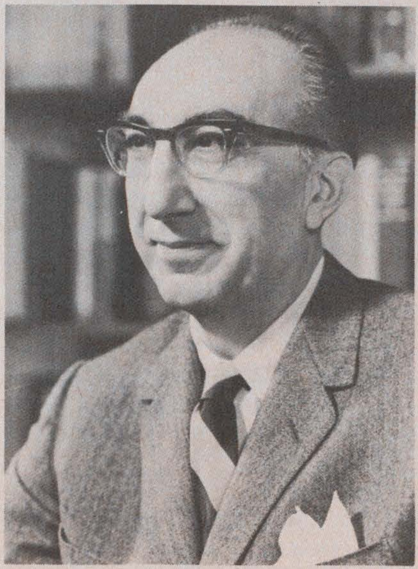
Proponents assert, however, that if Mr. Nixon continues Sentinel deployment or delays it only temporarily, he can strengthen his hand in upcoming arms-control discussions with the Soviet Union.

The Administration's review of the Sentinel program is scheduled for completion this month. Many observers in the capital recall that, prior to his election, President Nixon advocated Sentinel deployment, as did his Defense Secretary, Melvin R. Laird. The latter stated:

"If there are any errors that are going to made, as far as my administration of the department is concerned, they will be made on the side of the safety of the people of this country."

Be an EE, not an MD, surgeon tells engineers

Should the electronics engineer working in the growing field of medical electronics go back to school for a medical degree and perhaps take a few courses in chemistry, biology and physics? No, says Dr. Michael E. DeBakey, a leading heart surgeon and chief executive officer at Baylor Medical College in Houston, Tex.



Dr. Michael E. DeBakey, chief executive officer, Baylor Medical College.

While stressing the need to advance bio-engineering, Dr. DeBakey told engineers at a symposium in New York that this could best be done if the biologist, engineer, physicist, chemist and mathematician each stayed in his own field. The objective can then be achieved through collective endeavor, Dr. DeBakey said.

He recommended this approach because, he said, "the man who tries to acquire expertise in too wide a range of endeavor will find that he has only become the proverbial jack of all trades and master of none."

In examining the progress so far in the alliance between medicine and engineering, Dr. DeBakey said:

"The medical profession has lagged far behind industry in availing itself of the versatile computer and its usefulness in facilitating diagnosis and treatment and in coping with the information revolution.

"A properly programed computer can flag abnormal results of many tests, offer diagnostic suggestions, and predict, with 80 per cent accuracy, the six-month survival rate of patients with lung cancer. These mechanical analyzers can process 3000 samples of blood and other body fluids in one hour, make 18 separate tests on each sample, and print a data sheet on each specimen in minutes."

NASA urged to speed earth resources work

Full, unhesitating support for an earth-resources satellite program was urged by Rep. Joseph E. Karth (D-Minn.) in a speech before electronics engineers and managers at the WINCON conference in Los Angeles. He blamed NASA "foot-dragging" for delays thus far.

Karth, a member of the House Science and Astronautics Committee, urged that NASA look beyond the general-purpose spacecraft designed for many different uses.

"There is one very special planet in our solar system," he said, "and that is the one we live on. Perhaps we ought to spend at least as much money looking at it as we spend looking at other planets. The next

News Scope CONTINUED

few years ought to see an earth-resources satellite system take its place as one of NASA's major projects." (See Washington Report, p. 41.)

Karth noted that the time from initiation to scheduled launching of the earth-resources satellite in 1972 would be twice as long as for any other NASA program. "There is a preponderance of evidence," he said, "of foot-dragging, the setting up of straw men and the assignment of unique, unusual, and, I might say, ridiculous yardsticks. The major cause of the delays is the fact that NASA, as a matter of policy, has decided earth-resources experiments should be conducted as part of the manned space flight "effort."

The Congressman pointed out that a cost effectiveness test had been applied to the earth-resources program. "I know of no precedent for such a requirement anywhere else in the space program," he asserted. "Certainly no one ever applied such a test to the Manned Space Flight Program, the Physics and Astronomy Program, or the Planetary and Interplanetary Program. One shudders to think what the results of a cost-effectiveness analysis would have been for the Apollo Program. If each new project must pass the cost-effectiveness test, I have a strong feeling that the only one that will pass is the one that hasn't passed yet—the earth-resources program."

U. S. advised to check nonprofit R&D costs

The General Accounting Office has recommended the Executive branch study all nonprofit research organizations that are supported by Government contracts, with a view to determining if their contributions are economically sound. The Survey would include such organizations as the RAND Corp., the MITRE Corp., the Jet Propulsion Laboratory and the Institute for Defense Analysis. The GAO says that the functions and contributions of these organizations are of "sufficient importance to warrant a Presidential-directed interagency or commission study." The last such study of major research groups was conducted in 1962.

In fiscal 1969 Government R&D expenditures will exceed $17 billion. About 80 per cent of this goes to support private organizations. The GAO, the watchdog agency that reports directly to Congress, has indicated that the time might be ripe for a reconsideration of the present large use of contractors for the performance of R&D. The GAO suggests that the Nixon Administration redefine what research should be performed by existing Federal laboratories and what should be farmed out to nonprofit companies.

The nonprofit concerns regularly come under fire because of their relatively high pay scales. What is perhaps being overlooked is that they were organized originally to mobilize the best brains obtainable for military and space agency work—not easy to do at comparatively low Civil Service salary rates.

A review in 1962 indicated a real need for such nonprofit R&D groups. But, with the Federal raises approved over the last seven years, the GAO no doubt feels it's time to take another look.

Europe seeks to beef up its computer firms

The European computer industry, which has taken a back seat to American companies in its own territory, is trying to whip up some competition for the future.

International Computers, Ltd., of England, has had talks with Siemens and Telefunken of West Germany and Philips of Holland to explore possible European cooperation in computer research and development. This proposal follows the lines suggested by J. J. Servan-Schreiber, a Frenchman, in a book that long topped European best-seller lists and that caused much comment here.

IBM presently dominates the European computer market. It has about 70% of the market in West Germany, France, Italy, Sweden and Holland. International Computers, which recently acquired the computer section of English Electric Co., has about 50% of the British market.

Siemens has dipped into the continental computer market by buying some 100 RCA Spectra 70 systems and then reselling them; it plans to develop its own line. Philips also plans to come out with a line of five systems, ranging from small to large scale. Its first entry was in the medium range, and a gradual build-up is expected. Philips, too, has bought American machines from Honeywell and then competed for sales against Honeywell, according to Claude Smith, general manager of the company's New Information Services Div.

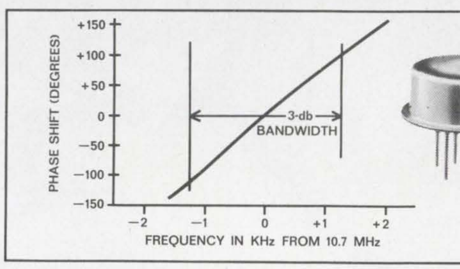
France, which has been trying to develop its own national computer industry under Plan Calcul, has not been very successful, Smith says. French businessmen are not backing the nationalistic effort, preferring instead to do business with American companies.

Servan-Schreiber suggested that computers are the key to the future of industrial strength. Thus, he believes if Europe did not mount a united effort the United States would gradually assume greater and greater dominance over European affairs.

According to International Computers, Ltd., the six countries mentioned earlier had a payments deficit of $72 million in computers (imports over exports) in 1967. This will rise to about $96 million by 1975. A coordinated effort, according to the company, could create a surplus of $312 million by 1975, expand European computer output by $672 million, and create 60,000 additional jobs.

Explorer I–11 years old

America's first satellite, the Explorer I that was launched into orbit on Feb. 1, 1958, completed 60,000 Earth revolutions as it ended its 11th year in orbit. The craft—modest by today's standards, it measures only 6 inches in diameter, 80 inches in length and weighs only 30.8 pounds—was never expected to last much over six years in orbit. It is now expected to say a fiery goodby to space this year.



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DAMON

Accusations rocking the aerospace industry

Officials challenging report by Budget Bureau analyst of deficiencies in electronic systems

Charles D. LaFond, Chief
Washington News Bureau

"A growing and prosperous nation can afford many luxuries, but the low over-all performance of electronics in major weapon systems developed and produced in the last decade should give pause to even the most outspoken advocates of military hardware programs."

With this introduction, Richard A. Stubbing, an analyst in the U. S. Bureau of the Budget, begins a graduate-study thesis that might have remained covered behind the ivy walls of Princeton University but for the fact that it was reviewed publicly by a Washington newspaper late in January. It is now being circulated, unabridged, by the hundreds throughout the country.

In part, the Stubbing paper, titled "Improving the Acquisition Process for High Risk Military Electronics Systems," charges:

- The performance of major weapons systems in the 1950s was poor; in the 1960s it was worse.
- The faulty performance results largely from the unreliability of overly complex electronic subsystems.
- Aerospace prime contractors obtain profits on defense programs that greatly exceed the average non-defense industrial return.
- Major contracts are awarded to aerospace companies despite their records of poor performance in meeting program requirements.

To reverse these trends, the author recommends a return to the competitive development approach employed by the Government more than two decades ago—that is, after examining definitive system needs and narrowing potential manufacturers in the contract definition stage, the Government should pick two suppliers to continue through to prototype development.

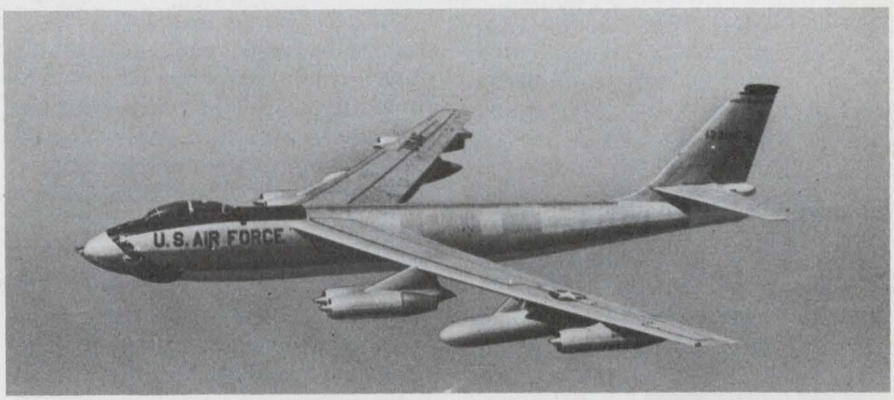
This step would be followed by rigorous system tests. A prime contractor would be selected on the basis of performance on each identified risk area for major subsystems. The minimum development time prior to procurement should be from five to seven years, Stubbing suggests.

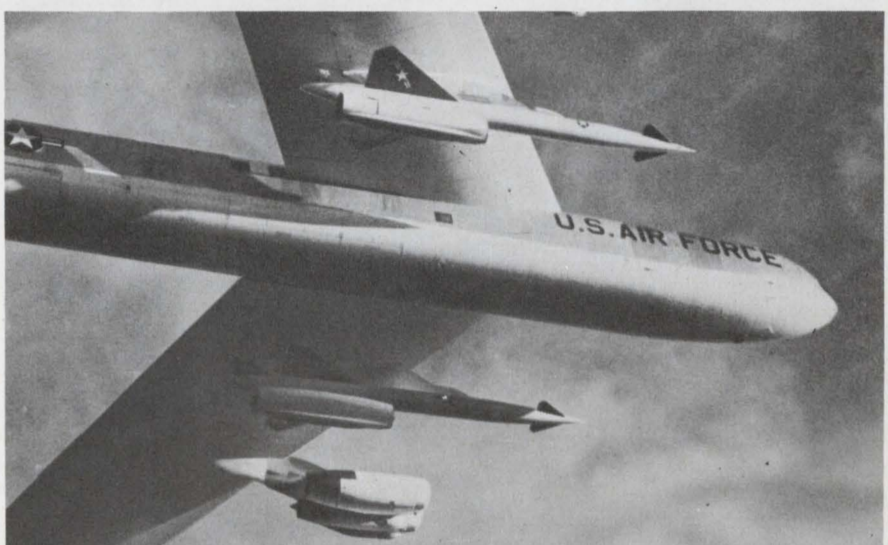
He further proposes early establishment of a second procurement source "to provide an element of competition in the award of annual requirements."

Major contractors queried by ELECTRONIC DESIGN take sharp issue with Stubbing.

Major failures reported

The Government analyst, who wrote this controversial thesis while studying for a master's degree at Princeton during a year's leave of absence from Government service, draws a grim picture of past weapons systems development and performance. Nine of a sample of 13 major Air Force and Navy aircraft and missile programs started since 1955 show dismal reliability, he asserts. Combined, they required a total expenditure of $40 billion, he reports.





The electronic systems aboard the retired B-47 (above) had one of the lowest reliability figures of any major aircraft system, according to aerospace critic Richard A. Stubbing. The B-52 (below) received a high rating.

(**Aerospace,** *continued*)

Two programs, costing $2 billion, were canceled, Stubbing says. Two, costing $10 billion, had only a three-year operational life and were phased out because of low reliability, he continues. And five, he says, that cost $13 billion had electronics reliabilities of less than 75 per cent of that required contractually.

"Less than 40 per cent of the effort produced systems with acceptable performance—an uninspiring record that loses further luster when cost overruns and schedule delays are also evaluated," Stubbing asserts.

Stubbing notes the increasing complexity of weapons electronics following World War II and the tendency to stretch the state of the art. Emphasis grew, he says, for more automatic fire control and all-weather capability for aircraft, and by 1967 costs rose by factor of 15 over those in 1955. Similarly, as missiles progressed from using ground radio control, to on-board inertial systems for guidance and control, their costs soared.

Conclusions are challenged

Electronic Design has questioned officials at General Dynamics, General Electric, Northrop, North American Rockwell, Sylvania, United Aircraft and Westinghouse. Most have challenged the conclusions in the Stubbing paper and all have requested anonymity.

In particular, they note his refence to the two multibillion dollar programs canceled, presumably the supersonic B-70 nuclear bomber and the long-range Skybolt air-to-surface missile. Neither weapon, they say, was dropped because of deficient electronics.

One expert close to the program reports the B-70 never did have its full complement of avionics. The program emphasis was on the development of a radically advanced supersonic, high-altitude aircraft, he says. Most of the electronics aboard the craft were used to support the night testing, he notes, and the B-70 avionics that were employed were subjected to tests far more stringent than those required by the specifications. They proved successful, he asserts.

The huge bomber reportedly was canceled because of a change in strategic requirements. The craft was intended for global high-altitude penetration. Advances in detection radars and antiaircraft missile defenses dictated low-altitude intrusion. Moreover, under the then Secretary of Defense Robert S. McNamara, the military emphasis switched from bombers to ICBMs.

The Skybolt cancellation was based on more complex political-military policy decisions. The present Defense Secretary, Melvin R. Laird, emphatically denies that the cancellation was in any way associated with electronic deficiencies, as implied by Stubbing.

Industry officials point out that the paper totally neglects the pressures created by a strategic weapons race in the mid-1950s. Following the Korean conflict, U. S. weapons progress was slow. Long-range bomber forces were limited, as were intermediate-range ballistic missiles. The only intercontinental ballistic missile nearing deployment was the Snark, a subsonic air breather similar to a jet drone.

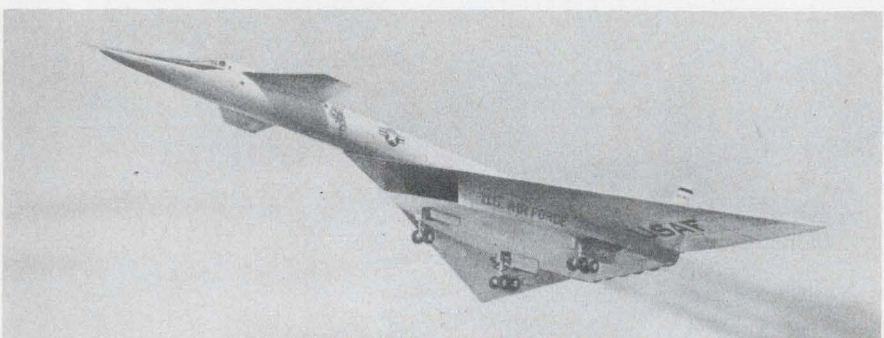
On the other hand, the Soviet Union had developed, earlier than expected, both high-yield nuclear weapons and high-thrust, long-range ballistic missile systems.

A crash program was instituted by the U.S. for concurrent development of three ICBMs—the Atlas, Titan and Minuteman. Each made use of different propulsion systems, reflecting the state of the art of fuels: Atlas used liquids, Titan liquid storables and Minuteman solid fuel.

The associated electronics, too, reflected the state of the art and the deployment needs. The first Atlas series used ground radio command for guidance and navigation. Follow-in Atlases, Titan and Minuteman used progressively more advanced all-inertial guidance systems to reduce response time and to negate the effects of radio blackout following any surprise nuclear attack.

Similarly new aircraft programs had to contend with substantial technological improvements in electronic countermeasures, new missile interception systems, long-range radar detection and discrimination capabilities.

Sophisticated weapons and defenses demand counter sophistication. Stubbing, industry spokesman declare, ignores these influences while damning complexity as an unnecessary luxury.



The B-70 is one of several multibillion-dollar programs canceled in recent years. Stubbing reports the program was dropped because of deficient electronics, but industry spokesmen vehemently deny the charge.

MTBF, a common denominator?

Stubbing defines "high risk" in the development of electronic systems as a condition wherein a major component must be redesigned to permit development of the weapon system. He also uses one parameter to assess performance—Mean Time Between Failure

(**Aerospace,** *continued*)
(MTBF).

He rates performance in terms of actual MTBF attained, as compared with the specified MTBF in the program contract. He further groups the resulting percentages "for simplicity" in "quartiles." Thus, if a system MTBF percentage falls between 13 and 37 per cent, he lists reliability as 0.25; between 38 and 63 per cent as 0.50; 64 to 89 per cent as 0.75; 90 to 115 per cent as 1.00; etc.

In 12 weapon systems deployed during the 1950-1960 period. Stubbing shows the following reliability for their electronics:

Aircraft			
B-47	(0.25)	B-52	(1.00)
B-58	(0.50)	F-100	(1.00)
F-102	(0.50)	F-104	(0.75)
F-4	(1.00)		
Missiles			
"A"	(0.50)	"B"	(0.25)
"C"	(1.25)	"D"	(0.50)

Sidewinder (1.25)

All are considered high-risk except the B-52, F-100 and F-104. Stubbing does not identify any of the missiles, except the infrared-homing, air-to-air Sidewinder, but he notes that missiles A, B, and C were produced under concurrent crash programs and were operational on time. No comment is made on missile D.

Current electronic systems (1960-1970) have become progressively worse, Stubbing charges. ■■

The sensational Stubbing report: How it developed

Who is Richard A. Stubbing, and how did his thesis gain such wide publicity?

Stubbing is a 38-year-old Bureau of the Budget examiner who was selected to attend the Woodrow Wilson School at Princeton University in 1967-68. In his work with the Budget Bureau, Stubbing, a Grade 14 employe, was an examiner of Air Force and Navy aerospace weapons programs.

Thus it appears that he carried with him to Princeton a fund of privy information concerning military development and procurement contracts, much of it classified, as well as study reports prepared previously by several national authorities.

With these data and his own accumulation of information gathered during his five years at the bureau and during a previous four-year stint as a cost engineer with Eastman Kodak, Stubbing subsequently wrote and submitted a master's-degree thesis, "Improving the Acquisition Process for High Risk Electronics Systems," dated May 3, 1969.

From that time onward, the facts become muddled.

Last November the Joint Subcommittee for Economy in Government, headed by Sen. William Proxmire (D-Wis.) held hearings on Defense Dept. contracting procedures and defense industry profits. Among the many who testified was Col. Albert W. Buesking, a retired Air Force officer, then a lecturer in public administration at the University of Southern California. Previously the colonel had been with the Air Force Office of Controller in the Pentagon.

Colonel Buesking revealed a picture of unusually high profits on over $8 billion of Minuteman ICBM contracts from 1958-1966. He cited after-taxes profits on the missile system program of over 20 per cent, or nearly double what he termed the general industrial average.

More to the point, he referred to an unpublished document that he described as prepared by a "Bureau of the Budget Analyst," and he quoted from it. "The current special partnership which exists between Government and the aerospace industry not only results in a very high incidence of delivered electronics systems with degraded performance, but there *are not effective mechanisms* in contractual arrangements to reward or penalize contractor performance."

The quotation is from Page 25 of the Stubbing thesis, except for a slight paraphrase of the italized portion (Stubbing said "is no effective mechanism").

Shortly after this testimony, it was reported that the Budget Bureau had "no knowledge of the document" cited by Colonel Buesking.

Nothing was heard publicly of the Stubbing paper until a summary of its entire contents was revealed in an exclusive story in the Washington Post by Bernard D. Nossiter last Jan. 26. He withheld Stubbing's identity but referred to the author as "a key Government official with access to secret data and responsibility for examining the costs of the Pentagon's complex ventures."

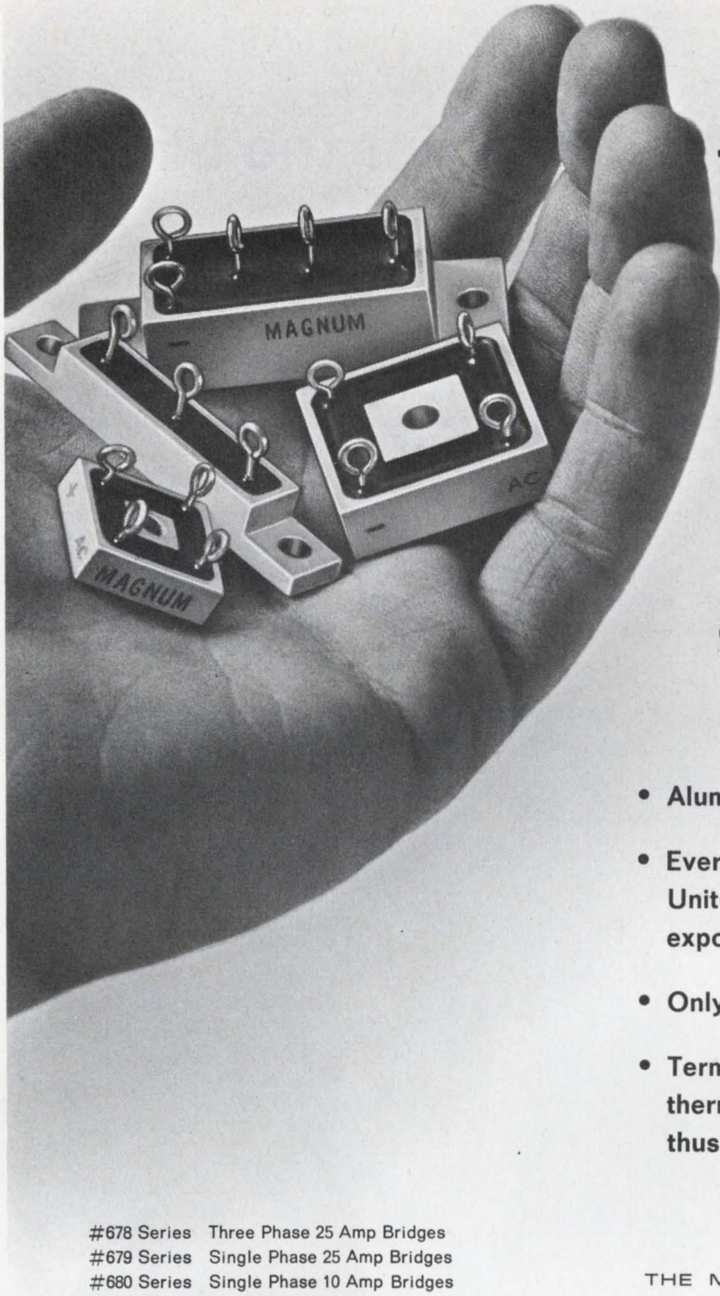
How the paper found its way to Nossiter has not been revealed. However, the most persistent rumor throughout Washington industrial offices is that a top aid on the Proxmire subcommittee staff placed a copy of the Stubbing thesis in the hands of Nossiter on Jan. 24.

Response to the revelations of poor electronic weapons performance and high industry profits was rapid. The newspapers and magazines cautiously rewrote the story and credited the *Washington Post*. A national TV commentator did the same but labeled the paper "junk."

The Electronic Industries Association obtained a copy of the thesis and reportedly sent out further copies to its member companies. It is awaiting their reaction.

William H. Moore, the EIA's vice president and director of its Government Products Div., acknowledges that release of the paper may lead to a Congressional inquiry "and is a threat to all military programs."

EIA's counterpart, the Aerospace Industries Association, is also waiting for member comments. An AIA spokesman, Carlyle Jones, notes that the publicity may add impetus to a bill introduced by Rep. Chet Holifield (D-Calif.) to establish a Hoover-type commission to study the entire Government procurement process.



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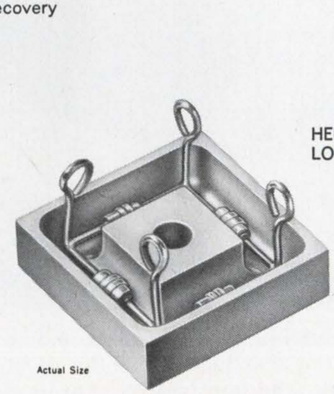

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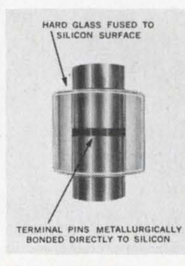

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INFORMATION RETRIEVAL NUMBER 20

Reading aids brighten outlook for the blind

Machines under development scan printed letters or words and provide a tactile or speech output

Elizabeth deAtley
West Coast Editor

"By the year 2000 I'll be able to move a probe or pick-up across the pages of a book and listen while a computer reads aloud to me from the page." So says Eugene Apple, blind chief of the Western Blind Rehabilitation Center, Veterans Administration Hospital, Palo Alto, Calif.

"A machine like that," he says, "would give the blind person what he has never had before—complete privacy. He could read anything—a personal letter, a periodical, or even the label on a can—without having to call in the neighbor or his Aunt Susie to read it to him."

The blind person can never hope to achieve comparable independence with Braille. Although reading rates can be high—over 200 wpm (100 wpm is average) — Braille is so difficult to learn that only about 10 per cent of all blind persons ever master it. Many use Braille only for specialized, simple tasks—like playing cards. Furthermore not all books are published in Braille, and few periodicals are available in it.

What efforts are engineers making to design a talking reader for the blind person? Must he wait, as Apple suggests, until the year 2000? Or is a system almost ready for him now?

Researchers in this field are following three main design approaches. They are attempting to develop:

- A low-cost, semiportable machine, with simple circuitry, that translates printed letters into a "tone code" that the blind person can hear, or into a "touch code" that he can feel with one hand. The user must learn to interpret the aural or tactile sensations, and so far the reading rates have been disappointingly low — 10 to 35 words a minute, even after long practice.
- A nonportable machine that scans the printed page and produces speech output. The equipment includes an optical character recognizer, a speech synthesizer and a control computer. Too large and costly for individual ownership, it could be used in libraries or schools to translate books and periodicals.
- The best of both worlds—a fully portable machine that could be hooked into a central computer at will through time-sharing. It would scan printed pages and produce speech.

These experimental machines have already been built:

- A semiportable tactile system composed of two units: a probe or scanner, and a stimulator. The blind person moves the probe

To use the Bliss-Linvill portable tactile reading aid, the operator moves the probe along the line of print and feels a bundle of stimulator pins vibrating in the shape of the letters. The light display box is used for visual trouble-shooting.

across the printed page with one hand and, by placing his other hand over the stimulator, receives vibrations in the shape of each letter. The machine was designed by Dr. James C. Bliss, manager of the Bio-Information Systems Group at Stanford Research Institute, Menlo Park, Calif., and Prof. John G. Linvill, head of electrical engineering at Stanford University.

- The Cognodictor, a speech machine developed by Mauch Laboratories of Dayton, Ohio. It scans printed pages and spells out each word.
- A speech machine developed at the Research Laboratory of Electronics, Massachusetts Institute of Technology. It scans texts and can recognize 40,000 different words, which it pronounces in real time with appropriate pauses and intonations.

Dr. Bliss and Professor Linvill believe their tactile machine can be adapted for speech and ultimately be linked to a time-sharing computer system.

"We have in mind," says Dr. Bliss, "that a person will have one of our reading aids to use as a stand-alone device, so he can read anywhere, though perhaps at a relatively slow rate. Then if he's near a phone, there will be another attachment that he can plug in, allowing him to call a central system and have it read aloud to him."

The letters tingle

To use the present Bliss-Linvill instrument, the operator moves a probe across the page with one hand and, with the index finger of the other (see photo), feels a bundle of stimulator pins that vibrate rapidly in the shape of letters. There are enough pins so that the operator can feel all or most of a letter at the same time.

This instrument seems to have a considerably higher potential reading rate than other tactile machines. After about 100 hours of practice, Dr. Linvill's teenage daughter Candy, who has been blind since infancy, reads at 35 wpm. This is as fast as a blind adult could expect to read Braille after instruction for the same length of time. Dr. Bliss believes the secret

(**Blind,** *continued*)
of his machine's practicality lies in the large number of stimulators—144 compared with a single row of eight in earlier models. He has found, in fact, that speed is a direct function of the number of rows of stimulator columns being used (each column contains 24 stimulators).

At present the instrument costs between $6000 and $7000 to produce, including labor, Dr. Bliss reports, but he believes it can be mass-produced for considerably less.

ABC's on the go

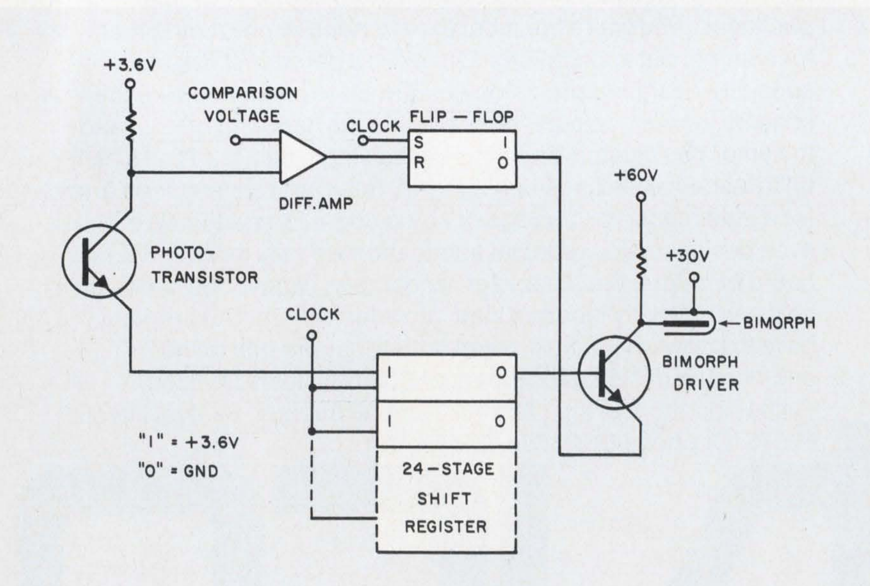
Another approach to the personally owned reading machine is the spelled-speech output. A laboratory prototype of the Cognodictor spells aloud at the rate of 80 to 90 wpm. It was developed by Mauch Laboratories under the auspices of the Veterans Administration. Dr. Hans A Mauch, head of the company, points out that to make sense out of the rapidly spelled letters, "you must learn a vocabulary of spelled words, so that when the machine says 'p-a-r-t-y,' your mind clicks and you think 'this is party.' " Tests conducted by Prof. Milton Metfessel of the University of of Southern California indicate that it is possible to understand spelled speech at this rate, says Dr. Mauch.

The Mauch machine has a prerecorded vocabulary consisting of 26 letters and certain additional signals for special purposes. It recognizes 26 upper- and lowercase letters in nine different styles of typography, but it cannot identify numerals or punctuation marks.

The instrument consists of two parts—a hand-held probe that the operator moves across the page, and a separate box that contains character-recognition circuitry, a drum for storing prerecorded spoken letters, a loudspeaker and a light panel for trouble-shooting. A new prototype that is being designed will be the size of an office typewriter but somewhat lighter in weight, says Glendon C. Smith, designer of the system.

The hand-held probe of the Cognodictor is called a Vistotactor. It is similar in principle to the Bliss-Linvill device. The operator moves it along the line of print and feels the vibrations of a single row of eight stimulators—two on each finger. As the probe moves over an "H," for example, six stimulators vibrate, then a single one in the middle, and finally the same six again. The operator uses this instrument to ensure proper alignment and to identify symbols that the machine misreads or fails to recognize. The Vistotactor contains a mechanism for adjusting the magnification, so that a wide range of type sizes can be read. The instrument can also be used as a "stand alone" device, if desired, but the reading rate is low—10 to 15 wpm.

At present only a single operator has used the machine extensively, Smith points out. The last time this operator was tested—after about 200 hours' practice—she read 32 wpm on a single line, Smith says, and averaged 23 to 24 wpm for a whole page.



1. **A single channel of the circuitry** in the Bliss-Linvill reading aid connects a phototransistor to a corresponding bimorph driver. A bimorph is a reed that has the property of bending when a differential voltage is applied. A 24-bit shift register clocked at 4800 Hz, multiplexes corresponding arrays of 6 by 24 phototransistors and 6 by 24 bimorph drivers. If the base of a phototransistor is dark at a given bit time, the bimorph driver turns on, bending the bimorph and lifting the stimulator pin attached to it. Each dark area beneath the probe causes the corresponding stimulator pin to vibrate 200 times per second.

A dream come true?

The experimental machine developed at MIT is reported to have an error rate of less than 0.3 per cent as it scans and recognizes the 40,000 different words and pronounces them.

The system is surprisingly compact, in view of its complexity. The total bulk—flying-spot scanner, a small general-purpose computer, and the speech synthesizer circuitry—is about the size of two grand pianos and two TV sets.

The machine scans words on the page and translates them into phonemes, or speech sounds, according to rules contained in a built-in dictionary. Then, following programed instructions, it translates the phonemes into electronic control signals. The speech output sounds quite mechanical—like a pipe organ talking—but it is clearly recognizable.

The built-in dictionary does not list all possible forms of every word—such as love, loving, lovely, etc., says Prof. Francis Lee, one of the designers of the system. This would require too large a memory. Instead, it contains root words, prefixes and suffixes. Thus the machine can break a word that is not in the dictionary into separate parts and consult the dictionary for the pronunciation of each part. For example, Professor Lee says, the machine would break the word "lovelier" into the root word "love" and the suffixes "li" and "er."

But suppose the dictionary does not contain the root word "love"? In this case, says Professor Lee, "the machine will apply the phonic rule that the final 'e' is mute and will probably says something like 'lohvelier,' because it won't recognize that the 'o' is pronounced 'uh.' "

In fact, he points out, the machine would attempt to apply phonic rules even to a string of consonants—like czprt. "It would probably blindly put all these consonants together," he says, "and come up with a sound no human being could produce."

This machine does what the blind person wants—it reads aloud from any text he chooses. But what about the cost? Could an individual ever hope to own one? Not, its designers think, within the next five or ten years, but they do expect to see it used in libraries and schools for the blind within that time.

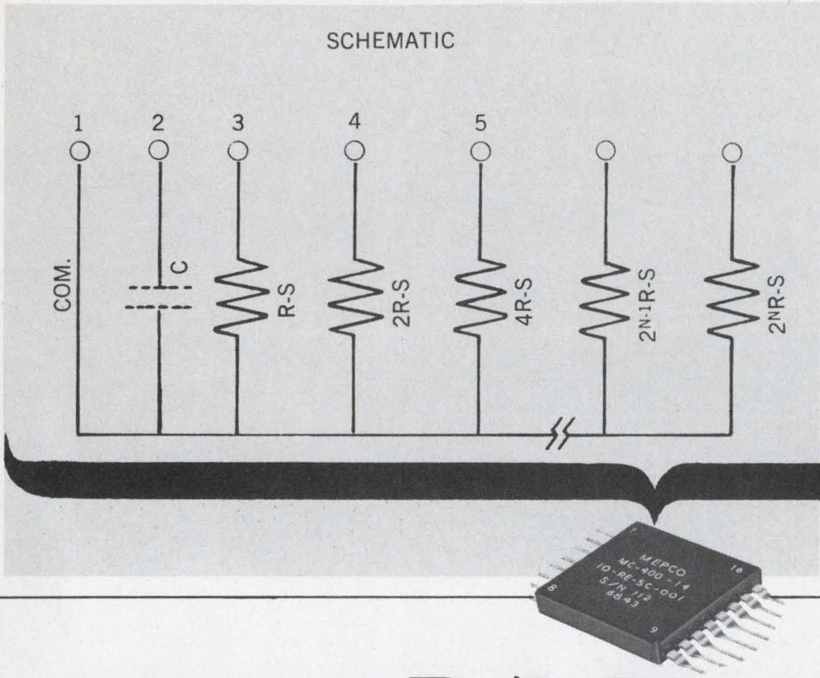
"What about time-sharing?" asked the VA's Eugene Apple when he heard about the MIT system. "You'd only need one computer for the whole San Francisco Bay Area and all the blind people around here could use it at the same time!"

Dr. Bliss agrees. He points out that the blind person could use such a system for many purposes besides merely reading from the printed page. For example, he says, "If you want to send a letter to a blind person now, you have a problem. You aren't about to write it in Braille, and if you type it or write it in longhand, the blind person has to get someone to read it to him. If there was a time-sharing facility available, you could call up the center and say, 'I'd like to leave a message in so-and-so's file.' Then you would type the message and it would be relayed to him."

Dr. Bliss and other researchers at the Stanford Research Institute are setting up simulation studies to determine whether blind users can tolerate the delays inherent in a time-shared system, when combined with the mechanical computer speech. ■■

#2 OF A SERIES

Standard Circuit of the Month



C = Optional

S = Switch Compensation

N = 3 through 9
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D/A Binary Current Summing Ladder

- **Resolution to 10 Bits**
- **Accuracy to 10 Bits (± ½ LSB)**
- **Standard Flatpack configuration**

Mepco Binary Current Summing Ladder Networks provide high speed, high accuracy conversion to within ½ LSB over a variety of standard temperature ranges. Available as factory stock in standard resistance values. These networks can also be compensated for specific switch requirements or adjusted for unique resistance values in accordance with customer specifications, assuring perfect mating with each customer's application.

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INFORMATION RETRIEVAL NUMBER 91

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Now, add 72 basic hardware instructions and most-wanted options: hardware multiply/divide, automatic bootstrap, multiplex data channel, direct memory access channel. And MAC's programmed data channel has 255 I/O addresses.

Then consider a basic quartet of true-nesting priority interrupts, expandable to 64 levels if needed.

And MAC is compatible with almost any real-time systems environment—data communication and acquisition, instrumentation, automatic test, or you name it.

MAC's third-generation software and documentation are ready now, all checked out and debugged. FORTRAN IV, loaders, debugging and editing programs, utility routines, I/O drivers, and LEAP, a macro-handling assembler that's way ahead of others in the MAC class. Plus LEAPFORT, to prepare new MAC programs off-line on large machines, and MACSIM, which lets you use a large computer to simulate MAC in operation.

In every feature and function, MAC gives the systems user his greatest measure of value. As a long-standing producer of computer memories and printed circuits, we've learned to make every little bit count. In performance, reliability and flexibility—and at a good price.

For more information, write to MAC, Lockheed Electronics Company, Data Products Division, 6201 East Randolph Street, Los Angeles, California 90022.

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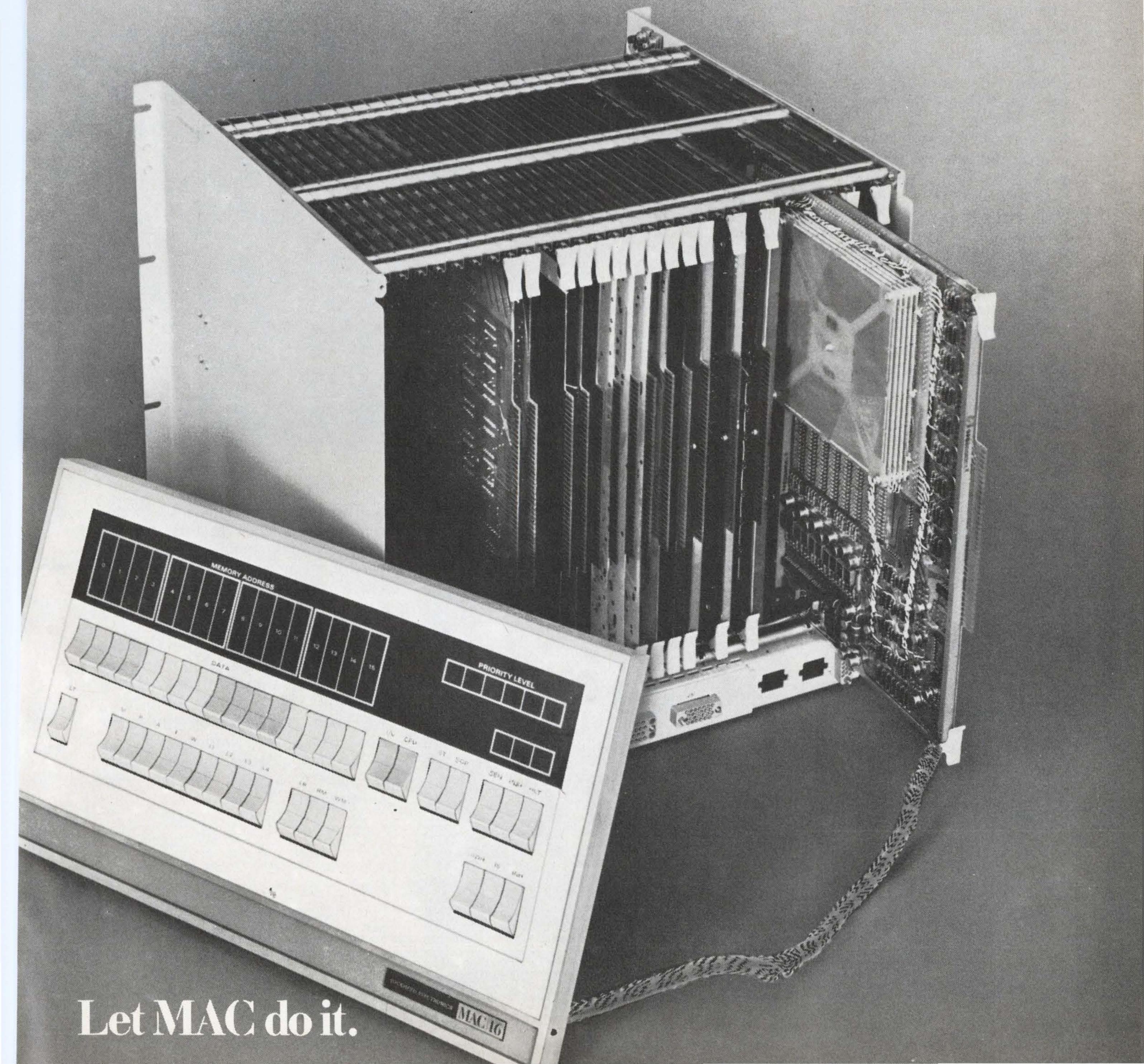
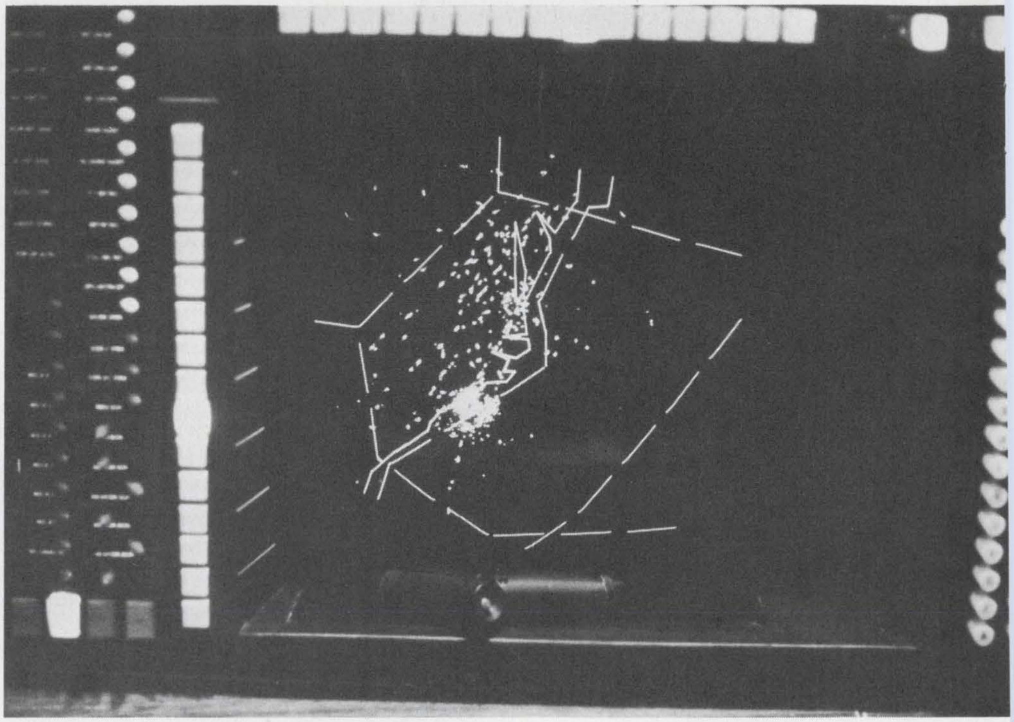


Air-defense display does more

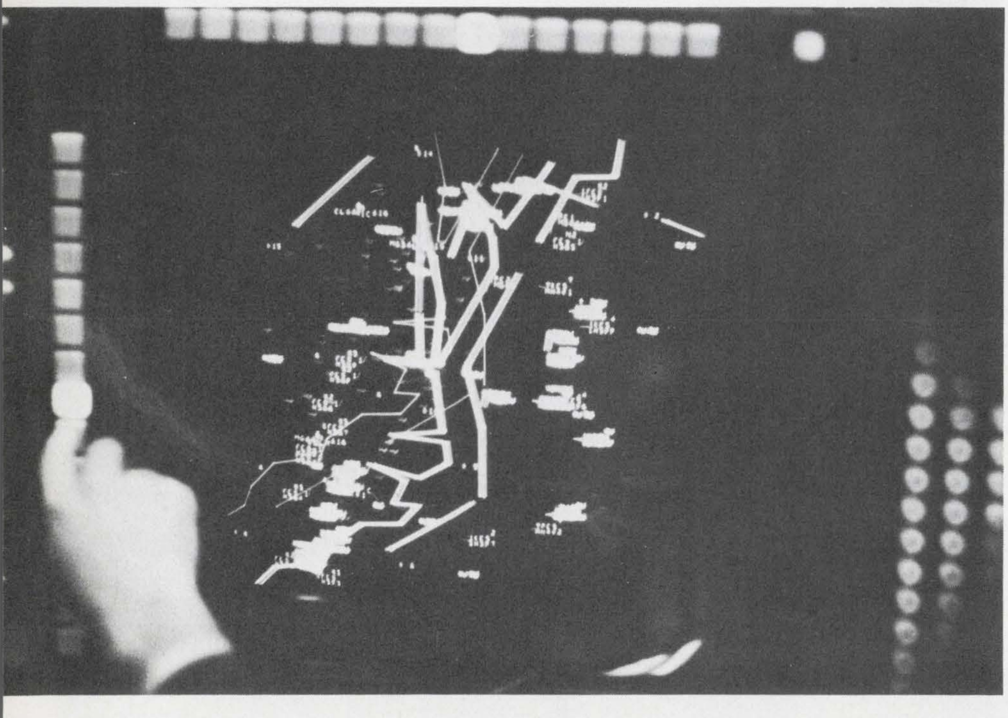
'Friend or foe' determination simplified with versatile TV-type screen and digital computer

John F. Mason
Military-Aerospace Editor

Photographs by Thecla



1. **The TV-like display** shows the geographical area (enclosed by broken lines) that the Buic III site in Fort Fisher, N. C., is responsible for defending should Sage, the first-line air-defense network, become inoperative. The area shown extends roughly from Washington, D.C., to Savannah, Ga. The blips are raw radar returns from aircraft. (No information about them has been requested from the computer.) The zigzag line (dead center) running through the air boundary forms the righthand side of an air corridor through which interceptors have been cleared to fly. The lefthand side of the corridor is the broken line that represents the coast line. This coast line is the only geographical data the operator has requested.



2. **The same area,** shown with different information. (In this display, the air-boundary lines have been removed.) The operator has just pushed the lighted button which shifts the entire scene to the center of his display. The other buttons in this row and along the top are used to center a particular area of interest. The aircraft displayed are no longer raw radar returns; they have been processed by the computer. Additional information appearing alongside each blip reveals the plane's altitude, heading and identification.

An Air Force sergeant, seated before a TV-type display, moves a small switch. Instantly, he sees a raw radar-picture of all the aircraft flying in his area. He flips another switch and these blips become aircraft symbols, processed by a digital computer that identifies each plane. A third switch brings forth data in alphanumeric form that reveal each plane's altitude, heading and speed.

One plane is not identified. Is it friend or foe? The operator points his light gun at the blip and asks the computer.

The computer checks through prefiled flight plans but has no stored information about the plane. The computer then assigns the unidentified aircraft a number so it can be easily referred to by other operators in the Buic III network while they try to identify it.

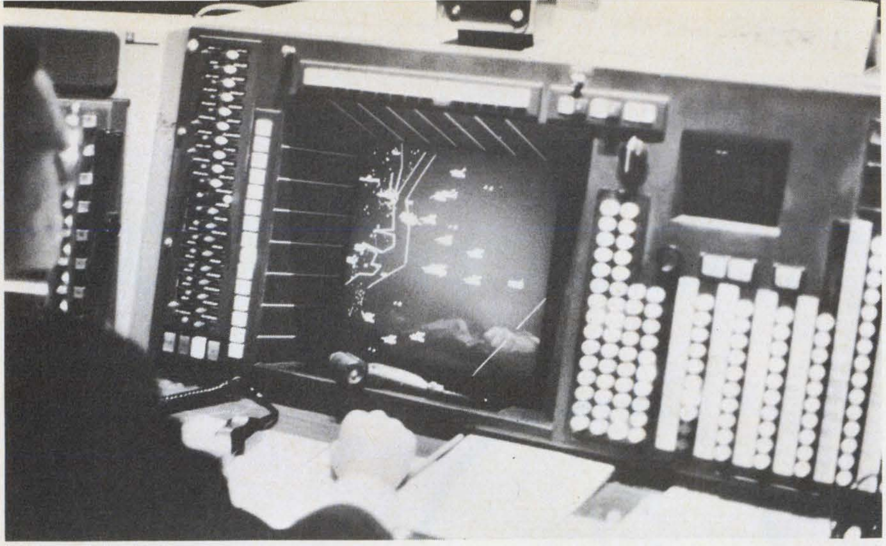
Buic III, (for Back-Up Interceptor Control system) (ED Sept. 12, 1968, p. 25), is a network of 15 sites — 13 in the U.S. and two in Canada — that, upon completion, will stand ready to command and control an air-defense operation if the first-line Sage sites should ever become inoperative. The first Buic III site was turned over to the Air Force at Fort Fisher, N.C., last month (ED 3, Feb. 1, 1969, News Scope, p. 21.)

The Buic III display, the newest data-display defense system to become operational, is considered to be a big jump over other displays—Sage displays, for example, are more than 10 years old—and could well dictate features that will appear in later displays. Buic III's versatility and capacity for displaying selective situations undoubtedly makes it desirable for a submarine sonar room, an airborne command and control system, and, of course, for other ground-based systems.

Other switches on the Buic III console will, at the sergeant's command, bring forth:

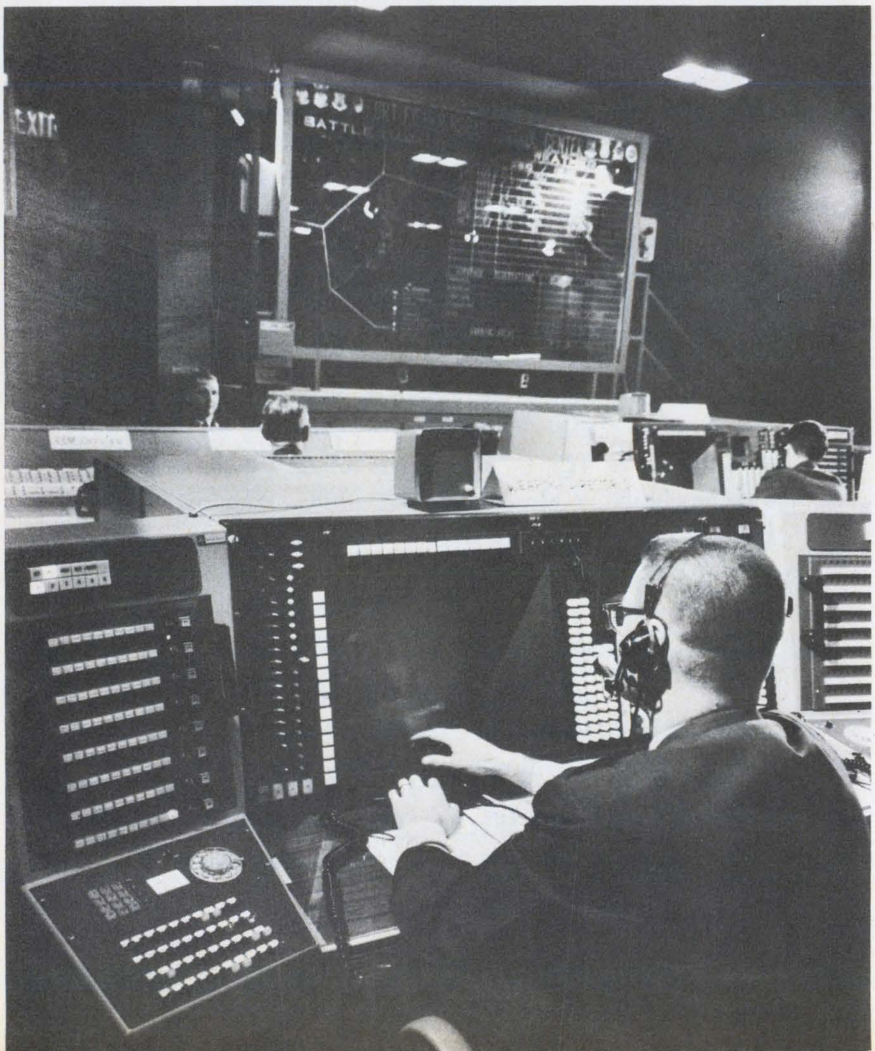
- A geographical map of the area;
- The air-space boundaries — geographical area of responsibility — assigned to a particular Buic III site;

(Continued on page 38)



3. **The operator has moved** the scene off to the left so he can get a better look at several unknown aircraft (center screen). The vertical rows of buttons, at right, are used to query the computer. The operator may aim his light gun (lying at bottom of screen above his hand) on the unidentified blip and press a button to ask the computer to assign a number to the plane. He may push another button in this keyboard for data from a particular radar. Left of the screen there is a vertical row of square buttons that move the picture. Farther left, a vertical row of switches are used to add or delete categories, such as geographic displays, radar sites, airbases and raw data.

4. **The communications console,** to the left of the operator, permits him to talk with any other console operator in the room, with another Buic site, with a Sage site, or with any aircraft shown on the screen. Air-ground communications might go first by landline to the ground-air line-of-sight transceiver station that is nearest to the aircraft of interest. In the background, the big screen is a status display showing battle damage and weather.



- The airbases that stand ready to receive, rearm and refuel manned interceptors;
- Ground-air missile site locations, marked off by circles that describe their effective ranges;
- Radar sites, similarly depicted, with range areas described;
- Ground-air radio transmitters that operate in line-of-sight frequencies—which link the Buic III commander, by landline, to the radio station closest to the aircraft; the station, in turn, relays the ground-to-air communications between an airborne pilot and the Buic III operator.

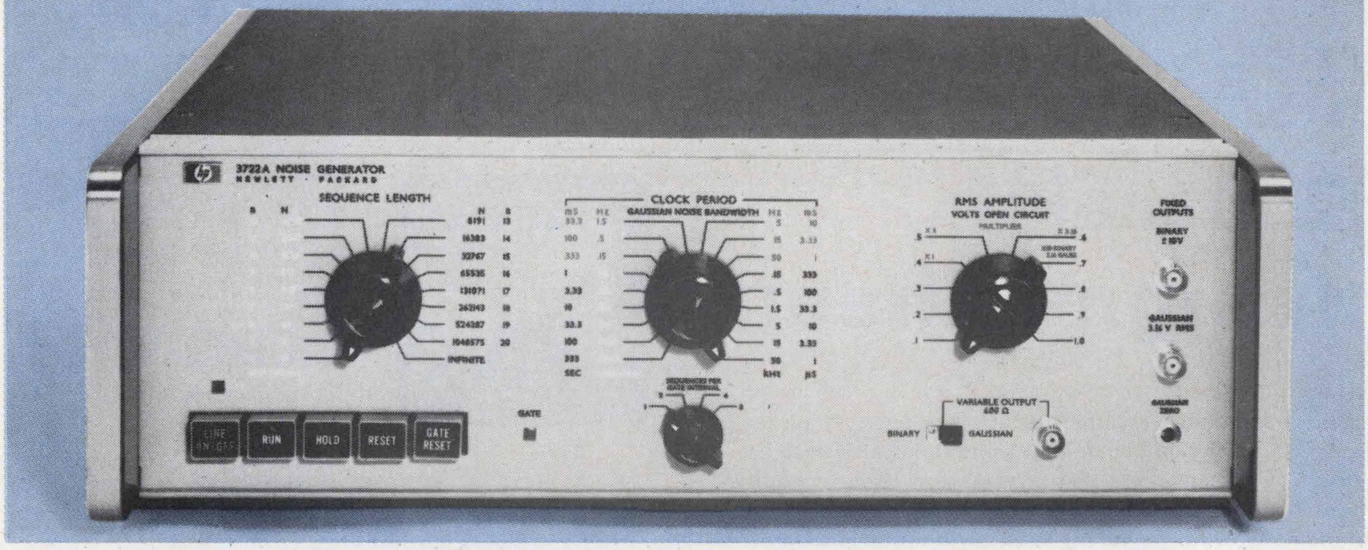
Another handy feature of the new display is its repositioning ability. It can shift the picture on its screen—in a sense, change its visual perspective—to give the operator a better view. For example, if action is all on one side of the screen, the operator shifts the entire scene to the other side, thus putting the focal point of activity in dead center—right before his eyes.

The superiority of the Buic III display over that generated by Buic II is achieved by better computer programing and some extra hardware. Requiring only one-third more equipment than Buic II —mainly memory cores and drums —the new system generates twice as much information to twice as many operator consoles.

Burroughs Corp.'s Defense Group, Paoli, Pa., produced the display and the two D825 computers that generate the information. The Systems Development Corp. of Binghamton, N.Y., produced and installed the programing.

Each data-processing set consists of two D825 digital computers—one operates in an active mode while the other performs a diagnostic function. Each contains four drum memories, and each memory contains two independent memory modules—word-organized ferrite core arrays that operate with a read-write cycle time of 4.33 microseconds. Access time is 1.67 microseconds. Each memory holds 4096 words of 48 information bits and one parity bit, for a capacity of 32,768 words.■■

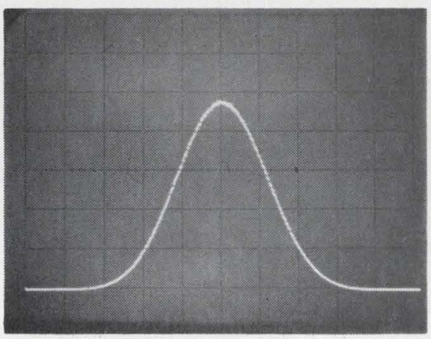
Put noise to work

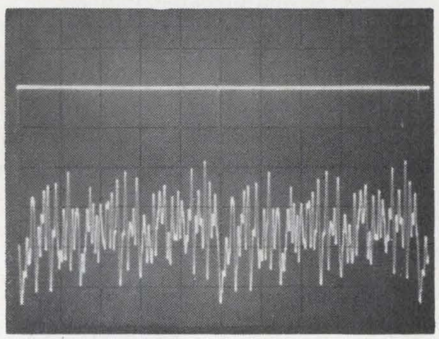


DC to 50 kHz, HP now offers calibrated, repeatable noise patterns, random or pseudo-random, constant power and excellent Gaussian distribution.

Write for Application Note 98-1, first in a series entitled "Noise at Work," this one discussing the design of process control systems.

EXCELLENT GAUSSIAN DISTRIBUTION
Using HP 5400A Multi-Channel Pulse Height Analyzer, ±250 mw; 1024 channels; Noise Generator: sequence length, 1,048,575; clock period, 3.33 μsec.





REPEATABLE
Sweep time of oscilloscope, 0.2 millisec/cm; Noise Generator: sequence length, 1023; clock period, 1 μsec.

The Hewlett-Packard 3722A Noise Generator now lets you harness noise so that it becomes a defined and calibrated input to your system. It allows you to synthesize and reproduce at will noise signals of constant noise power with a probability density function (pdf) in the classical Gaussian construction. This unique new instrument uses computer techniques to synthesize noise patterns of selectable length that are thoroughly defined and repeatable.

Because the 3722A employs a unique combination of digital and analog filtering, it is able to produce usable controllable power at low frequencies not previously possible. And, too, the digital nature of noise generation enables exact repetition of noise patterns of selectable length. This can save you hours of testing time, and you can test circuits, components or systems with confidence. System responses can be completely defined.

Ideal for such applications as control system response measurements, communications testing, acoustic measurements, temperature and flow fluctuations, study of air, water and earth turbulence—and other real-time analog simulation. HP 3722A, $2650.

For more information call your local HP field engineer or write Hewlett-Packard, Palo Alto, Calif. 94304; Europe: 1217 Meyrin-Geneva, Switzerland.

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SIGNAL SOURCES

INFORMATION RETRIEVAL NUMBER 25

When you need RF CAPACITORS, Centralab designs them

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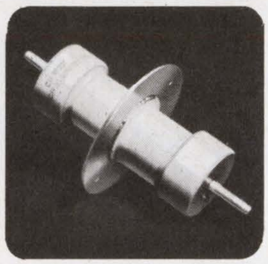

Feed Through

Single Cup,
including water cooled

Need dependable ceramic dielectric capacitors to replace vacuum, oil-filled or mica units? **Centralab designs them.** Need capacitors that are stable at high temperatures? **Centralab designs them.** Need capacitors to handle high voltage and high current? **Centralab designs them.** Need small size capacitors with high capacitance? **Centralab designs them.** Need capacitors to operate at medium current and voltage? **Centralab designs them.** Need transmitting capacitors for plate blocking with high power transmitting tubes? Or high transmission line coupling? Or bypassing in high voltage circuits? Or neutralizing? **Centralab designs them, too.** In fact, Centralab custom engineers transmitter capacitors for industrial equipment, commercial and military transmitters of all kinds.

And ceramic capacitors from Centralab offer more custom-design features, last longer and are backed by more comprehensive application engineering skill than any other capacitor you can use. Don't let lesser capacitors shut down your equipment.
Stay operational with Centralab.

To put the reliability of Centralab's ceramic RF capacitors to work for you, send reader service card today. Centralab's Application Engineering Department will contact you to discuss your design requirements. Or, if you prefer, send drawings and requirements directly to Application Engineering Department 2XO at the address below.

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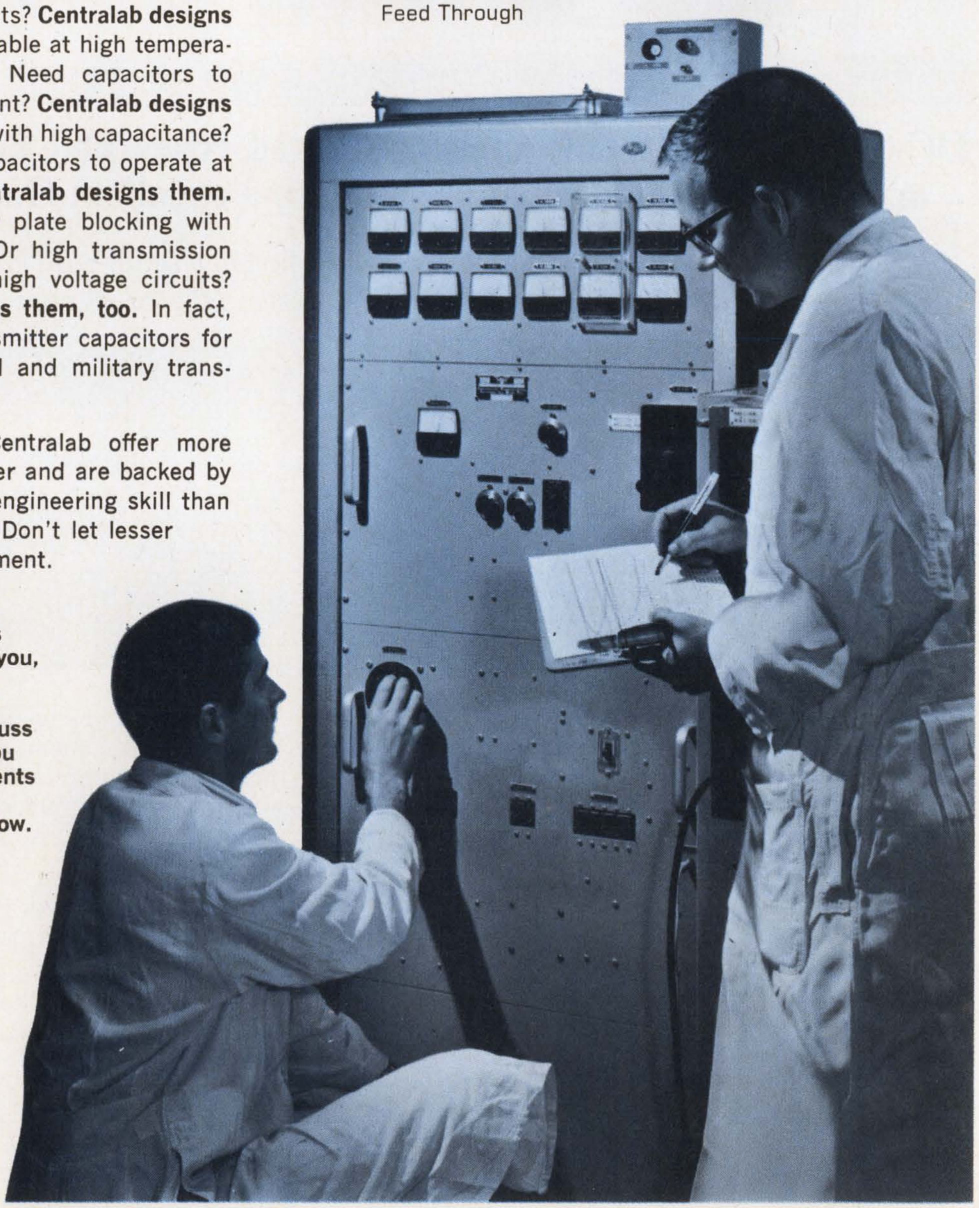

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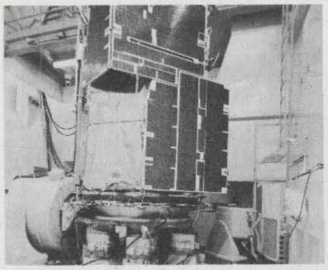
INFORMATION RETRIEVAL NUMBER 26

Push Earth satellites



Washington Report

CHARLES D. LAFOND
WASHINGTON BUREAU

More money for Earth-oriented satellites

Expand the applications satellite program, so say the experts of the National Research Council's Division of Engineering, in their latest—second—report covering the "Useful Applications of Earth-Oriented Satellites." The report recommends a broad continuing program that would cost from $200-300 million annually. The council says that "the practical benefits to be obtained from Earth-orbiting satellites appear to be very substantial, and would justify two to three times the current level of Federal support."

The report concedes that high economic gains have already resulted from the use of satellites in meteorology and communications. But applications for satellite techniques are needed in other fields. These include:

- A multi-channel distribution system for both public and private TV broadcasting.
- A multi-channel system for educational broadcasting to developing countries that could also be used for programs beamed to special interest groups (physicians, lawyers, engineers, etc.).
- A North Atlantic navigational satellite system that would provide traffic control while enroute for transoceanic aircraft and ships. (The council notes that such a system "would be likely to pay for [its] cost" when used by such internationally bound aircraft and ships alone.)

The council's report also stresses the need for an Earth-sensing satellite system to report on everything from agricultural conditions and water-resource management to global weather variations. The report stresses that the practical use of imaging sensor satellites is at hand, but that their practicality depends on the development of sensor signature: a catalog of data that would permit the discrimination of data for practical applications. The council recommends an immediate Earth-resources pilot program, and the initiation of a 10 to 12-year development plan for more sophisticated sensors.

Navy classifies news stories

For years, news reporters here have fought the "battle of the security stamp." Now, its getting tougher. The Navy has recently been placing a Secret classification on newspaper articles appearing here and throughout the country that openly reveal information concerning a "Project Sanguine." Just because information appears in public print, Navy officials say, is no reason for them to regard it as having been declassified. And, they say, continuing to classify the articles the Navy thus does not sanction publication of the material.

Now about the Project in question: establishment by the Navy of a large, very-high-power, very-low-frequency, transmitting station at a undisclosed location in Wisconsin.

The new system is designed to provide instant communications around the globe to all Naval forces, including submarines. This, by itself, conflicts with the fact that the Navy already owns two high-power megawatt, low-frequency stations established for exactly this same purpose in Maine and Washington.

Because Rep. Alvin D. O'Konski (R.-Wis.) has made much of the expected prosperity to come to his

Congressional district (he has projected up to 10,000 new jobs), it can be presumed that the Sanguine site is destined for the west central part of the state, in the vicinity of Chippewa Falls. The area is considered to be economically depressed, which may explain why the Congressman is so elated over the impending boom.

Also presumed: only those with a Secret clearance should have been able to read this.

New Zealanders fear Omega site

The U. S. Navy is apparently having the same trouble with New Zealanders that the Army is experiencing with people here at home in its attempts to locate ABM sites near cities. The Navy wants to locate new Omega navigational transmitter stations along the New Zealand coast, to cover a large part of the South Pacific area. The New Zealand Government has already agreed to let the U.S. make site surveys but, with the announcement that informal discussions were being held on location of the site, protests arose.

It's now evident that the Navy failed miserably in its public relations. The New Zealanders are convinced that erection of an Omega site automatically sets their country up as a prime target for a nulcear attack, in case of war. Nothing could be further from the truth. While Omega will indeed help U.S. Naval forces to establish more reliable means of navigation, the same system will be open for use by ships of all countries. As reported previously in this column, several British ships, including the new Manchester Guardian, plan to employ the Omega network.

Why the Navy didn't say this, before the New Zealanders became aroused, only the Navy knows. For not only would Omega aid other nations, but construction of the site itself could only help the local economy. Sites now under consideration include Lake Pearson and Lake Summer in the New Zealand Alps. Construction costs alone, which will probably go to local firms, will range from $4 to $6 million.

Army wants new tactical missiles

The Army missile command has just awarded conceptual design contracts to Boeing, Chrysler, LTV, Martin-Marietta and Northrop for development of a new Multiple Artillery Rocket System.

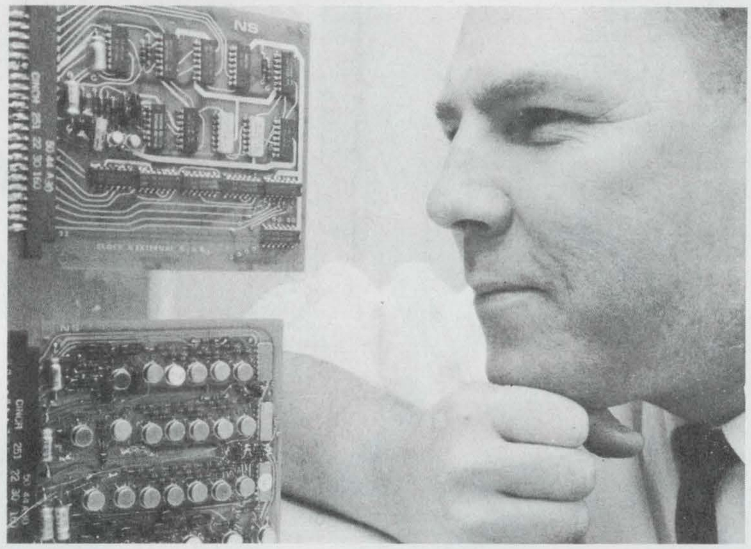
Worth roughly $500,000 each, the six-month studies seek designs for a mobile intermediate-range bombardment system that would be capable of performing area saturation and that could carry up to ten missiles. Informants say the weapon will include some form of simplified but reliable guidance and control system—very possibly, all fluidic.

The Missile Command has also asked industry to submit conceptual designs for four other missile systems. In a recent request for quotations, the Army asked for proposals for a tank-type device, with emphasis on fire power; a new weapon to replace the present light anti-tank assault weapon; an anti-tank assault/air defense weapon for use against both aircraft and armored land vehicles, and a new artillery-type missile that would be fired from Army aircraft.

No indication was given by the Army as to the type of electronic fire-control support and of guidance and control it wants for any of these weapons. The Army has left the complete design concept of each system up to the imagination of industry, in the hope that this open approach will serve to reduce R&D time for each system.

'Frighten us with orders'

Some very interesting predictions are being made by Dale Mrazek—wide use of MOS registers in memory and logic applications, and prices as low as 3 cents a bit. Skeptics who challenge National Semiconductor's ability to produce MOS at these prices don't bother him. "Frighten us with production orders," he says with a grin.



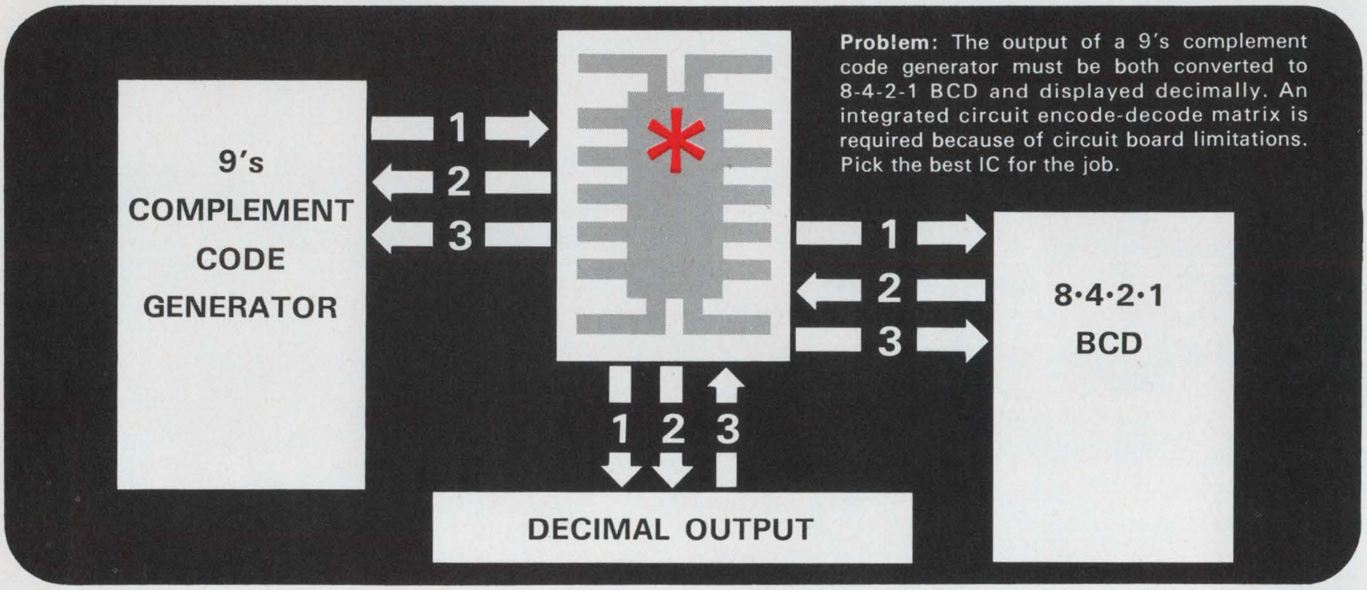
After earning a BSEE degree and doing post-graduate work at the University of Denver, Dale spent some time in the Midwest working on a/d converters, analog stimuli generators, logic switching and multiplexers. Then he joined Signetics to work in read-write and read-only memories—and was lured to National a year ago. Since then Dale has been spending a lot of his time acquainting engineers with the possibilities of MOS devices. See p. 50.

'Lighting' the world of the blind

Candy has been blind since infancy. She plans to enter college next fall and doesn't consider her blindness a real obstacle; she can read Braille at 160 wpm. Candy also happens to be the daughter of Prof. John Linvill, head of the Electrical Engineering Dept. at Stanford University and co-developer, with Dr. James Bliss of Stanford Research Institute, of a portable tactile reading machine for the blind.

Candy hopes to use the device to scan college lecture notes or books not available in Braille. After about 100 hours of practice, she has learned to read with the machine at 35 wpm. There are other reading aids under development for blind people like Candy. For a glimpse at the latest, turn to p. 30.

Pick the BEST IC for the job



Problem: The output of a 9's complement code generator must be both converted to 8-4-2-1 BCD and displayed decimally. An integrated circuit encode-decode matrix is required because of circuit board limitations. Pick the best IC for the job.

the BEST Solution:

THE RADIATION RM-84 DIODE MATRIX

Solve the problem easily. Combine only *four* * RM-84 diode matrices from Radiation and form a 16 x 10 matrix array. Six code conversions can be performed by this single bi-directional array to replace approximately 80 logic elements. The code pattern will be customized quickly from our complete stock of standard matrices.

Radiation diode matrices are dielectrically isolated, eliminating cross-coupling and allowing easy customization. These circuits can be combined with Radiation interface circuits to provide the most economical, convenient and reliable diode logic available.

Contact your nearest Radiation sales office. Ask about our diode matrix line. Let us help you pick The Best IC for The Job.

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EDITORIAL

Technology may yet save this madding world

How many social hours have you spent defending the engineer's and the scientist's role in improving civilization, while your doctor, lawyer and Indian chief friends have blamed modern technology for the evils in today's world? And how much time have you put in arguing against your friends' dire premonitions that computers will one day reduce all people from names and personalities to numbers with blank expressions?

Well, if you've been through these sessions, take heart. An educator with facts says you're right and they're wrong. Modern technology has elevated man to his highest level of individualism, according to a preliminary report on a long-range study of the impact of technology on society. Reporting in the fourth year of a 10-year study funded by IBM, Dr. Emanuel G. Mesthene, executive director of the Harvard University Program on Technology and Science, says: "This is probably the first age in history in which such a high proportion of people have felt like individuals." Technology, according to the study, is creating a fruitful society with a wide range of personal choices and high levels of self-worth.

However, individuals with their new-found freedoms have begun to make bolder demands on their government, warns Prof. Edward Shils, one of the Harvard program's researchers. And to demonstrate their individualism, he says, they will increase their demands, with a high probability of a rise in public disorders.

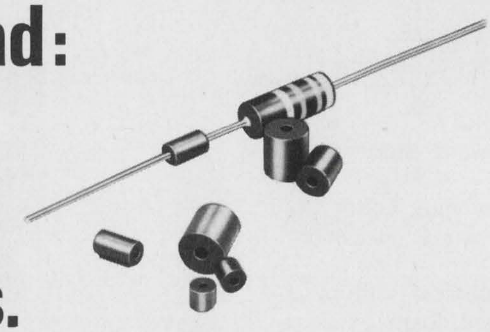
One step to maintaining stability in government, Dr. Mesthene suggests, may be to rely more on "technocrats" who can apply computer analysis techniques to solving the increasingly complex affairs of our growing society. How best to allocate the billions in the national budget . . . how to assign priorities so the most urgent programs are tackled first . . . how to adapt electronics systems approaches to social problems—these and more are likely areas for computer analysis.

But the individual citizen must be made fully aware of the role of the technocrat, lest his new feeling of individualism be submerged once more.

No easy task. Still, the new Administration in Washington may do well to fill important government positions with more experienced scientific and engineering decision makers and fewer experienced politicians.

HOWARD BIERMAN

The phenomenal ferrite bead:



Stackpole's simple solution to noise and filter problems.

Ceramag® ferrite beads offer a simple, inexpensive, yet effective means of obtaining RF decoupling, shielding, and parasitic suppression without sacrificing low frequency power or signal level.

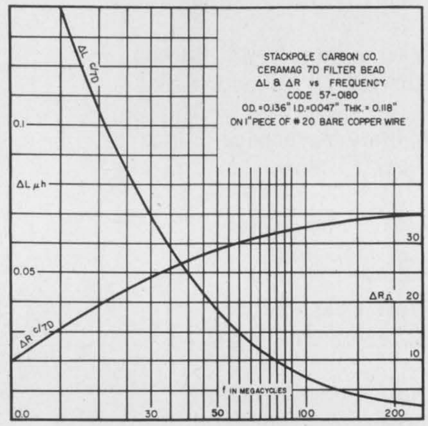
Unlike conventional RF chokes, beads are compact, have no DC losses, and will not couple to stray capacity and introduce detuning or spurious oscillations. Ceramag® beads offer an impedance which varies from quite low at low frequencies to quite high at noise frequencies. Beads need not be grounded; however, chassis contact is permissible when desired, as beads possess sufficiently high resistivity to preclude grounding.

Installation of Stackpole beads is easy. Simply slip one (or several) over appropriate conductor(s) for the desired noise suppression or high frequency isolation. Beads are available in sleeve form in a range of sizes starting at .025 ID, .060 OD, and .400 long. For special compact filtering applications such as cable connectors, beads can be supplied to tight mechanical tolerances.

Several ferrite grades provide a variety of attenuation characteristics. Inductance tolerance is normally $\pm$ 30% as measured on an LC meter. The performance of a Ceramag® 7D bead as a parasitic suppressor is shown in Figure 1.

Other applications might include: decoupling in "B" circuitry; noise suppression; RF isolation in filament circuits; use in combination with capacitors to form "L" networks.

FIGURE 1



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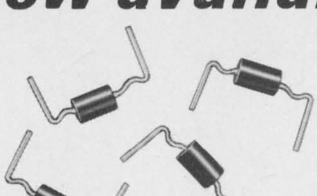
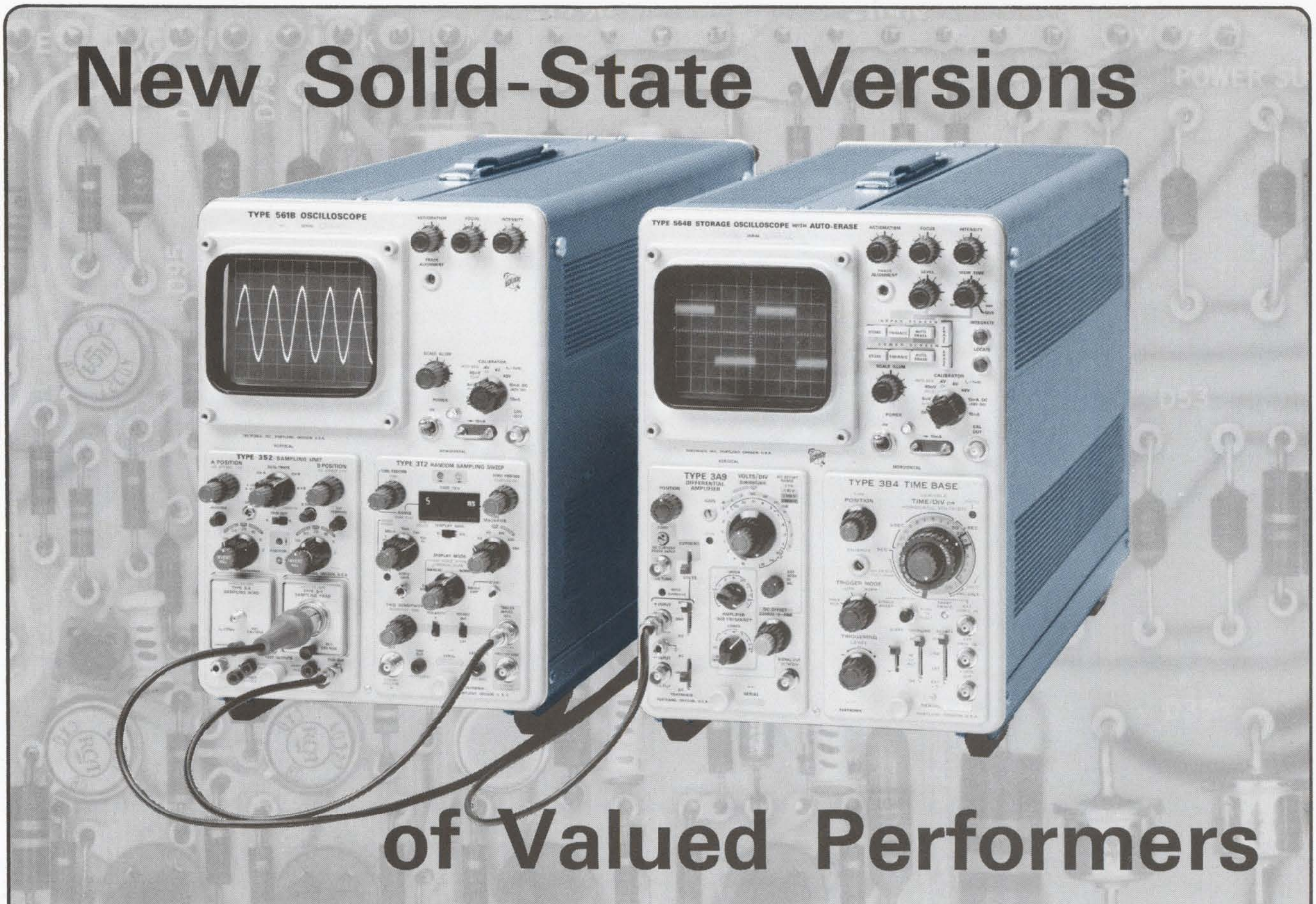


Additional savings in production time and labor costs are now possible by utilizing automatic insertion equipment to install Ceramag® ferrite beads in printed circuit boards.

product report

PLUG-IN OSCILLOSCOPES

New Tektronix 560B Series



Solid-state, large screen (8 x 10 cm), internal graticule, dual plug-in oscilloscope defines the new Type 561B. Use of solid-state components throughout offers low-heat dissipation for reliable operation to further expand the performance capabilities of this oscilloscope. Short-proof circuitry has been designed into all low-level power supplies, providing lower output impedance and minimum signal crosstalk. The addition of a quick-change line voltage selector permits operation from any of the following voltage ranges: 90 to 110 V, 104 to 126 V, 112 to 136 V, 180 to 220 V, 208 to 252 V, or 224 to 272 V over a line frequency range from 48 Hz to 440 Hz. The Type 561B calibrator accuracy has been significantly improved in both frequency and amplitude. The 1-kHz frequency is held to ±1%, while the amplitude is maintained at ±1½%.

Total measurement capabilities, through the use of more than 25 different plug-in units, offer the user complete versatility in measurement applications. The dual plug-in unit feature allows conventional displays or X-Y displays with either single-trace, dual-trace or four-trace units. Sampling displays, as well as spectrum analysis and raster generation, are also possible with the Type 561B.

The Type 564B offers all the advantages of the Type 561B, plus an added split-screen storage feature. Greater versatility is thus provided in that either half of the 8 x 10 cm display can be independently controlled, allowing stored or conventional displays on either the upper or lower half. The contrast ratio and brightness of the stored displays are constant and independent of viewing time, writing and sweep rates, or signal repetition rates.

Automatic erasure, after a preselected viewing time of 1 to 12 seconds, is added to the Type 564B MOD 121N. Also incorporated is a SAVE mode which interrupts the automatic erase cycle and preserves the stored information. Remote operation of the erase function is also possible with the Type 564B MOD 121N.

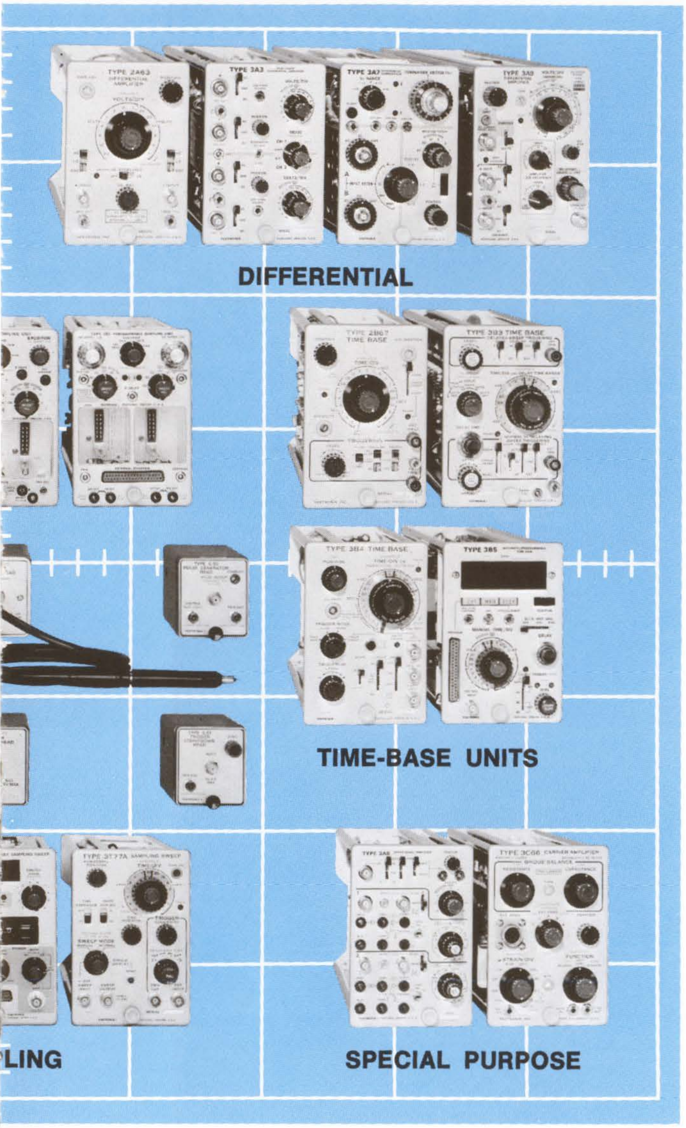
Both the Type 561B and Type 564B have rack-mounted counterparts that occupy only seven inches of rack height.

Type 561B	$ 560
Type 564B	$ 995
Type 564B Mod 121N	$1150

U.S. Sales Prices FOB Beaverton, Oregon

please open for additional information

ement Capability
Series Oscilloscopes



lines normally preclude the need for a pretrigger.

The Type 3S2 and its programmable counterpart, the Type 3S5, use the new sampling head principle. Both units are dual trace and will accept any of 6 available heads: the Type S-1 head is 50-Ω input, 350-ps t_r; the Type S-2 head is 50-Ω input, 50-ps t_r; the Type S-3 head includes a captive probe with 100 kΩ, 2.3-pF input impedance, 350-ps t_r; the Type S-4 head is 50-Ω input, 25-ps t_r; the Type S-50 head is a 25-ps pulse generator with a 400-mV, 100-ns wide pulse; and the Type S-51 head provides trigger countdown for stable synchronization from 1 GHz to 18 GHz. When using the S-1, S-2, S-3 or S-4 heads both the Type 3S2 and 3S5 provide deflection factors of 2 mV/div to 200 mV/div.

Companion sampling time bases are the Types 3T2, 3T5 and 3T77A. The Type 3T2 provides for either random or sequential sampling with sweep ranges from 20 ps/div to 100 μs/div. The Type 3T5 is a programmable counterpart of the Type 3S5 and provides 10 ps/div to 100 μs/div sweep ranges, as well as a calibrated sweep delay. The Type 3T77A provides calibrated sweep ranges of 20 ps/div to 10 μs/div. Each of these time bases includes a time expander that provides 10X expansion of the time scale while maintaining a constant number of dots/div.

DIFFERENTIAL

PLUG-IN	DF	BANDWIDTH	T_r	PRICE
2A63	1 mV/div	DC to 300 kHz	1.2 μs	$ 175
3A3	100 μV/div	DC to 500 kHz	0.7 μs	850
3A7	1 mV/div	DC to 10 MHz	35 ns	695
3A9	10 μV/div	DC to 1 MHz	350 ns	490

Differential operation is useful for measurements between two above ground points and for cancellation of in-phase signals such as hum pick-up at the signal source.

The Type 2A63 is a low-cost DC coupled differential unit. It provides 1 mV/div deflection factor at a bandwidth of DC — 300 kHz. The common-mode rejection ratio of this unit is up to 250:1.

The Type 3A3 is a dual-trace differential unit with deflection factors of 100 μV/div to 10 V/div at a constant bandwidth of DC—500 kHz, and up to 50,000:1 CMRR.

The Type 3A7 adds to its capabilities of up to 20,000:1 CMRR and deflection factors of 1 mV/div to 50 V/div, an internal comparison voltage for use as a differential comparator.

The Type 3A9, a state-of-the-art differential plug-in, provides selectable upper and lower frequency limits from DC to 1 MHz, 10 μV/div to 10 V/div deflection factors, and a CMRR of up to 100,000:1. A separate current probe input provides AC current readings from 1 mA/div to 1 A/div using available Tektronix current probes.

TIME-BASE UNITS

PLUG-IN	FASTEST RATE	MAGNIFIER	PRICE
2B67	1 μs/div	X5	$ 225
3B3	0.5 μs/div	X5	650
3B4	0.2 μs/div	X1 to X50	450
3B5	0.1 μs/div	X10, X100	950

Time-base plug-ins are linear sweep generators that provide a wide range of calibrated time ranges for accurate time measurements.

The Type 2B67 is a low-cost time base providing calibrated sweep speeds from 1 μs/div to 5 s/div. A 5X magnifier operates over the full time base and increases the fastest rate to 0.2 μs/div.

The Type 3B3 is used to generate normal and delayed sweeps from 0.5 μs/div to 1 s/div. A 5X magnifier increases the fastest rate to 0.1 μs/div, while an incorporated single sweep function facilitates photographic recording of waveforms.

The Type 3B4 features a direct reading magnifier of up to 50X operating over the full range of 0.2 μs/div to 5 s/div and extending the fastest range to 0.05 μs/div. A single sweep function and a calibrated external horizontal input are also incorporated.

A companion to the Type 3A5 vertical unit, the Type 3B5 operates automatically from 0.1 μs/div to 5 s/div.

SPECIAL PURPOSE

PLUG-IN	DF	BANDWIDTH	T_r	PRICE
3A8	20 mV/div	DC to 3.5 MHz	100 ns	$ 650
3C66	10 μstrain/div	DC to 5 kHz	70 μs	450

The Type 3A8 provides two operational amplifiers, each with an open loop gain of 15,000 at DC and an open loop gain bandwidth product of 10 MHz or greater.

The Type 3C66 carrier amplifier unit with suitable transducers allows for measurements as broad as the mechanical field itself. The Type 3C66 provides calibrated deflection factors from 10 μstrain/div to 10,000 μstrain/div at a bandwidth from DC to 5 kHz.

Complete Measur
with Tektronix 560

MULTI-TRACE

PLUG-IN	DF	BANDWIDTH	T_r	PRICE
3A3 Dual-Trace	100 μV/div	DC to 500 kHz	0.7 μs	$ 850
3A6 Dual-Trace	10 mV/div	DC to 10 MHz	35 ns	525
3A72 Dual-Trace	10 mV/div	DC to 650 kHz	0.54 μs	295
3A74 Four-Trace	20 mV/div	DC to 2 MHz	0.18 μs	650

Multi-trace plug-ins provide a time-sharing method of displaying output signals of two or more channels with a single gun CRT. It may be done in one of two ways: alternate mode of operation—switching is done in sequence after each sweep; chopped mode—switching is done in sequence at a rate not referenced to the sweep.

The Type 3A3 contains two independent high-gain differential amplifier channels with FET inputs. Deflection factors of 100 μV/div to 10 V/div at a constant bandwidth of DC—500 kHz as well as 50,000:1 common-mode rejection ratio are features of this plug-in.

The Type 3A6 can be operated in any one of five modes for variety of single- and dual-trace displays. The Type 3A6 has 10mV/div deflection factor, 35-ns risetime and internal vertical signal delay lines.

The Type 3A72 is a general-purpose dual-trace plug-in featuring 10 mV/div — 20 V/div deflection factor with DC — 650 kHz bandwidth.

The Type 3A74 provides four separate but identical channels. Each channel has a deflection factor of 20 mV/div from DC to 2 MHz. An internal trigger signal can be selected from one of two sources.

SINGLE TRACE

PLUG-IN	DF	BANDWIDTH	T_r	PRICE
2A60	50 mV/div	DC to 1 MHz	0.35 μs	$ 125
3A5	10 mV/div	DC to 15 MHz	23 ns	825
3A75	50 mV/div	DC to 4 MHz	90 ns	195

The Type 2A60 is a low-cost general-purpose plug-in with a DC — 1 MHz bandwidth and decade deflection factor steps from 0.05 V/div to 50 V/div.

The Type 3A5, an automatic plug-in unit, features a bandwidth of DC — 15 MHz and deflection factors from 10 mV/div to 50 V/div in its seeking mode. A manual control provides additional deflection factors of 1, 2 and 5 mV/div. Programmable functions include V/div, input coupling and AC trace stabilization by contact closure to ground.

The Type 3A75 is a wideband general-purpose plug-in unit with deflection factors of 50 mV/div to 20 V/div and a bandwidth from DC — 4 MHz.

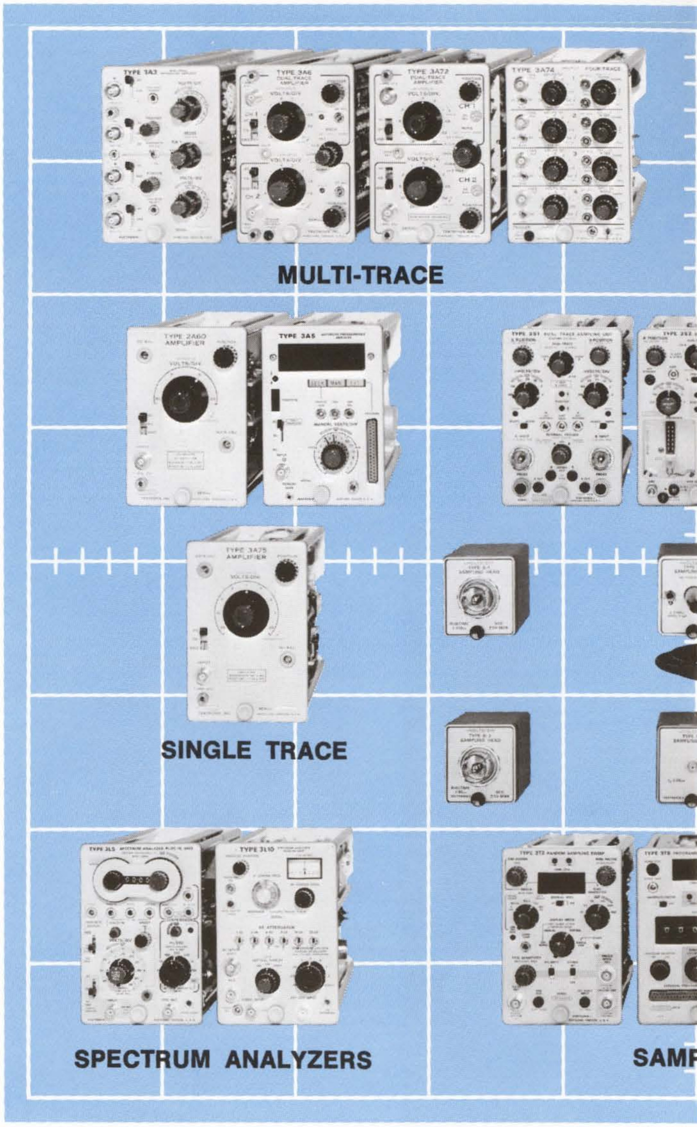
SPECTRUM ANALYZERS

PLUG-IN	DF	CENTER FREQ	PRICE
3L5	10 μV/div	50 Hz to 1 MHz	$1,125
3L10	—100 dBm	1 MHz to 36 MHz	1,275

Spectrum analyzer plug-ins provide a method of studying the energy distribution of a given electrical signal by plotting relative amplitudes against a frequency base.

The Type 3L5 operates over a center frequency range of 50 Hz to 1 MHz and provides accurate spectral and time-base displays from 10 Hz to 1 MHz. A deflection factor of 10 μV/div to 2 V/div and a dynamic range of 60 dB makes the Type 3L5 applicable for vibration studies, waveform analysis and noise measurements.

The Type 3L10 operates over a center frequency range of 1 MHz to 36 MHz, with a CW sensitivity of —100 dBm. Calibrated dispersion and coupled resolution on both the Type 3L5 and 3L10 make frequency measurements as easy and accurate as time measurements.



SAMPLING

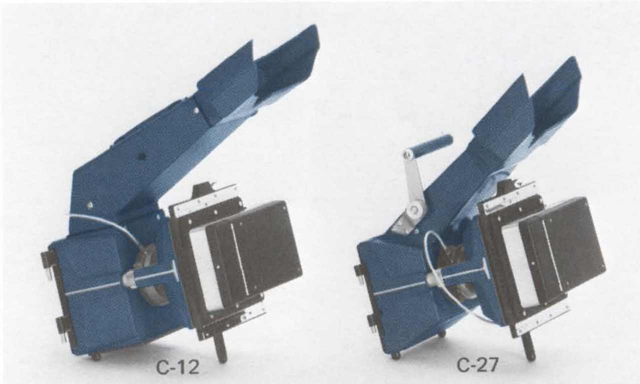
PLUG-IN	DF	BANDWIDTH	T_r	PRICE
3S1 Dual-Trace	2 mV/div	DC to 1 GHz	350 ps	$1,195
3S2 Dual-Trace	2 mV/div	S-Series Heads		850
3S5 Program	2 mV/div	S-Series Heads		1,550

PLUG-IN	FASTEST RATE	MAGNIFIER	PRICE
3T2	0.2 ns/div	X10	$1,000
3T5 Program	0.1 ns/div		1,650
3T77A	0.2 ns/div	X10	700

Sampling plug-in units convert the Types 561B and 564B into sampling oscilloscopes. As opposed to conventional or real-time oscilloscopes, sampling oscilloscopes do not display a waveform directly but rather rely on a stroboscopic approach of looking at many discrete portions of the input waveform to reconstruct it. Compared with conventional oscilloscopes, sampling provides better sensitivity with risetimes of 25 ps and equivalent bandwidths of 14 GHz and beyond. Time scaling, random-noise cancellation and better overload-recovery capabilities are other advantages offered by sampling techniques. However, as its name implies, multiple samples must be taken with the requirement that the input waveform must be repetitive.

The dual trace Type 3S1 is a nominal 50-Ω input unit with a risetime of 350 ps. Deflection factors of 2 mV/div to 200 mV/div are available. Internal delay

Extra Values . . . . .


C-12 C-27

CAMERAS

The C-12 and C-27 general purpose trace recording cameras are suitable for use with the Tektronix 560 series oscilloscopes. Both cameras feature lift-on mounting, swing-away hinging, comfortable binocular viewing, easily-accessible controls, and lens and back options. A special beam-splitting mirror in the C-12 reflects a portion of the image up through the viewing tunnel, giving the viewer the impression of a straight-on view of the CRT. This no-parallax binocular viewing is especially desirable when the oscilloscope has an external graticule.

C-12 . . . . $460
C-27 . . . . $430

ELECTRIC SHUTTER/SPEED COMPUTER

An Electric Shutter/Speed Computer is available for both the C-12 and C-27 cameras, permitting remote actuation of the camera. It is intended for use in areas where a large number of cameras need to be remotely controlled or when there is limited access to the oscilloscope and camera at the time of use.

C-12-E Electric Shutter Camera $665
C-27-E Electric Shutter Camera $635

SCOPE-MOBILE® CARTS

Type 201 Scope-Mobile® carts feature tilt locking in any one of nine tray positions. The adjustable tray locks in six 4.5° steps in the upward direction and two 4.5° steps in the downward direction from the horizontal axis. A storage drawer is provided in the Type 201-1 while the Type 201-2 provides both a storage drawer and a plug-in carrier.


201-2

Type 201-1 . . . . $130
Type 201-2 . . . . $140

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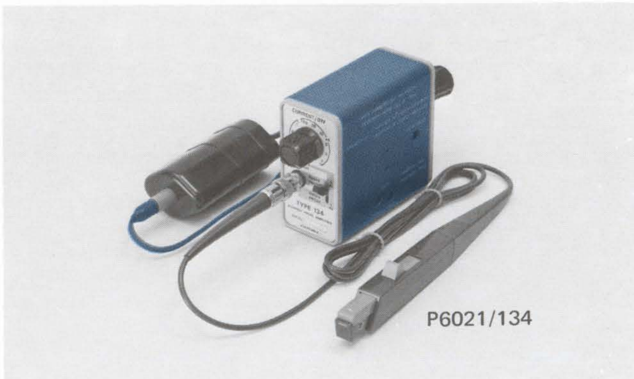
PROBES

Tektronix offers a choice of voltage and current probes designed to be compatible with circuit measurement requirements. The probes are designed to monitor the signal source with minimum circuit loading while maintaining waveform fidelity.

A prime consideration in selecting the proper probe is the circuit loading effect of the oscilloscope/probe combination. The probe with the highest input impedance will provide the least circuit loading. Probe attenuation ratio is also an important consideration. The oscilloscope must have enough gain to compensate for the attenuation of the probe.


P6021/134

The P6021 AC Current Probe and Type 134 Amplifier provide the facility for accurate current measurements over the wide range of 12 Hz to 40 MHz without breaking the circuit under test. Used with any plug-in unit having a deflection factor of 50 mV/div, the P6021/134 provides deflection factors from 1 mA/div to 1 A/div.

P6021/134 . . . . $295


P6042

The P6042 DC-50 MHz current probe utilizes a variation of the Hall effect, offering capabilities for making both high-frequency and DC current measurements. The P6042 consists of an amplifier with built-in power supply, six-foot probe cable, and probe head. Deflection factors from 1 mA/div to 1 A/div are provided when the P6042 is used with a plug-in unit having a deflection factor of 50 mV/div.

P6042 DC Current Probe $625

To help you select the right probe for your application, please consult Tektronix Catalog #28 or call your Tektronix Field Engineer.

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

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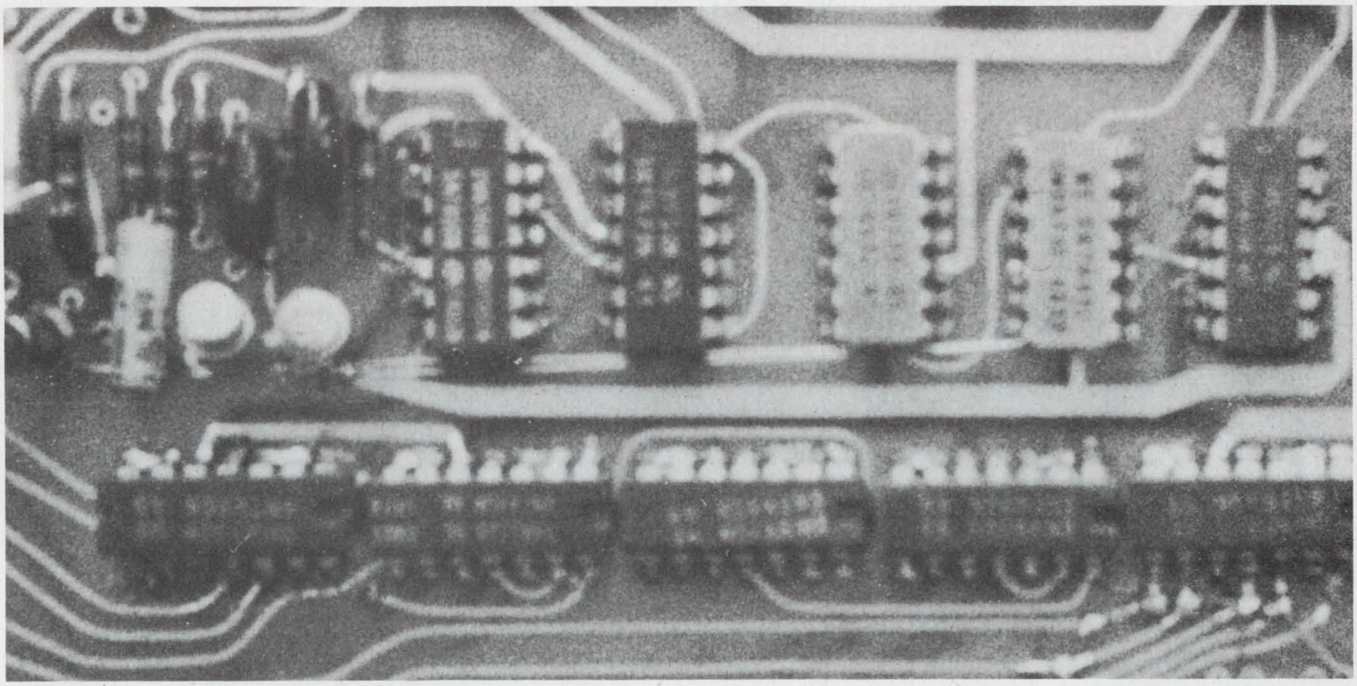
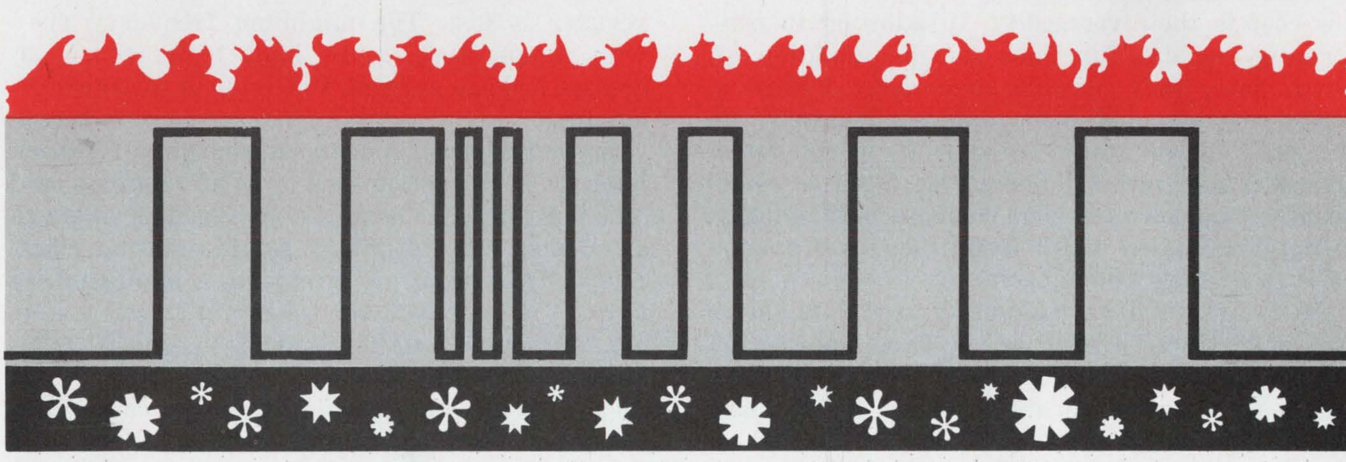
Technology



When you shift to MOS registers you shrink delay line cost, size and dissipation, and you also get the benefit of independently variable clock rates. Page 50.



Fever or chills got your rf power level? Try headache remedy No. 1: a servo loop that stops linear and nonlinear power variations caused by temperature variations. Page 60.

Also in this section:

Shrink delay line costs with MOS.

New shift registers offer low cost, size and dissipation plus independently variable clock rates.

Digital system designers used to be very cautious about committing themselves to electronic delay techniques. The required bistable circuitry was bulky and expensive and physical delay systems—glass rods with suitable drivers and transducers, for example—were usually more economical. But MOS shift registers have changed all that! MOS delay lines are a practical —often the least expensive—means of obtaining delay.

Short MOS delay lines, up to 500 bits, are now much cheaper than physical delay devices of comparable length. Typical MOS registers currently cost only 5 to 7¢ per bit, aaginst 15 to 25¢ per bit for magnetic or physical lines. And medium-length lines, up to a few thousand bits, are cost-competitive.

A potential cost saving, of course, is something that cannot be ignored by any designer. And that is what MOS registers offer. Coupled with their low cost is their versatility. In addition to performing register functions for manipulation of serial data, they provide time delay within a digital system, and store data—indefinitely, in the case of the static register. Properly gated arrays of registers will operate perfectly as small drum memories—and can compete economically in applications in which drum memories cannot be used to their full capacity.

MOS lines offer variable delays and data rates. An MOS shift register has a fixed number of storage locations, of course, but the shift rate and delay time per bit are governed by the clock period. To change the delay time, as required by the system, the clock period can be varied—from dc to a fraction of a microsecond for some registers. The clock can even be interrupted to temporarily store data in the line. This flexibility is exceedingly attractive to systems designers because the delay time can now accommodate the needs of the system. With physical delay lines, the system often has to be designed around the unalterable characteristics of the delay device.

Dale Mrazek, Senior Application Engineer, National Semiconductor Corp., Santa Clara, Calif.

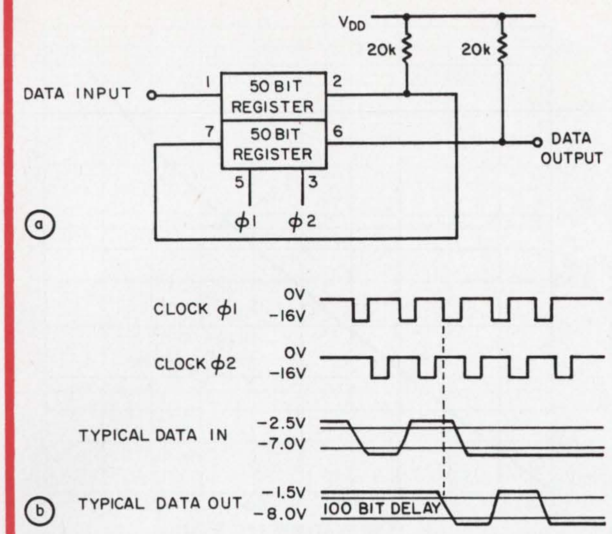
Two families of MOS registers—static and dynamic—are used in digital delay lines. Both types produce output logic levels within the standard MOS range of eight to ten volts. The outputs can be tied to the inputs, to recirculate data (Fig. 1), or data can be shifted directly into other register or logic circuits. Both register families are readily interfaced with bipolar logic circuits such as TTL. There are, however, several important differences between static and dynamic registers.

Register types and how they differ

Dynamic registers require a two-phase clock that must always run at or above some minimum frequency, typically 400 Hz at an operating temperature of 70°C. They depend upon charge storage for data retention, and if the clock runs too slowly, or stops, the information stored in the register is lost. The minimum frequency rises with temperature, since high temperature increases leakage current and reduces charge-storage time.

Static registers, in contrast, contain a feedback latch in each storage cell (register stage) and will not lose data even if the clock is stopped. Also, they require only a single external clock, internally generating a second, complimentary clock. The price paid for the nondestructive storage feature of static registers is more transistors per storage cell. Static cells are about one and a half times as large as dynamic cells—they occupy about 45 square mils of area on the chip. Cost per bit is higher—static registers cost about 7¢ per bit, in large quantities, as opposed to 5¢ per bit for dynamic registers. Power dissipation is also higher. Static cells generally dissipate 1.8 per bit (independent of frequency) against 0.8 mW per bit (at 1 MHz) for dynamic registers (new dynamic cell designs will make possible 0.3 mW per bit operation at 1 MHz in the near future).

Registers capable of storing up to 512 bits per IC package are representative of the present state of the art. Generally, the more cells per package the lower the per-bit cost of the registers



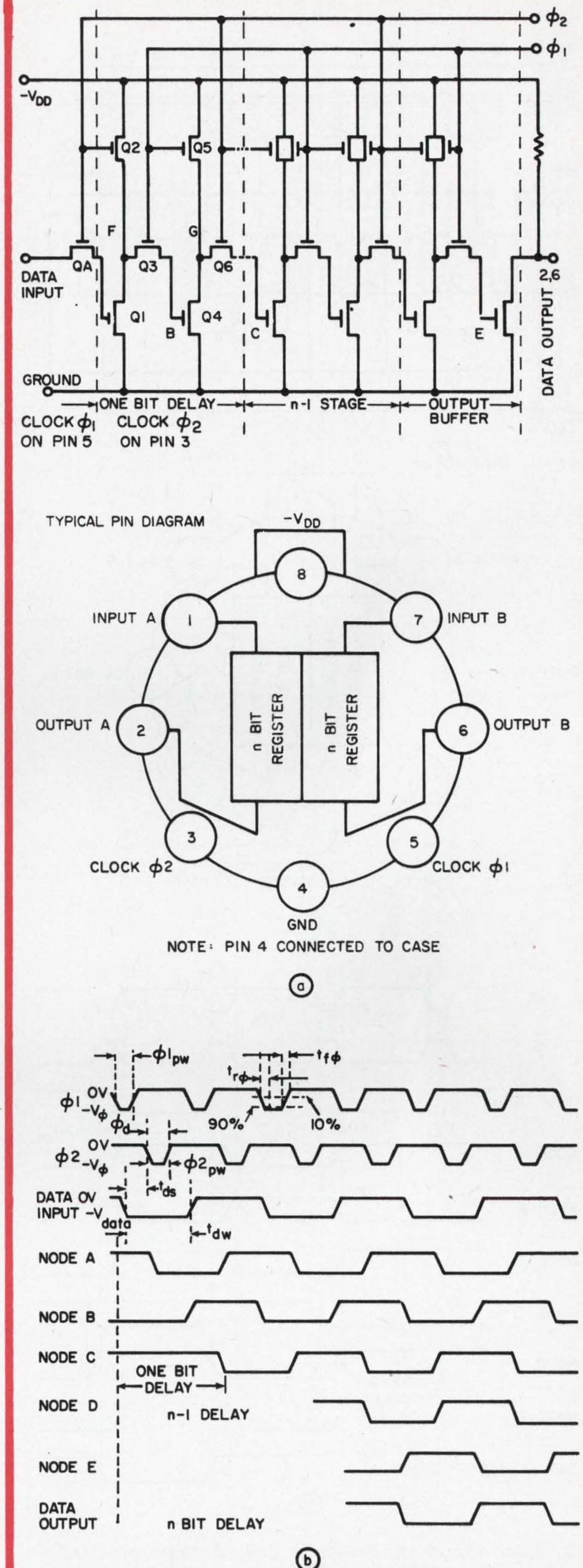
1. **A dual dynamic register is series-connected to make a simple 100-bit delay line** (a). Data clocked to the register input appears 100-clock-pulses later (b) at the output.

and thus of the delay line itself. Off-the-shelf registers generally have capacities that are powers of 2, such as 64 bits, because they are designed for use by logic designers who use binary systems. They are also available in capacities that are multiples of 25, such as dual 100-bit (200 bits per chip), for designers who live in the decimal world. Odd-numbered capacities for special applications can be produced to order by the vendors.

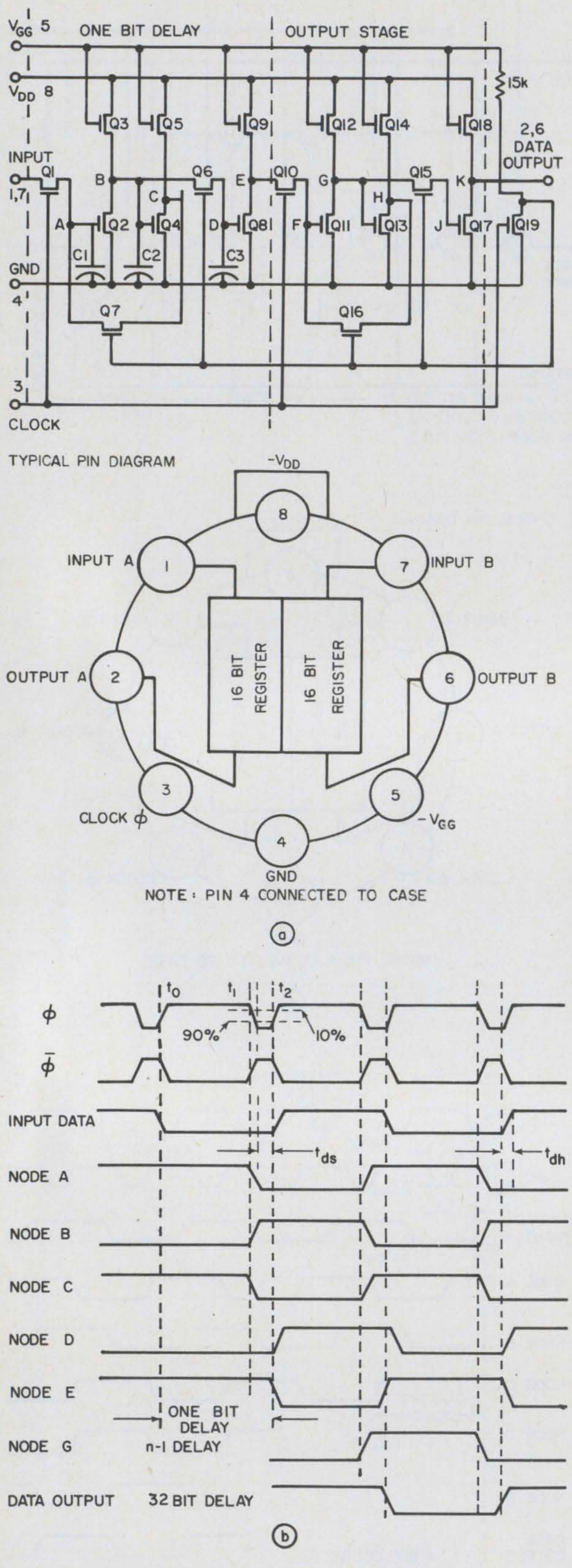
The total delay in each type of register equals the product of the clock-period and the number of storage locations. A 100-bit register clocked to shift data at 1 MHz, for instance, will delay each bit of data by 100 μs. Lines and recirculating loops within lines can be composed of series or parallel units clocked at the same or at different rates. Line capacities, data storage, and delays can therefore vary greatly.

A storage stage in an MOS dynamic register typically contains six field-efffect transistors: two inverters, called *Q1* and *Q4* (Fig. 2), load resistances *Q2* and *Q5*, and couplers *Q3* and *Q6*. The clocks, Φ1 and Φ2, supply the negative gate voltages required to turn on the resistors and couplers, while the data input signal biases the inverters. The register operates as follows:

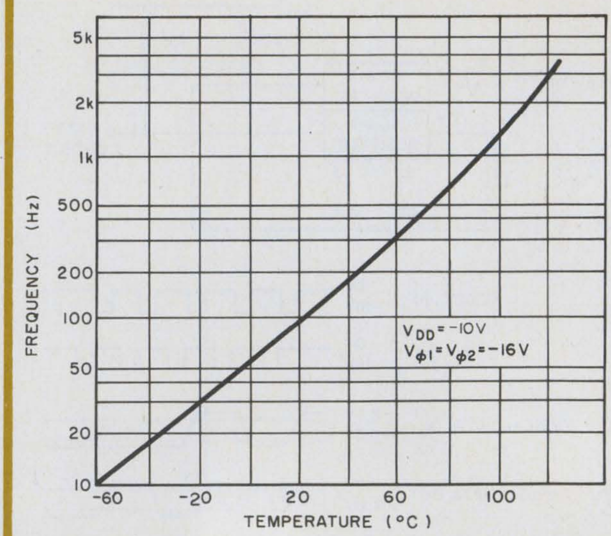
Assume that the register has been set up by a Φ1 clock pulse to receive a logic "1" pulse at the input. Conventionally, the input data-bit for a logic "1" is a negative voltage near the drain-voltage level $-V_{DD}$ (and for a logic "0" is a voltage near ground level). Input coupler *QA*, inverter *Q1* and resistance *Q2* will all be off (no conduction between source and drain). As clock Φ2 goes negative it turns on *QA*, coupling the data input to node *A*, turning on *Q2*. Since the input was negative, *Q1* also turns on, charging



2. **The dynamic shift-register cell contains six MOS transistors.** Information is shifted within the cells when Φ1 goes negative (turning on devices Q3, etc.) and is shifted between cells when Φ2 goes negative (a). The data is clocked out of the register during the Φ1 clock time, n-clock-periods after data entry, where n is the size of the register in bits (b).



3. **Each static shift-register cell contains nine transistors** in an Eccles-Jordan feedback-latch configuration (a), with Q6 and Q7 acting as cross-coupling resistors. Information is transferred between cells on the clock pulses via Q1 and Q10 (b), and is transferred within cells on the complementary clock pulses ($\bar{\Phi}$), which are generated internally. The static register will store bits indefinitely, even if the clock is interrupted.



4. **The minimum operating frequency of a dynamic register** depends on its operating temperature. The dynamic cell does not have a feedback latch and must depend on charge-storage for retention of data. Leakage resistance, directly proportional to temperature, limits the storage time—and hence imposes a minimum operating frequency.

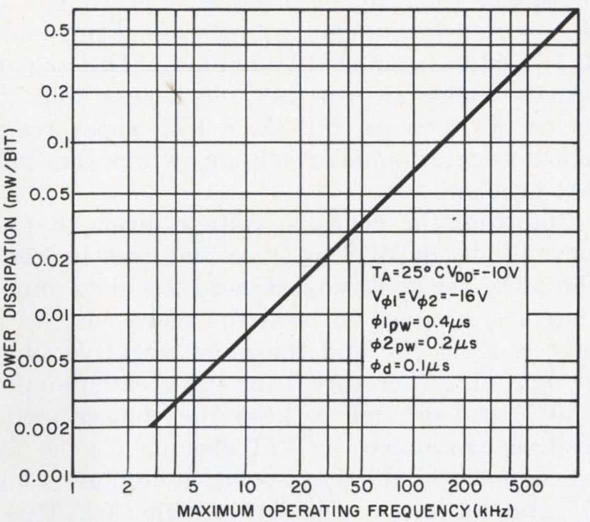
the gate-to-source capacitance at node *A*. Now the voltage at node *F* can be $-V_{DD}/2$. As Φ2 returns to ground level (zero state), *Q2* turns off and node *F* is allowed to discharge to 0 V.

When Φ1 goes negative, *Q3* and *Q5* turn on. However, *Q4* is held off, since node *F* is now at ground potential. Therefore node *G* is at $-V_{DD}$, and it maintains that potential until the next Φ2 clock appears. Coupler *Q6* is the input to the next cell; it performs the same function as does *QA*, and the "1" bit represented by $-V_{DD}$ can be transferred into the next stage.

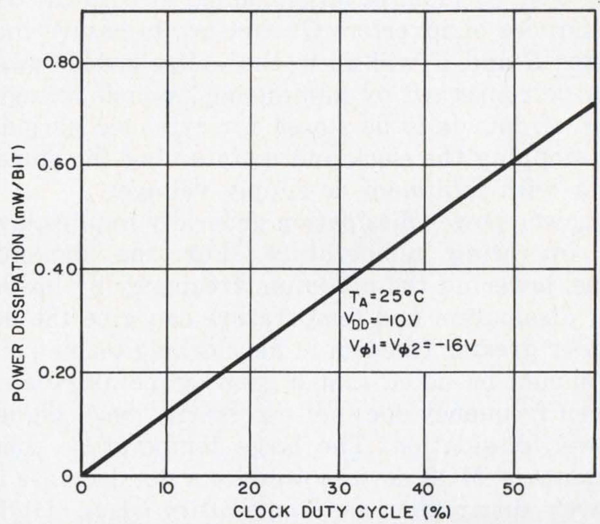
If the data input was near ground level (logic "0"), *T1* would be held off at Φ2 and *Q4* would turn on at Φ1. Node *G* would then be at ground level at the next Φ2 pulse, and the next stage would see a "0" bit through *Q6*.

In a typical static register, on the other hand, each storage cell consists of nine FETs (Fig. 3); couplers *Q1*, *Q6* and *Q7*; inverters *Q2*, *Q4* and *Q8*; and load resistances *Q3*, *Q5* and *Q9*. The loads are continually biased ON by the input gate voltage $-V_{GG}$, while the complimentary clocks Φ and $\overline{\Phi}$ switch the other FETs.

Each data bit is maintained within a stage by the feedback and latching action of couplers *Q6* and *Q7*; these can be considered the cross-coupling resistors of an Eccles-Jordan flip-flop. If the external clock Φ is stopped (that is, reduced in frequency to dc), *Q6* and *Q7* will remain on or off, depending on the state of $\overline{\Phi}$. Aside from making the state of the stored bit independ-



5. **Power dissipation increases with operating frequency** in a dynamic register, because a current path between supply and ground exists only during the time that one of the clock phases is in the negative state. Since the clock pulse width is held constant, the clock duty-cycle—hence power dissipation—increases with frequency.



6. **The dynamic register-cell dissipates power** only when the load resistor is clocked ON. If the clock-pulse duty-cycle is lowered, power dissipation is decreased, so the narrowest possible clock should be used. A typical cell will dissipate the same power at 100 kHz with 1.0 μs clock pulses as it will at 10 kHz with 10.0 μs clock pulse.

ent of leakage time, this arrangement simplifies external clocking and driving circuitry.

When the Φ clock goes negative it switches on *Q1, Q10,* and *Q19*. Device *Q19* and the 15-kilohm resistor generate the positive pulse of clock Φ, which turns off *Q6* and *Q7*. Node *E* is now at the level appropriate to the state of the delayed data bit. This bit can now move into the output stage, and the storage cell is set up to receive a new input data bit.

Assume the new bit is a "1", a pulse near $-V_{DD}$. As *Q1* turns on, the input charges the gate-to-source capacitance of *C1, Q2,* turning on *Q2*. This allows node *B* to discharge. The gate-to-source capacitance, *C2,* of *Q4* also discharges, turning off *Q4* and placing the logic "1" level of $-V_{DD}$ at node *C*.

When Φ returns to ground level and Φ goes negative, *Q1* and *Q10* turn off, *Q6* and *Q7* turn on, and any information stored in *C3* at the gate of *Q8* discharges to ground. Hence, *Q8* turns off and node *E* rises to the "1" level.

However, if the new input bit is a "0" (signal near ground level), *Q2* cannot turn on. The $-V_{DD}$ level is maintained at node *B* and *Q4* remains on. Therefore, node *C* goes to ground. When *Q6* and and *Q7* switch on, *Q8* is also turned on and node *E* is held at ground level. Thus *Q10* sees a "0" bit during the next clock cycle.

Off-the-shelf registers run at 1 MHz

Specially designed and processed MOS registers can operate at frequencies up to 5 MHz. The more typical off-the-shelf registers being discussed here will run at up to 1 MHz with relatively low signal, supply and clock voltages (such as —10 V rather than the maximum of —25 V). They achieve 2-MHz operation with reasonable amplitudes and tolerances $V_{DD} = 10.5 \pm 5\%$ and $V\Phi = 17 \pm 1$ V, for example.

The minimum frequency, or maximum clock period, of a static register can be whatever the designer desires. The minimum frequency of a dynamic register, however, depends largely on operating temperature (Fig. 4). The lower the operating temperature, the less the leakage current, and the longer the charge-storage time available for data retention.

Power dissipation in both types varies with applied voltages, but a dynamic register dissipates power only when a load resistor is clocked on, only when a current path exists between $-V_{DD}$ and ground. Its power dissipation thus varies with frequency (Fig. 5). This characteristic offers the user of dynamic register numerous options for reducing power dissipation. He can, for instance, minimize the ON time of the loads in the circuit, by making the clock pulses narrow and lowering the duty cycle (Fig. 6). After the storage capacity and input-output rates needed by the external system are satisfied, power consumption can be reduced further by slowing down the internal register operation.

Power dissipation in a static register is higher, on a per cell basis, than in a dynamic register; it varies little with frequency. A static register's load resistors are always ON. Also loads *Q3* and

$Q9$ (Fig. 3) must be large compared with the ON resistance of inverters $Q2$ and $Q8$, to assure that nodes B and E will go to the $-V_{DD}$ level. Power can be conserved by minimizing applied voltages and, if data is to be stored for extended periods, by stopping the clock and maintaining the stored data with minimum dc supply voltages.

Lower power dissipation generally implies lower operating temperature. For the dynamic type, lowering the minimum frequency by lowering dissipation and temperature can give the designer greater freedom in his clocking techniques. It should be noted that higher temperature at a given frequency does not necessarily mean higher power dissipation. The large temperature coefficients of MOS devices produce a net decrease in power dissipation as temperature rises. High-temperature operation is not generally desirable. Furthermore, operation at less than maximum temperature improves frequency response; the charging resistances of the MOS devices are less and RC time constants are shorter.

Break the speed limit

For some applications, the normal maximum frequency of 2 MHz is too low. Suppose, for example, that a 3-MHz or 4-MHz rate will allow the delay line to work more efficiently with transmission lines or external logic circuits. Increases in frequency of up to 100% can be achieved at little additional cost, by using certain types of TTL logic gates between registers, as follows:

An MOS register's upper frequency is generally limited by the output transistor. Its ON resistance is usually made low (Fig. 7) to guarantee that capacitive loading of the register by a following register or MOS device will not produce an RC product high enough to seriously impair the information response time.

However, low-impedance MOSFETs are physically large devices (typically in mils, 100-times larger than internal MOS devices; they take up 10% of the available real estate on a typical die) with large input capacitances (typically 0.2 pF), which must be driven by a high-impedance transistor in the last storage stage of the register. As a result, the output time constant is relatively long, perhaps 100 ns, and the clock period must be long enough to permit charge transfer through the output stage. Internal MOS cells can run at 20 MHz, but coupling to the output devices reduces speed capability to roughly 2 MHz.

An easy way around this seeming impasse is illustrated in Fig. 8. Test results show that the TTL gates used allow the MOS registers to run at a maximum frequency of nearly 4 MHz rather than 2 MHz. Input-output times can be shorter because the importance of capacitive effects is reduced—the source driving the input has lower impedance than an MOS output circuit, and the MOS output terminates in much lower impedance (3.3 kilohms against 10 kilohms). The register output-voltage swings are much less than the normal MOS range, but since TTL gates are designed to detect smaller voltage swings they solve that problem, too.

Note that the negative voltage levels that are conventional in MOS logic are not used in Fig. 8. The MOS registers do not need negative inputs. They are designed to treat the more positive inputs as logic "0" and the more negative inputs as logic "1". Therefore, each register is supplied +10 V and ground, to keep the voltage swings positive, as required by TTL circuits. To the TTL gates, however, the more positive voltage is logic "1" and the more negative is logic "0". This is taken care of by the +5 V and ground supplied to the gates.

The reversal doesn't affect the data accuracy. Although a positive input is shifted through the register as though it were a logic "0", the TTL gate detects the output as a logic "1". Likewise, an input at ground is shifted as a logic "1" but detected as a logic "0".

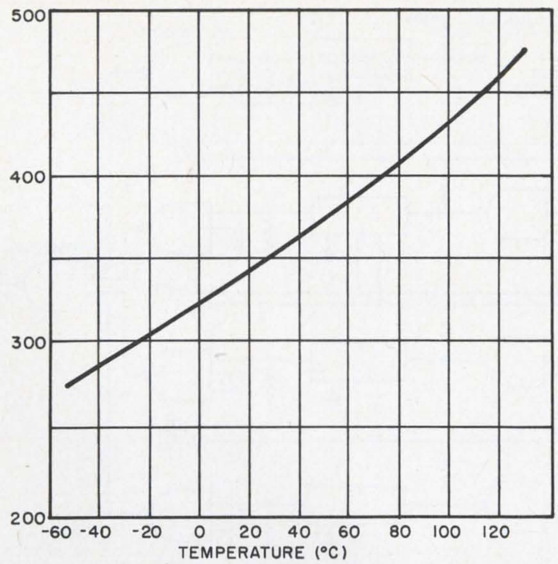
Not all TTL gates can be interfaced with MOS. The gate must be designed so that its positive output of about +4 V can be pulled up to about +10 V (Fig. 8) and look like a high-impedance load to the MOS register input. A standard TTL gate can achieve this voltage translation. The output stage contains a high-value resistor in parallel with the external 2-kilohm pull-up resistor connected to the +10 supply. The smaller resistor between the register output and ground pulls the MOS output down to the TTL input level.

Parallel delay lines for high data rates

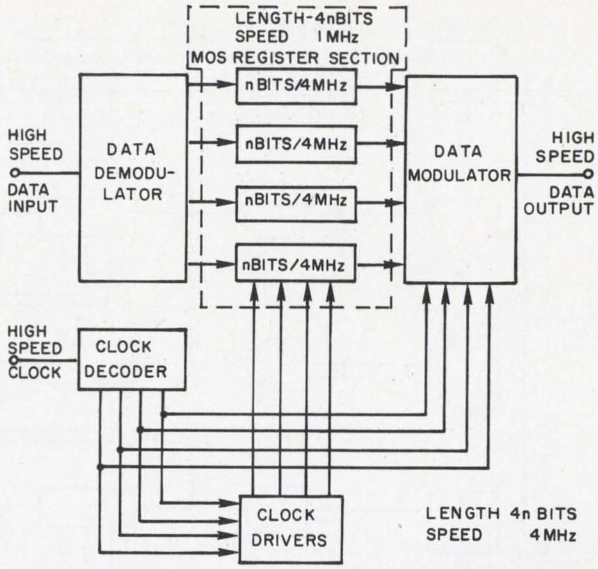
If registers, or register series, are operated in parallel, the input-output data rates can be multiplied by the number of delay lines in parallel.

The general configuration of such a high-speed line is shown in Fig. 9. The data demodulator distributes the input data stream so that register 1 gets bits 1, 5, 9, etc.; register 2 gets bits 2, 6, 10, etc. and so forth. The data modulator reassembles the bit stream and restores the original data rate. With four registers in parallel ,the delay line can accept data at four times the shift rate of the individual registers.

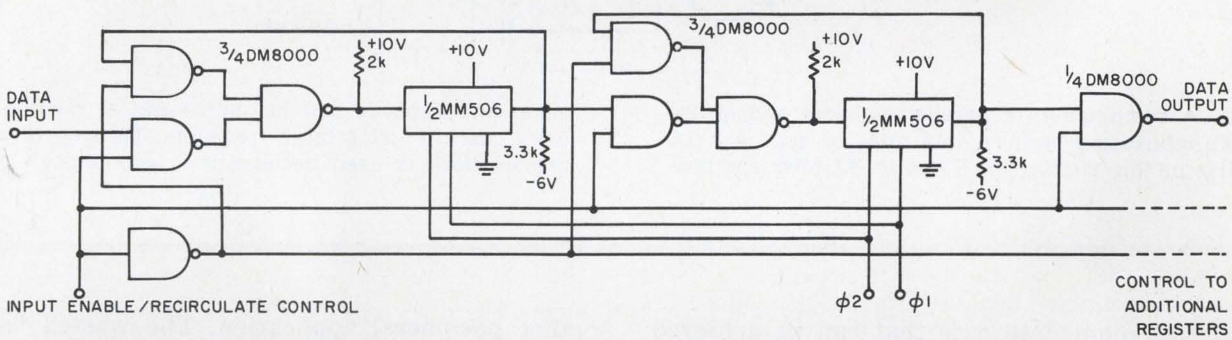
A circuit design that takes advantage of the MOS/TTL interface technique and that has accepted data at rates up to 16 MHz, is given in Fig. 10. The eight-to-one improvement in speed, compared with a conventional MOS delay line of siimlar capacity (800 bits), is achieved at the cost of only seven TTL packages. The capacity can be raised, at no additional cost, by using larger registers.



7. **The output impedance of the dynamic register** is typically below 500 ohms; when the output device is ON the output terminal is connected to ground through less than 500 ohms. The output impedance increases with temperature.



9. **Clock rates can be multiplied by paralleling registers** and using data modulators and demodulators. Data can enter and leave this line at 4 MHz, while individual registers are clocked at only 1 MHz. This system can be expanded.

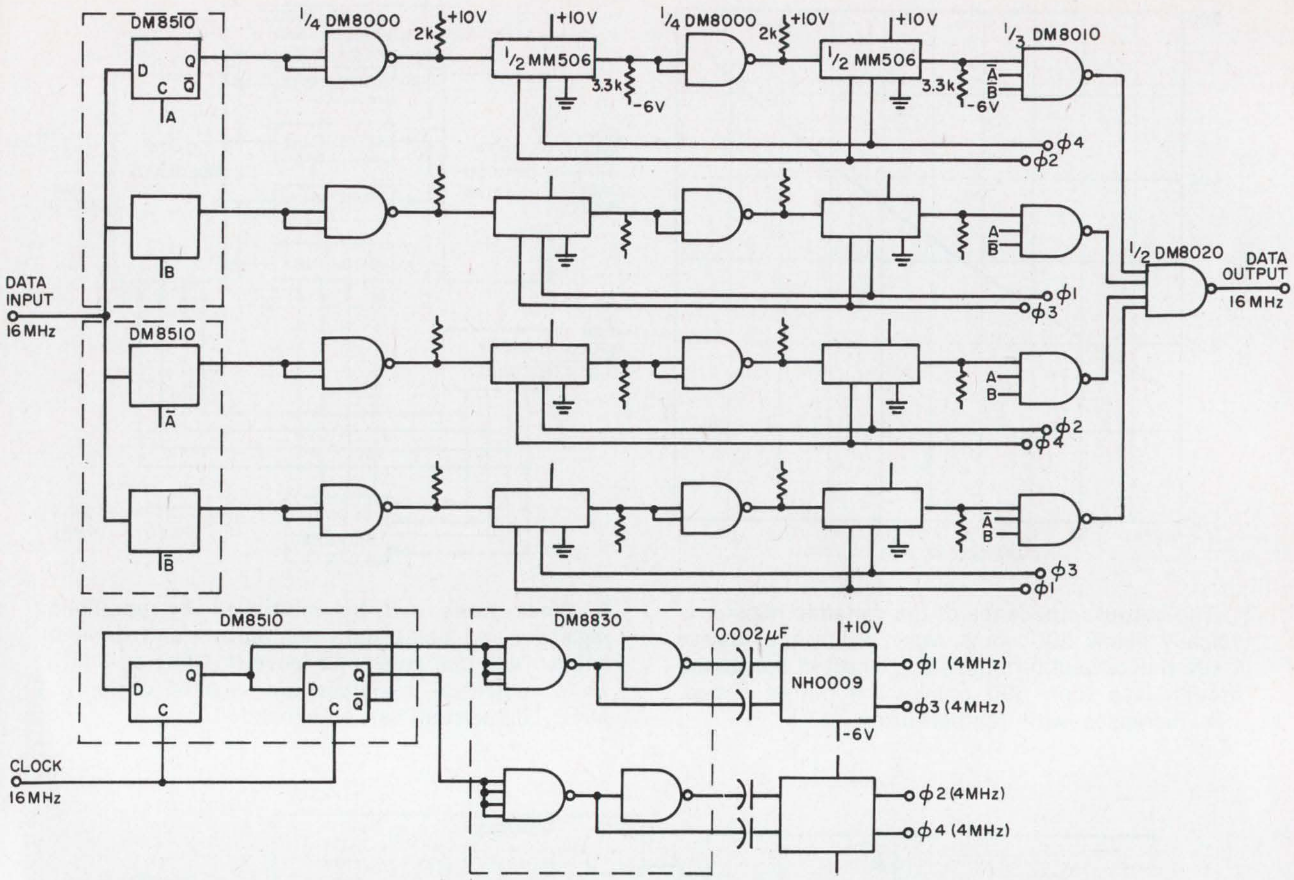


8. **TTL interfaces lower register loading and improve output detection,** allowing higher register speed. Each segment of the line may be used as a recirculating loop, controlled by steering gates.

Table. Characteristics of typical MOS registers

Typical characteristics	Static registers	Dynamic registers
Minimum operating frequency		
at 25°C	dc	10 Hz
at 125°C	dc	10 kHz
Maximum operating frequency	2 MHz	2 MHz
Line delays per bit (typical)	no maximum 0.5 μs* minimum	25 ms maximum 0.5 μs* minimum
Normal clock configuration	single phase	two-phase**
Signal voltage levels		
logic "1"	−8.0 V	−8.0 V
logic "0"	−1.0 V	−1.0 V
Power dissipation		
at 1 kHz	1.5 mW/bit	0.8 μW/bit
at 1 MHz	1.5 mW/bit	0.8 mW/bit

* The minimum may be lowered to 0.25 μs by the use of TTL input drivers and output detectors.
** Some types of dynamic registers employ four-phase clocks but generate the two additional phases internally from the normal two-phase clock input.



10. **A combination of parallel registers and MOS/TTL interfacing** permits data rates to approach 16 MHz in this circuit (a). Rates to 32 MHz are possible, and capacity can be increased, at minimal extra cost, by using larger registers. Division of a master clock is used because it is economical.

The maximum data rate that can be achieved by paralleling registers is about 32 MHz at present. The limit is imposed by the speed with which TTL circuits can detect and reassemble the outputs of the parallel registers. Today's TTL circuits can commutate data down to easily acceptable MOS register clock rates.

The operation of the circuit shown in Fig. 10 is straightforward. The high-speed clock enters at TTL logic levels and is divided into a two-phase clock by the *A* and *B* flip-flops, which are connected as a synchronous counter. The clock is divided again at the line driver into four clock phases, which are distributed to the system components. The phases used by the registers, and their sequence, are shown in the figure. The clock pulses can be as wide as 0.2 μs.

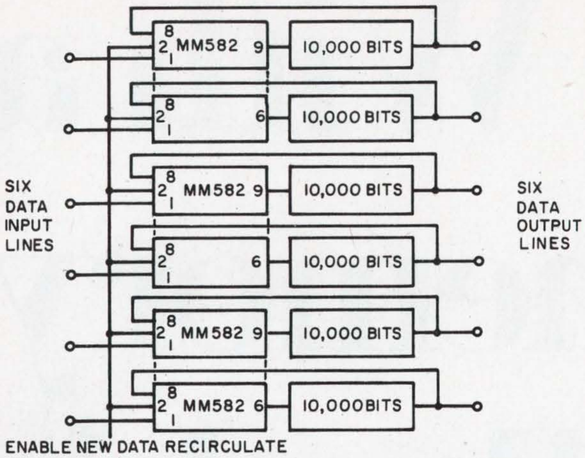
Division of a master clock was used because it is a more economical technique than generating four separate clocks, and it synchronizes operation of the delay line. However, other clocking techniques (some of which will be discussed later) could be used.

The memory capacity of a conventional magnetic-drum memory is often too great for a computer peripheral application. The wasted "overhead" makes the drum's cost per bit prohibitive. Since a drum memory is basically a rectangular array of synchronous delay lines, MOS registers can be substituted at much less cost.

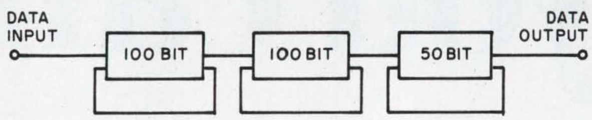
As an example, a 60,000-bit MOS "drum" is shown in Fig. 11. Word length is six bits. Each line in the array contains 100 registers storing 100-bits each. MOS digital multiplexers or TTL gates will handle the input gating required to recirculate data in the memory—that is, they revolve the "drum"—or write in new data and erase the data that was stored.

The system differs from those previously described, since all bits in a word appear in parallel at the input or output of a register series. A single enable pulse causes the multiplexer to gate a new word into the drum at any specific bit-position interval. The system can therefore access a specific word on the data-output lines by using a counter-addressing technique to tap into the data-output line. All registers can be operated by the same clock signals.

To reduce the access time, each delay line may be segmented into minor loops such as in Fig.



11. **An MOS drum memory** is a rectangular array of synchronous delay lines. This design stores 10,000 six-bit words, with MOS multiplexers handling the required input gating.



12. **The access time of a large MOS memory is reduced** by breaking the line into minor recirculating loops. Any segment of the above line can be accessed at 100-bit intervals.

12. It is possible, for example, for a bipolar-logic system to individually access each 100-bit or 50-bit segment of the drum by employing the MOS/TTL configuration (Fig. 8). The effective reduction in access time equals the number of bits in a line, divided by the number of bits in the largest minor loop. For example, the over-all delay in a 10,000-bit line is 5 ms at 2 MHz, but the access time of each 100-word segment of the drum is only 50 μs. The loops should be equal in size, or multiples of one another, to keep the stored bits parallel and the word structure intact.

Special clocking varies delay and data rate

Only the most basic forms of clocks have been described so far. Specialized clocking techniques can be devised to vary the delays within a line, to vary the input or output data rates (or both), and to reduce the power dissipation by reducing the duty cycles in a line or segment of a line.

If the designer wishes to extend delay duration in a line or recirculating loop, for instance, he can inhibit the clock. As soon as the register is loaded, the block of a static register may be stopped, or the clock of a dynamic register may be delayed (for the maximum period permitted by the operating temperature).

Suppose a designer wants to take 1,000-bit samples of sensor data and process them with a computer. The sensor's data-output rate is 200 kHz, but the computer operates at 2 MHz and may not, because of higher-priority tasks, be able to accept the sensor data as it is accumulated. The delay may last as long as 10 ms. Recirculation of the data in a delay line is not desirable, it must be available any time the computer demands it. Nor does the designer want to fill computer memory with low-priority data.

To solve his problem, the designer builds a serial 1,000-bit, 2-MHz delay line. While the sample is being accumulated in the registers, a 200-kHz clock is applied. After 5 ms (1,000-times the clock period), the clock is inhibited and the data sample is held in store until a command from the computer starts the 2-MHz clock. The data is on its way into the computer in 500 ns. The delay line can be made part of the sensor subsystem, where it will not affect any part of the computer.

Two-speed clocking has many other uses. It is handy whenever digital circuitry operating at one rate must be mated to circuitry operating at some other rate, such as in the time-sharing of high-speed transmission lines or processors. The input rate and delay per bit can be near dc (25 ms is the maximum clock period of a dynamic register at 70°C; the clock period of a static register may be as long as desired in a static register), while the output rate can be made extremely high by paralleling registers. ■■

Test your retention

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

1. What are two important differences between static and dynamic registers?

2. What is the maximum practical frequency for off-the-shelf MOS registers?

3. What is a safe minimum frequency for dynamic MOS registers at 70°C?

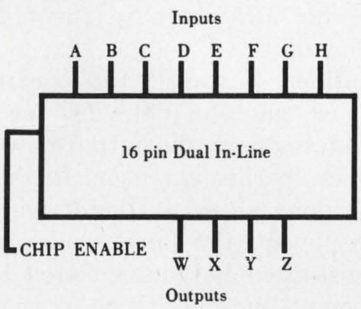
4. Two schemes for increasing the clock rate of shift registers are proposed. What are they?

With a memory like this you can forget the logic

FROM YOUR TRUTH TABLE

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

TO YOUR MM 521



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INFORMATION RETRIEVAL NUMBER 32

Keep your rf power level constant

by using a servo loop and a saturated rf amplifier to correct temperature drifts and other perturbations.

Part 1 of a two-part article

If you've ever been involved in the design of rf equipment, you know that it is often necessary to keep the output power level of a device constant under a variety of environmental conditions. For example, if you are designing an exciter to drive a TWT, you know that TWTs are extremely sensitive to their input drive level and that, therefore, system specifications on the exciter output power stability are very tight.

To obtain constant output power under hostile environmental conditions is no easy task; especially when the power source is a chain of rf amplifiers and frequency multipliers. Linear temperature compensation in the rf stages is of some help, but it's not enough.

Another approach, discussed here, is the use of a servo loop to reduce output power level variations.

In the servo-loop approach (Fig. 1) a small sample of output power is converted to a dc voltage and compared with a reference voltage to generate an error signal. The error voltage then controls the gain of a preceding stage of rf amplification. This closed-loop control system provides several advantages over open-loop approaches; the most important advantage is that it keeps the output power level fixed, despite severe nonlinearities in the rf chain. It also offers flexibility in setting the power level and suppressing power-supply ripple, transients and other external variables.

Of course, as is well known, servo loops can introduce problems of their own when they are introduced into a system. These problems, however, can be successfully corrected once their cause is recognized, as we shall see.

Full control is best

If the power level is sensed at some point in the rf chain other than at the output, the system is said to have *partial control.* This is to distinguish it from the *full control* situation in which the power is monitored right at the output where the level-stability specifications must be met. Full control is obviously better than partial control, because it can compensate for all errors in the chain, no matter where they occur.

In some situations, however, full control may not be feasible. For example, if the last few stages in the chain are multipliers, the output power level may be too low to operate a sensor. In this case, sensing must be done at an earlier stage, where there is enough power; the uncontrolled portion of the chain must then be compensated by conventional open-loop techniques, such as the use of thermistors or diodes.

Generally speaking, the servo loop will have to compensate for two types of variables, external and internal. External variables include such items as variations in input drive power and power supply voltage. Internal variables are the impedance and gain changes within the rf chain that are caused by temperature changes.

In designing a loop for a particular set of specifications, you may find that the effects of all the variables cannot be reduced to the required level at the same time. For instance, a loop with sufficient gain to eliminate certain temperature-variation effects may not be fast enough to handle power-supply ripple. Therefore, the first step in designing a servo loop system is to reduce the number of variables to a minimum. Fortunately, the external variables can be reduced quite easily.

Input power variations can be reduced by driving the chain from a series of limiter stages. All amplifier stages following the level-control stage must be linear, of course, to achieve linear control characteristics.

Power supply voltage variations can be reduced by employing a regulated dc-to-dc converter. If this isn't possible, because of space or efficiency requirements, then the servo loop will have to take care of this problem itself.

Ripple and transients are always present to some degree on power supply lines. As mentioned before, the loop may be too slow to remove the relatively high ripple frequency. If left uncorrected, this will result in undesirable amplitude modulation of the output power. To prevent this, a low-pass filter whose cutoff frequency is slightly

Arpad D. Vincze, Senior Design Engineer, Philco-Ford Corp., Palo Alto, Calif.

below the loop's cutoff frequency should be placed in the supply line. This way, the servo loop and the line filter will combine to eliminate ripple from dc to the highest ripple frequency.

The only variables that are left are internal to the loop. Under these conditions, the loop may properly be called an *isolated loop*. In addition to providing better performance than a non-isolated loop, the isolated loop has the advantage of being easier to analyze because of the reduced number of variables.

A saturated stage provides control

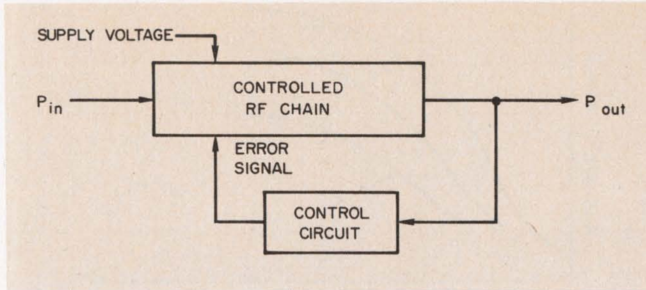
At this point in the design of our system, we must decide what type of control to use. Our decision will depend on the signal level and frequency at the point of control, as well as considerations of economy, space and the time that is available to complete the job.

One widely used method employs a p-i-n diode as a variable attenuator. The attenuation of such a diode can be controlled by adjusting the forward bias current through it. Although these diodes can provide continuous level control in many applications, some of their properties make them a bad choice in certain cases. For example, if a single p-i-n diode is used as a series or shunt attenuator, it may cause a considerable mismatch in the rf circuit. Reasonable match over a broad dynamic range can only be achieved at the cost of additional circuit complexity.

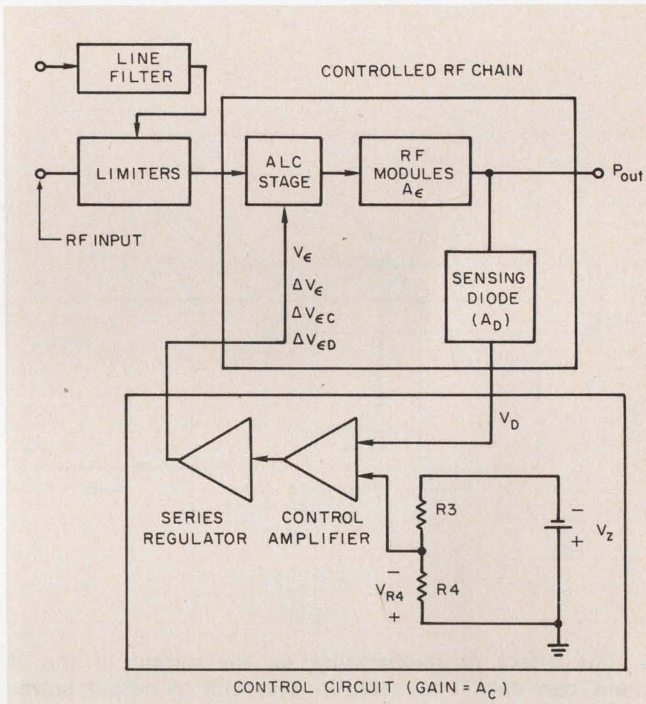
A second disadvantage of p-i-n diodes is that they only act as variable attenuators, for signals whose period is much shorter than the minority-carrier lifetime of the diode semiconductor. As the signal period increases, the p-i-n diodes begin to behave like ordinary rectifying junctions. Thus, at the lower rf frequencies (100-200 MHz) and higher power levels (over 10 mW), they can cause considerable distortion by rectifying the signals. One approach that overcomes these two problems is the use of a saturation-type level control employing a transistor stage instead of a diode.

With this scheme, the level-controlling stage is operated in saturation and the output power is controlled by controlling the supply voltage to the stage. Thus, this method is most properly called *automatic level control,* (alc). This can be contrasted with conventional agc, where the gain of the agc stage (or stages) is controlled, most often, by changing the small-signal impedances in a fairly linear fashion. In this case, linear operation occurs below the saturation region. It is clear that the conventional analysis of an agc scheme does not apply to the saturation method; we will have to analyze this loop ourselves.

The simple block diagram of Fig. 1 is expanded in Fig. 2 to show the details of each block. Each of the components of the two major blocks is char-

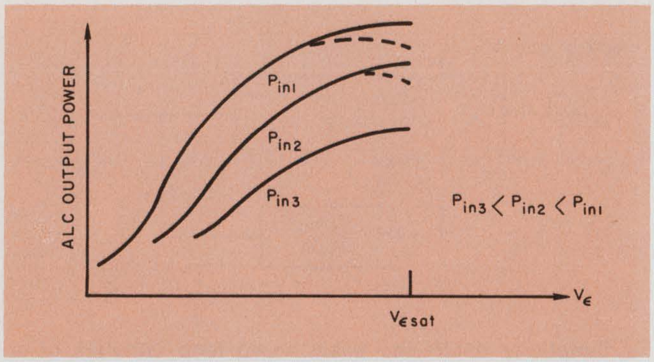


1. **Simplicity itself: the basic servo loop** consists of an rf chain and a control circuit. The chain is a series of cascaded rf amplifiers and frequency multipliers; the control circuit contains an amplifier and a stable reference voltage.

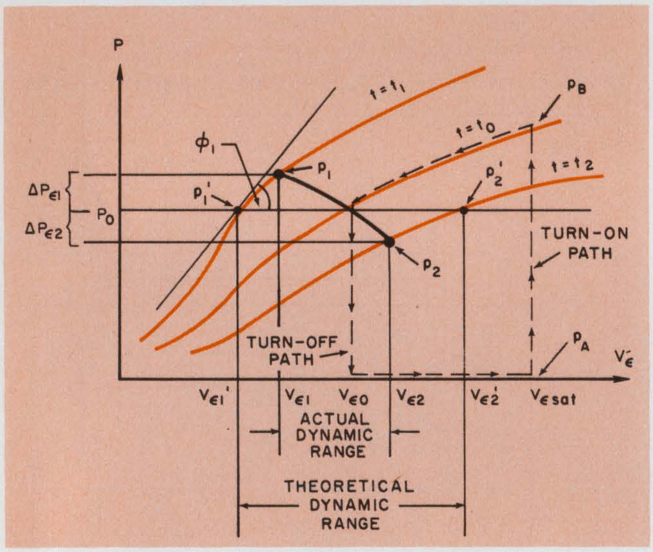


2. **Automatic level control** is provided by a saturated rf amplifier whose output is controlled by varying its supply voltage.

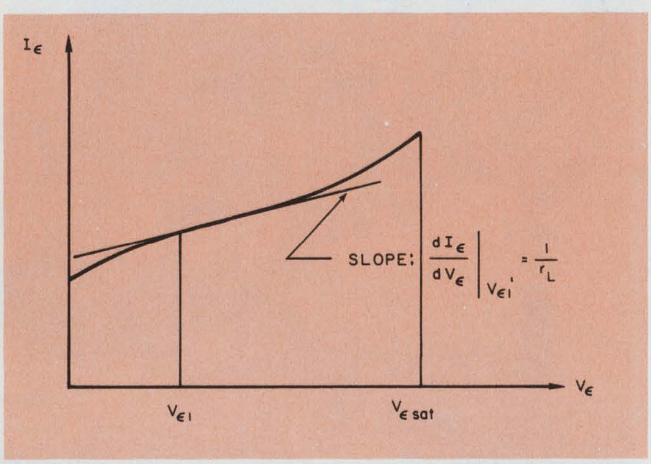
The author, Arpad D. Vincze, is holding a ×24 frequency multiplier/rf amplifier chain.



3. **The alc stage transfer characteristics** are plotted for different values of input power. Note that as the supply voltage gets high enough to pull the amplifier out of saturation, the output power may dip (dashed lines) if the amplifier Q is too high.



4. **The effect of temperature on the output** of the rf chain can easily be seen in this plot of output power vs error voltage for three different temperatures. The reference temperature is t_0; t_1 is below t_0, and t_2 is above it. The dashed line shows the turn-on/turn-off locus. The solid black line is the locus of normal operation.



5. **The incremental input resistance** of the alc stage can be found from this plot of I_ϵ vs V_ϵ. The resistance is the reciprocal of the slope of the curve.

acterized by certain nonlinear parameters. A full description of these parameters, over a wide operating range, would involve solving a nonlinear differential equation with variable coefficients for each of these parameters. Fortunately, this laborious job can be avoided because operation is restricted to a small neighborhood about an operating point. This allows us to perform a linear analysis without introducing a significant amount of error.

Let's examine the rf chain

The controlled rf chain basically consists of the alc stage, additional rf modules (amplifiers, multipliers, etc,) and the sensing diode. Although they are not within the rf chain, the preamplifier/limiters have the important role of providing isolation from input power variations.

Let's examine each of the components of the controlled rf chain, in turn, to clearly see how each affects the performance of the loop.

The operation of *the alc stage* is based on the simple fact that the output power of a saturated rf amplifier is limited by the supply voltage. The type of biasing on the alc stage transistor is unimportant—class A, B or C can be used. It is important that sufficient input power be applied to this stage to keep it within the linear control region (that is, well into saturation); otherwise, the loop gain will go down to zero, resulting in total loss of control.

It is also important to have a relatively low-*Q* circuit in the collector of the alc transistor to minimize detuning effects. This is understandable, because of the change in depletion layer capacitance that results from changes in supply voltages. This all means that higher power stages, in general, yield greater stability and broader dynamic ranges, because their collector impedance levels are low.

A typical alc stage transfer characteristic curve with input power as a parameter, is shown in Fig. 3. Detuning near the endpoint of the dynamic range may cause a negative sloping—shown by the dashed line—resulting in a 180° phase reversal in the loop. However, as we shall see later (Eq. 22), if the loop gain is less than unity and the static-error voltage is sufficiently high, then the operating point can go "over the hill" without difficulties.

The transfer characteristic of the controlled rf chain is shown in Fig. 4. The output power of the chain is plotted against the alc voltage for three different temperatures. The transfer constant of the chain, A_ϵ, is defined at a particular point as

$$A_\epsilon = dP/dV_\epsilon \qquad (P,t,V_\epsilon \text{ fixed}) \; . \qquad (1)$$

P is the output power of the chain and V_ϵ is the alc voltage. A_ϵ is always positive in the active operating region of the system.

The incremental input resistance of the alc stage is also important, as it will affect the stability of the loop. This resistance, r_L, is determined from the curve of alc current vs alc voltage in Fig. 5. The slope of the curve is given by

$$dI_\epsilon/dV_\epsilon = 1/r_L \qquad (2)$$

If r_L is too high, it may cause excessive loop gain —hence, loop instabilities. This problem can be cured by putting a lower resistance (in series with a large dc blocking capacitor) across the alc supply line.

We note that the curve of Fig. 5 does not intersect the I_ϵ axis at the origin. This is because the large input signal can cause current flow, even at zero power supply voltage. As the rf drive power is lowered, the intercept point will move down toward the origin.

Referring to Fig. 6, the resistors R_e and R_b are used to set the correct bias level and damp parasitic oscillations, respectively.

The sensing diode converts the output power to a dc analog signal at the sensing point. Conversion is obtained by rectifying a small sample of output power, coupled by either a directional coupler or a small resonant coupling loop.

A plot of sensing-diode voltage vs output power is shown in Fig. 7. The diode transfer constant, A_D, is defined at a particular power level—as

$$A_D = dV_D/dP, \ (P\text{=const.}) \ . \qquad (3)$$

The flat portion of the curve, at high power levels, is caused by reverse breakdown of the diode. The diode should be operated below this region.

High diode efficiency and fast turnon and turnoff times are important for good performance, especially at high frequencies. Hot carrier diodes are very suitable in this regard. For example, the HP 2350 type can provide 5 Vdc into a 10-kilohm load with only 10 mW of coupled power at 2 GHz.

The detector diode has an incremental resistance, r_D, that must also be considered. For the HP 2350, r_D = 2 kilohms. In our future calculations, r_D will refer to the resultant of the internal diode resistance and all the external resistors that may be put across it (such as R_{DL} in Fig. 6).

Although the temperature drift of the hot carrier diode is small, compared with conventional diodes, it still contributes to the total loop drift, and must be taken into account. The sensing diode drift constant is defined as

$$K_D = \Delta V_D/\Delta t, \quad \text{V/°C.} \qquad (4)$$

Note that K_D is a constant—not dependent on the operating point—therefore an incremental, rather than a differential, notation has been used.

There are additional components of drift that can be added to K_D. The low-pass filter capacitor may vary with temperature, and the loading across the diode and the VSWR of the line may also change, resulting in different output voltages at different temperatures.

The following suggestions should be followed in designing the rf sensing circuit:

- Aim for high detected voltage, preferably a couple of volts. One way to do this is to increase the fraction of power coupled to the diode. As will be seen later, this will reduce all other drift components and minimize the compensation required for differential drifts.
- Locate the diode where the VSWR is low and where there are no temperature-sensitive field intensities caused by high-Q circuits.
- Use a clean rf signal (with the second harmonic at least 15-dB down) for monitoring purposes, because the coupling loop may respond to the higher harmonics and yield erroneous results.
- If any parts of the sensing-diode assembly must be cemented together, use a bonding agent that exhibits low mechanical hysteresis when it is temperature cycled. (Q-Max A27 is a good choice.) If this is not done, the small permanent deformations that will result can cause a long-term drift in the reference level. The cemented assembly should be temperature-cycled a few times, to cure the cement before final measurements are made.

Since the monitored output power changes very little when the loop is closed, and the diode contact potential changes linearly with temperature, A_D, r_D and K_D can be considered constant at any given output power level.

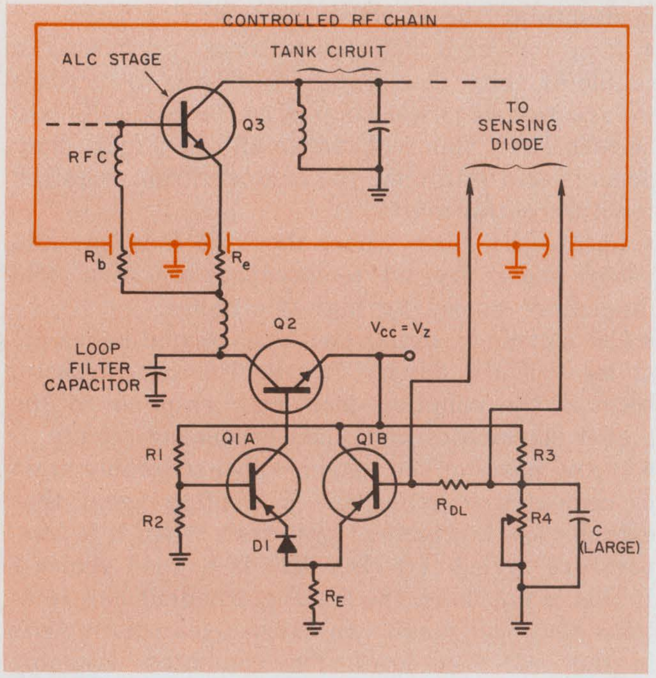
The control circuit closes the loop

The control circuit contains a high-gain dc amplifier with low temperature drift. Any simple circuit or device, such as a dc operational amplifier with adjustable gain, can be used. The amplifier must sense the output power variations as represented by changes in the sensing-diode voltage, must compare them with a reference voltage, and must amplify the difference to provide an error signal. A series-regulator transistor is used after the high-gain stage to provide additional current amplification.

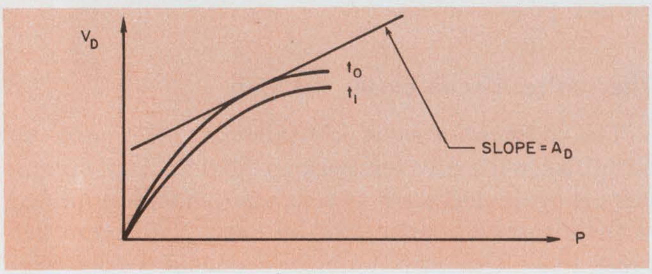
The simple control circuit of Fig. 6 was chosen for analysis because it explicitly shows some of the important factors governing the drift mechanism.

An npn transistor was chosen as the series regulator ($Q2$), and a matched pair of pnp transistors ($Q1$) was selected as the high-gain amplifier. This combination allows V_ϵ to vary from zero to V_{cc} while using only one single-polarity power supply. The common-mode variations are suppressed by making R_E sufficiently large or, perhaps, by replacing it with a current source. (A good value for R_E is $R_E = 10[r_e + (R_B + r_{bb}')/\beta_1]$, where, referring to $Q1$, r_e is the emitter-base diode incremental resistance; R_B is the equivalent parallel resistance of R_1 and R_2; r_{bb}' is the base spreading resistance, and β_1 is the current gain.)

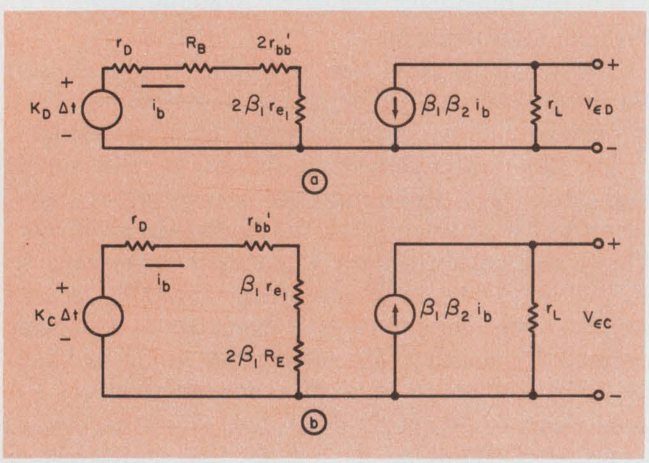
The power level is adjusted by varying R_4.



6. **A wide dynamic range** is achieved with only a single-polarity power supply by using an npn transistor for Q2 and a pnp pair for Q1. Diode D1, in the emitter leg of Q1A, provides linear temperature compensation for the control circuit, and R_e sets the bias level of the alc stage.



7. **Stay away from the flat portion** of these sensing diode curves. The flattening is caused by reverse breakdown of the diode. The curves are shown for two temperatures, $t_o > t_1$.



8. **The linear drift behavior** of the control circuitry is analyzed with these equivalent circuits. Separate models are needed for differential-mode drift (a) and common-mode drift (b). R_B is the equivalent parallel resistance of R_1 and R_2 of Fig. 6.

The required dynamic range of the control circuit can be read off the abcissa of Fig. 4. Actually two ranges are shown: a theoretical one and an actual one. The actual dynamic range is smaller than the theoretical, because, for finite loop gain, the system follows the operating locus of Fig. 4 rather than the horizontal line, $P = P_o$. Nevertheless, good design practice dictates considering the wider dynamic range. Hence, the amplifier performance must be specified between $V_{\epsilon 1}'$ and $V_{\epsilon 2}'$. The output current required from the alc stage can be easily read off the curve of Fig. 5, using the voltages we just mentioned. These numbers will determine the power dissipation of the series regulator transistor.

While it is not necessary for the control amplifier to be perfectly linear, it is obviously important that it stay out of saturation over the theoretical dynamic range. The operating point should be set about halfway between minimum and maximum collector current.

At this point we can see an additional reason for wanting a rather high voltage out of the sensing diode. When there is no rf input power into the system, the control amplifier is saturated, sitting at point P_A on Fig. 4. When the power is turned on, the operating point jumps vertically to P_B and then moves toward its final position, as the loop filter capacitor discharges towards V_{ϵ_o}. The sensing diode voltage must be large enough to pull the amplifier out of saturation, from P_B to the final operating point.

The control circuit operates as follows: if the output power increases, V_D will increase so that Q1B becomes more forward biased. This will reduce the collector current of $Q1A$, which, in turn, will lower the collector current in $Q2$. This will cause a decrease in V_ϵ and a lowering of the output rf power. The gain of the control circuit is defined, at a point, as

$$A_C = dV_\epsilon/dV_D, \ (V_{\epsilon 1} \text{ specified}). \qquad (5)$$

It is a negative quantity and will vary with the operating point.

Handling nonlinearities

Since all of the parameters in Eqs. 1-5 (except K_D) are strong functions of the operating point, and since we want to operate the system over a relatively wide dynamic range, we might anticipate formidable difficulties in analyzing the behavior of our system. Actually, graphical techniques can be used to find the locus of output power variations very neatly. Although the locus isn't coincident with the $P = P_o$ line (Fig. 4), it is close enough for us to evaluate A_ϵ at the intersection of the $P = P_o$ line and the appropriate constant-temperature curve, without introducing any significant errors.

The other nonlinear variables are handled in a similar way, using the curves of Figs. 4, 5 and 7. The slope of the tangent to these curves yields the transfer characteristic at any point.

An important point to note in this connection is that the transfer characteristics should be plotted with the actual loading present. For example, when plotting P vs V_D, the diode should be loaded with the equivalent input impedance of the control circuit. Since the equivalent impedance may be a tricky thing to duplicate, the safest bet is to plot these curves with the actual circuit loading, wherever this is possible.

Find the setting sensitivity

Now that we have described the system building blocks, their functions, the parameters that describe them and methods of measuring them, we can proceed to establish the system design equations. First, we will discuss the static performance of the system; the dynamic performance will be covered in part 2 of this article.

We define the *setting sensitivity*, S, of the system as follows

$$S = dP/dR_4 = (dP/dV_{R4})(dV_{R4}/dR_4), \quad (6)$$

where V_{R4} and R_4 are shown in Fig. 6. Note that V_{R4} is derived from a stable zener diode voltage, V_Z.

Referring to Fig. 2, we see that a change in R_4 results in a change in P, and hence in V_D as well. This will generate an error voltage, dV_ϵ. Since V_D and V_{R4} are in series, we can write

$$dV_\epsilon = A_C\,(dV_{R4} + dV_D). \quad (7)$$

Substituting $dV_\epsilon = dP/A_\epsilon$, and $dV_D = A_D\,dP$, and arranging terms, we get

$$dP/dV_{R4} = A_C A_\epsilon/(1 – A_L), \quad (8)$$

where $A_L = A_C\,A_\epsilon\,A_D =$ the loop gain.

From Fig. 2 (or Fig. 6) we see that $V_{R4} = V_Z\,[R_4/(R_3 + R_4)]$. Differentiating with respect to R_4 gives

$$dV_{R4}/dR_4 = V_Z\,[R_3/(R_3 + R_4)^2]. \quad (9)$$

And finally, we can write

$$S = [A_C A_\epsilon/(1 - A_L)]\,[V_Z R_3/R_3 + R_4)^2]. \quad (10)$$

In the case of very large total loop gain $(A_L >> 1)$, this reduces to

$$S = [V_Z/A_D]\,[R_3/(R_3 + R_4)^2]. \quad (11)$$

It is a good idea to keep S as low as possible, to make the system as insensitive as you can to aging effects in the resistors. S can be reduced by increasing R_4 and decreasing V_Z. However, this places unnecessary restrictions on the operating point. A better approach is to make A_D as high as possible. This, as we have mentioned, will improve the loop performance in many other ways as well.

The temperature drift of our system will have two components: linear and nonlinear. The linear drift is caused by changes in the various junction potentials and leakage currents; the nonlinear, by temperature gradients in the rf chain. Let's first look at the linear temperature variations.

These are of two types: common mode and differential mode. The common-mode drift will be negligible, if the amplifier is designed properly. The differential-mode drift is the important component; it is, essentially, the drift of the sampling diode.

In our anlysis of the linear temperature drifts, we will make the following assumptions:

- Leakage currents in Q_1 are negligible, because the driving source is essentially a voltage source.
- The dual transistors (Q_1) have negligible differential temperature drift.
- The drift in dc β of Q_2 can be neglected because the closed loop compensates for it.
- $\beta >> 1$.

Referring to Figs. 2 and 8, the change in output power caused by an incremental change of the error voltage is given by

$$\Delta P\varepsilon_D = A\varepsilon\,(\Delta V\varepsilon_C + \Delta V\varepsilon_D) + \Delta P\varepsilon_D\,A_C\,A\varepsilon\,A_D. \quad (12)$$

Note that, because of feedback, the output power change appears on the righthand side of the equation as well as on the left.

From the circuits of Fig. 8, we can write

$$\Delta V\epsilon_C = \frac{\beta_2 r_L\,K_C\,\Delta t}{[(r_{bb}' + r_D)/\beta_1] + r_{e1} + 2R_E} = A_{CC}\,K_C\,\Delta t, \quad (13)$$

and

$$\Delta V\epsilon_D = \frac{-\beta_2 r_L\,K_D\,\Delta t}{[(R_B + 2r_{bb}' + r_D)/\beta_1] + 2r_{e1}} = A_C K_D\,\Delta t. \quad (14)$$

A_{CC} and A_C are the common- and differential-mode gains, respectively; K_C and K_D are the common- and differential-mode drift coefficients, and $\Delta V\epsilon_C$ and $V\epsilon_D$ are the error voltages caused by the two drifts. Next, we define the common-mode rejection ratio,

$$G_C = A_{CC}/A_C; \quad (15)$$

and finally, we substitute Eqs. 13, 14, and 15 into Eq. 12 to get

$$\Delta P\epsilon_D = [A_\epsilon A_C K_D\,\Delta t/(1 – A_L)]\,[1 + G_C K_C/K_D]. \quad (16a)$$

Now, for a well-designed differential amplifier, $R_e >> [(R_B + 2r_{bb}' + r_D)/\beta_1] + 2r_{e1}$, so that $G_C << 1$.

This means that

$$\Delta P\epsilon_D = K_D A_\epsilon\,A_C\,\Delta t/(1 – A_L) \quad (16b)$$

and, if $A_L >> 1$,

$$\Delta P\epsilon_D = –K_D\,\Delta t/A_D. \quad (16c)$$

Eqs. 16b and 16c will both be needed, depending upon the loop gain. If A_L is greater than about 20, Eq. 16c can be used, otherwise Eq. 16b is safer.

What about the nonlinear drift?

In Eq. 16 we have an expression for the change in output power caused by linear temperature drift effects. Now, we will find the change caused by nonlinear effects. To do this, we will make three assumptions.

- A_D is constant over the temperature range.
- A_ϵ is constant in the vicinity of the operating point.
- The loop is statically stable (see Eq. 22).

Our approach will be graphical because the system nonlinearities make an analytical approach quite difficult, to say the least. Referring to Fig. 4, we see a horizontal line drawn at the power reference level, P_O. If the loop gain were infinite, the locus of operation of the system would be this horizontal line, that is, $P = P_O$ for every temperature. In reality, the loop gain is not infinite and the locus tilts upward to the left because

$$\Delta P_\epsilon = \Delta V_\epsilon / A_D A_C \neq 0, \qquad (17)$$

and because A_C is negative and A_D is positive. This means that the power will be below the reference line for all temperatures above the reference temperature, t_o, and be above it for the lower temperatures.

From Fig. 4 and Eq. 17, we can write

$$\Delta V_{\epsilon 1} = V_{\epsilon 1} - V_{\epsilon 0} = A_C A_D \Delta P_{\epsilon 1}. \qquad (18)$$

If we draw a line tangent to the $t = t_1$ curve, where it crosses the $P = P_o$ line (at point P_1'), and we let this tangent represent the curve in the vicinity of P_1', we can write:

$\tan \phi_1 = A_{\epsilon 1} = \Delta P_{\epsilon 1} / (V_{\epsilon 1} - V_{\epsilon 1}')$, from which

$$\Delta P_{\epsilon 1} = A_{\epsilon 1} (V_{\epsilon 1} - V_{\epsilon 1}'). \qquad (19)$$

Eqs. 18 and 19 contain two unknowns, $V_{\epsilon 1}$ and $\Delta P_{\epsilon 1}$. Solving for them, we get

$$\Delta P_{\epsilon 1} = -A_{\epsilon 1} (V_{\epsilon 1}' - V_{\epsilon o}) / (1 - A_L), \qquad (20a)$$

which, for $A_L >> 1$, becomes

$$\Delta P_{\epsilon 1} = (V_{\epsilon 1}' - V_{\epsilon o}) / A_C A_D; \qquad (20b)$$

and

$$V_{\epsilon 1} = (V_{\epsilon o} - A_L V_{\epsilon 1}') / (1 - A_L). \qquad (21)$$

Now, once the data of Fig. 4 has been obtained, we can find ΔP_ϵ as follows: Say we want to find $\Delta P_{\epsilon 1}$, the change in output power when the temperature goes from t_o to t_1. We draw a horizontal line at the specified output power level. Then, we read the values of $V_{\epsilon 1}'$, $A_{\epsilon 1}$, and $V_{\epsilon o}$ off the graph at the intersection of the $t = t_1$ curve and the horizontal line. We get A_D from the $t = t_1$ curve of Fig. 7 at the reference power level. And, we can get A_C from Eq. 14. Finally, we get $\Delta P_{\epsilon 1}$ from Eq. 20.

Make sure the loop holds

In closing our discussion of the static behavior of the loop, we will consider a phenomenon that is often mistaken for oscillation but is really a static problem. It sometimes happens — usually at a high temperature — that the loop fails to hold the power level; the alc stage jumps to full saturation, and the output power goes to its highest value.

This can be caused by insufficient loop gain. To see how this might happen, assume that the output power increases by an amount dP. Then an error voltage, $dV_\epsilon = dP/A_\epsilon$, must be generated to keep the operating point stable. This means that the error voltage supplied by the sensing diode/control amplifier combination must exceed the above value of dV_ϵ, or, in other words, $|(dP)\ (A_C\ A_D)\ | > dP/A_\epsilon$. This can be written as

$$|A_C A_D A_\epsilon| = |A_L| > 1. \qquad (22)$$

If this loop-hold criterion is violated (usually because of insufficient A_ϵ) the loop will be unable to correct for the temperature drift and, if its Q is too high, or the rf chain and/or the alc stage are not tuned properly, the alc stage may follow the dashed curve of Fig. 3 and drive the output power to its maximum.

Equation 22 sets a lower limit on the loop gain. The upper limit will be determined in the discussion of loop stability in Part 2. However, in the meantime, we can ask this question: "For a given value of A_L, what should the relative values of A_ϵ, A_C, and A_D be?" Based on our earlier discussions, the best play is to make A_D as large as possible; this will reduce S (Eq. 11), reduce $\Delta P_\epsilon / \Delta t$ (Eq. 16c), and reduce ΔP_ϵ (Eq. 20b). A_D can be increased most easily by increasing the fraction of the output power that is coupled to the sensing diode. Merely increasing A_C may not solve the problems; it may even cause instabilities, as we shall see next time. ■ ■

Test your retention

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

1. What is a saturation-type automatic level control? How does it differ from conventional agc?

2. A high-power alc stage will, in general, be more stable than a low-power stage. Why?

3. Why is it desirable to have the sensing diode transfer function (A_D) as high as possible? How can you increase it?

4. What is the source of most of the linear temperature drift in the system?

5. What is the loop-hold criterion?

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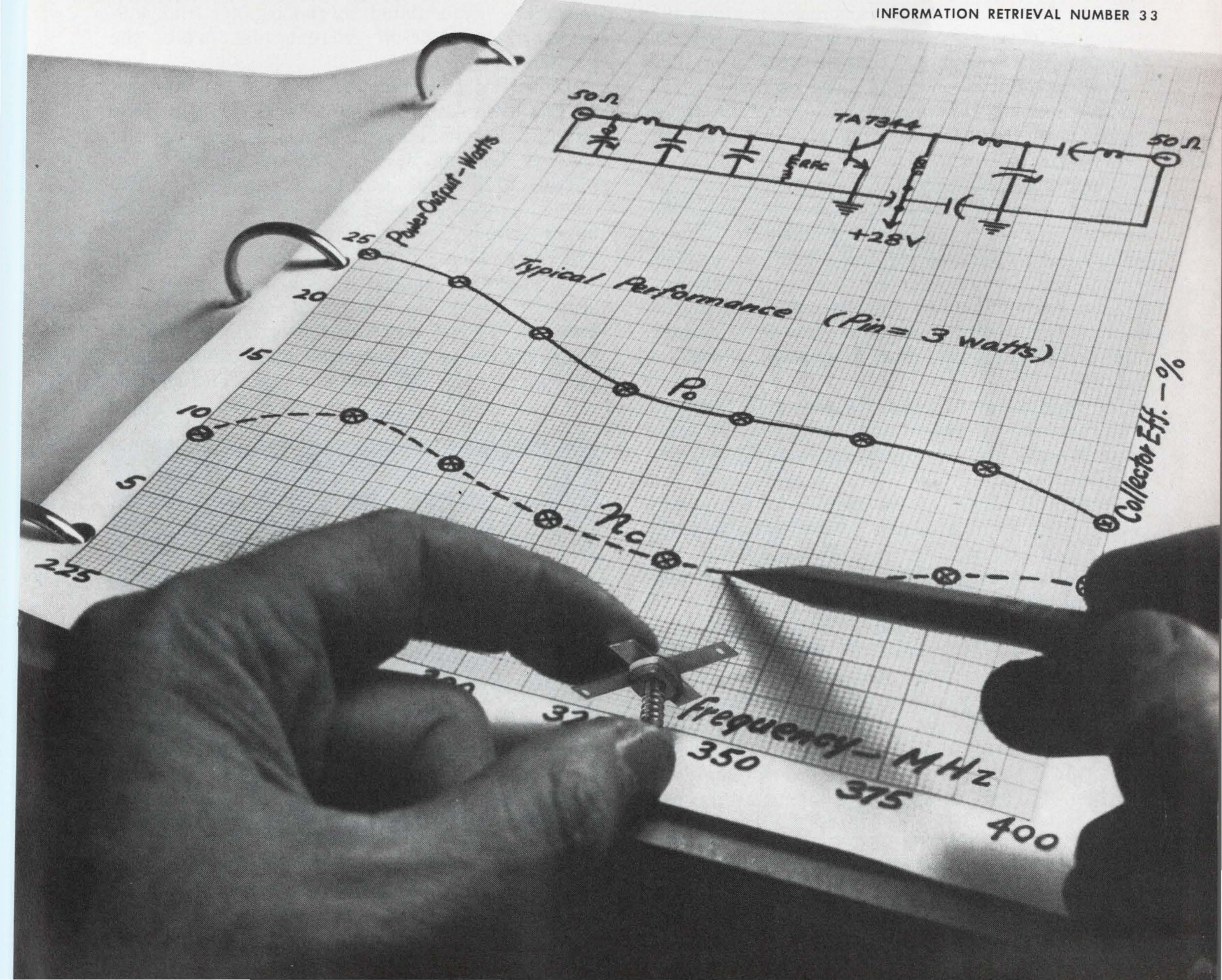


Build your own acoustic coupler

and convert a standard teletypewriter into a portable time-shared computer terminal.

A time-shared computer is as close as the nearest telephone, for those who have a portable computer terminal. Such a terminal can consist of nothing more than a standard teletypewriter coupled acoustically to the telephone line through the telephone handset. This differs from the conventional approach, in which teletypewriter terminals are directly wired into the telephone network through special data-sets. Although the inputs to these data-sets are dc, tone signalling is used for actual data transmission, since the telephone network will not pass direct currents. The acoustic telephone coupler also uses tone signalling—but it eliminates the need for wired connections by sending and receiving its tones through the handset and thus can be used with any telephone.

The design and construction of such an acoustic coupler involves inexpensive, readily available components. It is simple to connect to a teletypewriter, needs no control knobs or adjustments for signal level, and performs well over ordinary telephone lines. The circuitry is enclosed in a small box that contains two foam-padded apertures, in which the telephone handset is cradled.

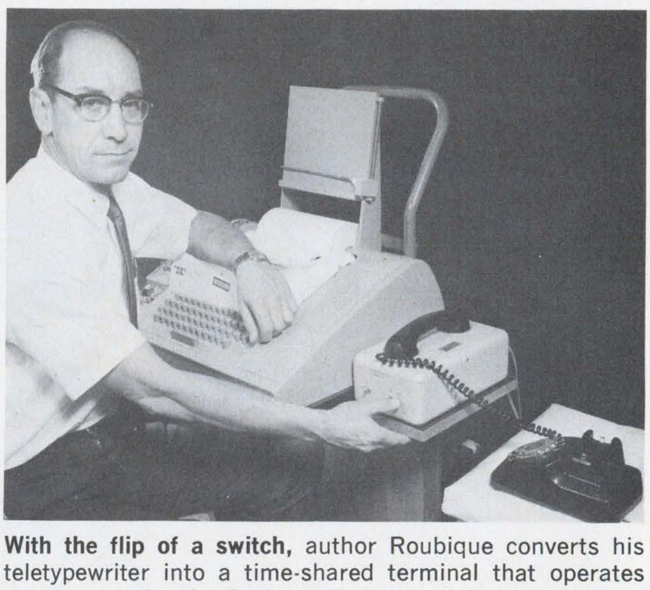
To operate the terminal, the user dials the computer on the telephone and waits for the computer to send back its answering tone. Upon hearing the tone, he "plugs" the handset into the coupler and turns on the coupler and teletypewriter. The terminal is now connected to the computer and is ready for use. To disconnect, the user simply hangs up the telephone handset and shuts off the terminal.

The coupler is designed to be connected to a Model 33 or 35 Teletypewriter, or equivalent unit (Fig. 1). These units normally operate at 10 characters per second, or about 100 words per minute. They use the 8-unit ASCII code, preceded by a one-unit start pulse (space), and followed by a two-unit stop pulse (mark) for each character. There are 11 equal-length bits per character, with bit durations being about 9 ms.

The teletypewriter has separate pairs of terminals for its keyboard and printer. Each time a key is depressed, the keyboard circuit opens and closes to generate the serial binary code that corresponds to the character to be transmitted. The changing current through the keyboard-contacts shifts the frequency of a tone generator in the coupler, and this FSK tone is sent to the computer. For receiving, FSK tones from the computer are demodulated in the coupler and converted into an on-off current that drives the printer.

To permit simultaneous transmission and reception over a single telephone line (full-duplex operation), two sets of frequencies are used. At the user terminal, one set is assigned for transmitting and a different set for receiving. The computer uses the same two sets of frequencies, but these are interchanged with respect to transmit and receive.

To eliminate confusion as to assignments, in situations where one terminal can call another terminal, the one which initiates the communications operates in the originate mode; the responding terminal in the answer mode. The coupler



With the flip of a switch, author Roubique converts his teletypewriter into a time-shared terminal that operates over conventional telephone lines.

Charles J. Roubique, Design Engineer, ESSA Research Laboratories, Boulder, Colo.

described here operates only in the originate mode (see box).

The coupler circuitry is comprised of two units: a transmit unit, on an etched circuit card for convenience, and a receive unit on two etched circuit cards. Liberal use is made of inexpensive linear integrated circuits in the design. A digital integrated circuit is also used.

Transmitting unit uses twin-T oscillator

The transmitting unit (Fig. 2) consists of a twin-T oscillator driving an audio amplifier. The frequency of the oscillator is shifted by changing the value of the shunt resistance (R_3 and R_4) in the feedback circuit. This can be done with little effect on the output amplitude. An LC oscillator was tried, but rejected, because it had larger amplitude changes, and also required extensive magnetic shielding to avoid coupling the transmitter signal into the receiver input coil.

Maximum frequency stability in this type of oscillator is achieved when the twin-T network (R_1 through R_4, and C_1, C_2), made up of stable components, is isolated from changes in transistor parameters. This is accomplished in the circuit by driving the twin-T from the low-impedance output of emitter follower, *Q3*, and by letting the network output drive the high-impedance input of another emitter follower, *Q1*. The required amplification is provided by voltage amplifier *Q2*. Control transistor *Q4* acts as a switch, which shifts the output to a higher frequency by paralleling R_{4a} and R_{4b} with R_{3a} and R_{3b}. This occurs each time a "mark" is produced by the keyboard.

Resistors R_{5a} and R_{5b}, from the base of *Q4* to ground, cause a current of 20 mA to flow through the keyboard contacts in the teletypewriter. This amount of current is required for reliable operation of the contacts. Diode *CR3* is needed when pin *8* is connected for half-duplex operation. If this pin *8* is connected to pin *8* of the receiver output card, any characters being transmitted will also be typed on the transmitting teletypewriter.

The diode feedback network, *CR1* and *CR2*, around bias resistor R_{11} is used to limit the oscillator output so that no change in amplitude occurs when the frequency is shifted.

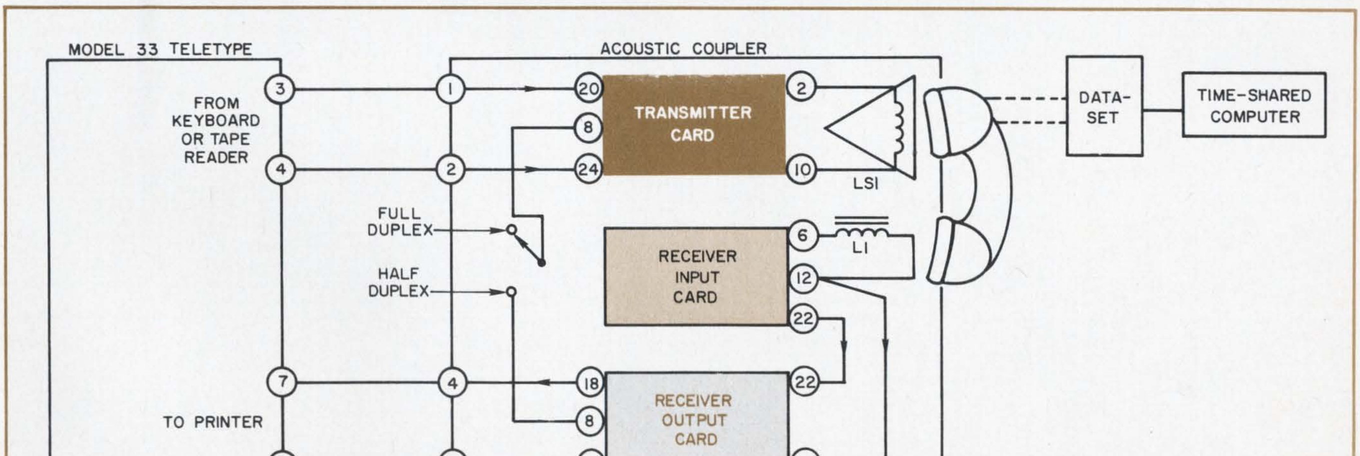
The audio amplifier consists of an integrated-circuit operational amplifier, *AR1*, driving a complementary output-pair of transistors, *Q5* and *Q6*, which operate class-B. Bias stability is provided by the feedback loop consisting of R_{15} and R_{16}. Ac feedback through C_7 eliminates the crossover distortion inherent in class-B operation. R_{14} adjusts the output level for reliable operation.

Originate vs answer mode

For a terminal to operate in the answer mode, its transmit and receive frequencies are the reverse of those of a terminal operating in the originate mode. These frequencies are as follows:

	Mark	Space
Originate mode		
transmit	1270 Hz	1070 Hz
receive	2225 Hz	2025 Hz
Answer mode		
transmit	2225 Hz	2025 Hz
receive	1270 Hz	1070 Hz

The conversion is accomplished by changing the values of certain frequency-determining components, as specified in the text.



1. **Acoustic coupler converts a teletypewriter** into a time-shared computer terminal. The transmitter portion of the coupler converts the dc signals from the teletypewriter into tones that can be sent over telephone lines. The receiver portion converts the tone signals from the central computer back into dc.

To convert the transmitting unit of Fig. 2 for operation in the answer mode, capacitors C_1 and C_2 are changed to 0.0015 μF, capacitor C_3 to 0.0033 μF and resistor R_{4a} to 33 kΩ.

Receiving unit converts FSK signal to dc

The receiving unit of the coupler consists essentially of an amplitude limiter feeding two tuned circuits, which act as a demodulator. The demodulated signal is then shaped by a digital circuit and supplied to the teletypewriter printer.

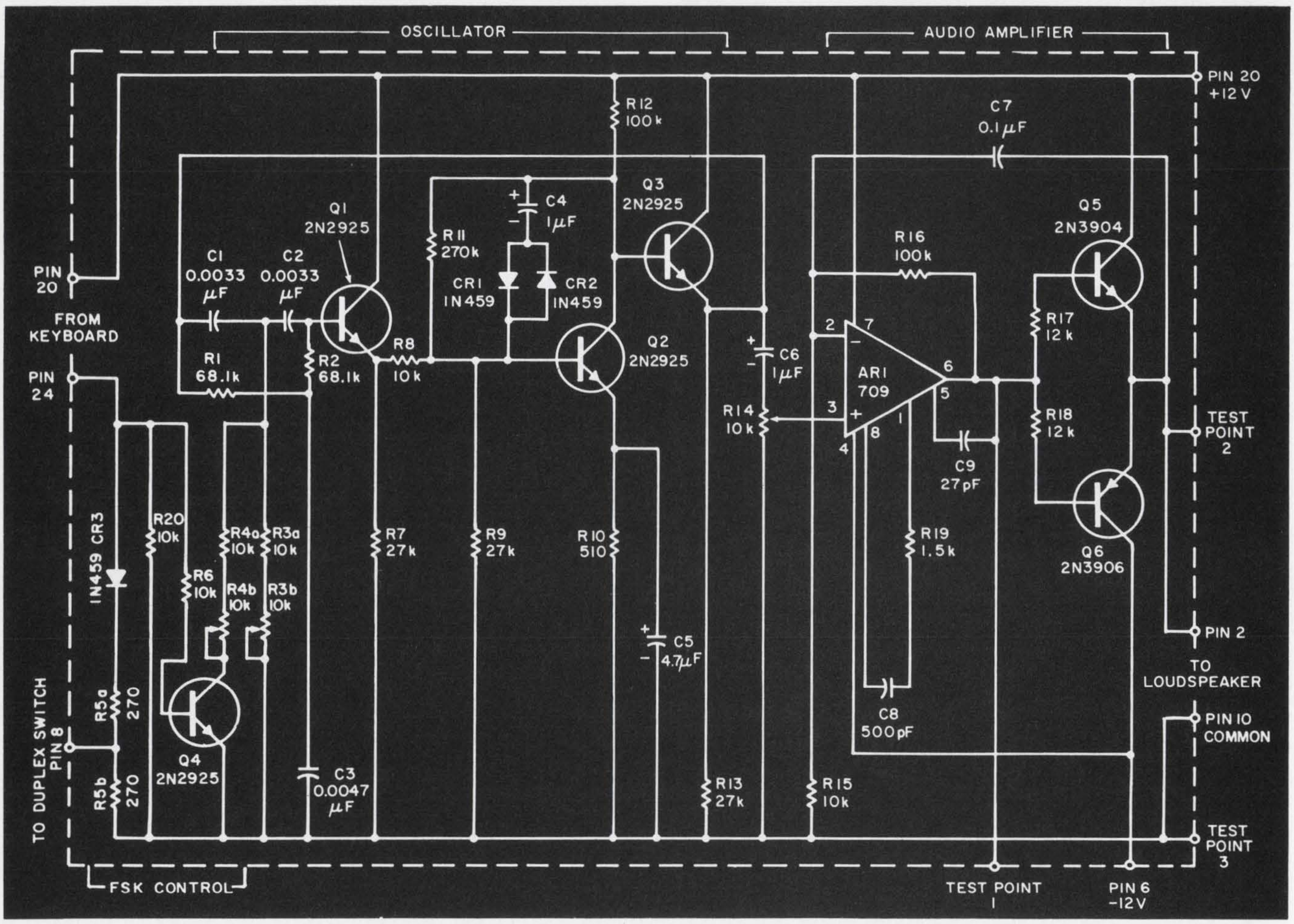
A diagram of the receiver input card, which provides amplification, noise rejection and limiting, is shown in Fig. 3. The input signal comes from a simple, commercial magnetic pickup coil designed for recording from telephones. This type of coil is used instead of a microphone to reduce response to room noise.

After amplification by stages *Q1* and *Q2*, the signal is filtered by band-pass filter L_2-C_{11}, which attenuates telephone-line noise that lies outside the frequency region of interest. For optimum noise rejection, the 3-dB points of the filter should coincide with the frequencies of maximum deviation from the mean.[1] The required Q in this case is approximately 10, which is closely realized with the L_2-C_{11} band-pass filter. The filter is resonated at 2125 Hz, which is the mean receiving frequency.

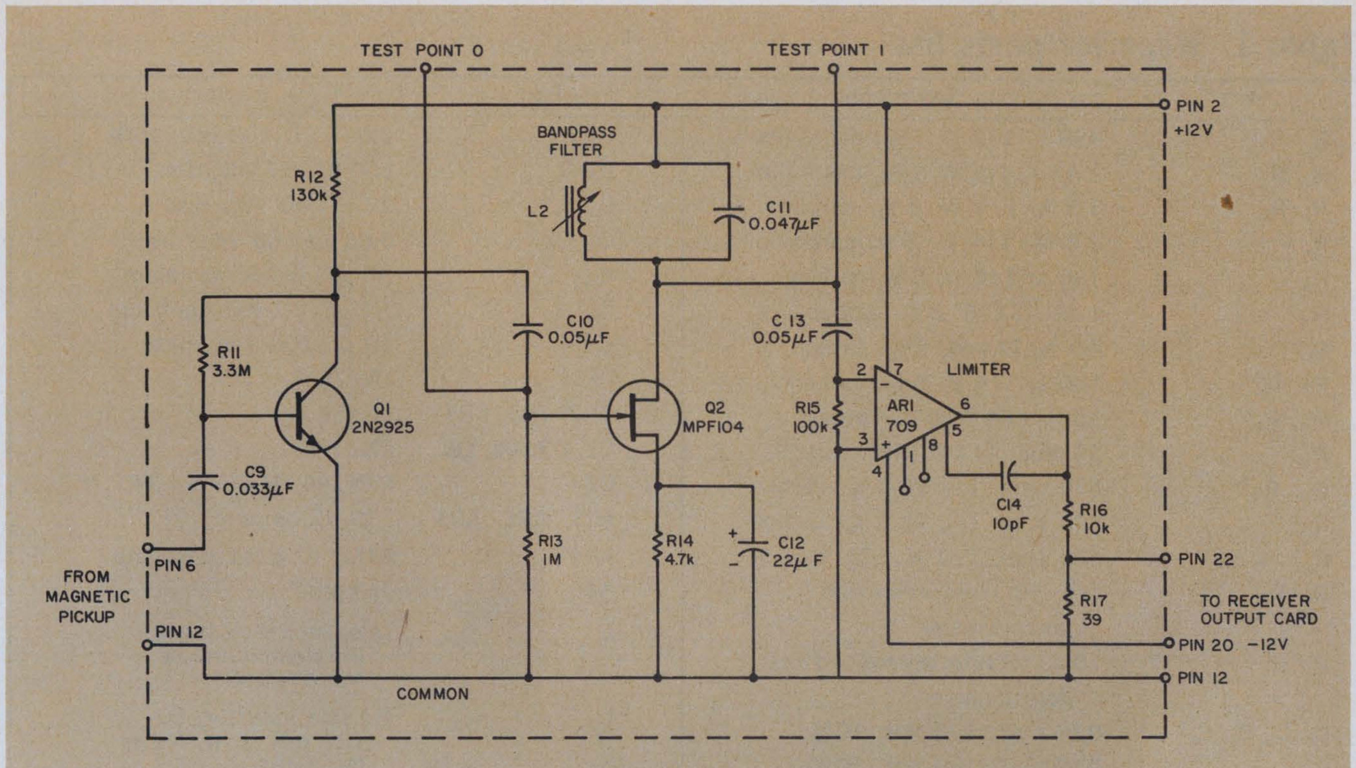
The integrated circuit operational amplifier, *AR1,* is used at full open-loop gain as a limiter. Full limiting is realized with a signal of 1 mV, peak-to-peak, from the input pickup coil. Above this voltage, the operation of the receiving unit is independent of signal level.

The receiver output card (Fig. 4) takes the amplified and limited FSK signal and demodulates it into the dc current pulses required for teletypewriter operation. The signal from the *AR1,* is used at full to open-loop gain as a limiter. limiter is divided by resistors R_{16} and R_{17} (on the receiver input card), and supplied to the mark and space filters. These filters use operational amplifiers connected in the so-called infinite-gain multiple-feedback arrangement to obtain the equivalent of a parallel-resonant, single-tuned circuit.[2]

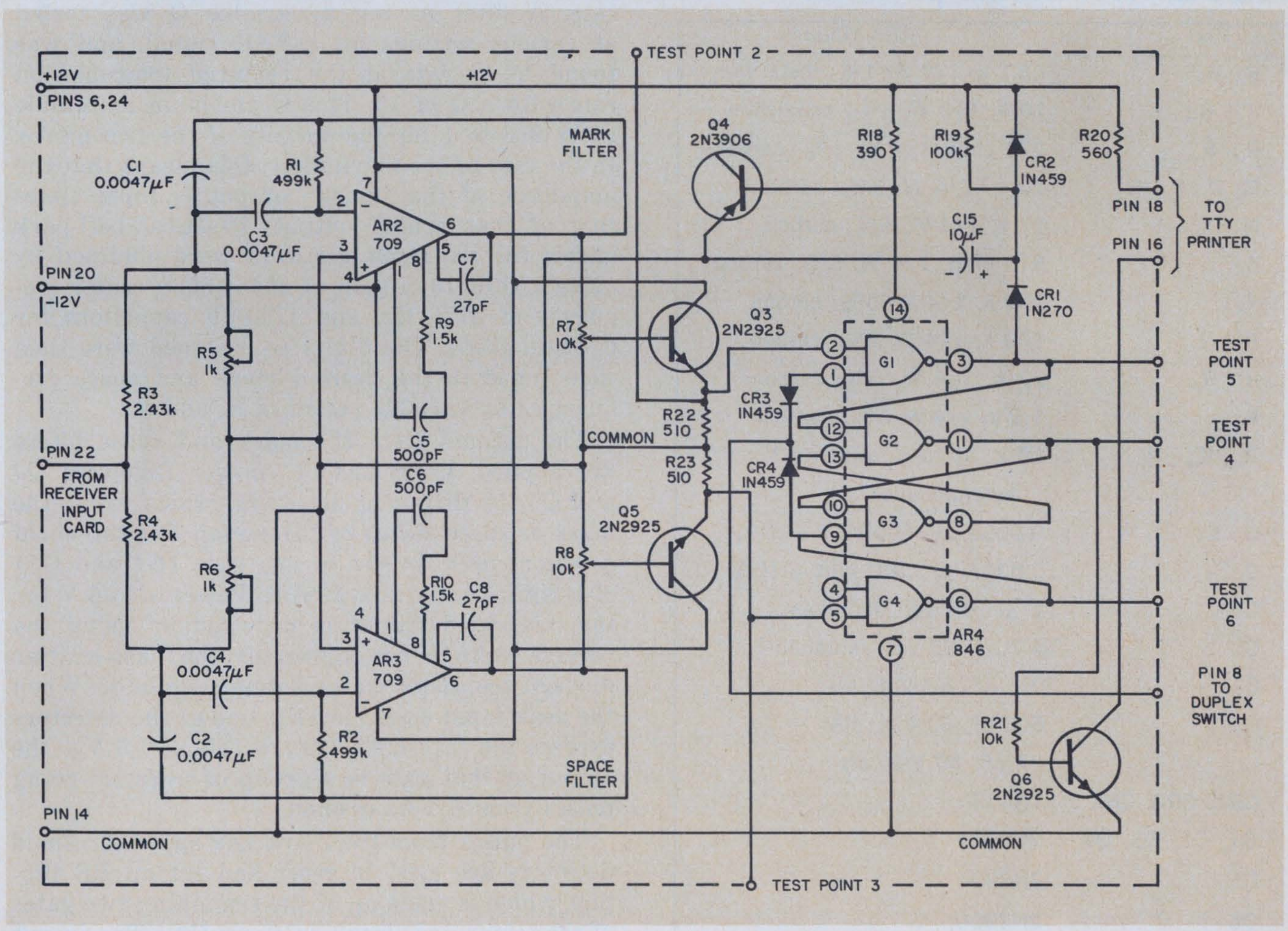
For demodulation of this type of FSK signal, there is an optimum Q for proper filtering. A very low Q would not provide sufficient rejection of the space frequency by the mark filter, and vice versa. A very high Q, on the other hand, would not allow the filter output to follow the



2. **The transmitter portion of the coupler** converts the ON-OFF dc currents from the teletypewriter into a frequency-shift tone signal, which is applied to the telephone handset through the output loudspeaker.



3. **The receiver input circuit** provides noise rejection and limiting of the tie signals received on the telephone lines.



4. **The receiver output circuit** converts the frequency-shift tone signal into the ON-OFF dc currents required by a teletypewriter. The circuit uses two IC operational amplifiers and one digital IC.

Table 1. Receiver parts list

Part	Description	Part	Description
R_1, R_2	499 k, 1/2 W, 1%, metal film	C_{11}	0.047 μF, 100 Vdc, 10%
R_3, R_4	2.43 k, 1/2 W, 1%, metal film	C_5, C_6	500 pF, 50 Vdc, disc
R_9, R_{10}	1.5 k, 1/4 W, 5%, carbon	C_7, C_8	27 pF, 50 Vdc, disc
R_{11}	3.3 M, 1/4 W, 5%, carbon	C_{10}, C_{13}	0.05 μF, 50 Vdc, disc
R_{12}	130 k, 1/4 W, 5%, carbon	C_{12}	22 μF, 6 Vdc, tantalum
R_{13}	1 M, 1/4 W, 5%, carbon	C_{15}	10 μF, 10 Vdc, tantalum
R_{14}	4.7 k, 1/4 W, 5%, carbon	C_{14}	10 pf, 100 Vdc, mica
R_{15}, R_{19}	100 k, 1/4 W, 5%, carbon	CR1	1N270
R_{16}, R_{21}	10 k, 1/4 W, 5%, carbon	CR2, CR3, CR4	1N459
R_{17}	39 ohm, 1/4 W, 5%, carbon	Q1, Q3, Q5, Q6	2N2925
R_{22}, R_{23}	510 ohm, 1/4 W, 5%, carbon	Q2	MPF104, N-channel FET
R_{18}	390 ohm, 1/2 W, 5%, carbon	AR1, AR2, AR3	709, IC op amp
R_{20}	560 ohm, 1/2 W, 5%, carbon	AR4	846P IC quad dual-gate
R_5, R_6	1 k, 15 turn, wirewound potentiometer	Q4	2N3906
R_7, R_8	10 k, 15 turn, wirewound potentiometer	L_1	Telephone pickup coil, Burstein-Applebee No. 17C253
C_1, C_2, C_3, C_4	0.047 μF, 100 Vdc, 10%	L_2	Tunable inductor, 60-130 mH, J. W. Miller No. 6324
C_9	0.033 μF, 100 Vdc, 10%		

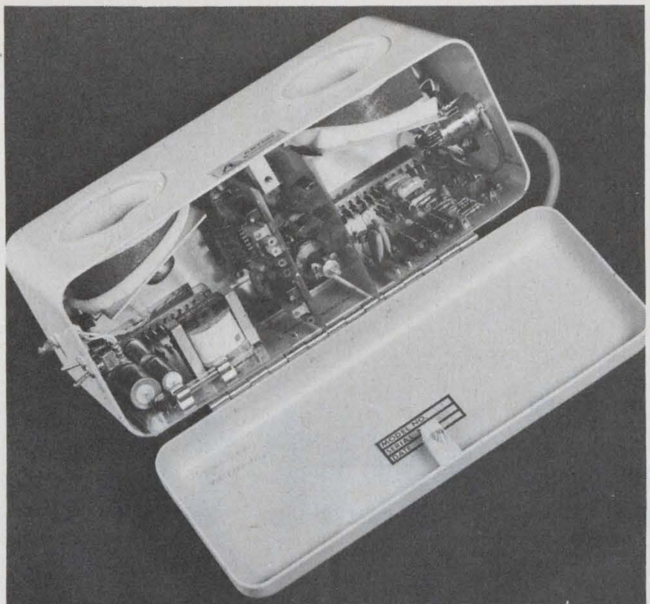
Table 2. Transmitter parts list

Part	Description
R_1, R_2	68.1 k, 1/2 W, 1%, metal film
R_{3a}, R_{4a}	10 k, 1/2 W, 1%, metal film
R_{5a}, R_{5b}	270 ohm, 1/4 W, 5%, carbon
R_6, R_8, R_{15}, R_{20}	10 k, 1/4 W, 5%, carbon
R_9, R_{13}	27 k, 1/4 W, 5%, carbon
R_{10}	510 ohm, 1/4 W, 5%, carbon
R_{11}	270 k, 1/4 W, 5%, carbon
R_{12}, R_{16}	100 k, 1/4 W, 5%, carbon
R_{17}, R_{18}	12 k, 1/4 W, 5%, carbon
R_{19}	1.5 k, 1/4 W, 5%, carbon
R_{3b}, R_{4b}, R_{14}	10 k, 15 turn, wirewound potentiometer
C_1, C_2	0.0033 μF, 100 Vdc, ±10%
C_3	0.0047 μF, 100 Vdc, ±10%
C_4, C_6	1 μF, 35 Vdc, tantalum
C_5	4.7 μF, 25 Vdc, tantalum
C_7	0.1 μF, 50 Vdc, disc
C_8	500 pF, 50 Vdc, disc
C_9	27 pF, 50 Vdc, disc
CR1, CR2, CR3	1N459
Q1, Q2, Q3, Q4	2N2925
Q5	2N3904
Q6	2N3906
AR1	709, IC op amp
LS1	2 in., 8-ohm speaker

signal modulation at the required transmission rate. A filter having a variable Q was tested at various settings on a FSK signal, and was found to operate at the required transmission rate with a Q of 15. This Q yields an amplitude ratio of 3 to 1 for the outputs of the two filters. In the case of the mark filter, this means that the amplitude of the "mark" output is three times that of the "space" output. Practical ball-park values for the input resistors were obtained by using a Q of 15, a gain of about 80, a center frequency of 2125 Hz, and 4700-pF capacitors for C_1 through C_4. The filters so designed were then each tuned to the desired mark and space frequencies by variable resistors R_5 and R_6.

The outputs from the mark and space filters are applied, by means of emitter followers *Q3* and *Q5*, to threshold detectors, which sense the mark or space status of the signal. The threshold detectors each consist of one gate (*G1* and *G4*) of a digital integrated circuit. Power of +6 V for the integrated circuit is provided by using the reverse voltage breakdown of the base-emitter diode of transistor *Q4* as a shunt regulator. When the peak input signal level to one of the detectors exceeds the threshold voltage (about 1.5 V), the output of that gate is a group of negative-going pulses from 6 V to ground.

The pulses from the mark and space threshold detectors are used to reset and set an RS flip-flop, which is made up of the remaining two gates of the integrated circuit (*G2* and *G3*). The output of the flip-flop is +6 V in the mark interval, and 0 V in the space interval. Transistor *Q6* is thus



Compact packaging is easy due to the relative simplicity of the coupler circuitry. The two receiving boards are mounted vertically in the center, while the transmitting board is at the lower right. The power supply, which must provide a +12 V and a −12 V at a current of 100 mA, is at the lower left.

driven into saturation for mark intervals and cut off for space intervals. The mark intervals cause a current, limited to 20 mA by resistor R_{20}, to flow through the teletypewriter printer terminals. No current flows during space intervals.

The network, made up of *CR1*, *CR2*, C_{15}, and R_{19}, ensures that the flip-flop delivers a mark output when the ac power is first turned on. This feature keeps the teletypewriter from running "open" (chattering away in a random fashion before being connected to the computer).

The power supply for the coupler, not shown here, must provide a regulated +12 V and —12 V dc, both at 100-mA capability. A line or load regulation of $\pm 1\%$, with a 0.1-V ripple is adequate for this application.

To convert the receive unit for operation in the answer mode, capacitors C_1 through C_4 are changed to 0.01-μF each, and C_{11} to 0.20 μF.

All components used in the coupler are standard items, and are listed in Tables 1 and 2.

Initial adjustment is easy

The procedure for initial adjustment of the coupler is not difficult; it requires only a few pieces of common test equipment. For the transmitter, the space frequency is set at 1070 Hz by adjusting R_{3b}, with the input terminals open. Next, the input terminals are shorted together and the mark frequency is set to 1270 Hz by adjusting R_{4b}. The acoustic drive to the telephone transmitter must then be adjusted so that the level on the telephone line is approximately 1 mW. For the 8-ohm speaker used here, this level corresponds to about 0.2 V peak-to-peak across the speaker terminals.

Adjustment of the receiving unit is somewhat more complicated. The band-pass filter is set by feeding a 2125-Hz signal of about 0.1 V into test point *0*, and adjusting variable inductor L_2 for maximum signal at test point *1*. This is easily checked by sweeping an audio oscillator through 2125 Hz and observing the frequency at which peaking occurs.

The mark and space filters are set next. For the mark filter, an oscilloscope is connected to test point *2* and the oscillator is again swept to find the resonant frequency. If potentiometer R_5 is initially set at about 500 ohms, the mark filter frequency should be reasonably close to 2225 Hz. (It may be necessary to adjust gain potentiometer R_7 so that an output can be seen.) The oscillator is set to 2225 Hz, and R_5 is adjusted for peak amplitude, as seen on the scope. R_7 is now adjusted so that the output is a series of positive-going partial sinusoids, with the peaks at 2 V above the zero-volts baseline, as observed on the dc-coupled oscilloscope.

Adjustment of the space filter is similar, except that potentiometers R_6 and R_8 are used to set the center frequency of 2025 Hz and the 2-V peak output. Sweeping the oscilloscope back and forth between 2025 Hz and 2225 Hz should now cause the output at test point *4* to switch between two levels.

The coupler has been found to perform satisfactorily under normal telephone communication conditions, over local and long distance circuits. In typical use, the error rate is less than one wrong character per thousand.

Noise immunity tests have been made by injecting random noise through a large isolation resistor into test point *0*, while receiving a standard test message over an essentially noise-free local circuit. The random noise was bandwidth-limited by a 300-Hz to 3-kHz filter, an approximation of voice-grade-line bandwidth. The noise input was adjusted to cause an average of one error per line. Then, signal power and signal-plus-noise power were both measured at test point *1* with an rms voltmeter. Five units were tested; the signal-to-noise ratios at one error per line (72 characters) were all between —1.4 dB and 0.0 dB. If a nominal signalling bandwidth of 300 Hz is assumed, then the equivalent signal-to-noise ratio in that bandwidth is 8.6 to 10 dB. ■■

References:

1. H. S. Black, *Modulation Theory* (Princeton, N. J.: D. Van Nostrand Co., 1953), p. 200.
2. "Handbook of Operational Amplifier Active RC Networks," Burr-Brown Research Corporation, 1966, p. 78.

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INFORMATION RETRIEVAL NUMBER 34

Use--don't abuse--the SCR. Here's a refresher for those who, through over-familiarity or under-exposure, are not getting the most from their SCR designs.

Part 1 of a two-part article

SCRs have been a common circuit component for a long time, but cases of misapplication are still not unusual. The trouble usually arises because the wrong device is selected for a particular application or because important firing considerations are neglected or misunderstood.

This article is aimed at those designers who may be growing careless in their approach to SCR design. In this first part, the specifications that define an SCR and indicate its usefulness for a particular application are analyzed. The second part of the article will cover the firing requirements and characteristics of SCRs.

Specifications tell the story

The parameters normally specified by the SCR manufacturer are listed in Table 1. Although manufacturers may use different designations for the same parameter, the information on most spec sheets is usually the same.

The first current parameter of an SCR that

Average forward current, I_{ave}

The first current parameter of an SCR that should be examined by the designer is the average forward current of the device (I_{ave}). This tells the designer the maximum average current that the device can conduct under certain conditions of case temperature and conduction angle. For any application, the maximum I_{ave} that the device will carry must be determined, and an SCR must be selected that can conduct this current.

There are two important factors to consider in selecting a device having the proper I_{ave} rating. The first is the minimum angle of conduction at which the SCR will carry this maximum I_{ave} current. From the curves of I_{ave} vs power dissipation and I_{ave} vs maximum case temperature given on the manufacturer's data sheet, one can see that the smaller the conduction angle, the greater is the power dissipation and the lower is the allowed case temperature for a fixed I_{ave}. Therefore, if a device is to carry a maximum average current when its conduction angle is 90°, the maximum case temperature and the power dissipated must be obtained from the 90° conduction angle curve.

For example, if the device depicted by the curves of Fig. 1 were to conduct an average current of 30 A, with a minimum conduction angle of 90°, the case temperature would have to be maintained at a maximum of 98°C. Although the I_{ave} maximum rating specified by the manufacturer for this particular SCR is 70 A, it would be difficult at such a current and with a 90° conduction angle, to maintain the case temperature at or below the maximum allowable value of 63°C. This seeming discrepancy arises from the fact that the I_{ave} rating given in the title of the specification sheet is for a conduction angle of 180°. The reason for the derating of the SCR with decreasing conduction angle is that the form factor of the current increases, so the peak and rms currents increase accordingly, thereby causing increased heating in the device.

T_j and θ_{jc}

The next two specifications are related to the I_{ave} specification in that they determine whether or not the device may be sufficiently cooled. The first of these two is the maximum operating junction-temperature of the device (T_j)—one of the most important SCR specifications. If this junction temperature is exceeded, the junctions that give the SCR its switching characteristics become permanently damaged, causing the device to fail permanently. Although most SCR manufacturers' specifications show maximum case temperatures rather than junction temperatures, their main concern is that the user maintain the junction temperature of the device (T_j)—one of The actual junction temperature of a production SCR cannot be measured; it must be calculated.

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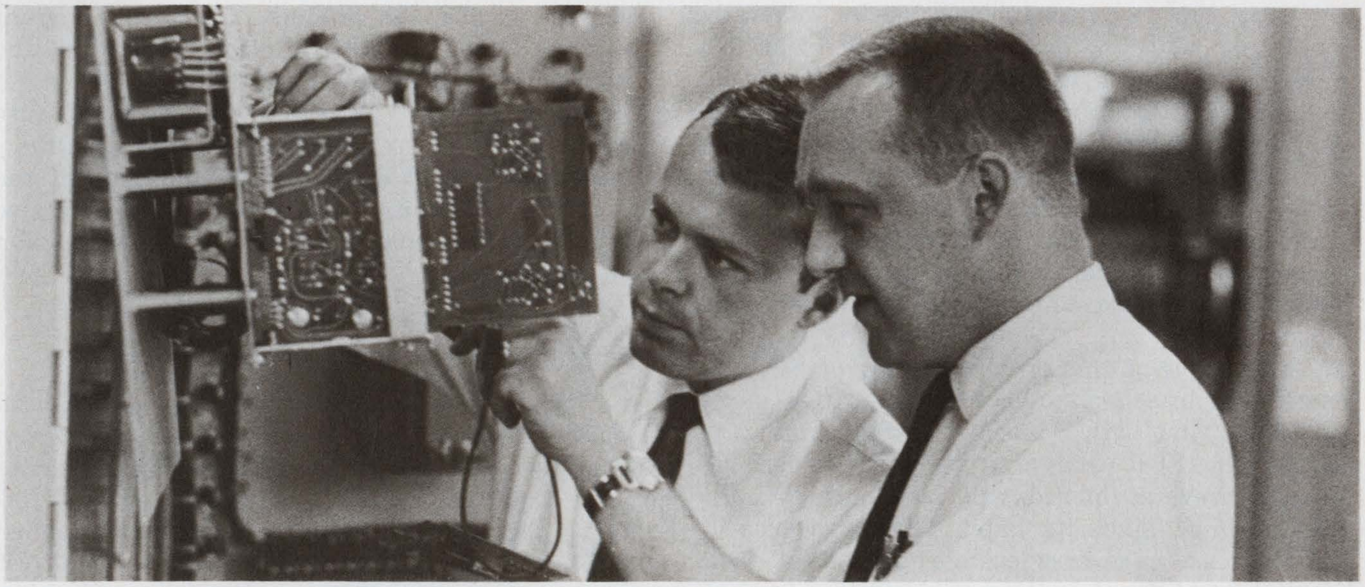


Authors Randall (left) and Ritchey check the control circuitry in an SCR static power rectifier.

This is where the second specification, θ_{jc} enters the picture.

θ_{jc} is the maximum thermal impedance of the device from junction to case; it is defined as the ratio of the difference between the junction temperature and the case temperature to the power dissipated in the device, and is given in degrees centigrade per watt.

Since the case temperature of an SCR can be measured rather simply, and the power dissipated can generally be measured, the actual junction temperature may be calculated from $T_j = P_d \theta_{jc}$, where P_d is the power dissipated in the device. In general, the SCR manufacturers have performed this calculation for the designer by displaying the maximum case temperature requirements of a device.

Rms forward current, I_{rms}

Mention should be made of the rms forward current (I_{rms}) rating of an SCR. This is the current that actually causes the junction to heat up.

But since, in most applications, it is the I_{ave} current that is usually of most concern, SCR manufacturers publish their data with respect to I_{ave}. However, there is a fixed ratio between I_{rms} and I_{ave} for any conduction angle, and this ratio is taken into account in the manufacturers' specifications.

Peak forward surge current, I_{fm}

The next parameter to be considered is peak forward surge current (I_{fm}). This defines the maximum peak current, based on one half-cycle of a 60-cycle sine wave, that the device can withstand in the forward direction. Most specifications contain a derating graph that shows the maximum peak current that an SCR may conduct for a specific number of cycles. For example, the curve of Fig. 2 shows that the SCR depicted by the curve can tolerate a peak sine-wave current of 875 A for 60 cycles. The main use of this parameter is to determine whether or not a particular SCR can withstand the peak current it may be subjected to for a certain number of cycles, such as in-rush currents to a motor or capacitor bank, or during fuse blowing in current limited circuits.

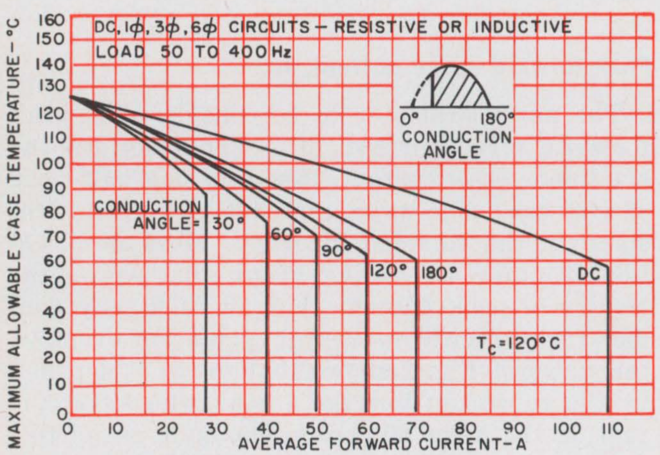
I_{fb} and I_{rb}

The peak forward (I_{fb}) and peak reverse (I_{rb}) leakage current parameters are self-explanatory, in that they are the currents that flow through the SCR when it is in its blocking, or nonconducting, state. An important point to be considered in the case of the reverse leakage current, though, is the condition of the gate circuit of the SCR. The I_{rb} parameter specified is generally valid only when the gate-to-cathode junction has a zero or negative voltage applied to it. If the gate of the SCR is forward biased when a reverse current is trying to flow through the SCR, the reverse leakage current will be higher than that listed in the specification. This increase causes greater heating of the SCR junction and it is necessary, therefore, that it be considered when determining the cooling requirement for the device.

An example of this is when a pair of SCRs is being used in a back-to-back configuration in an ac circuit and both SCRs are gated simultaneously. The SCR that has its anode-to-cathode junction reverse biased will have a higher I_{rb} than normal, since its gate is forward biased. This increase in reverse leakage current will then result in additional heating taking place in that SCR.

Holding current, I_{ho}

The holding current (I_{ho}) of an SCR is the minimum current that must flow through the device in the forward direction to insure that it will remain in the conducting state if the gate



1. **Power dissipation in an SCR,** and therefore the allowable case temperature, is dependent on the conduction angle. The curves shown are for the G.E. series C52 SCRs, and are based on a sinusoidal current waveform.

signal is removed. I_{ho} is also important for commutation, or turnoff, of an SCR; because, for proper commutation, a reverse current must be provided that, when combined with the maximum forward current, results in a net forward current that is less than the I_{ho}.

Fuse rating

The last parameter involving the current flowing from anode to cathode of an SCR is the fuse rating, or I^2t rating. This has the unit ampere^2-seconds, and is the product of the rms current squared that flows through the device and the time during which this current flows. When selecting a fuse for protecting an SCR, the fuse rating must be less than that of the SCR. Otherwise, an overload will cause the junction of the device to exceed its I^2t rating, causing excessive heating of the junction and possible destruction of the SCR.

Repetitive peak forward blocking voltage V_{fb}

Thus far the parameters discussed have been concerned with the various currents that can flow through the anode-cathode circuit of an SCR. The next class of parameters covered includes the various voltages which can be applied across the anode-cathode of the device. The first of these is the repetitive peak forward blocking voltage (V_{fb}), which is the maximum peak voltage that can be applied between anode and cathode and have the SCR remain in its blocking state. This parameter is extremely important to the designer, because the usefulness of the SCR depends primarily on its ability to remain in the blocking state with a forward voltage applied across it. It is essential, therefore, that the peak voltage applied across the anode-to-cathode of an SCR does not exceed this rating.

Repetitive peak reverse voltage rating V_{rb}

Every SCR also has a repetitive peak reverse voltage rating (V_{rb}), which defines the maximum peak voltage that can be applied between anode and cathode, in the reverse direction, without causing the device to switch from the nonconducting to the conducting state. This rating has the same function as the reverse blocking voltage of an ordinary diode.

V_{ft} and V_{rbt}

The nonrepetitive peak forward voltage (V_{ft}) and nonrepetitive peak reverse voltage (V_{rbt}) parameters are transient ratings of the V_{fb} and

V_{rb}, respectively, based on one half-cycle peak of a 60 cycle sine-wave. These parameters are very important for selecting the proper SCR for an application where transients are encountered. This is particularly true in the case of the V_{rbt} rating, since, if it is exceeded, the SCR will be permanently damaged.

If the V_{ft} parameter is exceeded, the device may switch from the nonconducting to the conducting state, but may not necessarily be permanently damaged. Such transient switching ON of the SCR for a half cycle may or may not be acceptable to the designer, depending on the particular type of circuit in which the device is being used.

Forward voltage drop, V_f

The final parameter concerning the anode-cathode voltage across an SCR is forward voltage drop (V_f), which defines the voltage drop from anode to cathode when the device is conducting. It is this voltage that must be considered when determining the power dissipated in the SCR. The V_f parameter is also an important consideration when the SCR is to be used in power circuits of very low voltages (below 10 V).

dv/dt rating

The dv/dt rating of the SCR specifies the maximum allowable rate of rise of the forward anode-cathode voltage applied to the SCR. If a voltage is applied between anode and cathode at a higher rate, the device may switch from the nonconducting state to the conducting state. In any circuit, therefore, the rate of rise of the applied forward voltage of the SCR must be considered; when necessary, this must be limited by some means. Techniques for accomplishing this will be covered in Part 2 of this article.

Gate trigger current, I_{gt}

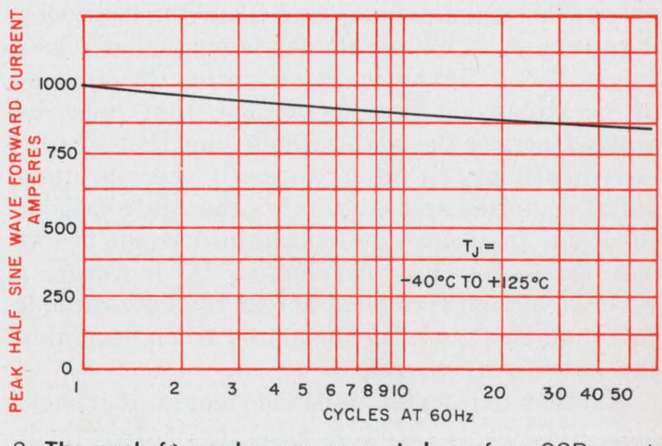
Thus far the parameters discussed have dealt primarily with the anode-cathode structure of the SCR. The following discussion deals with the gate-cathode ratings.

The first of these parameters, I_{gt}, is the minimum gate current that will cause the SCR to switch from the nonconducting to the conducting state. In other words, the SCR is guaranteed to turn on when the specified I_{gt} is flowing through the gate-cathode junction and anode current is available. For any gate current less than the specified I_{gt}, the device may or may not turn on.

If the SCR is to be subjected to high *di/dt* values, special design considerations must be

Table 1. Typical SCR parameters

Symbol	Definition	Typical units
V_{fb}, V_{fom}	Repetitive peak forward blocking voltage	V
V_{rb}, V_{rom}	Repetitive peak reverse voltage	V
V_{ft}	Nonrepetitive transient peak forward voltage	V
V_{rbt}, V_{rom} (Nonrep)	Nonrepetitive transient peak reverse voltage	V
I_{fb}	Peak forward leakage current	mA
I_{rb}	Peak reverse leakage current	mA
I_{rms}	RMS forward current	A
I_{ave}	Average forward current	A
I_{fm}	Forward surge current	A
I^2t	Fusing rating	$A^2 - s$
V_f, V_{fm}	Forward voltage drop	V
I_{ho}	Holding current	mA
T_J	Operating junction-temperature range	°C
T_{stg}	Storage temperature range	°C
Θ_{Jc}	Maximum thermal impedance, junction-to-case	°C/W
I_{gt}	Gate trigger current	mA
V_{gt}	Gate trigger voltage	V
V_{gnt}	Nontriggering gate voltage	V
I_{gfm}	Peak forward gate current	A
V_{grm}	Peak reverse gate voltage	V
P_{gm}	Peak gate power	W
$P_{g(ave)}$	Average gate power	W
V_{gfm}	Peak forward gate voltage	V
T_{on}	Typical turnon time	μs
di/dt	Rate of rise of anode current	A/μs
T_{off}	Turnoff time	μs
dv/dt	Rate of rise of anode-to-cathode forward voltage	V/μs



2. **The peak forward surge current, I_{fm},** of an SCR must be derated if the peak current is to be conducted for more than one half-cycle.

given to the I_{gt} parameter. In these cases, the gate current should reach a peak of at least five times the I_{gt} rating within at least 1 μs. This current should then decay exponentially to the minimum value of I_{gt} specified, and should remain at this value for the required width of the gate pulse. The term "hard-gate firing" is used to describe a gate current that has this characteristic. The purpose of hard-gate firing is to spread the anode-cathode structure of the SCR into conduction as rapidly as possible, thereby rendering the whole area available to conduct current.

Peak forward gate current, I_{gfm}

The next gate-cathode parameter to be considered is the peak forward gate current (I_{gfm}). This parameter defines the maximum forward peak current that can flow through the gate-cathode junction of the SCR without causing damage. The designer must take care not to exceed the I_{gfm} rating when he is designing or selecting a circuit for supplying hard-gate firing to an SCR.

Gate trigger voltage V_{gt}

The gate trigger voltage (V_{gt}) parameter given in the specification defines the minimum voltage that must be applied to the gate to insure that the SCR turns on. Since the SCR is a current operated device, the more important gate parameter to consider is the gate current. However, the V_{gt} parameter aids the designer in determining the open-circuit voltage of the required gate-current source.

Nontriggering gate voltage, V_{gnt}

The nontriggering gate voltage (V_{gnt}) defines the maximum voltage that can appear across the gate-cathode junction of the SCR without causing it to turn on. This parameter is particularly useful to the designer in determining the amount of back-bias, or reverse voltage, that must be applied across the gate-cathode junction to prevent misfiring. In other words, if there are any voltage noise spikes across the gate-cathode junction, they must be maintained equal to—or less than—the V_{gnt} parameter. If, however, a reverse voltage is applied across the gate-cathode junction, this must be considered when designing the gate firing source.

Another parameter to be considered, if a back-bias voltage is used across the gate-cathode junction of the device, is the peak reverse gate voltage (V_{grm}). The designer must be sure that the back-bias voltage does not exceed the value specified for V_{grm}. If it should, the gate-cathode junction may be permanently damaged.

Peak forward gate voltage, V_{gfm}

When a hard-gate-firing circuit is being designed, the peak forward gate voltage (V_{gfm}) rating of an SCR must be considered. This parameter defines the maximum peak voltage that can be applied across the gate-cathode junction of the device without causing permanent damage. The gate source, therefore, must not apply a voltage higher than the V_{gfm} rating.

$P_{g(ave)}$ and P_{gm}

The average gate power, $P_{g(ave)}$, and peak gate power, P_{gm}, parameters must also be considered when designing hard-gate-firing circuits. A careful check of the current and voltage waveforms across the gate-cathode junction of the device will usually tell the designer whether or not he is exceeding these ratings.

The remaining parameters generally given on an SCR specification sheet are the turnon (T_{on}) and turnoff (T_{off}) times of the device. These define the actual time it takes the device to switch on or off. Both parameters are most important in applications such as inverters where proper circuit operation depends upon how fast the SCR can be turned on or off. ■■

The second part of this article will cover the firing requirements and characteristics of SCRs.

Test your retention

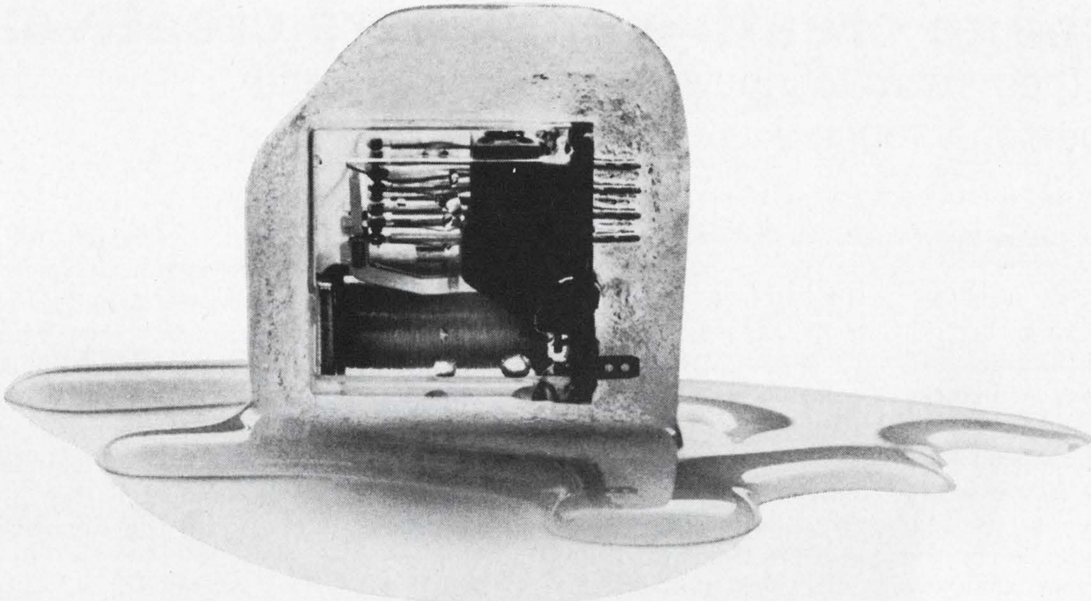
Here are questions based on the main points of this article. Their purpose is to help you make sure you have not overlooked any important ideas. You'll find the answers in the article.

1. What is the significance of conduction angle in selecting an SCR having a suitable I_{ave} rating?

2. What SCR parameters must be considered in the design of hard-firing gate circuits?

3. What is the fuse rating of an SCR, and why is this significant when designing SCRs into circuits?

4. What is the primary usefulness of the nontriggering gate voltage specification V_{gnt}?



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INFORMATION RETRIEVAL NUMBER 35

Manage creative engineers creatively

Give them room to innovate on the job and add the personal touch. Here are some hints.

Lawrence Locke, Management and Careers Editor

Creative workers have surface traits that sometimes bother other people. Some wear wildly printed neckties or sport long sideburns or a handlebar moustache. Some go to the other extreme and dress extraordinarily slovenly. The first impression many managers get is:

"This guy is a kook. Watch out."

You could, as a supervisor, lose a gifted talent if you handle creative engineers this way. Supervisors who would work effectively with creative engineers must be creative managers. You can start by shucking off extraneous personal biases.

To provide working conditions that will yield the maximum output from creative engineers, know how the creative process works and what the creator's outstanding traits are (see "Yes, You Can Develop Your Creativity," ED 3, Feb. 1, 1969, p. 66, and "Don't Wait for Brainstorms," ED 4, Feb. 15, 1969, p. 102).

But that isn't all you need to manage innovative engineers. You must add understanding, tolerance and encouragement—frequently encouragement of traits and behavior that may seem to be adding a wrench to the cogs of a smooth-running organization.

The personal touch helps

How a manager gets along with his creative engineers has little to do with rules and regulations. He is dealing with people who think of themselves as different—and they are different. So the supervisor's personal touch—his ability to empathize with other people—is the key to success. Most management experts agree that the *creative person's relationship with his working supervisor is more important in motivating him than any other factor.*

That's a surprising statement. It may topple completely a few shaky assumptions you already have—for instance, that money is the major magnet for creative people with talent to sell; that creative people tend to ignore their supervisors and go it on their own; that the manager should cut himself loose from the creative man.

All these ideas go overboard. What remains is this: the manager is not a time-oriented boss, but an advisor who works with his creative engineers. He learns what they want, what will help them turn out better solutions faster—and he gets it for them.

What do creative engineers want? The same things, in large part, that all engineers want. But in the case of the innovator, they are vital to his productivity; he won't function well at all without them.

Here are 11 guidelines for managers. The creative engineer wants:

- A permissive atmosphere where he is trusted to be productive. He believes in himself, and he wants his manager to.
- Freedom to pursue problems he finds intriguing. This not as risky as it sounds, since studies indicate that more-creative people are more concerned with practical values than less-creative people.[1]
- The chance to talk freely and frankly with his supervisor.
- Freedom from routine jobs—filling out reports, for instance—that pull him away from his problem research.
- Colleagues of his caliber with whom he can mix on the job. Of course, this does not mean that all creative engineers are "groupers." Some prefer to work strictly alone.
- Information on the company policy under which he must operate. This does not refer to narrow procedures; rather, the company's broad aims.
- Appraisal of his work by his supervisor soon after it is submitted.
- Time—and a place—where he can be alone without looking like an oddball or a loafer.
- The option of having professional colleagues and contacts who are not in the company. This includes membership in professional societies, lecturing, writing.

Dr. Daniel E. Noble, vice-chairman of the board of Motorola, Inc., and the holder of eight patents in electronics, suggests how to find and use creative people.

"We use the search-and-find method, not esoteric analysis, to find creative men. We urge our supervisors to watch for, and give credit to, young innovators (old ones should be known already)."

"Plant your creative people in stimulating soil. Expose them to new facts. More important, expose them to product-design problems at all levels—engineering, production and consumer."

"Few creative people make it without support. A man who gets an idea must get a hearing—and backup from his superiors. Here, it's important to have a high-ranking executive who supports creative talent."

Who's who in creativity: eight types

Creative people don't fit into molds. Yet when researchers at the Institute of Personality Assessment and Research, University of California, Berkeley, studied 45 engineers, and scientists who were working on space or missile problems, they found eight discernible creative types.

But—as a report by Wallace B. Hall, associate research psychologist at the institute, makes clear—no one person fits any one type perfectly. The traits overlapped, so that each creator had some of the characteristics of several of the eight types. Researchers classified the people they were studying by noting the *predominant* traits.

Harrison C. Gough at the institute lists the eight creative types as follows:

1. **Zealot.** Dedicated, driving, indefatigable, with a lively sense of curiosity. Others see him as tolerant, serious-minded and conscientious, but not as getting along easily with others.
2. **Initiator.** Begins at once to generate ideas; stimulating to others and a good team man. Seen as ambitious, well-organized, industrious, a good leader, efficient and not a worrier.
3. **Diagnostician.** Sees himself as a good evaluator; finds strong and weak point quickly in any problem, a good troubleshooter. Not critical of others' mistakes. Observers label him forceful, self-assured and unselfish.
4. **Scholar.** A man with an exceptional memory, looking for detail and order, but not a perfectionist. Seeks help when needed and adapts to others. Well-informed in his own field, not a bluffer. Described as conscientious and thorough, dependable, lacking somewhat in confidence and decisiveness.
5. **Articifer.** Sees himself as good at perfecting ideas that others suggest; does not attempt to do what he cannot. Seen as direct, honest, getting on well with others, observant and responsive to cues given by others' behavior.
6. **Ethetician.** Favors analytical thinking, prefers problems leading to elegant solutions. Has widespread interests and tends toward impatience with too much order and detail or if results are slow. Observed as clever and spontaneous, with a degree of immaturity, impatience and indifference toward deadlines and obligations.
7. **Methodologist.** Vitally interested in methodological issues; open about own work and enjoys discussing his plans. Has little competitive spirit and is tolerant. Characterized by others as considerate, not too ambitious but occasionally difficult.
8. **Independent.** Dislikes and avoids administrative details; not a good team man nor a driving one, but has a lively sense of curiosity. Prefers to think in reference to physical and structural models rather than in analytical and mathematical ways. Seen as active, robust, hard-headed and forthright in judgment. May behave abruptly or impolitely, but has little self-doubt.

- Special consideration for harmless idiosyncrasies that might upset strait-laced managers.
- Freedom to fail—or to suggest far-out solutions without being ridiculed.

Ways to keep creative engineers content

Corresponding in a rough way to the creative engineer's wants are positive steps that a manager can take to create a good working atmosphere. These actions apply, incidentally, to less-creative engineers, too.

Here they are:

- Be honest. Creative engineers want straight answers that they can rely on. Most really are not interested in "office politics."
- If you have a criticism or comment to make about the man's work, tell him and not your fellow managers. And tell it to him privately.
- Use personal conversations, rather than elaborate evaluative forms and reports, to get a fix on the status of a project. Conversations with your engineers may take more of your immediate time, but you'll get fuller, straighter answers in person—and you won't tie your engineers up filling out forms you haven't time to read."
- Keep your engineers informed of developments in the company. You don't have to have the whole story, if company security is involved, but your men should hear the significant facts from you, not from the office grapevine.
- Show concern for your engineer's personal welfare and problems. Don't pry, but if a death in the family, illness, even a divorce occurs, express your willingness to overlook a temporary drop in the man's productivity.
- Consciously try to develop a warm and affectionate attitude toward your men. Many managers are stunned to learn that their subordinates think they are cool, indifferent or brusque. Consider how you handle daily contacts with the staff. Are you interested, abrupt, friendly, businesslike? Put yourself in their shoes.
- When you evaluate an engineer's work, balance criticism with praise. One good technique is to pick out the good elements and mention them first. Then, establishing confidence, move into the points that need improvement.
- Give your engineers feedback from the top when there is favorable comment on their

achievements. If there is criticism, talk it over with the engineer without saying that the dissatisfaction originated higher up. If you think the criticsm is invalid, go to the top and find out why it was made. Perhaps blame is falling on the wrong man.

So far so good. But what does the manager do when Mr. Creative balks at a rule or attracts unwanted attention? Let's look at two problems a manager might encounter with his creative engineers. Each problem situation is followed by action choices. Pick as many as you think are solutions. The answers are on p. 129.

Note: The choices are by no means the *only* actions a manager could take, but they are to help you see if you are moving in the right direction. Pick the best solutions of those available.

Here are the two problem situations:

Case A. *Bill Creative makes a point of coming in an hour late and leaving two hours early. He deliberately attracts attention when he does this, irritating other department employes who work 9 to 5. Yet he consistently comes up with good insights and problem solutions. He is valuable, but he is causing trouble among the other employes. What does the manager do?*

Action choices:

1. Ask him in and tell him he is doing outstanding work. Then explain to him that though he may not know it, he is causing a problem. Could he come in at 9 a.m. and, if he must leave before 5 p.m. could he do it only occasionally—and without fanfare?

2. Publicly embarrass him one morning by telling him he is late and note that he has been leaving early while all the other engineers are working full hours.

3. Invite him in and tell him he is doing an excellent job, but you have some pressing problems you'd like him to put his talents to. Could he arrange his schedule so that in the future he could stay until you leave—usually not later than 6 p.m. Let him know that if he follows through successfully, he could get a substantial raise.

4. Tell him privately that he is doing fine work but would he please keep the department hours. If he comes in late next day (without excuse or explanation) fire him immediately.

5. Ignore your department's reaction and do nothing. You are dealing with a highly temperamental person and to say anything will only create more problems and worsen the situation.

Case B. *Several engineers have made it known to you that Charles Creative sits at his office desk for long periods with his feet up as he taps the side of his head with a pencil. Recently two engineers, thinking he was killing time, walked into his office and tried to strike up a conversation. Each was met by blank, rather cold stares. Is something wrong with Charles? The office conversation about him is beginning to embarrass him. What do you do?*

Action choices:

1. Mention casually in presence of all engineers that Charles is doing an excellent job on this or that problem.

2. Suggest to Charles that he be more receptive to other staff members.

3. Have a door put on Charles' office or move him to a more secluded area.

4. Warn your other engineers not to bother Charles because he is doing creative thinking.

As you can see, there are many possible solutions to each management problem. Obviously, there is no pat formula that will guarantee that creative engineers will hurdle obstacles and create for you, while the rest of the staff happily carries on the less-innovative assignments. There always will be problems. But some of the major roadblocks can be removed when they are in your personality or management manner, or when they are the result of popular misconceptions and fears about creative people.

The cardinal rule for the manager of creative engineers is: Work *with* them and be willing—almost eager, in fact—to change the job environment and the rules to suit their needs. ■■

Reference:

1. M. R. Feinberg, "Fourteen Suggestions for Managing Scientific Creativity," Research Management, Vol. XI, No. 2 (1968).

Test your retention

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

1. What is the most important of all work factors for the creative engineer?

2. What is a good technique to use when evaluating an engineer's work?

3. In what three "places" are obstacles to creative management most likely to arise?

4. In general, which should you change to improve working conditions: the creative person's habits or the environment?

5. Can managers use the same techniques when supervising creative engineers that they use with less-creative engineers?

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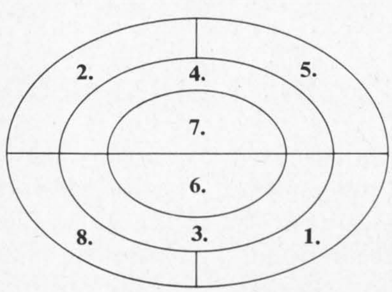
3. Assemblies with subminiature basic switches, Type AT—Versatility is the keyword for these compact assemblies. Miniature, standard, or pull-to-unlock levers. Momentary or maintained contact action 2 or 3 position levers. $\frac{1}{4}$ or $\frac{1}{2}$ inch bushings. Up to a dozen or more precision snap-acting Type SM basic switches, each SPDT. Silver contacts for 5 amp. rating or gold contacts for low energy reliability. Solder post, or single or double turret terminals.

4. Assemblies with high-capacity basic switches, Type AT—Precision snap-acting Type V3 basic switches are UL and CSA listed for 15 amps and $\frac{1}{3}$ hp at 125-250 vac. Up to 10 individual SPDT switches can be ganged in one assembly. Rugged construction, positive 3-hole mounting. Two lever lengths. Convenient screw terminals.

5. Magnetically-held toggle switches, Type ET—Two or three position levers, magnetically maintained, manual or remote electrical release. Environment-proof construction. MIL-S-3950 (immersion-proof). MIL-S-5272 (explosion-proof). SPDT or DPDT. Turret, screw or leadwire terminals. Standard, flat tab, or pull-to-unlock levers.



6. Assemblies with hermetically sealed basic switches, Type AT—Maximum protection for switch contacts with hermetically sealed (MIL-S-8805, Class 5) subminiature or standard size precision basic switches. MIL-S-5272 (explosion-proof). MIL-S-6743 (corrosion-resistant). For temperature extremes from —300° to +500° F.

7. Rocker button toggle switches, Type TP—Pushbutton operation with toggle switch versatility. Translucent button for edge-lighting and engraved legends, or transparent button for removable legends. Above-panel or flush-panel mounting. Same circuitry and rating as Type TL.

8. Panel sealed toggle switches, Type TS—Rugged construction, vibration and shock resistant. Sealed lever, plus panel seal (MIL-S-3950B). 1 or 2 pole, 2 or 3 position. UL and CSA listing: 15 amp. 125-250 vac, $\frac{1}{2}$ hp 125 vac, 1 hp 250 vac. Solder, screw, or quick-connect terminals.

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INFORMATION RETRIEVAL NUMBER 36

Presettable up/down counter is simple and inexpensive

The design of an up/down counter becomes somewhat complex when specifications require the counter to be preset to any starting number. A relatively simple circuit that performs the function is shown in (a).

In the circuit, only two types of standard logic blocks are used: dual-input NAND gates, with outputs collector-ORed, and J-K flip flops. No discrete components are used, and the logic yields maximum counter stages for a given number of logic blocks. The timing required to preset and count is shown in (b). Counter input is always a standard, positive pulse with flip-flop transition occurring on the ONE-to-ZERO edge.

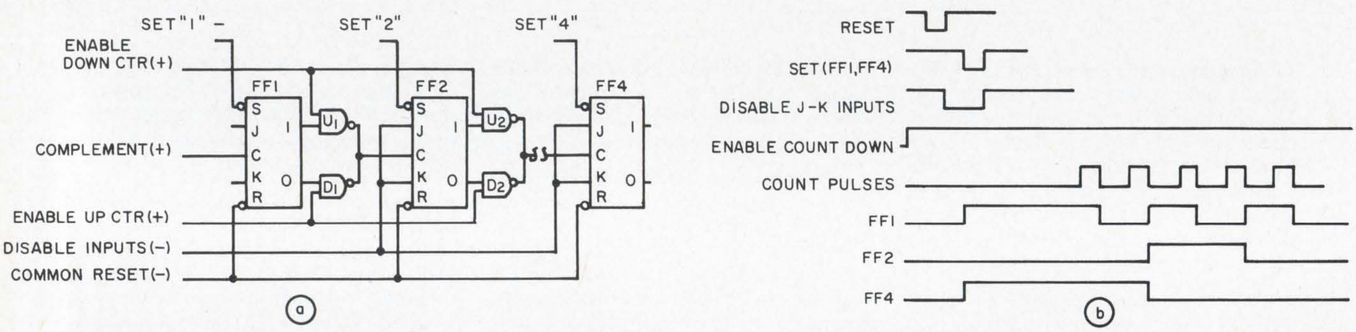
To preset the counter, a dc reset pulse resets all flip-flops, followed by a dc set pulse that selects the proper starting binary number. One important requirement is that during the set pulse, the J-K inputs must be held at ground to disable any false inputs caused by a flip-flop going from the ZERO-to-ONE state.

As in normal counter operation, gates *D1* and *D2* select the count-up mode, and gates *U1* and *U2* select the count-down mode. To count, positive pulses on the complement clock line of the flip-flop for the least-significant digit will step the counter in the selected direction.

The timing for counting down from binary number 101 is illustrated in (b).

Edwin M. Goldberg, Senior Engineer, Dataram Corp., Princeton, N.J.

VOTE FOR 311



J-K flip-flops and dual-input NAND gates form this simple up/down counter (a), which uses only two types of standard logic blocks. Timing waveforms are shown for counting down from binary 101 (b).

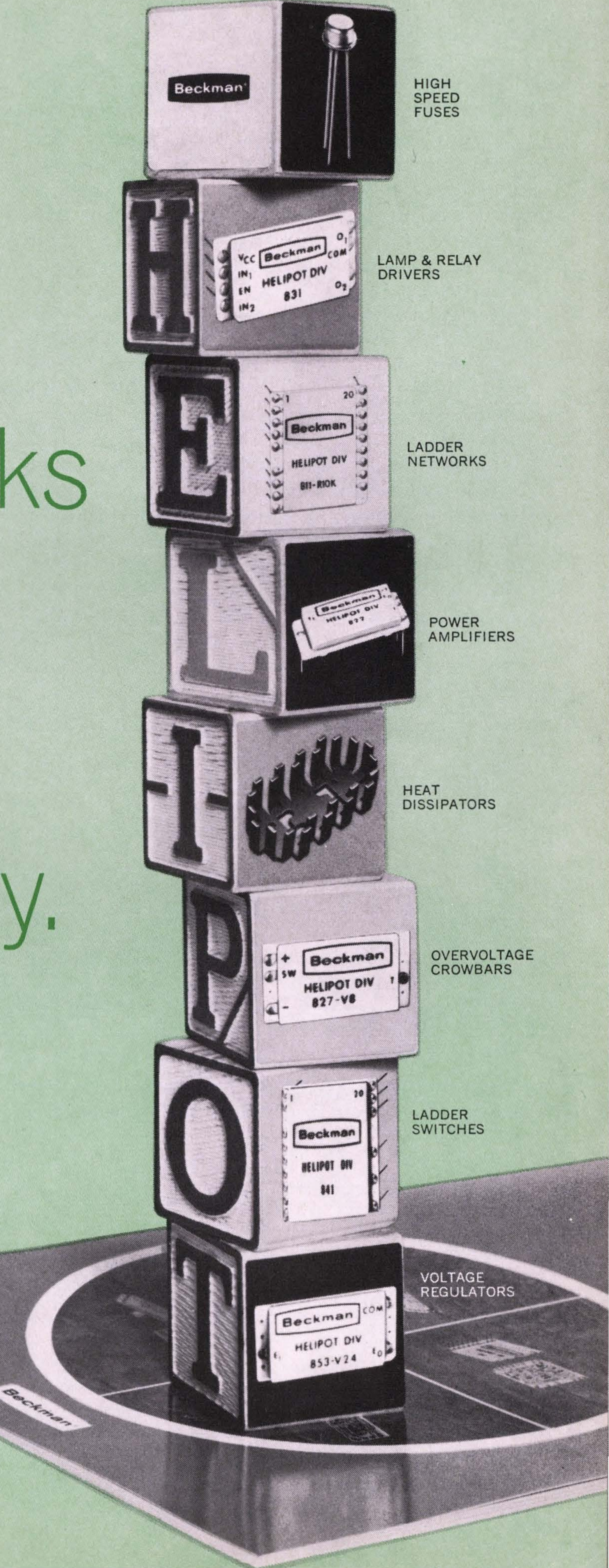
Linearize your TTL gates – then build useful circuits with them

A TTL logic gate can be easily transformed into a linear amplifier and can thus become the basic circuit for some interesting designs. As shown in Fig. 1 for the SN7400 gate, the addition of the feedback results in a quite linear relationship between gate input and output.

Two such linearized gates connected in series create a linear amplifier that has a phase lag equal to 360 degrees. If the loop is closed through a crystal or a capacitor, oscillations will result.

One very useful circuit that has been built with this technique is a high-accuracy clock (Fig. 2). The output voltage is a square wave that can be used for directly driving other gates, flip-flops or frequency dividers. The supply voltage specified for the SN7400 is 5 V ± 0.25 V. However, supply voltage changes of ±0.25 V have been found to have a negligible effect on frequency drift, with the actual drift being only one part in 10^7.

Helipot building blocks stack up to more convenience and economy.



Helipot's wide and expanding selection of *standard hybrid cermet microcircuits*—locally stocked throughout the country—give you reliable, inexpensive, off-the-shelf solutions to your complex design problems. In addition, Helipot building blocks help eliminate expensive design time and reduce purchasing, stocking, and production to their minimums. Whatever your need, you'll be interested in the new 48-page *Helipot Microcircuits Catalog.* For your copy, simply send a request on your company letterhead.

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During temperature tests of the clock it was found that frequency drift with temperature, due to changes in integrated-circuit parameters, is negligible. Keeping the crystal at constant temperature, and changing the temperature of the microcircuit chip, resulted in a frequency drift equal to 0.1 PPM/°C (or 10^{-7}/°C). Thus, when the complete clock (the crystal and the microcircuit) are subjected to temperature changes, only the crystal is responsible for frequency drift. The highest operating frequency for the crystal clock is 20 MHz and the lowest frequency is 1 MHz.

Applications for this kind of clock include remote-control systems using pulse coding, or telemetry systems. One simple arrangement for keying the clock is shown in Fig. 3. Another useful application is in a ramp-type a/d converter. The clock in this case is switched on and off at the start and end of conversion. (capacitor discharging).

The same linearized-gate principle can be used to build a cheap square-wave generator whose outputs are identical to those of a free-running multivibrator; that is, both Q and $\overline{Q}$ outputs are available. Such a generator is shown in Fig. 4.

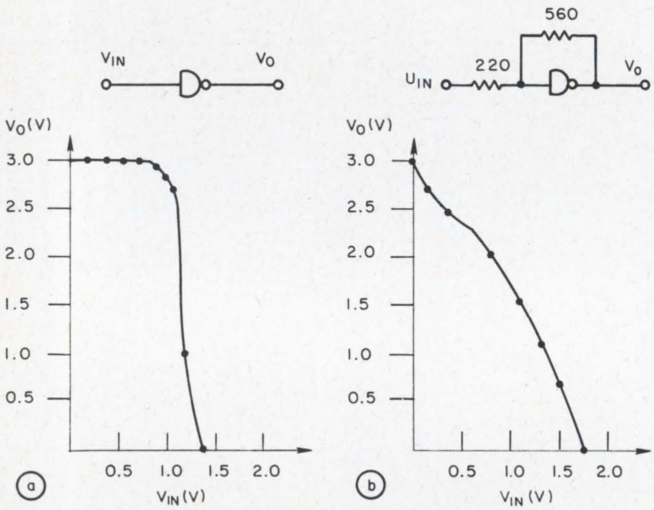
The highest operating frequency for the generator is 12 MHz. The lowest operating frequency is unlimited, and the unit has been found to be working at 0.1 Hz.

Potentiometer *P1* is used for frequency adjustment. For a fixed value of capacitor C_1, *P1* can cover one decade of frequencies. Diode *D1* provides temperature stabilization.

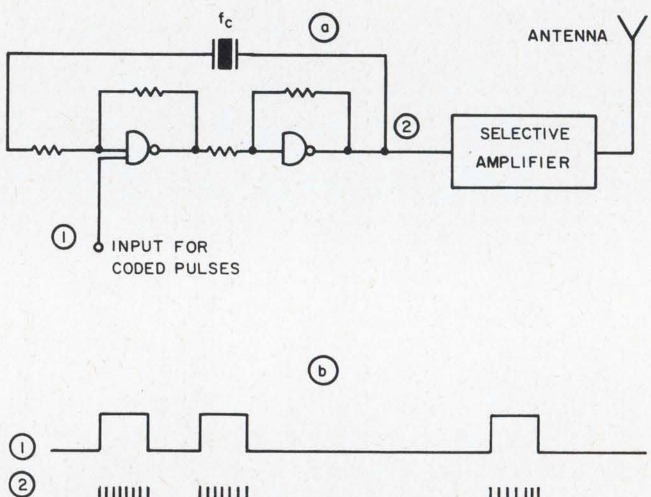
All of the above circuits have worked satisfactorily with TTL NAND gates manufactured by Texas Instruments, Sprague and Siemens.

Jacek H. Kolataj, Design Engineer, Oy Nokia AB Electronics, Helsinki, Finland

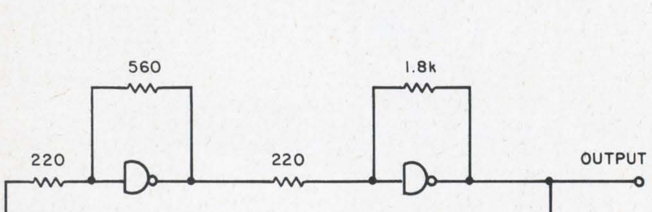
VOTE FOR 312



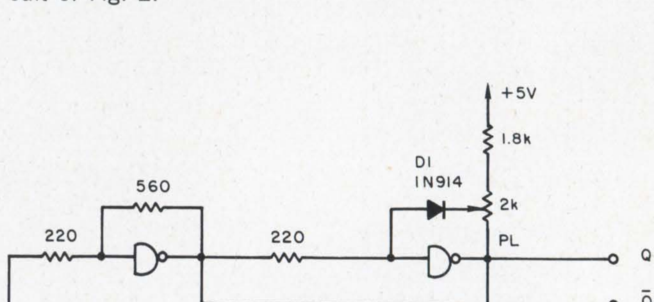
1. **Normal input/output voltage relationship** of a TTL NAND gate (a) can be made quite linear by the addition of a feedback circuit (b).



3. **Keying feature can be added** easily to the clock circuit of Fig. 2.



2. **Highly accurate clock** can be built from two linearized gates and a crystal.



4. **Square-wave generator** with complementary outputs can be varied in frequency over a wide range.

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MDS The time reduction achieved by the MDS Data-Recorder method of computer input preparation demands continuously reliable operation. And this in turn demands the highest standards of performance from each and every component.

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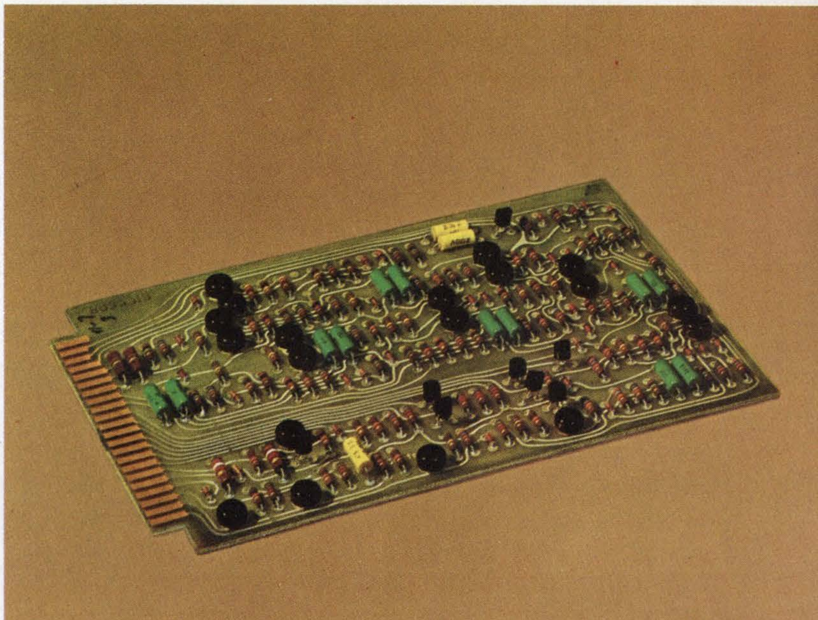
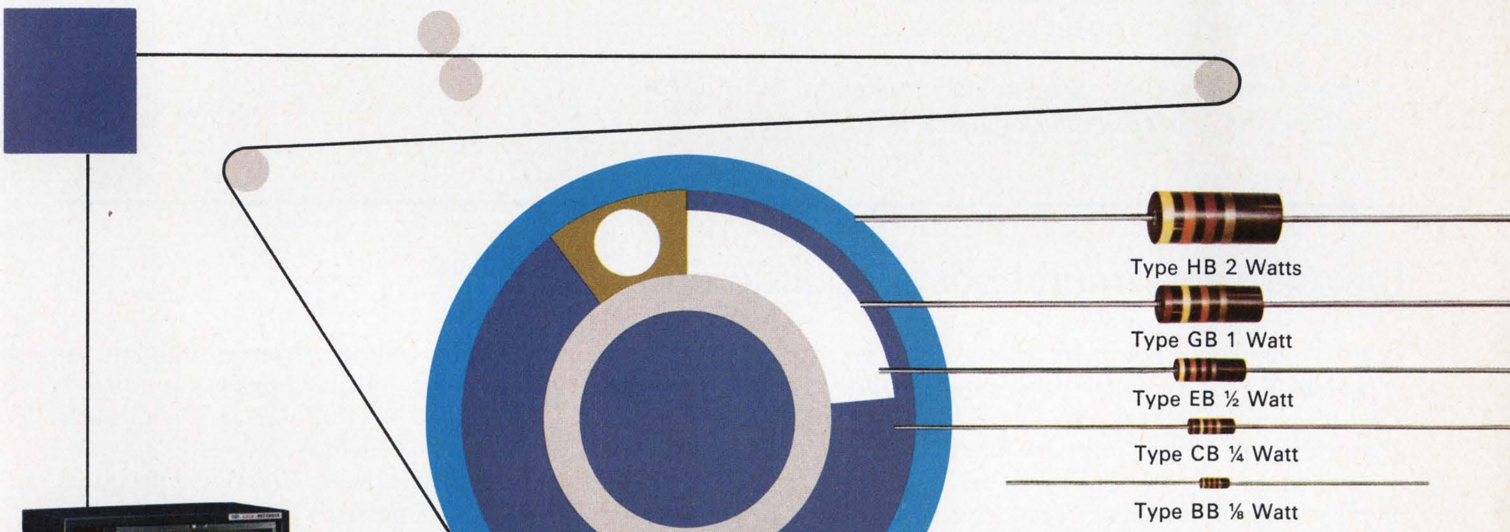
Performance records are equally excellent. For example, Allen-Bradley hot-molded resistors meet the requirements of the new MIL-R-39008A Established Reliability Specification at the *highest* level—the S level. And this is true for *all* three ratings—the 1 watt, ½ watt, and ¼ watt—and over the *complete* resistance range from 2.7 ohms to 22 megohms.

For complete specifications on this quality line of hot-molded resistors, please write to Henry G. Rosenkranz, and request a copy of Technical Bulletin 5000. Allen-Bradley Co., 1201 S. Second St., Milwaukee, Wis. 53204. Export Office: 1293 Broad St., Bloomfield, N.J., U.S.A. 07003. In Canada: Allen-Bradley Canada Ltd.



Typical printed circuit board used in the MDS 1101 Data-Recorder, showing the extensive use of Allen-Bradley hot-molded ¼ watt resistors.



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 at the S level.* Shown actual size.

Mohawk 1101 Data-Recorder permits transcribing of data from source documents direct to ½" computer magnetic tape.

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Low-cost meter uses Hall effect for magnetic measurements

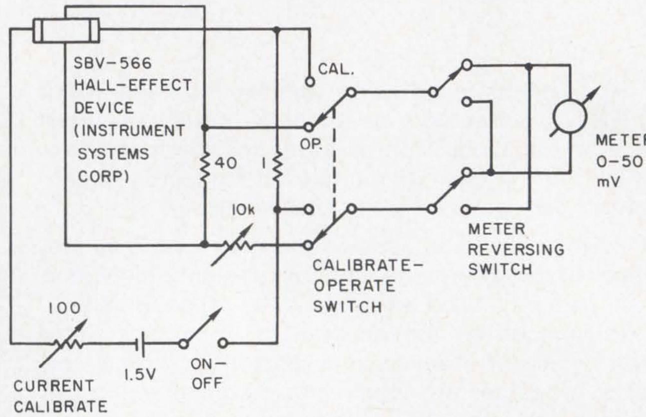
When working with magnets and magnetic structures, the need sometimes arises for a simple technique of comparing the magnetic devices with a known standard. Such qualitative measurements are often useful for incoming inspection, quality assurance, etc. A low-cost Hall-effect device can be used as the basis of a simple instrument for making measurements. If the instrument is calibrated with a standard magnet (available from most magnet companies), the instrument can also be calibrated to read magnetic flux.

The heart of the instrument is a Hall-effect device, 0.1-by-0.1 by 0.031-in, that costs approximately \$6.

For protection and ease of handling, the Hall-effect sensor is epoxy-cemented to the end of a phenolic rod. The control and output leads run down the rod and are also epoxy-coated. The output of the device, with a 15-mA control current and a link flux of 10 Maxwells is greater than 80 mV.

In the circuit (see illustration), the Hall-effect device is loaded with 40 ohms, which is the recommended value for optimum linearity. The voltage drop across the 1-ohm resistor, which is controlled by the "current-calibrate" resistor and a 1.5-V D-cell, is used to establish the 15-mA control current.

After initial set-up, the standard magnet is measured and a corresponding mark is made on the scale of the instrument meter. This mark is then the basis of comparison for the magnetic measurements. The flux calibration potentiometer is used to adjust the meter, so it reads in the desired portion of the scale. The reversing switch is necessary, since a magnet or magnetic structure can be magnetized in either of two directions. Battery life for the unit is in excess of 300 hours of operation, at 4 hours per day.



Hall-effect device produces an output voltage that is proportional to the strength of the magnetic field it is measuring.

Harry Teder, Chief Engineer, Advanced Development, Telex-Magnecord-Viking, Minneapolis, Minn.

VOTE FOR 313

Inexpensive circuit boosts op amp output current

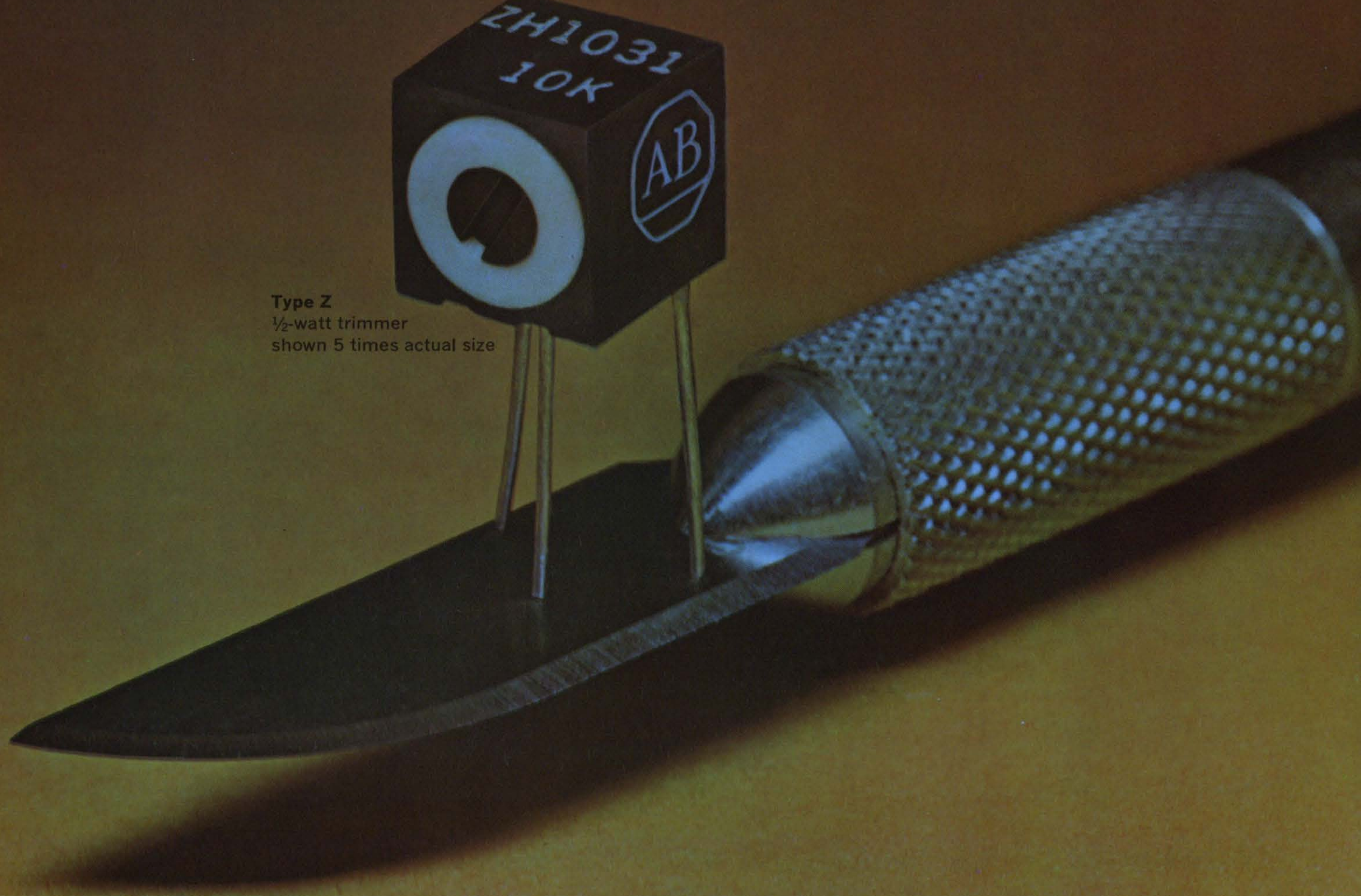
Most electronic laboratories have stocks of IC operational amplifiers that are capable of delivering a few milliamperes of current—but operational amplifiers having higher current capabilities (±100 mA or more) are rare, and they are usually more expensive. Thus, large load-power comes at great expense if operational amplifiers are used.

The circuit shown in Fig. 1 is essentially an inexpensive operational amplifier current-booster. Transistors $Q1$ and $Q2$ are arranged in push-pull fashion, and operate as emitter followers ($Q1$ amplifies positive-going signals and $Q2$ amplifies negative-going signals. The four biasing resistors, R_1 through R_4, serve to eliminate cross-over distortion, which is a common problem in class-B operation.

With zero output signal from amplifier K, point A is at ground potential. For this condition, R_1 and R_2 are chosen so that $Q1$ is at collector cutoff. Alternatively, collector current may be idling at a few milliamperes. As the voltage at point A increases (a positive-going signal), the voltage across the load, R_L, increases in a similar manner, since $Q1$ is acting as an emitter follower. The same action occurs when point A is negative-going, except that $Q2$ is operating. Feedback, through resistor, R_f, is included for linearization.

The same technique shown in Fig. 1 can be used for even larger power outputs by using two Darlington pairs in a similar arrangement. A four-transistor current booster capable of supplying well over an ampere of load current, is shown in Fig. 2. Again, the four resistors, R_1 through

Allen-Bradley cuts space requirements with new sealed type Z cermet trimmers

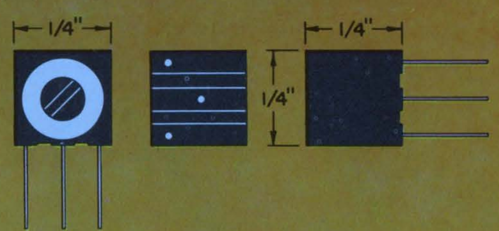


this latest addition to the Allen-Bradley line of cermet trimmers...the type Z...affords high performance in an especially compact package

The cermet material—an exclusive formulation developed by Allen-Bradley—provides superior load life, operating life, and electrical performance. For example, the full load operation ($\frac{1}{2}$ watt) for 1000 hours at 70°C produces less than 3% total resistance change. And the temperature coefficient is less than ± 250 PPM/°C for *all* resistance values and throughout the *complete* temperature range (−55°C to +125°C).

The Type Z is ruggedly constructed to withstand shock and vibration. The unique rotor design ensures smooth adjustment and complete stability under severe environments. The leads are permanently anchored and bonded. The connection exceeds the lead strength—opens cannot occur. Leads are weldable.

The enclosure is *SEALED*. It is both dust-tight as well as watertight, and can be potted. Mounting pads prevent moisture migration and also post-solder washout. For full specifications on this new spacesaving cermet trimmer, please write Henry G. Rosenkranz, Allen-Bradley Co., 1201 S. Second St., Milwaukee, Wis. 53204. Export Office: 1293 Broad Street, Bloomfield, N.J., U.S.A. 07003. In Canada: Allen-Bradley Canada Ltd.



SPECIFICATIONS SUMMARY

Adjustment: Horizontal or vertical.

Temperature Range: −55°C to +125°C.

Resistances: 50 ohms through 1 megohm. Lower resistances available.

Tolerances: ±20% standard, ±10% available.

Resolution: Essentially infinite.

Rotational Life: Less than 2% total resistance change after 200 cycles.

Rotation: 300° single turn.

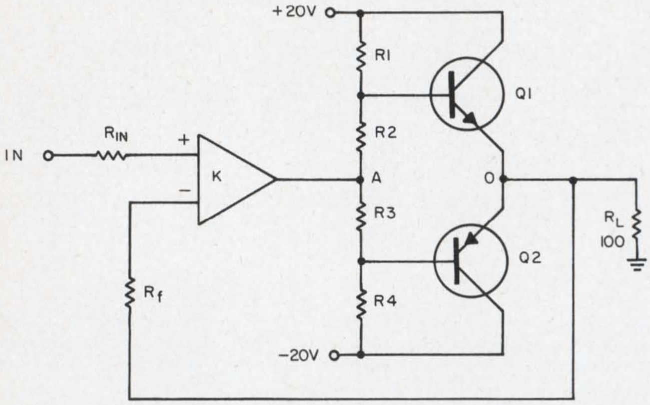
End Resistance: Less than 3 ohms.

268E-1

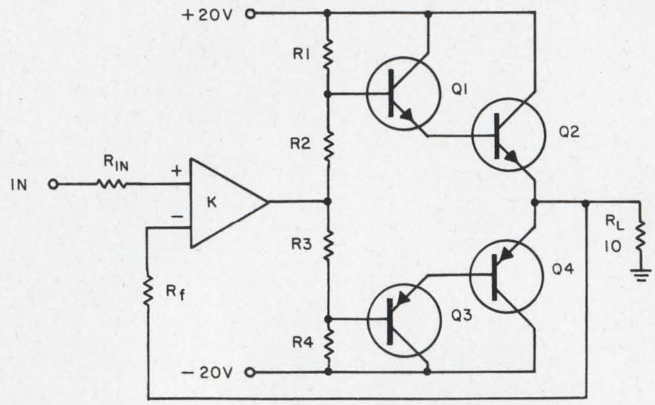
A·B QUALITY

ALLEN-BRADLEY

QUALITY ELECTRONIC COMPONENTS



1. **Push-pull emitter followers Q1 and Q2** boost the output current from the operational amplifier. The circuit can deliver 15 V to a 100-ohm load.



2. **Q1 through Q4 are complementary Darlington pairs.** They can boost the output of a low-current operational amplifier to well over 1 A.

R_4, are chosen so that each Darlington pair is just beginning to conduct.

Transistors $Q1$ and $Q2$ are a 2N5190 and a 2N5193, respectively, which are marketed as a complementary pair. Although the use of a high-gain operational amplifier and feedback reduces the need for matched transistors, for best linearity a complementary pair should be used.

The configuration shown in Fig. 1 can deliver ±15 V to a 100-ohm load. The input impedance to point A is approximately 2000 ohms, and the voltage gain from point A to point 0 is approximately 0.7.

Corresponding results can be expected from the circuit of Fig. 2. The voltage gain is less, but the input impedance is higher. A typical value of load resistor would be 10 ohms. This would yield an output current of approximately ±1.5 A.

D. K. Belcher, Research Associate, University of Kentucky, Lexington, Ky.

VOTE FOR 314

Network provides broadband input-capacity compensation

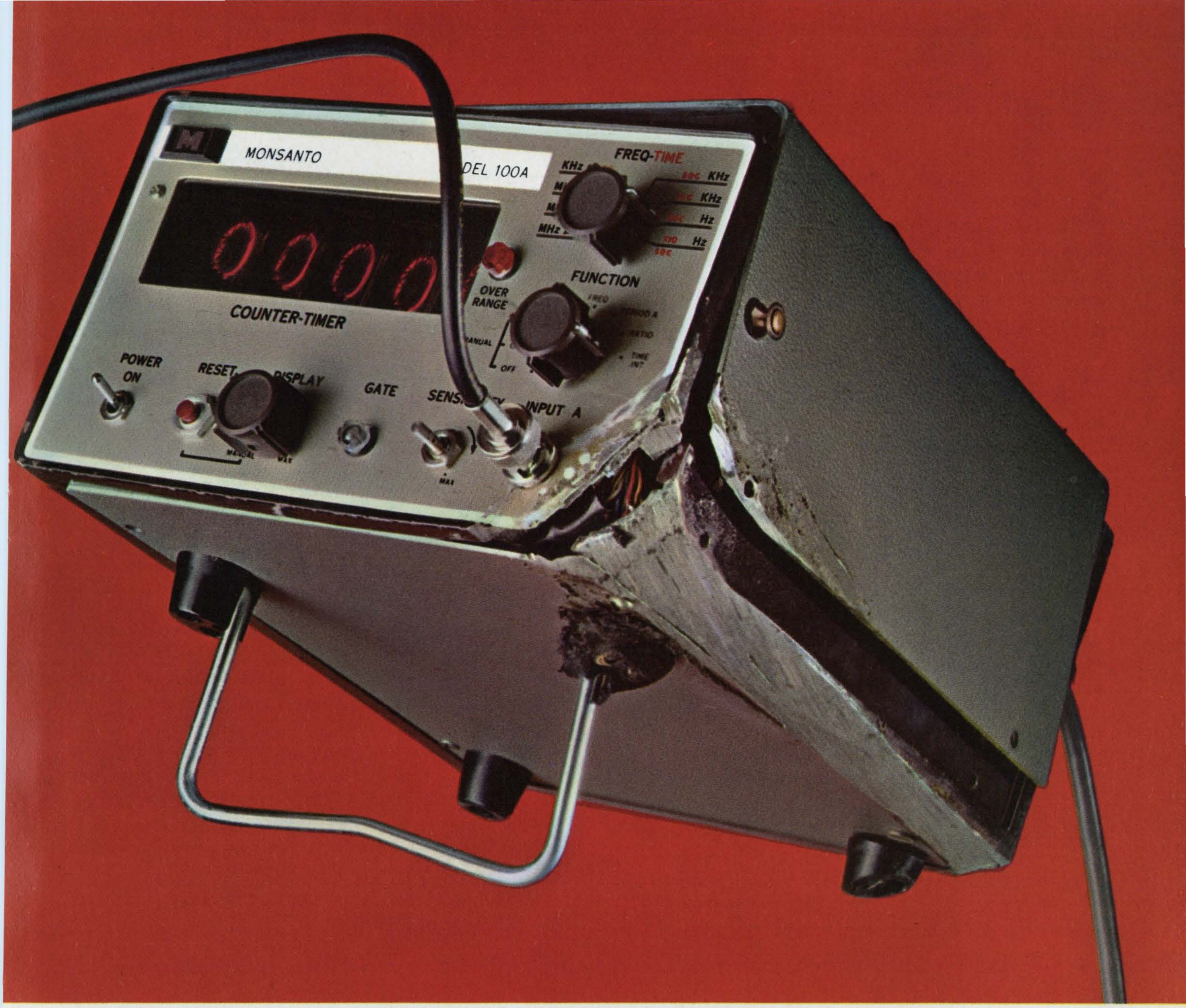
Techniques for video interstage compensation of shunt parasitic capacities are well-known and normally involve the manipulaton of a voltage transfer function until a required passband is obtained. Separating the stages, though, may necessitate a transmission line interconnection, which requires a specific resistive termination to minimize reflections. Thus, a network is required that provides broadband compensation of an input capacity and that, at the same time, maintains a constant input resistance. A circuit for accomplishing this, in which the maximum frequency of interest and the amount of shunt parasitic capacity is given, is shown in (a).

A low-pass filter, composed of one T-section and an m-derived initiating and terminating half-section, makes up the circuit. The circuit is redrawn in (b), in which the series m- and T-section inductances have been combined.

The following relationships are derived for the circuit of (b) from ordinary filter theory.

$$
\begin{aligned}
L_1 &= (1 + m)\,[R/(2\pi f_0)] && \text{henrys} \\
L_2 &= R(1 - m^2)/(2\pi f_0 m) && \text{henrys} \quad (1) \\
C_2 &= m/(2\pi f_0 R) && \text{farads} \\
R &= 1/(\pi\, f_0\, C_1) && \text{ohms,}
\end{aligned}
$$

where f_o is the cutoff frequency of the filter and



This counter fell off a plane. It didn't need service (but when one does, we're ready).

This Model 100A Counter-Timer was enroute to a customer. A freight handler laid it on the wing of the airplane—and forgot it. The package finally slid off as the wheels left the runway. Instantly freed of its container, the "Small Wonder," as our customers sometimes call it, chased the plane for about a hundred yards, then ground-looped.

Our nearby Service Center, bored with inaction, brightened at the thought of a real challenge when it was brought in. But they were disappointed: electrically, the "Small Wonder" picked up right where it left off in Final Inspection. (Of course, *mechanically* there were a few abrasions to take care of, as you can see.)

Please help us keep our 37 Service Centers with their factory-trained technicians alive and well. Call the one nearest you anytime you feel that a Monsanto instrument requires service or calibration . . . or even verification of its performance. In addition to their expertise and factory specified test equipment, all carry a complete stock of spare parts. If there should be a defect in materials or workmanship during the 2-year warranty period, it won't cost you anything.

Monsanto Company, Electronic Instruments, West Caldwell, New Jersey 07006.

Monsanto

m is the well-known parameter of an m-derived termination.

The maximum frequency of interest, f, is assumed to be below the cutoff frequency to ensure a flatter characteristic over the passband. Experience has shown the following relations to be adequate in most cases:

$$f_0 = 7f/6$$
$$m = 0.6 \quad . \qquad (2)$$

Combining Eqs. 1 and 2, results in the following design data:

$$R = 0.273/(f\,C_1) \text{ ohms}$$
$$L_1 = 0.0595/(f^2\,C_1) \text{ henrys}$$
$$L_2 = 0.0397/(f^2\,C_1) \text{ henrys} \qquad (3)$$
$$C_2 = 0.3\,C_1 \text{ farads} \quad .$$

These circuit values may be adjusted by increasing f and/or C_1. However, minimum power is expended for constant voltage across C_1 when R is maximum, consistent with the given values of f and C_1. A trade-off may be necessary, therefore, when practical values of circuit components are considered.

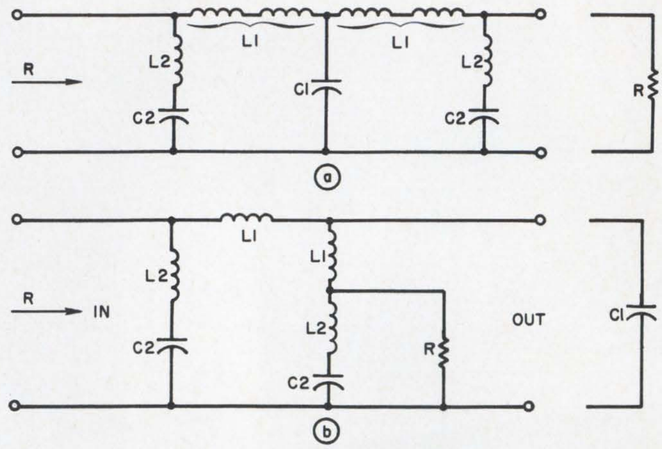
An actual design example of the circuit is as follows:

Given: $f = 30$ MHz
$C_1 = 43$ pF

the circuit values, as calculated from Eq. 3, are:

$R = 212$ ohms $\rightarrow$ 210 ohms $\pm$ 5 per cent
$L_1 = 1.54\ \mu$H $\rightarrow$ 1.5 μH $\pm$ 5 per cent
$L_2 = 1.025\ \mu$H $\rightarrow$ 1.0 μH $\pm$ 5 per cent
$C_2 = 12.9$ pF $\rightarrow$ 12.0 pF $\pm$ 5 per cent ,

where the calculated values are rounded off to the nearest standard values.



A low-pass T-section with m-derived terminations makes up the low-pass filter network (a). Rearrangement of the network shows the input and output terminals (b).

A network using the above component values fulfills the given boundary conditions. It is now necessary to match the calculated value of R to the coaxial cable feeder. In an actual example of this circuit, a 53-ohm coaxial cable was used. Assuming sufficient driving power, R could be taken as 53 ohms, thus directly matching the feeder, with f and C_1 appropriately adjusted. Power was marginal, so a transformer was used for matching the feeder, resulting in an acceptable SWR of 1.5 from 2 to 30 MHz.

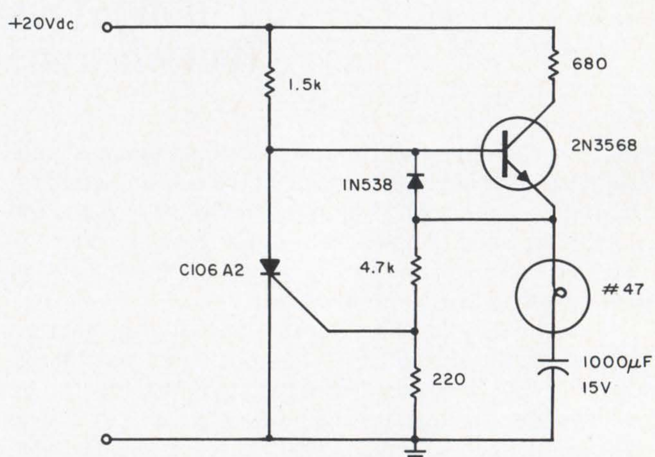
S. Sabaroff, Senior Scientist, Hughes Aircraft Co., El Segundo, Calif.

VOTE FOR 315

SCR relaxation flasher has long life, low power drain

Battery-operated power flasher lights are used in an endless variety of applications, including warning lights, automobiles and advertising displays. A major disadvantage of many flasher units, though, is that their usability depends greatly on battery charge condition. This limitation is reduced to a large extent by the SCR relaxation flasher shown. The circuit will maintain a slower—but—good flashing capability even after considerable battery degradation, such as up to 1000-ohms internal impedance.

The flasher is astable because charging current falls below the SCR holding current during capacitor discharge. To verify this, note that the discharge path for the 100-μF capacitor is through the lamp, through the diode, and to ground through the SCR. Forward-biasing the diode back-biases the transistor, and the only



Flashing occurs each time the capacitor discharges through the turned-on SCR. When the discharge current falls below the SCR holding current, the SCR turns off, and the capacitor begins charging for another cycle.

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remaining current from the power supply is through the 15-kΩ pull-up resistor. With the large (220-Ω) gate resistor, the SCR will not stay ON with this small current. Therefore, once the capacitor discharges (flashing the bulb), the SCR turns off.

Once the SCR is OFF, the diode becomes back-biased and the transistor conducts again, supplying about 30-mA capacitor charging current. The 4.7 kΩ-220 Ω divider across the capacitor determines the capacitor voltage at which SCR gate conduction, and therefore flashing, occurs.

Peter Lefferts, Chief Engineer, Tia Electric Co., Princeton, N.J.

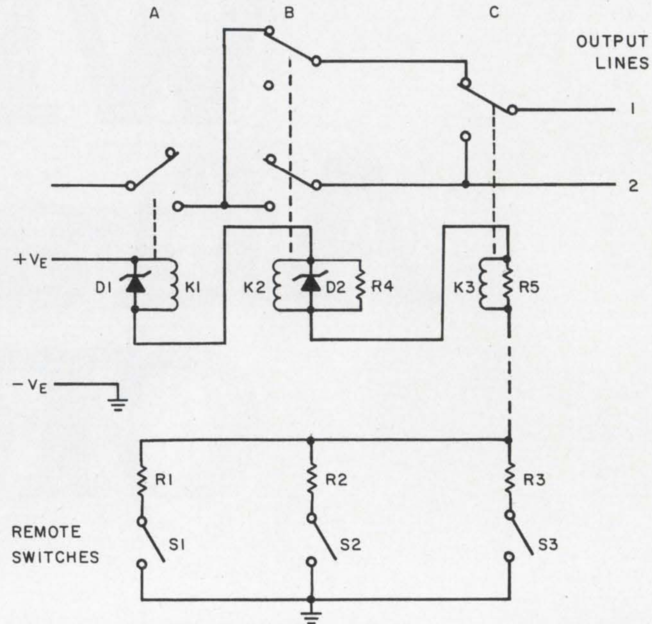
VOTE FOR 316

Two wires transmit and identify remote switch closures

An unusual and intriguing problem arises in control applications when a single pair of wires must transmit and identify a number of separate switch closures. One technique for accomplishing this, in the case of three remote switches, is shown in the illustration. Although the circuit shown is for three switch closures, more than three can be accommodated by extending the circuit.

In the circuit, a supply voltage is selected that will actuate all three relays in series. The value of R_1 is chosen to permit only sufficient current flow to actuate *K1*. Shunt resistor R_4 is selected to prevent *K2* from being actuated when switch *S1* is closed. Resistor R_2 is selected so that, when *S2* is closed, sufficent current flows to actuate *K2*. Zener diode *D1* limits the voltage drop across *K1* by carrying the extra current needed to actuate *K2*.

Shunt resistor R_5 is chosen to prevent *K3* from being actuated when switch *S2* is closed; and resistor R_3 is selected to conduct sufficient current



Logical states of the two output lines depend on which remote switches are closed.

to actuate *K3*. Zener diode *D2* limits the voltage drop across *K2* by carrying the extra current needed to actuate *K3*. The relay-contact transfer logic used in this application is as follows (different logic can be used depending on the requirements):

LINE	ABC	ABC	ABC	ABC
1	0	1	0	1
2	0	0	1	1

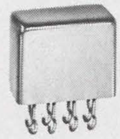
Typical circuit values when using Allied Control T154-2C, 6-volt coil relays are: R_1—120 ohms; R_2—86 ohms; R_3—62 ohms; R_4—110 ohms; R_5—51 ohms; *D1* and *D2*—3.3 V, 1 W, V_E = 18 V. Current requirement for the circuit is approximately 100 mA, maximum.

Roy J. Krusberg, Engineer, Winder, Ga.

VOTE FOR 317

IFD Winner for November 7, 1968
M. Stevens, Staff Engineer, Harlow, Essex, England. His Idea "Two op amps provide floating output circuit" has been voted the Most Valuable of Issue Award.
Cast your vote for the Best Idea in this Issue.

IFD Winner for November 21, 1968
Walter Ellermeyer, Design Engineer, San Diego, Calif. His Idea "Infinite input impedance circuit uses one op amp" has been voted the Most Valuable of Issue Award.
Cast your vote for the Best Idea in this Issue.



ACTUAL SIZE

Relays: 1/6-Size Relay Model BR10

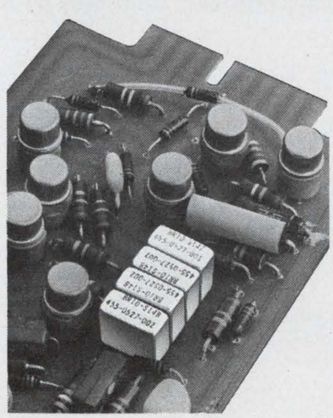
☐ Dry Circuit to 1 Amp. ☐ DPDT ☐ Welded or Soldered ☐ Universal Contacts ☐ To MIL-R-5757

Babcock's Model BR10 1/6-size crystal can relay packs a lot of performance in a small package. Its unique universal contacts give you "non-stop" operation from dry circuit to 1 amp...one subminiature relay to meet all your requirements for high-density circuit-board applications—at no cost premium.

You'll find that this small, versatile, DPDT unit has everything. Designed to specification MIL-R-5757, it features rugged unitized construction for increased shock and vibration resistance. Both soldered or welded versions are offered. Regular and gold-plated plug-in, solder-hook, and long-lead terminal styles are available, in standard circuit-board grid pattern, with a range of mounting types.

The Model BR10 has a record of dependability, attested by its proven conformance to MIL-R-5757 and specified use in programs requiring operation under the most severe environmental extremes. Built-in reliability, outstanding performance, application flexibility...all assurances that your relay is *better because it's Babcock.*

The Babcock Model BR10 relay has proven its reliability in a variety of aerospace and commercial avionics applications. Its subminiature size makes it ideal for single and multi-relay circuit-board installations. In fact, a brace of four BR10's has been found to take less board space than a similar group TO-5 units. You get efficient high-density packaging, *plus* full 1-amp. capability.



Need 2-amp. performance? The Model BR10 will operate dependably at 2 amps. (28 VDC), through 100,000 operations, in the temperature range −65 °C to +125 °C. Contact our Applications Engineering Group for further details.

SPECIFICATIONS

Contact Rating	**1 amp. @ 28 VDC**
Operate/Release Time	**3.5 ms., max.**
Pull-In Power	**100 mw**
Bounce Time	**2 ms., max.**
Shock	**50 g's (11 ms.)**
Vibration	**30 g's, 38-2000 Hz**
Operating Temp.	**−65 °C to +125 °C**
Life	**100,000 operations, min.**

Get complete information on the versatile, subminiature Model BR10 today...contact Babcock Electronics Corp., Relays Division, Subsidiary of Esterline Corp., 3501 Harbor Blvd., Costa Mesa, Calif. 92626. CALL COLLECT (714) 540-1234 or TWX 910-595-1517.

Available off-The-Shelf from AVNET, POWELL or PDQ.

Challenging opportunities now exist at Babcock for experienced relay-switch engineers.

INFORMATION RETRIEVAL NUMBER 42

Book Reviews

Shop manual

Machinery's Handbook, 18th Edition, Erik Oberg and Franklin D. Jones (Industrial Press, New York) 2293 pp. $16.00.

Any engineer who occassionally must roll up his sleeves and get his hands dirty will have considerable use for *Machinery's Handbook*. A must item for every shop and production area, this is one of the few "handbooks" that is really hand-sized—3 × 6-1/2 inches.

Its 2293 pages contain nearly all the data that might conceivably be required in a model shop. Unlike other shop handbooks of similar scope, this one is not merely a compendium of tables. It contains a lot of how-to-information for the man who is more at home with a Smith chart than a Bridgeport.

CIRCLE NO. 401

Birth of a dream

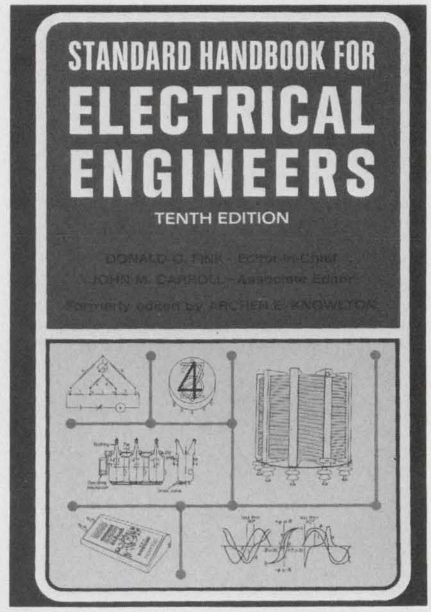
The Story of Jodrell Bank, Sir Bernard Lovell (Harper & Row, New York) 265 pp. $5.95.

Bernard Lovell's account of the birth of the world's largest, fully steerable radiotelescope cannot fail to impress the reader with the magnitude of this achievement.

Drawing on his correspondence and diaries, Lovell recreates a time when the mammoth reflector was only a vision. He paints the tale of its creation against a backdrop of political conflict and bureaucratic bungling. In recapturing his uncertainties and his triumphs, the author has given us the story of the telescope and the story of a man who had the courage to stand firmly behind an idea through uncertain trying years.

CIRCLE NO. 402

EE Handbook



Standard Handbook for Electrical Engineers, 10th ed., Donald G. Fink, (McGraw-Hill Book Co. New York City), 2466 pp. $32.50.

Useful to engineers in all the technologies, the tenth edition of the *Standard Handbook for Electrical Engineers* retains the basic design data and applications information relating to the generation, transmission, distribution, control, and conversion of electricity. Expanded to include such current material as semiconductors and data processing, the revised handbook also covers other new topics, for example, high-voltage dc transmission, and nuclear power fuels and reactors.

The information on solid-state technology covers basic semiconductor theory, the properties of many semiconductor materials, transistor fabrication, and transistor circuit models. The data-processing section discusses analog and digital computation, computers, computer organization, number systems, logic design, input-output systems, and programing.

The handbook has 29 sections in all, in addition to a comprehensive index. Standard listings include units and conversion factors, as well as codes and standards.

CIRCLE NO. 403

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Respond to the career opportunities advertised in this issue. Fill out and send us this handy resume. **Electronic Design** will do the rest – neatly typed copies of this form will be mailed to the companies of your choice, indicated by the circled Career Inquiry Numbers at the bottom of this page.

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Desired Salary	**Availability Date**

Employment History – present and previous employers

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City, State			
Dates	to	to	to
Title			
Specialty			

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College			
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We have made significant improvements to the popular 1191 Counter. Now you can get more performance but still at low price. The 1191-B has:

More Frequency Range. DC to 35 MHz, direct count. The addition of an inexpensive GR scaler (now or at a later time) extends the frequency range to 100 MHz or 500 MHz.

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More Versatility. The 1191-B provides all the functions you'd expect from a high-quality counter-timer: frequency, single and multiple period (1 to 10^8 periods), time interval (10^{-7} s to 10^9 s), frequency ratio (1 to 10^8), count (to 10^8). In addition, a unique strobed-period mode (described below) affords even more performance per dollar. All functions, including secondary controls, are dc programmable.

More Useful Counting Time. A unique strobed-period mode of the 1191-B allows you to measure the period between *successive* pulses or the time between *successive* occurrences. The count-display scheme used by other counters allows measurement of every other period, at best. But the 1191-B can generate a clear and restart signal immediately upon completion of display time (which is as low as 1 μs), so no information is lost.

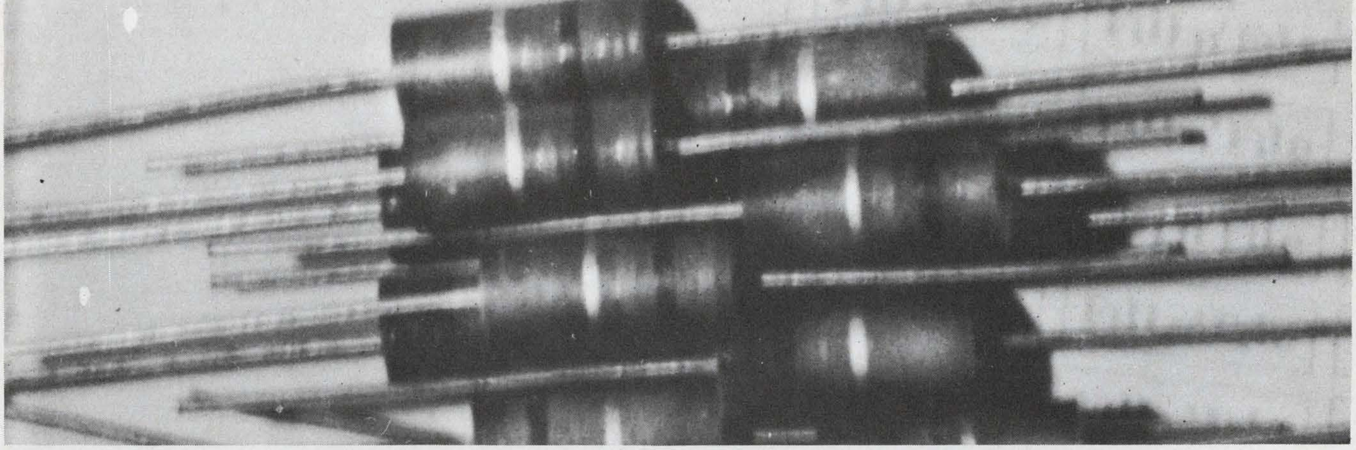
More Value. The base price of the 1191-B is $1395; this model contains a room-temperature crystal oscillator with drift $<\pm 2 \times 10^{-6}$ per month. An additional $300 buys a high-precision oscillator with drift $<\pm 1 \times 10^{-8}$ per week. Fully buffered 1-2-4-8 BCD output at standard DTL levels can be ordered for another $100.

For more information call your nearest GR Office. Or write General Radio, West Concord, Mass. 01781; telephone (617) 369-4400. In Europe: Postfach 124, CH 8034 Zurich 34, Switzerland.

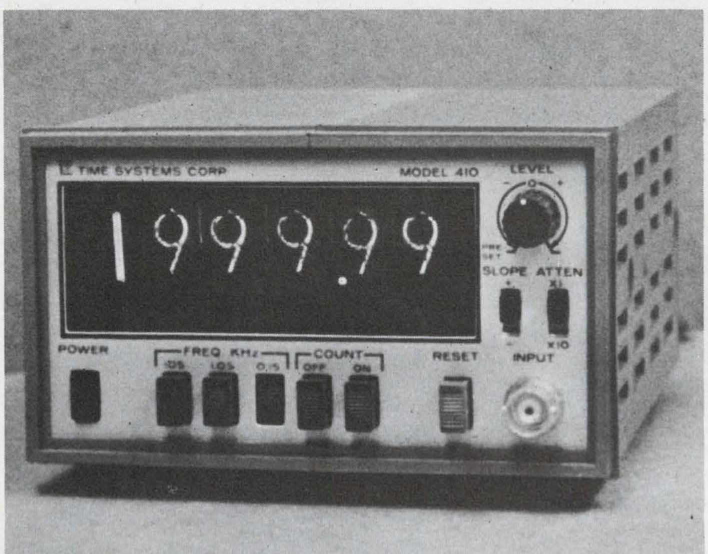
GENERAL RADIO

INFORMATION RETRIEVAL NUMBER 43

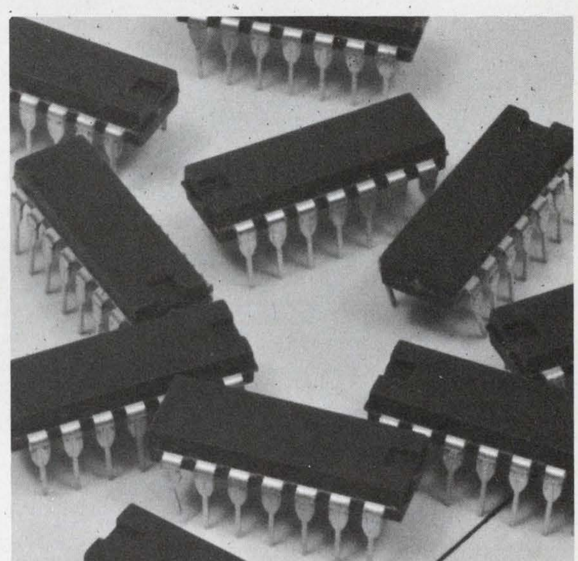
Products



Filing system for component parts uses combination see-thru plastic dome and heavy-duty index card. Try it out for yourself through our Evaluation Samples, p. 130.



Low-frequency counters in 3 by 4.9 by 6-3/4-in. package can be remotely programed, p. 118.



Two up/down counter chips, binary and decimal, rep to 30 MHz, p. 108.

Also in this section:

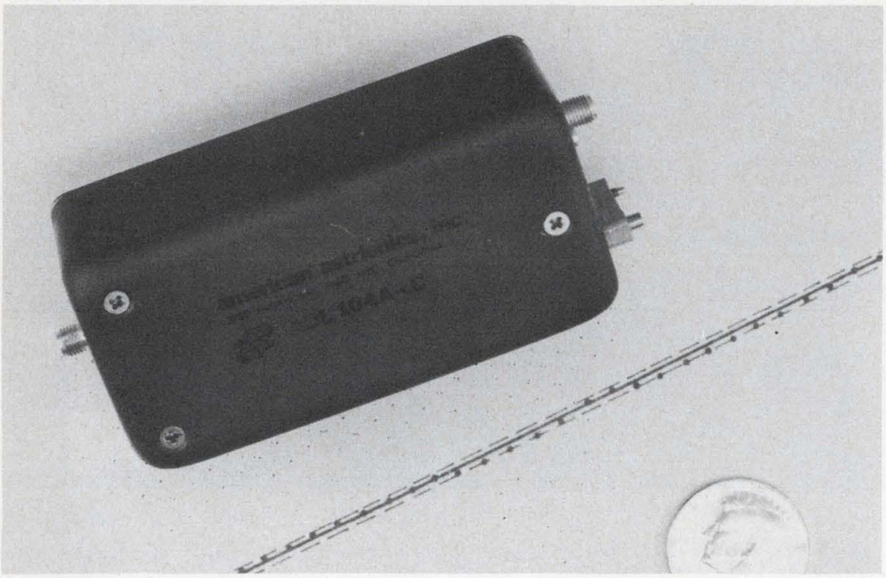
Rf log detectors span 40-MHz video bandwidth, p. 104.

Low-cost digital clock accepts four-line BCD data, p. 112.

Oxide capacitor strips jam 100 pF in 0.016-in. square, p. 121.

Design Aids, p. 132 . . . **Application Notes,** p. 134 . . . **New Literature**, p. 136.

Two-stage rf log detectors cover 40- MHz video band



American Astrionics, Inc., 3950 Fabian Way, Palo Alto, Calif. Phone: (415) 328-6800. P&A: detectors, $1650 each; amplifiers, $690 to $11.95; 4 wks.

Providing the ability to go directly from rf to video frequencies in one small package, a new line of rf log detectors features a 40-MHz bandwidth over rf passbands between 0.1 to 0.5 GHz and 12 to 18 GHz. Series ADL-8040 units consist of an rf tunnel diode detector and a video log amplifier. The entire assembly is contained in a box that measures only 2 by 2 by 4 in.

To yield an over-all transfer function, the video log amplifier has a transfer function that is matched and calibrated to the square-law transfer function of the rf detector. The linearity of this combined transfer function is ±1.5 dBm, referred to the input over the temperature range of −55 to +100°C.

Because they are linear systems for low-amplitude signals and logarithmic ones for high-amplitude signals, the new detectors can amplify small signals and attenuate large ones. This type of performance is ideal for detecting a large number of channels of pulsed data.

The new detectors have an input dynamic range of −42 dBm minimum to +5 dBm maximum. Their tangential sensitivity is −48 dBm, and maximum input power is +15 dBm. Nominal input impedance is 50 Ω, while VSWR ranges from 2.5 maximum to 2 minimum. Each assembly dissipates 1.3 watts of power while operating from a ±12-V ds supply.

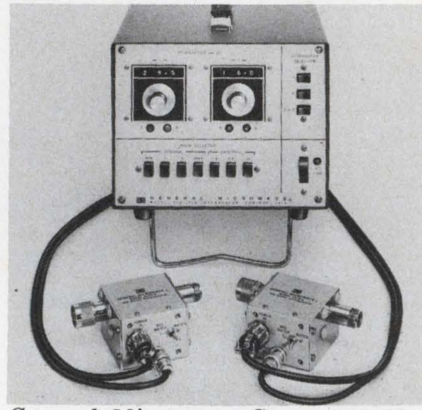
Seven standard versions are available: model ADL-8040-V with an rf passband of 0.1 to 0.5 GHz; model ADL-8040-U, 0.5 to 1 GHz; model ADL-8040-L, 1 to 2 GHz; model ADL-8040-S, 2 to 4 MHz; model ADL-8040-C, 4 to 8 GHz; model ADL-8040-X, 8 to 12 GHz; and model ADL-8040-K, 12 to 18 GHz.

Series AL video log amplifiers can be purchased separately. They have an input dynamic range of 50 dB minimum to 80 dB maximum. Their output risetimes and falltimes vary from 9 ns minimum to 35 ns maximum. Output noise with zero input ranges from as little as 5 mV rms to a maximum of 10 mV rms.

Other rf passband characteristics for the detectors are available on request, as well as linearities of better than ±1 dB. In addition, units can be matched to track each other within ±0.5 dB, for such applications as side lobe suppression systems.

CIRCLE NO. 250

Pushbutton attenuator goes up to 8 GHz



General Microwave Corp., 155 Marine St., Farmingdale, N.Y. Phone: (516) 694-3600.

When combined with one or two model N172AL p-i-n diode attenuators, a new control unit operates as a direct-reading continuous or a step-variable microwave attenuator from 50 MHz to 8 GHz. The 310 pushbutton system enables direct programing of attenuation levels as well as remote programing through external resistances or voltages. Attenuation varies from 30 dB per attenuator in the matched mode to 90 dB per attenuator in the mismatched mode.

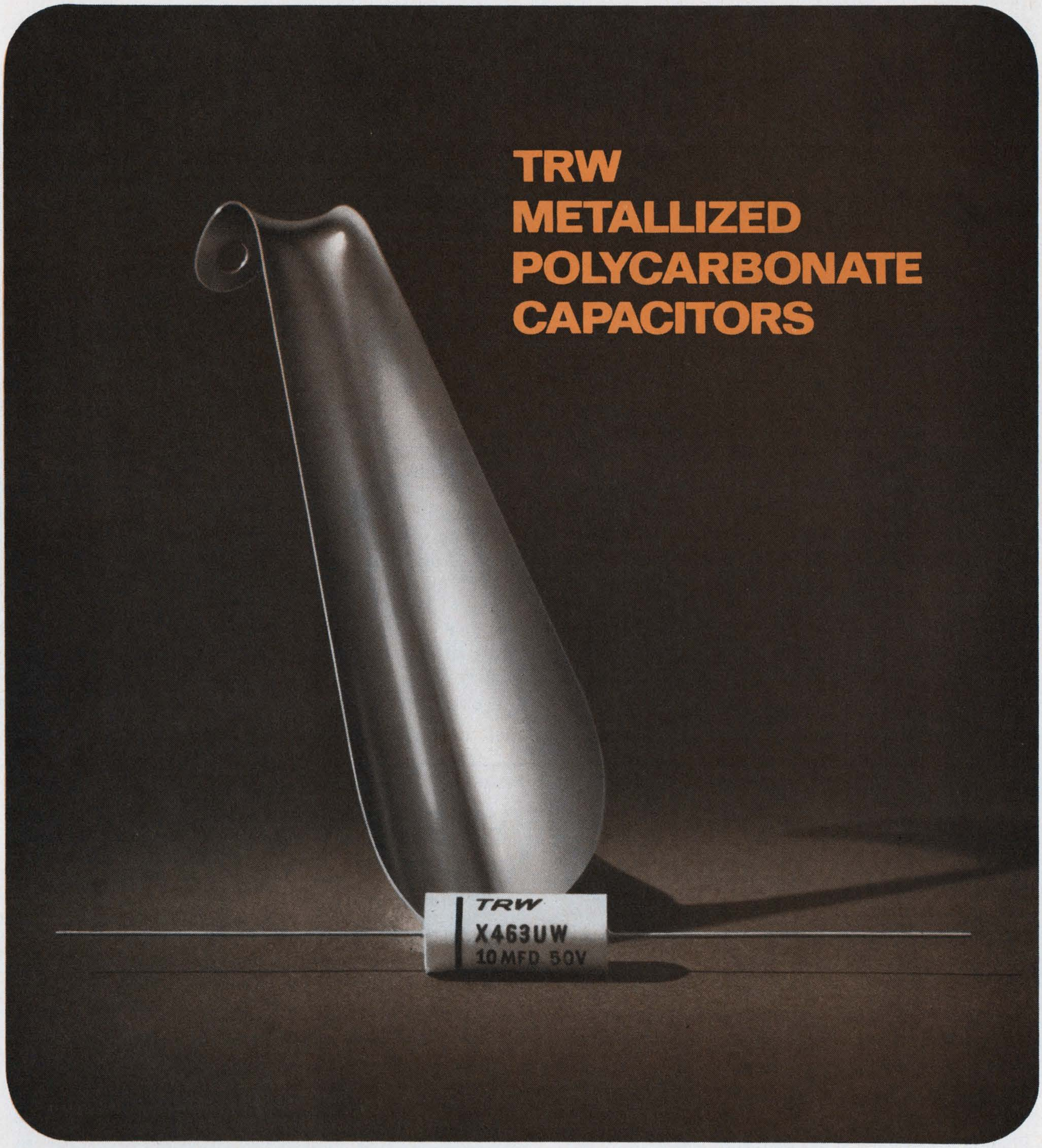
CIRCLE NO. 251

Rf power transistor gains 5.6 dB at 400 MHz

Fairchild Semiconductor, 313 Fairchild Dr., Mountain View, Calif. Phone: (415) 962-2530. P&A: $60; stock.

Capable of dissipating 21 W at 25°C, an rf power transistor, model MSA 8505, delivers 5.6 dB of power gain at a frequency of 400 MHz. This unit can evenly distribute internal currents, with no sacrifice in frequency response, by using thin-film stabilizing feedback resistors and discrete emitters.

CIRCLE NO. 252



...small enough to fit!

TRW 50-volt Metallized Polycarbonate Capacitors are made to squeeze into tight places. Imagine 10 microfarads measuring .547″ x 1¼″ long... the smallest wound capacitor on the market!

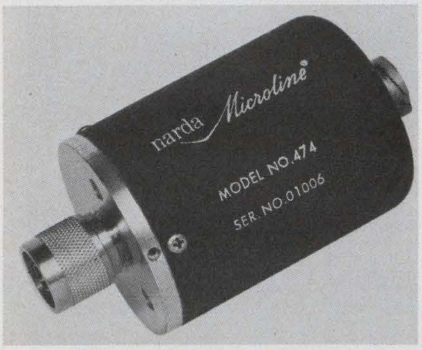
Short on size and long on reliability, the X463UW series meets all requirements of MIL-C-27287.
VOLTAGE—50V, 100V, 200V, 400V
CAPACITANCE—.001 through 10 mfd
TOLERANCE—available to ±1%.

For data, write TRW Capacitor Div., Ogallala, Neb. Phone (308) 284-3611. TWX 910-620-0321.

TRW®

INFORMATION RETRIEVAL NUMBER 44

Rf power transducer senses 10 μ W to 1 mW



The Narda Microwave Corp., Commercial St., Plainview, N.Y. Phone: (516) 433-9000. P&A: $375; stock.

With an accuracy of ±1%, a new power transducer for continuous monitoring applications measures low-level rf power (10 μW to 1 mW) from 10 MHz to 12.4 GHz. Model 474 converts rf power at the source to dc power for transmission to remote stations for readout. It weighs only 22 oz.

CIRCLE NO. 253

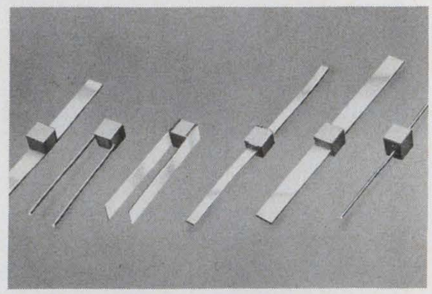
Solid-state modulators operate to 14 GHz

G-L Microwaves Corp., sub. of G-L Industries, Inc., 825 Black Oak Ridge Rd., Wayne, N.J. Phone: (201) 835-1717. P&A: $335 typical; 2 to 3 wks.

Using hybrid IC techniques to optimize performance, octave-bandwidth solid-state modulators for frequencies from 100 MHz to 14 GHz feature low reflection characteristics with a high isolation of 50 dB minimum. These stripline current-controlled attenuator/switches provide fast and noiseless control of signal source level.

CIRCLE NO. 254

Low-loss capacitors have Q of 10,000

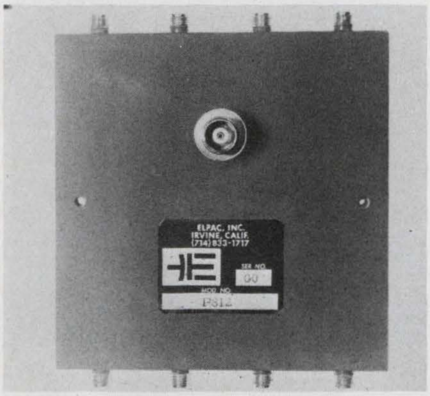


American Technical Ceramics, One Norden Lane, Huntington Station, N.Y. Phone: (516) 271-9600. Availability: stock to 2 wks.

Occupying only one-tenth of a cubic inch, microwave porcelain capacitors handle 10 W at 1 GHz and have a Q of 10,000 at 100 MHz. Series MPC units hold insertion loss to less than 0.03 dB and VSWR to under 1.05. They are self-resonant above C band and always maintain an extremely low inductance.

CIRCLE NO. 255

X-band power divider isolates 8 outputs



Elpac, Inc., RF/Microwave Div., 18651 Von Karman Ave., Irvine, Calif. Phone: (714) 833-1717.

Operating over the frequency range of 8 to 12 GHz, a stripline power divider accepts up to 50-W cw input power and provides eight outputs that are mutually isolated by at least 10 dB. The phase of the output signal at all output ports is identical within ±10°. Insertion loss is 9.5 dB ± 1 dB to any output port; input VSWR is 1.5 maximum.

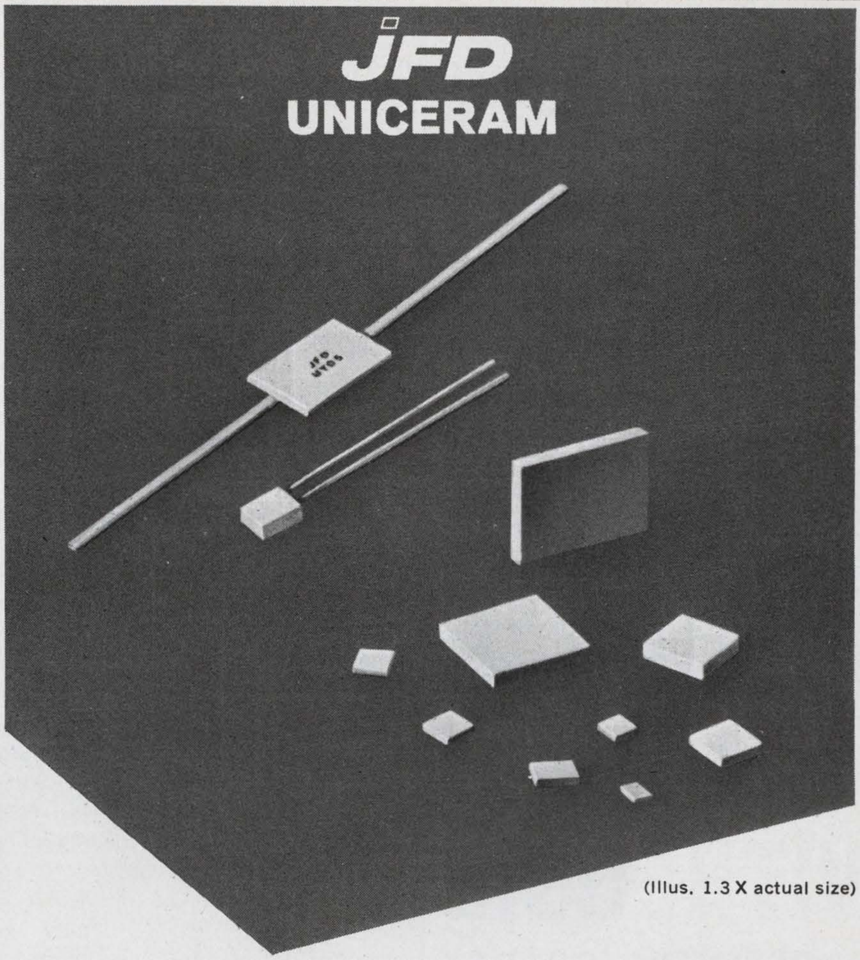
CIRCLE NO. 256

PTM laser system socks out 1.2 GW

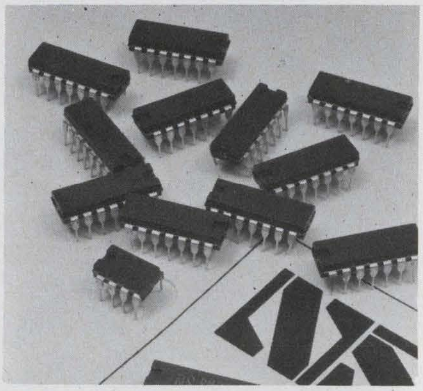
Union Carbide Corp., Korad Dept., 2520 Colorado Ave., Santa Monica, Calif. Availability: 60 days.

The first commercial laser system to use a pulse-transmission mode (PTM) technique at gigawatt levels is now available. The new laser, designated as model K-1600, has output powers as high as 1.2 GW. According to the company, previous giant-pulse lasers using the PTM technique have attained only 30 to 40 mW. Besides greatly reducing damage to optical components, the PTM technique decreases laser pulsewidth from 15 ns to 5 ns or less.

CIRCLE NO. 257



Up/down counters clock at 30 MHz



National Semiconductor Corp., 2975 San Ysidro Way, Santa Clara, Calif. Phone: (408) 245-4320. P&A: $31.50 or $54.25; stock.

Two new monolithic up/down counters perform with a maximum clock frequency of 30 MHz. They operate synchronously within each stage, but semi-synchronously when cascaded from one counter to another. This type of operation is due to their clocks which go through a two-gate delay between stages from input to output.

The DM7560/DM8560 is an up/down decade counter that can be preset to any number from 0 to 9; the DM7563/DM8563 is an up/down binary counter that can be preset to any number between 0 and 15. Both devices are TTL compatible.

Counting is performed through two clock lines: one controlling the count in the up direction; the other in the down direction. Two outputs, the borrow and carry functions, can be connected to the clock inputs of subsequent counters to provide for counting to large numbers.

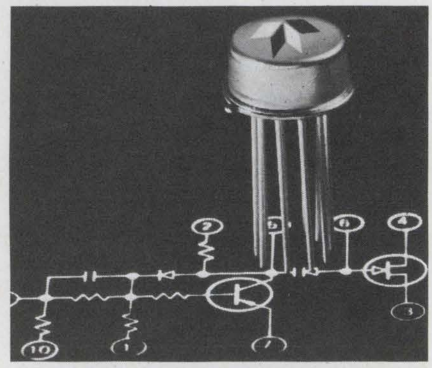
A load input controls the asynchronous entry of preset numbers and sets all outputs to the appropriate state. An extra, clear pin allows presetting to 0. In addition, the new counters permit two or more stages to be cascaded by using only four pins—clock up, clock down, carry and borrow.

Both units are housed in a 16-pin dual-in-line package.

The DM7560 and DM7563 are military temperature models. The DM8560 and DM8563 are industrial temperature models.

CIRCLE NO. 258

FET analog gates switch in 50 ns

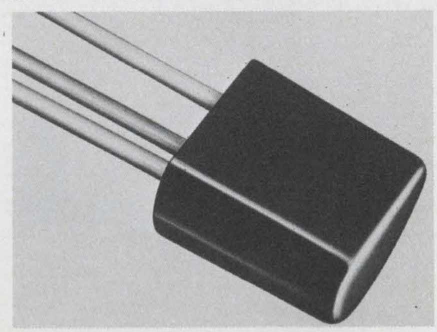


Crystalonics, A Teledyne Co., 147 Sherman St., Cambridge, Mass. Phone: (617) 491-1670. P&A: $42; stock.

Designed for analog gating, an spst FET switch is a hybrid IC that has maximum turn-on and turn-off times of only 50 ns. Other features of model CA610 include 30-Ω maximum on-resistance, zero offset voltage and direct operation from DTL or TTL circuits. The unit is packaged in a low-profile TO-5 metal can.

CIRCLE NO. 259

Plastic transistors are TO-18 devices

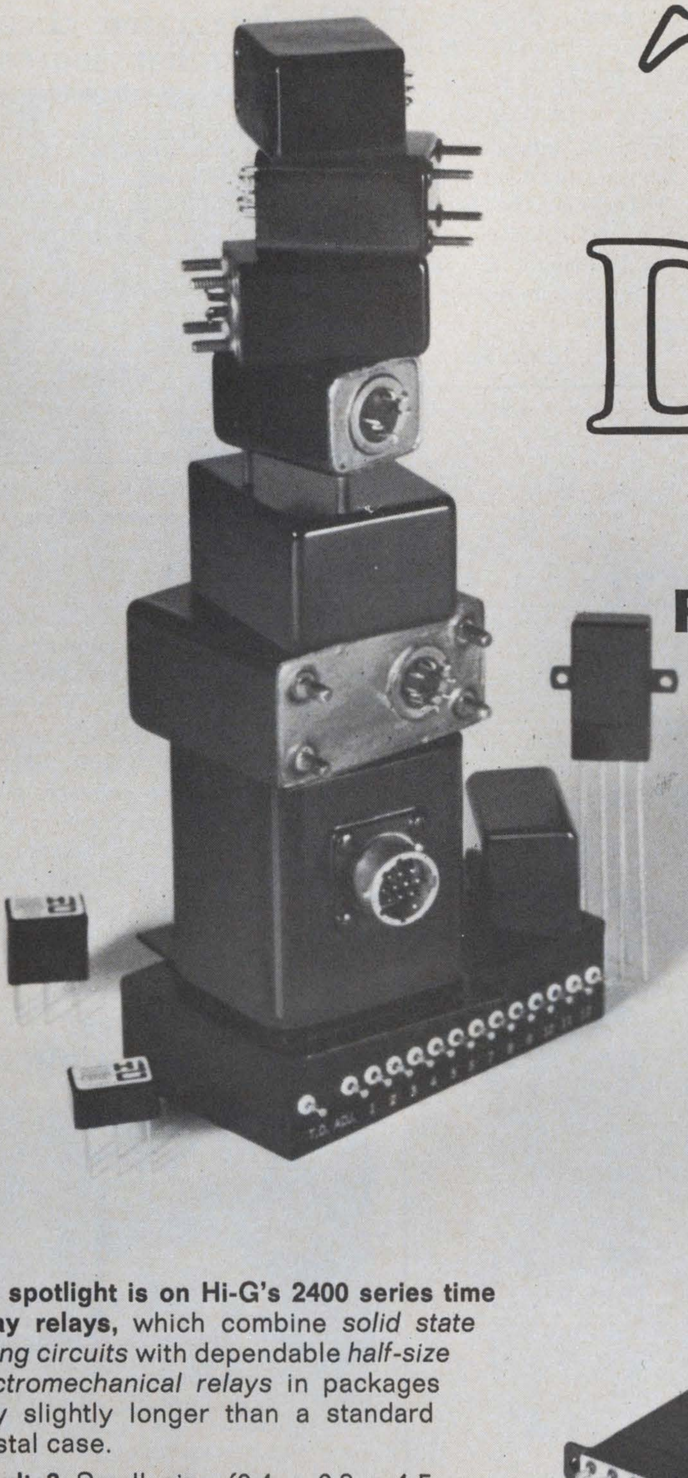


General Electric Co., Semiconductor Products Dept., 1 River Rd., Schenectady, N.Y.

Designed for use in switching and amplifier applications, npn and pnp epoxy-encapsulated transistors are now available with TO-18 lead configurations. Four devices initiate the new family: types GET706, GET2222, GET3013, and GET3638 (electrically corresponding to the 2N series of products). These high-reliability units can withstand high-temperature reverse bias at 150°C for 168 hours.

CIRCLE NO. 260

which
Time Delay
FITS YOUR REQUIREMENTS?



Hi-G time delays come in many packages.
In addition to the series 2400 crystal can type highlighted below, our electronics line includes:

Fixed and Adjustable Time Delays
Up to 300 seconds delay. Contact ratings up to 10 amps. Special variations available to accomplish delay-on-break and interval timing.

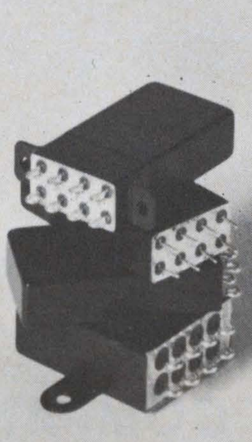
Solid State Timing Modules
Solid state reliability offers flexibility in choice of secondary switching capability.

Voltage Sensors
DC and AC level sensing provides precise switching logic over the temperature range of −55 to +125°C. Interface with transducers to sense heat, light, and pressure.

Phase Sequence Relays
To protect phase sensitive loads against phase reversal, open or grounded phase.

The spotlight is on Hi-G's 2400 series time delay relays, which combine *solid state timing circuits* with dependable *half-size electromechanical relays* in packages only slightly longer than a standard crystal case.

Results? Small size (0.4 x 0.8 x 1.5 inch), lightweight (1.2 ounces). High current carrying capacity (see below) and the rugged performance of Hi-G electromechanical relays. Long life and fast response of hybrid circuits.
Hi-G 2400 series relays operate on 18 to 31 volts unregulated and need no external resistance or capacitance to obtain maximum timing.

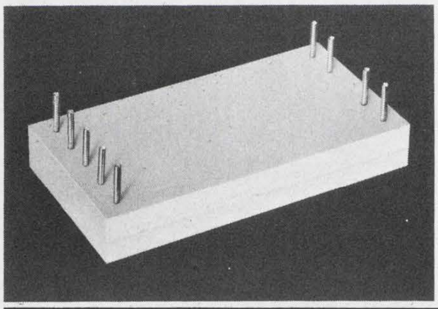


SPECIFICATIONS:
Delay Times:
50 milliseconds to 100 seconds on make.
Delay Time Tolerance:
±10% (5% on special request).
Contact Rating:
2 amps resistive @ 30 VDC.
1 amp @ 115 V, 400 Hz.
Temperature Range: −55°C to +125°C.
Vibration: 20 G, 10 to 2000 Hz.
Shock:
50 G, 11±1 milliseconds duration.

Call, write, or check the reader service number for more information. If you want application engineering assistance, an experienced Hi-G representative awaits your telephone call.

Hi-G INCORPORATED
SPRING STREET AND ROUTE 75 • WINDSOR LOCKS, CONN. 06096 • 203-623-2481

Hybrid audio amp delivers 5 watts

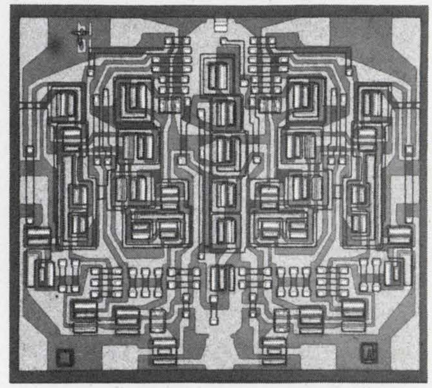


Bendix Semiconductor Div., South St., Holmdel, N.J. Phone: (201) 946-9400. P&A: $6.23; stock.

Operating from a 14-V supply, a new hybrid IC audio amplifier develops 5-W rms output power. Designated the BHA0004, the thick-film class B complementary amplifier features internally set idle current and requires only three external components.

CIRCLE NO. 261

ECL integrated circuits have another source

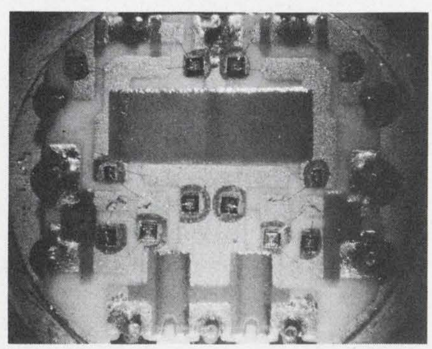


Stewart Warner Microcircuits, Inc., 730 East Evelyn Ave., Sunnyvale, Calif. Phone: (408) 245-9200. Price: $1.70 to $8.60.

Fourteen new logic circuits are now available from Stewart Warner, another source for Motorola's line of MECL II ICs. Two series initiate the new family, which is called ECL II. These are the SW1000 units for industrial temperature ranges and the SW1200 units for military temperature ranges. Circuit functions include gates, clocks, and expanders.

CIRCLE NO. 262

MOS clock driver adjusts pulse width



National Semiconductor Corp., 2975 San Ysidro Way, Santa Clara, Calif. Phone: (408) 245-4320.

Using two external capacitors, model NH0009/NH0009C MOS clock driver varies its pulse width from 100 to 300 ns. Designed to operate in conjunction with a line driver to provide fixed-width clock pulses for MOS shift registers, the device reps to over 2 MHz with typical risetimes of 40 ns and typical falltimes of 120 ns.

CIRCLE NO. 263

Amplifier chip holds 20-nA offset

National Semiconductor Corp., 2950 San Ysidro Way, Santa Clara, Calif. Phone: (408) 245-4320. P&A: $50; stock.

Featuring on-chip frequency compensation, a high-performance operational amplifier guarantees a bias current of 100 nA and an offset current of 20 nA over the full military temperature range. Model LM107 achieves these specifications with no sacrifice in drift (0.2 nA/°C, 15 μV/°C) and offset voltage (3 mV).

CIRCLE NO. 264

Hybrid circuits use MSI chips

Fairchild Semiconductor, 313 Fairchild Dr., Mountain View, Calif. Phone: (415) 962-2530. Price: $28 to $68.

Two new hybrid integrated circuits, a byte parity generator and a ripple carry adder, are made with two identical MSI circuits that consist of four independent binary adders with complementary outputs. The SH2204 generator has a 35-ns typical input to odd parity delay, while the SH2205 adder has an 8-ns typical carry propagation delay per bit. The functional differences between these twin circuits are due to the different interconnection patterns between the two MSI chips.

CIRCLE NO. 265

High-voltage rectifiers sell for under a dollar

Motorola Semiconductor Products Inc., P.O. Box 20924, Phoenix, Ariz. Phone: (602) 273-8466. Price: 50¢ to 90¢.

Costing less than one dollar, high-voltage Surmetic rectifiers reflect price cuts of 47% to 87%, depending on the reverse voltage rating. Types MR990A to MR996A are capable of handling continuous forward currents of 0.25 A at temperatures as high as 75°C.

CIRCLE NO. 266

Keyboard display console works like teleprinter

Digital Equipment Corp., Maynard, Mass. Phone: (617) 897-5111. P&A: $7900; summer, 1969.

A new keyboard display terminal, which operates like a conventional teleprinter, is virtually noiseless and accepts data at the rate of 1200 baud, as compared to the 110-baud rate of a teleprinter. Model VT03 full-duplex console has a local memory for display refreshing, thus eliminating the demand on processor time that is usually required for this function. It displays up to 960 characters, arranged in 12 rows of 80 characters.

CIRCLE NO. 267

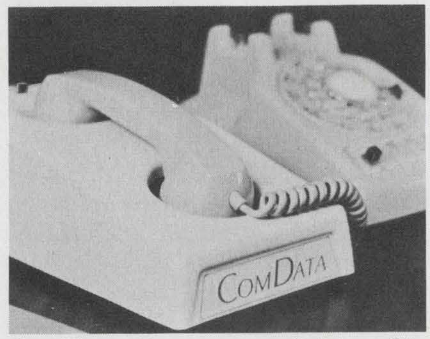
A/d converter module compares in 100 ns

Pastoriza Electronics, Inc., 385 Elliot St., Newton Upper Falls, Mass. Phone: (617) 332-2131.. P&A: $2500 to $3500; stock to 30 days.

Using a successive approximation technique, a new analog-to-digital converter module completes each bit comparison within 100 ns (1-μs total conversion time for 10 bits). Model FAD-10 is completely contained on a single plug-in card.

CIRCLE NO. 268

Acoustic data sets transmit over noise

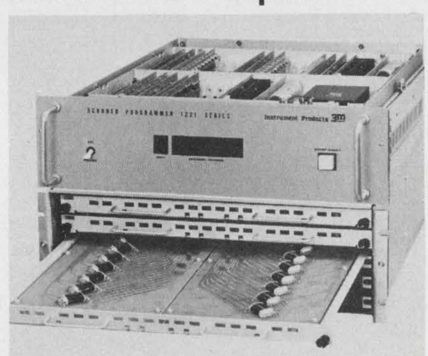


ComData Corp., 7544 Oakton St., Niles, Ill.

Series 301 acoustic data sets incorporate advanced signal-processing techniques to assure reliable transmission of data under such adverse operational conditions as high ambient noise, degradation of telephone line service caused by low signal levels, and variation in the characteristics of handsets used by different telephone companies.

CIRCLE NO. 269

High-speed scanners handle 10^4 inputs



3M Co. Instrument Products, 300 S. Lewis Rd., Camarillo, Calif. Phone: (805) 482-1911. P&A: from $4900; 30 to 45 days.

Directly interfacing to TTL positive or negative logic levels, high-speed programmable reed-relay scanners select one of ten thousand input channels and route the selected channel to one of ten output channels. Models 1221A and 3383 are supplied in standard rack-mountable chasses and feature complete guarding for high common-mode rejection in system applications. Their thermal emf is less than 10 μV.

CIRCLE NO. 270

If You Think The New Zeltex Model 148 'Op Amp' Is Expensive,
((((((((You're In For A Shock))))))))

This Chopper-Stabilized Amplifier Costs Only...

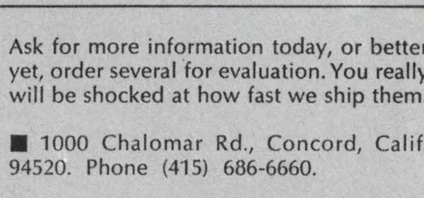
$58

Model 148 has greater gain and is faster than anything comparable. Take a look at the next best thing.

	Model 148	Brand X
DC Voltage Gain, Minimum	10^8	10^7
Gain Bandwidth	1 MHz	500 kHz
Input Bias Current, Maximum	50 pA	100 pA
Full Output Frequency, Minimum	100 kHz	3 kHz
Input Voltage Drift	0.5 μV/°C	0.5 μV/°C
Slew Rate	6 V/μs	0.2 V/μs
Temperature Range	–25° to 85° C	10°C to 60°C
Price (10-24)	$58.00	$84.00

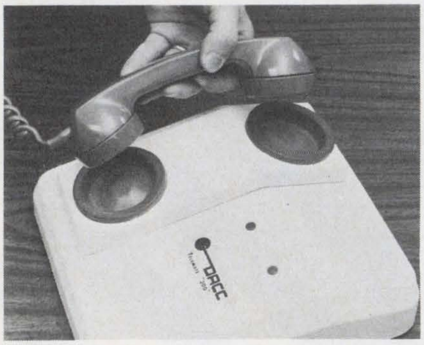
Ask for more information today, or better yet, order several for evaluation. You really will be shocked at how fast we ship them.

■ 1000 Chalomar Rd., Concord, Calif. 94520. Phone (415) 686-6660.



A Subsidiary of REDCOR CORP.

Acoustic coupler isolates 20 dB

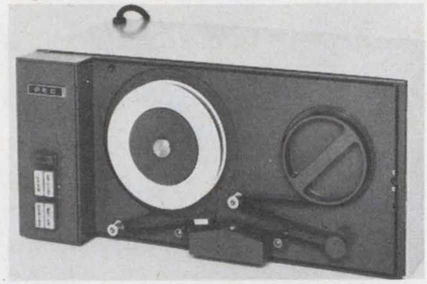


Direct Access Computing Corp., Communications Equipment Group, Southfield, Mich.

A new line of acoustic/magnetic data couplers, Telemate 300, provide an acoustic isolation of 20 dB minimum with a data rate of 300 baud. They connect conventional telephones to remote input/output terminal devices and have several different cable interface connections. Each unit also features half- and full-duplex operating modes.

CIRCLE NO. 271

Digital tape transport operates at 10 kHz

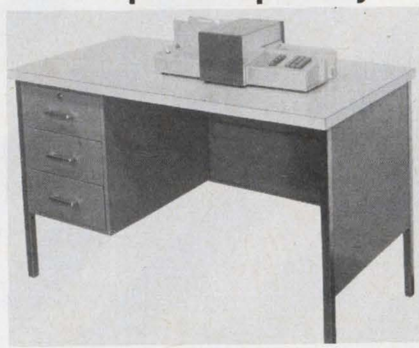


Peripheral Equipment Corp., 9551 Irondale Ave., Chatsworth, Calif. Phone: (213) 882-0030. Price: $2750.

Designed for use with small digital computers and data communication terminals, a digital magnetic-tape transport transfers data at rates as fast as 10 kHz. Model 7820 is an IBM-compatible, 9-track write/read unit that handles 800 bits per second at tape speeds of 12.5 in. per second. It uses a single-capstan velocity servo system to eliminate the pinch roller.

CIRCLE NO. 272

Card-reader system works photo-optically



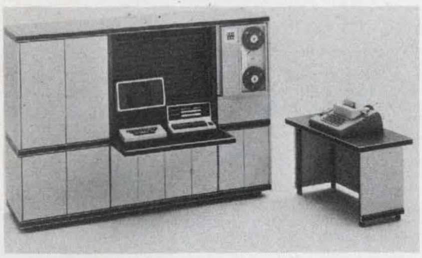
Vema Industries, Wyckoff, N.J. Phone: (201) 891-3200. P&A: from $900; 6 to 10 wks.

Model 500-30A card-reader system, which features an automatic hopper feed that can stack up to 250 cards, functions photo-optically for accuracy and speed. The new system can be supplied with interfacing, from Hollerith to ASCII, for use with standard teletype equipment. It is also available with data phone.

CIRCLE NO. 273

INFORMATION RETRIEVAL NUMBER 53

Microfilm recorder generates graphics



Information International, 11161 W. Pico Blvd., Los Angeles. Phone: (213) 478-2571. Price: from $225,-000.

Able to generate graphic information directly on microfilm from a digital output, a high-speed recorder offers four times the resolution of previous systems—16,384 by 16,384 programmable points. Ideal for data retrieval systems, the FR-80 microfilm reader has over 300 million addressable points per film frame and a speed of 10,000 characters/s.

CIRCLE NO. 274

Digital correlator works on-line

Mandrel Industries, Inc., Electro-Technical Labs Div., P.O. Box 36306, Houston, Tex. Phone: (713) 774-7561. Price: $20,000 to $22,000.

For the first time, an on-line system correlates digital data for eventual analog display. Previous correlators handled only analog data. The DC-100 digital correlator can be used with any system that receives and/or records echo-sounding signals in digital format and employs a sweep signal. It automatically accepts digital output from the system and correlates that output to the sweep signal generated by the system. The correlated signals may then be passed through an eight-bit d/a converter for analog monitoring.

CIRCLE NO. 275

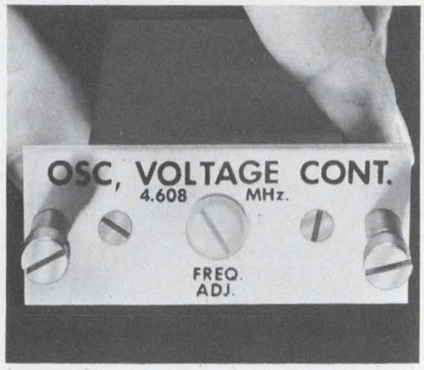
Fast FET op amp has gain of 10^6

Fairchild Controls, Modular Products, 423 National Ave., Mountain View, Calif. Phone: (415) 962-3833. Price: $55.

In addition to a 2-μs settling time to 0.01% of final amplitude, a high speed FET-input op amp features an open-loop dc voltage gain of one million. Model AD0-60 slews at the rate of 100 V/μs and has an output current of 20 mA. Its full-power frequency is 1.5 MHz maximum, while its gain-bandwidth product is 10 MHz minimum.

CIRCLE NO. 276

Palm-sized VCO resonates at 4.6 MHz

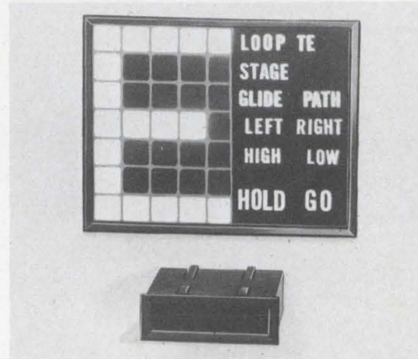


Electronic Research Co., div. of Textron Electronics Inc., 10,000 W. 75th St., Overland Park, Kan. Phone: (913) 631-6700.

Designed for communications systems with limited space and power, a new voltage-controlled oscillator delivers a frequency output of 4.6 MHz within a space of 3 by 1.75 by 1 in. Model EROS-400-147L has a temperature stability of 20 ppm from −35 to +85°C and an aging rate of 15 ppm per year.

CIRCLE NO. 278

Modular displays stack together



Info-Lite Div. of Cartelli Technology, Inc., 103 Ascan Ave., Forest Hills, N.Y. Phone: (212) 263-2495. P&A: $1 to $2; 3 to 4 wks.

Modular lighted information displays employ a building-block approach for such display applications as annunciators, numeric and alphanumeric readouts, and code/pattern indicators. Series 68000 includes modules that measure, in inches, 3/8 by 3/8, 3/8 by 3/4, 3/8 by 1-1/8, and 3/8 by 1-1/2. They use standard T-1-3/4 lamps.

CIRCLE NO. 280

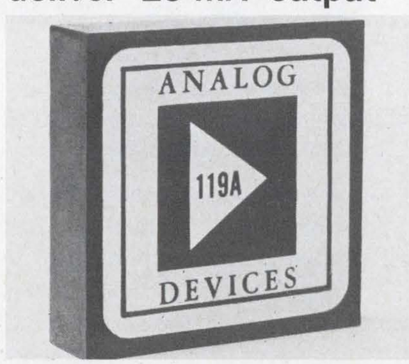
Dual op-amp supply has 100-mA outputs

Computer Products, Inc., 2801 E. Oakland Park Blvd., Fort Lauderdale, Fla. Phone: (305) 565-9565. P&A: $42.95; stock to 3 days.

Model PM 552 is a regulated dual power supply for operational amplifiers that provides two floating outputs of ±15 V dc at 100 mA. It has provisions for externally trimming each output to the exact desired voltage. The compact supply measures 2.3 by 3.5 by 1 in. and can be mounted on a PC board; it weighs less than 13 oz.

CIRCLE NO. 277

Operational amplifiers deliver 20-mA output

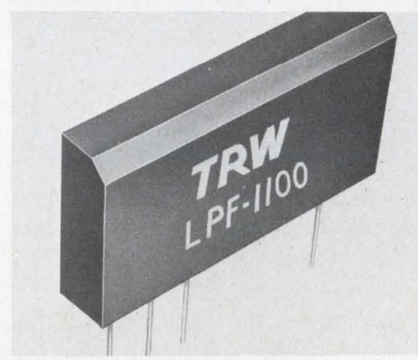


Analog Devices Inc., 221 Fifth St., Cambridge, Mass. Phone: (617) 492-6000. P&A: $24 or $34; 3 wks.

Using a new circuit-design principle to greatly increase the collector impedance of the input-stage transistors, two high-current operational amplifiers are able to supply 20 mA at ±10 V. Voltage drift for model 119A is 20 μV/°C; 5 μV/°C for model 119B. Both units feature a small-signal bandwidth of 1.5 MHz and a full-power bandwidth of 100 kHz.

CIRCLE NO. 279

Active IC filter rolls-off 54 dB

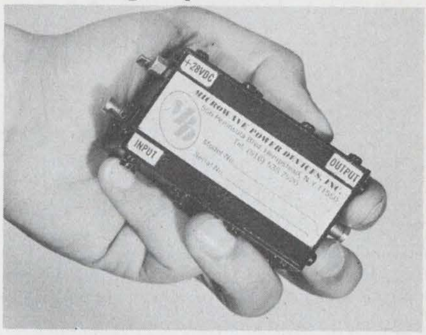


TRW Microelectronics Div., 14520 Aviation Blvd., Lawndale, Calif. Phone: (213) 477-6061. P&A: $16; 60 days.

Occupying less than 0.2 in.^{3}, a low-pass active filter with a combined notch filter provides 54-dB/octave roll-off near cut-off. This new microcircuit, designated as type LPF-1100, operates over a temperature range of −30° to +70°C. It is available with cut-off frequencies to 20 kHz and voltage ratings from 10 to 15 V dc.

CIRCLE NO. 281

Vhf transistor amps challenge power tubes

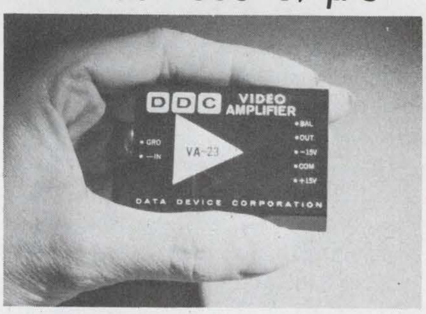


Microwave Power Devices, 226R Merrick Rd., Lynbrook, N.Y. Phone: (516) 593-2430. Availability: 4 to 8 wks.

Covering the instantaneous bandwidths of 125 to 175 MHz, transistor amplifiers achieve output powers as high as 100 W with a nominal power gain of 10 dB. The over-all gain of these amplifiers can be increased to provide full output power with an input power drive of only 10 mW. Typically their harmonic response is greater than −20 dB below rated power output with efficiencies in excess of 50%. Input VSWRs are on the order of 1.5.

CIRCLE NO. 282

Wideband amplifier slews at 1600 V/μs



Data Device Corp., 100 Tec St., Hicksville, N.Y. Phone: (516) 433-5330. P&A: $200; stock to 3 wks.

With a slew rate of 1600 V/μs, model VA-23 dc wideband amplifier has a full output of ±10 V at 30 mA when frequency is 30 MHz. At 60-mA output, the frequency for full output is 15 MHz, and the slew rate is 1000 V/μs. The unit has an open-loop voltage gain of 98 dB at rated load, and a voltage drift of 10 μV/°C. Its unity-gain frequency is 150 MHz.

CIRCLE NO. 283

Pushbutton counters have 3 by 5-in. face

Time Systems Corp., 265 Whisman Rd., Mountain View, Calif. Phone: (415) 961-9321. P&A: $345 to $395; 2 wks.

Four new, low-cost low-frequency counters, which occupy only one-third the volume of comparable instruments, offer an 8-4-2-1 BCD output along with remote programing capability. Also featuring full input signal conditioning controls and pushbutton selection of function and time base, series 410 counters can measure frequency as well as totalize. Their package size is only 3-in. high by 4.9-in. wide by 6-3/4-in. deep; they weigh approximately two pounds.

Models 410-1 and 410-2 have a five-digit display plus overrange for measurements from 2 Hz to 200 kHz. Models 410-3 and 410-4, which have a six-digit display plus overrange, cover the frequency range of 2 Hz to 2 MHz. All models provide a flashing, overflow indicator and automatically locate decimal point for reading out in kilohertz.

Input signal conditioning provisions include a trigger level control with a preset position for triggering at zero crossover, switch-selectable positive or negative slope; and a two-position attenuator (X1 and X10). These controls allow the user to employ the counters over a wide range of input waveform conditions, including noisy signals.

Maximum input signal sensitivity is 100 mV rms for a sine wave and 300 mV pk-pk for a pulse. All the 410 counters have an accuracy of plus-and-minus one count, plus-and-minus the time-base accuracy. The gate times, which can be selected either manually or remotely, are 0.1, 1 and 10 seconds.

CIRCLE NO. 299

Digital clock costs $240

Instrument Displays, Inc., 18-36 Granite St., Haverhill, Mass. Phone: (617) 373-1333. Price: $240.

A new digital clock display, which accepts four-line 8-4-2-1 BCD data and converts it to decimal time of the year or of the day, sells for only $240 in single-unit quantitites. Model MD600T uses integrated circuits and Nixie display tubes to present time in hours, minutes and seconds. It is packaged in an extruded housing that occupies only 5-1/2 by 2-1/2-in. of front-panel space.

CIRCLE NO. 284

Digital counter has dual channels

Monsanto Co., Monsanto Electronics Technical Center, 620 Passaic Ave., West Caldwell, N.J. Phone: (212) 751-2323. P&A: $895; 4 wks.

Compact model 106A five-digit reversible counter has a 5-Hz-to-5-MHz counting rate for each of its two channels. It can count each channel to 5 MHz; find the sum and difference of both channels to 1 MHz; count one channel to 1 MHz with direction controlled by the polarity of a third signal; or count one channel to 1 MHz with direction determined by the phase of channel A with respect to channel B.

CIRCLE NO. 285

Benchtop inspector simplifies operation

Field Emission Corp., Melrose at Linke St., McMinnville, Ore. Phone: (503) 472-5101. P&A: $2380; 30 to 60 days.

A workbench X-ray inspection system works with the simplicity of an office machine to solve the two problems of voltage setting and exposure time. Faxitron 805 uses a voltage sensor to give the optimum setting for radiographic contrast and exposure time, and shuts itself off automatically when the film receives the proper exposure.

CIRCLE NO. 286

Digital multimeter disregards noise

Dana Laboratories, Inc., 2401 Campus Dr., Irvine, Calif. Phone: (714) 833-1234. P&A: $1800; 30 to 60 days.

Model 4470/230 digital multimeter maintains an accuracy of ±0.01% of reading, ±0.01% full-scale, against virtually any noise found in normal operating environments. Designed with a 10-MΩ input impedance and active three-pole broadband filtering, the new instrument has thirty times the noise protection of an integrating DVM at line frequency.

CIRCLE NO. 287

Photocells ain't what they used to be...

they're a heck of a lot better

Photocells are doing jobs today that they couldn't have done ten—five—or even two years ago. There have been that many improvements!

HIGHER STABILITY
MORE UNIFORM RESPONSE TO COLOR TEMPERATURE
HIGHER SPEED RESPONSE
WIDER VARIETY OF PACKAGES AND SIZES
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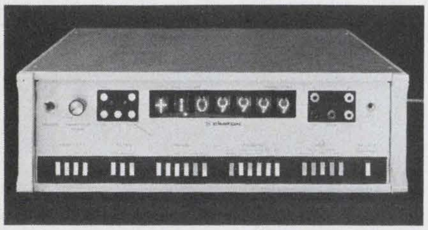
Let us show you how the "light touch in automation and control" can help solve your problems. Call (212) 684-5512 or write Clairex, 1239 Broadway, New York, N.Y. 10001.

CLAIREX ELECTRONICS, INC.®

Digital multimeter is 0.001% accurate

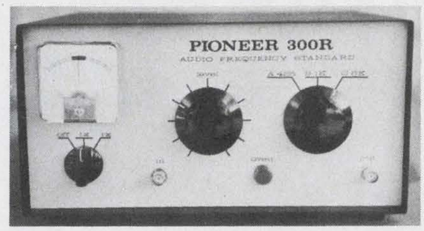


Lear Siegler, Inc., Cimron Div., 1152 Morena Blvd., San Diego, Calif. Phone: (714) 276-3200. P&A: $2990; stock.

Featuring IC plug-in circuitry and closed-loop tracking logic, a six-digit multimeter has an accuracy of ±0.001% full-scale (±0.005% of reading from 100 nV to 1099.9 V dc) and continuously samples the output at a rate of 14 readings per second. Also able to measure dc ratios, model 6753 is the first DVM incorporating automatic desensitization to insure valid readings in the presence of extreme noise.

CIRCLE NO. 288

Solid-state af source has 0.005% stability



Pioneer Electronics, 738 Pacific St., San Luis Obispo, Calif. Phone: (805) 543-0930. P&A: $169.50; 4 wks.

Model 300R is a secondary audio-frequency standard with a high stability of 0.005%. It has provisions for switch selecting up to three frequency outputs, from 1 to 6 kHz. There is also a built-in attenuator for receiving applications. This compact solid-state unit can be used in the receiving mode to directly calibrate oscillators without using an oscilloscope or other indicating device.

CIRCLE NO. 289

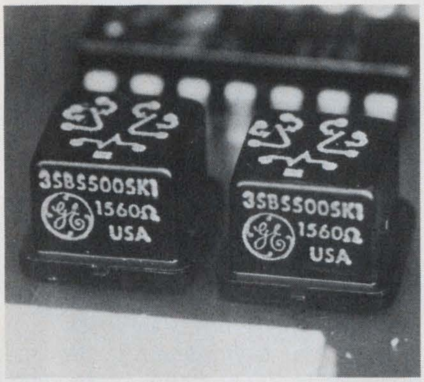
Pen-sized probe shows logic state

Automated Control Technology Inc., 3452 Kenneth Dr., Palo Alto, Calif. Phone: (415) 328-6080. P&A: $18.50; stock to 30 days.

Presenting a visual distinction between logic 1 and logic 0 conditions, a pen-sized probe can be used to observe quiescent states or low-repetition-rate pulses. The solid-state device, called LogicProbe 31A, has a high input impedance to prevent the upset of flip-flops or one-shots.

CIRCLE NO. 290

Square TO-55 relay doubles inside pull

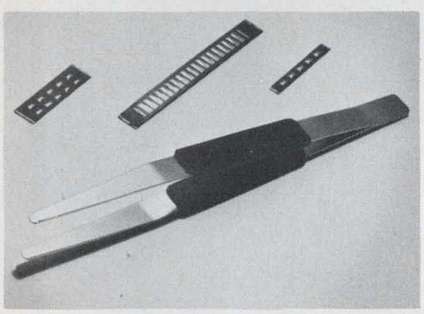


General Electric Co., Schenectady, N. Y. Price: from $29.

Housed in a square enclosure, a TO-55 transistor-sized dpdt relay allows extra room for a magnet that has two and a half times the pull of magnets designed for a round enclosure, and room for larger contact gaps and greater overtravel—thus improving contact closure. Rated at 1 A, the unit measures 0.370-in. square by 0.275-in. high.

CIRCLE NO. 291

Oxide capacitor strips put 100 pF in 0.016 in.²

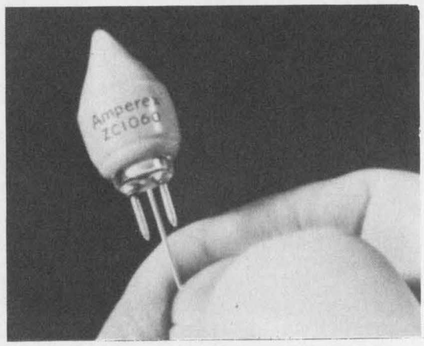


Syncrotech Inc., Edgerton, Ohio. Phone: (419) 2346.

Offering a component density that exceeds even the smallest subminiature mica capacitors, new refractory oxide capacitors present 100 pF in a space as small as 0.016-in. square. Designed for use in delay lines, filters and hybrid circuitry, type ROC capacitors are furnished in chip strips 0.020-in. thick, with widths from 1/8 to 1/2 in.

CIRCLE NO. 292

Gas-filled trigger tube switches 5-kA circuits

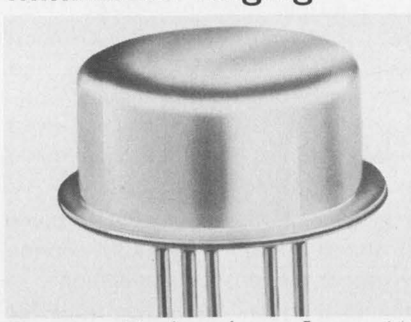


Amperex Eectronic Corp., Professional Tube Div., Hicksville, N.Y. Phone: (516) 931-6200.

A subminiature gas-filled trigger tube, type ZC1060, can handle peak currents as high as 5000 A at 60 J per discharge. The required trigger waveform is a 30 μs 3.5-kV pulse at 400 to 500 kHz; trigger energy can be as low as 1 mJ. With normal anode voltage (350 to 800 V), ignition delay of the ZC1060 is a maximum of 2 μs. Open circuit impedance is 300 MΩ; in the conducting condition, impedance falls to 30 mΩ.

CIRCLE NO. 293

Monolithic filter minimizes ringing

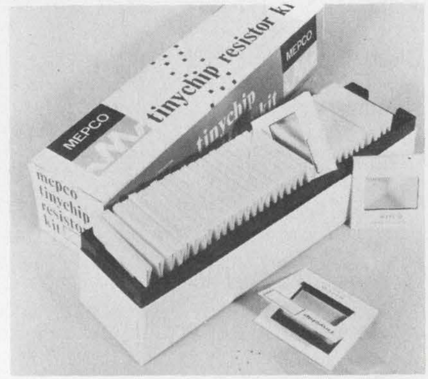


Damon Engineering, Inc., 115 Fourth Ave., Needham Heights, Mass. Phone: (617) 449-0800.

For minimum delay distortion in pulse-modulated systems and reduced ringing in swept-frequency applications, a new monolithic crystal filter provides an impulse response with a Gaussian shape and holds ringing down at least 35 dB. Model 6354 MA is a 4-pole design housed in a cold-welded TO-8 enclosure. It has a center frequency of 10.7 MHz, a 3-dB bandwidth of 2.5 kHz and a 40-dB bandwidth of 17.5 kHz maximum.

CIRCLE NO. 294

Chip resistor kit goes to 100 kΩ



Mepco, Inc., Columbia Rd., Morristown, N.J. Phone: (201) 539-2000. Price: $149.50.

A new kit of chip resistors, which contains a total of 400 chips, offers a selection of forty resistance values, from 56 Ω to 100 kΩ. The chips are packed in individual compartments in a storage/selection tray, and resistance values are marked on each envelope. This expedites quick selection, eliminates the need for measuring each chip as it is needed, and guards against picking a chip resistor with the incorrect value.

CIRCLE NO. 295

Fluidic rate sensor differentiates output

General Electric Co., Specialty Fluidics Operation, Section 37-209, Schenectady, N.Y. Phone: (518) 374-2211.

Model MD11 rate-sensing circuit is a fluidic frequency-sensing device whose output is proportional to the rate of the input signal. It can also detect a single-sided frequency signal and produce a corresponding differential output signal.

CIRCLE NO. 296

Computerized tester measures solderability

Multicore Sales Corp. div. of British Industries Co., Westbury, N.Y. Phone: (516) 334-7450. Price: $1785.

With a highly reliable digital timing method, a computerized test machine accurately measures the degree of solderability of terminal component wires. The testing procedure consists of lowering a previously fluxed specimen into a molten globule of solder. The solder is then cut in two and the time required for it to reunite is measured.

CIRCLE NO. 297

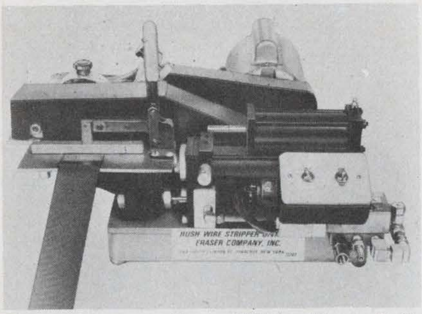
Mixer/dispenser cleans itself

Jesco Products Co., Inc., 20749 Ryan Rd., Warren, Mich. Price: $1575.

A unique fluid dispenser precisely meters and mixes small quantities of dual-component materials such as epoxies, polyesters and polyurethanes and then cleans itself before fouling can occur. Model 100 delivers any pourable material into a mixing chamber by means of air-operated positive-displacement pistons.

CIRCLE NO. 298

Flat-cable stripper removes polyimide

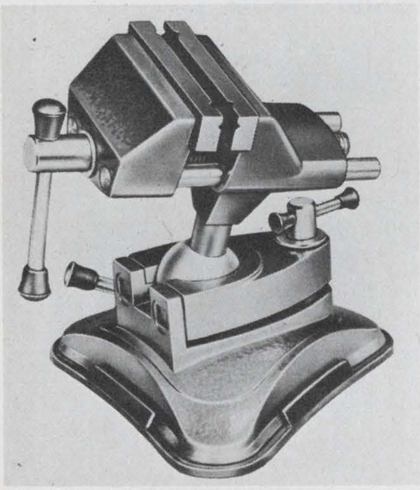


The Eraser Co., Oliva Dr., P.O. Box 1342, Syracuse, N.Y. Phone: (315) 454-3237. P&A: $1495; stock.

Using a single polyimicon stripping wheel, model 3000 stripper removes insulation, including polyimide, from only one side of a flat cable. Any width of cable up to 6 in. may be stripped as far back as 5 in. from the cable end.

CIRCLE NO. 330

Vacuum-base vise swivels and tilts



Edmund Scientific Co., 380 Edscorp Bldg., Barrington, N.J. Phone: (609) 547-3488. Price: $17.98.

Acting as the operator's third hand, a swivel-action vacuum-base vise keeps virtually any position. The new tool, model 71,144, is able to rotate 360° horizontally and 180° vertically. It comes supplied with special slip-on rubber jaws for handling fragile and delicate objects. Over-all dimensions are 6-1/4-in. high by 6-1/4 in. wide.

CIRCLE NO. 331

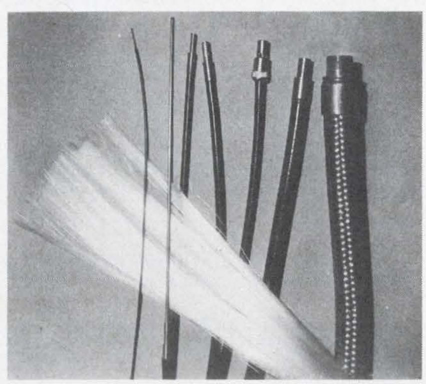
Room-cured silicone withstands 525°F

Emerson & Cuming, Dielectric Materials Div., Canton, Mass. Phone: (617) 828-3300.

Curing at room temperature, a two-part silicone rubber potting and encapsulating compound withstands temperatures as high as 525°F. Eccosil 4852 can be bonded to other silicones, or to other substrates when used with a primer. It is pourable in its uncured state, contains no solvents, and is 100% reactive. Its dielectric strength is 550 V/mil.

CIRCLE NO. 332

Amber epoxy cures red

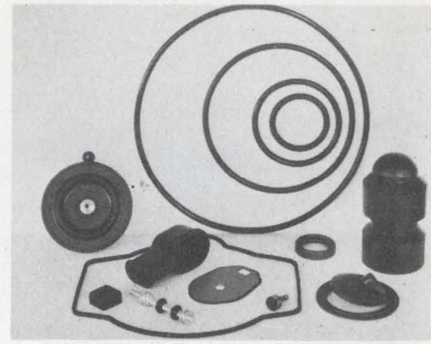


Epoxy Technology, Inc., 65 Grove St., Watertown, Mass. Phone: (617) 926-1949.

Providing a visual check of its curing cycle, a new two-component epoxy compound goes from clear amber to a deep red, as its curing progresses. The time-temperature relationship for Epo-Tek 360 may be varied at will to permit controlled curing. A primary application, using this property, is the bonding of optical glass fibers.

CIRCLE NO. 333

Rubber compound retains shape



Plastic and Rubber Products Co., 2150 Parco Ave., Ontario, Calif.

Called Parco-Fluor 994-75, a new fluoroelastomer exhibits twice the ability to recover its original shape after compression than do previously available and similar rubber compounds. It resists even the most corrosive fluids and is capable of withstanding extremely high temperatures for extended periods.

CIRCLE NO. 334

Fluorocarbon epoxy resists 450°F

Mereco Products, div. of Metachem Resins Corp., 530 Wellington Ave., Cranston, R. I. Phone: (401) 781-4070. Price: $16/kit.

Designed for bonding Teflon, Rulon and similar fluorocarbon polymers, either to themselves or to other substrates, a new epoxy adhesive extends the continuous-duty working temperature of these materials to 450°F. In addition, type 3446 adhesive can intermittently withstand temperatures as high as 1000°F.

CIRCLE NO. 335

Thou shalt not invert.

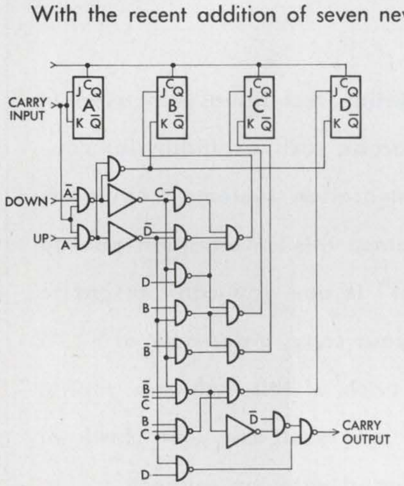
Not when you have AND, OR, NAND and NOR functions available in one logic family.

With the recent addition of seven new gates to the line, Utilogic II now allows you to implement functions simply, any way you choose — with AND, OR, NAND or NOR elements. No other logic family permits this flexibility.

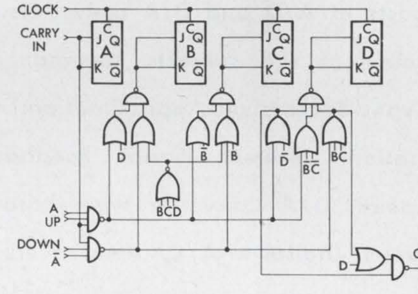
It's possible to eliminate inverters, commonly required in DTL designs. The Utilogic II implementation of the Up-Down Counter shown below requires 11% fewer packages than the typical DTL version. In terms of comparative system costs based on 1000-up pricing, the Utilogic II implementation saves you *30% in parts cost alone.*

The new circuits include dual 4-input expandable, triple 3-input and quad gates in both OR and NAND logic functions, plus a triple 2-input expandable OR gate and a diode expander.

All the new circuits are immediately available in volume in a 14-pin dual-in-line silicone package in the SP (0°C to 75°C) and LU (10°C to 55°C) operating temperature ranges. Utilogic II, as you recall, has three times greater noise margins and double the fan-out of any other available logic family. And its performance has been proven by over 15 million elements in the field. For our Utilogic II Handbook write Signetics, 811 East Arques Avenue, Sunnyvale, California 94086. Bless you.



DTL implemented up-down counter



UTILOGIC II implemented up-down counter

Signetics Integrated Circuits
A SUBSIDIARY OF CORNING GLASS WORKS

SIGNETICS SALES OFFICES: Wakefield, Massachusetts (617) 245-8200; Trumbull, Connecticut (230) 268-8010; Poughkeepsie, New York (914) 471-3292; Syracuse, New York (315) 469-1072; Fort Lee, New Jersey (201) 947-9870; Radnor, Pennsylvania (215) 687-2660; Silver Spring, Maryland (301) 946-6030; Clearwater, Florida (813) 726-3734; Winter Park, Florida (305) 671-5350; Dayton, Ohio (513) 433-4133; Minneapolis, Minnesota (612) 920-3256; Rolling Meadows, Illinois (312) 259-8300; Richardson, Texas (214) 231-6344; Garden Grove, California (714) 636-4260; Burbank, California (213) 846-1020; Redwood City, California (415) 369-0333.

DISTRIBUTORS: Avnet Electronics Corp., Burlington, Mass. (617) 272-3060; **Cesco Electronics, Ltd.,** Montreal, Quebec, Canada (514) 735-5511. **Compar Corporation at the following locations:** Huntsville, Alabama (205) 539-8476; Los Angeles, California (213) 245-1172; Burlingame, California (415) 347-8244; Hamden, Connecticut (203) 288-9276; Clearwater, Florida (813) 446-2991; Orlando, Florida (305) 855-3964; Park Ridge, Illinois (312) 692-4125; Baltimore, Maryland (301) 484-5400; Newton Highlands, Mass. (617) 969-7140; Minneapolis, Minnesota (612) 922-7011; St. Louis, Missouri (314) 542-3399; Albany, New York (518) 489-7408; Endwell, New York (607) 723-8743; Woodbury, New York (516) 921-9393; Fairport, New York (716) 271-2230; Syracuse, New York (315) 471-3356; Winston-Salem, North Carolina (919) 723-1002; Seattle, Washington (206) 763-1711. **Hamilton Electro Sales,** Culver City, Calif. (213) 870-7171; Cherry Hill, N.J. (609) 662-9337; **Hammond Electronics,** Orlando, Florida (305) 241-6601; **Kierulff Electronics,** Seattle, Wash. (206) 763-1550; **G. S. Marshall,** San Marino, Calif. (213) 684-1530; **Milgray-Delaware Valley, Inc.,** Philadelphia, Pa. (215) 228-2000; **Pioneer Standard Electronics,** Rockville, Maryland (301) 427-3300; **Schley Electronics,** Watertown, Mass. (617) 926-0235; **Semiconductor Specialists, Inc.,** Elmhurst, Illinois (312) 279-1000; **Terminal-Hudson Electronics,** New York, New York (212) 243-5200; **Universal Electronics, Inc.,** Houston, Texas (713) 781-0421; **Wesco Electronics, Inc.,** Los Angeles, Calif. (213) 685-9525; Palo Alto, Calif. (405) 968-3475.

DOMESTIC REPRESENTATIVES: Compar Corporation at the following locations: Scottsdale, Arizona (602) 947-4336; Denver, Colorado (303) 781-0912; Southfield, Michigan (313) 357-5369; Haddonfield, New Jersey (609) 429-1526; Albuquerque, New Mexico (505) 265-1020; Albany, New York (518) 489-7408; Endwell, New York (607) 723-8743; Fairport, New York (716) 271-2230; Syracuse, New York (315) 471-3356; Rocky River, Ohio (216) 333-4120; Fairborn, Ohio (513) 878-2631; Dallas, Texas (214) 363-1526; Houston, Texas (713) 667-3420. Ozark Electronic Marketing, Inc., St. Louis, Missouri (314) 423-7200.

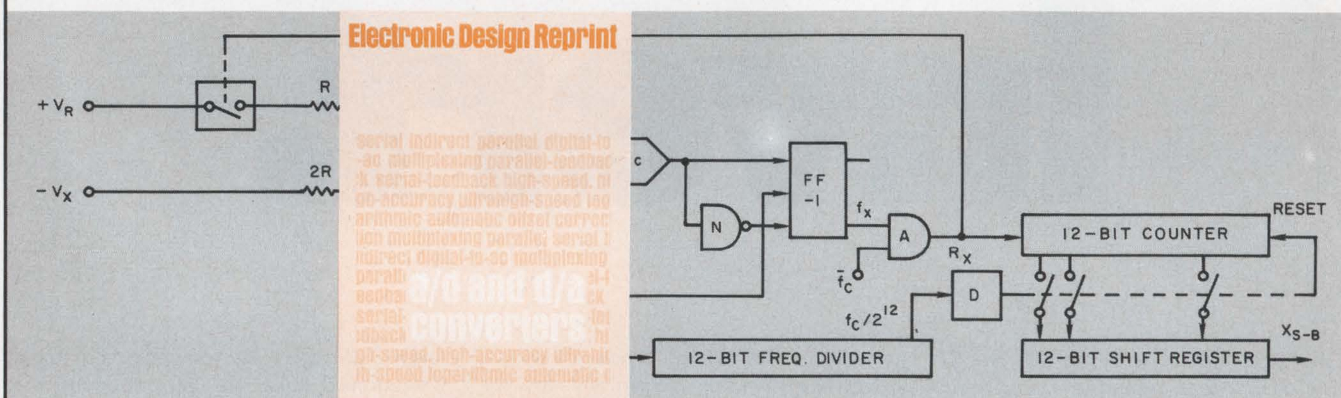
INTERNATIONAL SALES: France, Germany, Italy, Belgium, Holland, Luxemburg, Spain—**Sovcor Electronique,** 11, Chemin de Ronde, Le Vesinet, (S.-&-O.) France. United Kingdom, Ireland, Sweden, Denmark, Norway, Switzerland, Austria, Portugal—**Electrosil Ltd.,** Lakeside Estate, Colnbrook-By-Pass Slough, Buckinghamshire, Great Britain. Australia—**Corning,** 1202 Plaza Building, Australia Square, Sydney, N.S.W. 27-4318. Canada—**Corning Glass Works of Canada, Ltd.,** Leaside Plant, Ontario, Canada (416) 421-1500. Israel—**Talviton,** P.O. Box 3282, Tel-Aviv, Israel 236-666. Japan—**ASAHI Glass Co., Ltd.,** Corning Products Sales Dept. No 14, 2-Chome Marunouchi, Chiyoda-ku, Tokyo, Japan 211-0411.

INFORMATION RETRIEVAL NUMBER 66

Another useful design tool from Electronic Design:

"A Practical Design Guide For A/D and D/A Conversion"

By Hermann Schmid, senior engineer, General Electric Company



100 pages, 8½ x 11

This Electronic Design reprint contains complete, up-to-date design information covering all aspects of A/D and D/A converters. Here are just some of the subjects covered: A/D Converter Types-Successive Approximation; Charge Equalization; Indirect; Serial Feedback; Ultra-High Speed; D/A Converter types-Parallel; Serial; Indirect; Digital-to-A/C. Also covers automatic offset correction and time sharing.

As digital computation techniques are used in increasingly broad areas such as industrial control systems, instrumentation systems, computers and telemetry systems, this information-packed "how-to-do-it reprint" is one you can't afford to be without. To get your copy, order now at $2.75 each. To keep the price of this valuable reprint as low as possible, we must ask your check or money order be included with the request.

Reader Service Department, Electronic Design, 850 Third Avenue, New York, N.Y. 10022

Gentlemen:

Please send me .... copy (ies) of "A Practical Design Guide For A/D and D/A Conversion." ($2.75 each. This includes all mailing and handling charges.)

Enclosed is .... ☐ Check ☐ money order.

Checks payable to Electronic Design.

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Hydrocarbon greases lubricate controls

William F. Nye, Inc., P.O. Box G-927, New Bedford, Mass. Phone: (617) 992-1327.

Kilopoise damping greases are special lubricants that smooth the motion of instrument controls, optical-system focusing mechanisms and other delicate equipment. They are hydrocarbon greases intended for assemblies where a fine adjustment or slow motion is produced by hand, and where free motion must be damped. The Kilopoise greases are also suitable as sealants and pressure-tight greases.

CIRCLE NO. 336

Answers to problems posed on p. 85

Case A. Right off, forget choices 2 and 5. Ignoring the situation (choice 5) will only increase employe unrest and gossip, which may well foment a much more unpleasant situation in a short time. If you try choice 2, your creative man may walk out on you. The reaction in choice 4 is a little too hasty. Give the man time to think over and change his habits. Choice 1 might work, depending on how subtly you handle it. Choice 3 probably is best. By telling your man he is important to the company and to you, and by showing that you are willing to acknowledge his importance, you may win him over.

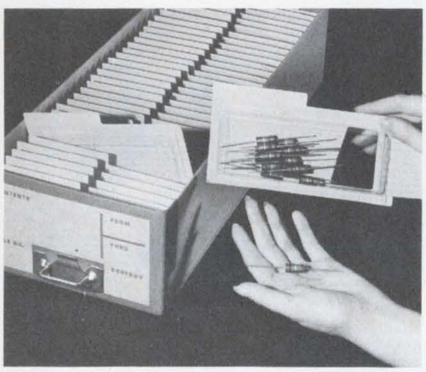
Case B. Choice 3 isn't bad. A creative man should have privacy to mull over a solution. As a follow-up action, choice 1 would let your other employes know you value Charles for good reasons. Forget about choices 2 and 4. You didn't hire Charles to converse with the staff; protect him so he can work with ease. Choice 4 probably would prompt a lot of embarassing remarks about "the creative genius," etc. There's no need to point out creative people in this way; their work will speak for them.

Evaluation Samples

Transformer insulation

A sample packet of flexible-coated and mica-based insulation materials for transformer construction is available free. The packet contains samples of flexible-coated nonwoven fabrics for class B and F applications and corona-resistant flexible mica insulations for class F and H applications. Included are: materials descriptions, listings of typical properties, and a handy applications chart for determining the proper materials to use in many transformer construction techniques. 3M Co.

CIRCLE NO. 337



Inventory system

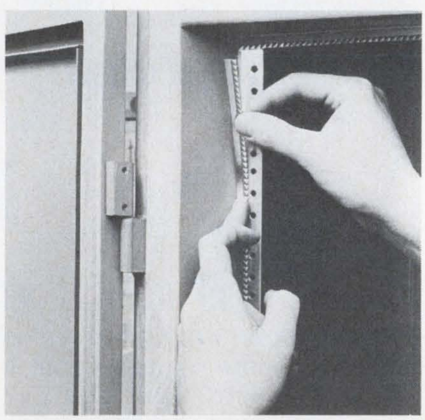
The key element of a new file system is a reusable transparent plastic dome permanently secured to a heavy-duty index card with a sliding (self-stopping) card insert. Pulling out the sliding card insert until its opening matches the opening in the file card, allows a part to be placed into the container. Repeating the process removes the part. The new system permits the actual part to be inventoried with both file card and records in one self-contained unit. The system is mistake-proof, because the actual part is filed with the written records for visual identification. These record/inventory cards are available in a wide range of standard sizes. Cost is as low as 10¢ per card. Samples and literature are available. APSCO Packaging Co.

CIRCLE NO. 338

Captive floating nuts

A kit of self-locking, captive floating fasteners, designed to correct hole misalignments in chassis and panels, is offered as an aid to electronic packaging. Locking effect is achieved by distortion of a round extension, situated above the base of the fasteners. A dry, Teflon-type lubricant is applied to the thread to facilitate insertion and removal of the screws. Precision Metal Products Co.

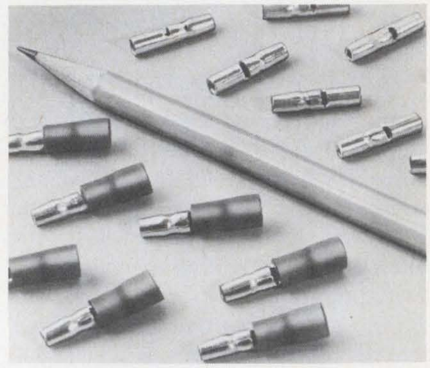
CIRCLE NO. 340



Self-adhesive gaskets

Designers are invited to sample a new type of self-adhesive finger strips for rfi/emi shielding applications. Designated series 97-555, these beryllium copper strips measure only 3/8-in. in width and are stocked in 24-in. lengths. Installation is simplified by an aircraft-quality self-adhesive backing that eliminates soldering or mechanical fastening. Complete specifications and a sample strip of the new material are available without charge. Instrument Specialties Co., Inc.

CIRCLE NO. 341



Snap terminal

A bullet-type snap terminal that accommodates 16 to 14 gage wire features several production advantages and is available in both insulated and noninsulated versions. The new terminal is made from pure annealed electrolytic copper and exceeds U. S. Government pull-test requirements. A full 1/4-in. crimp barrel offers sufficient room for use with any crimping plier. Further information and samples are available from the manufacturer. Zerick Manufacturing Corp.

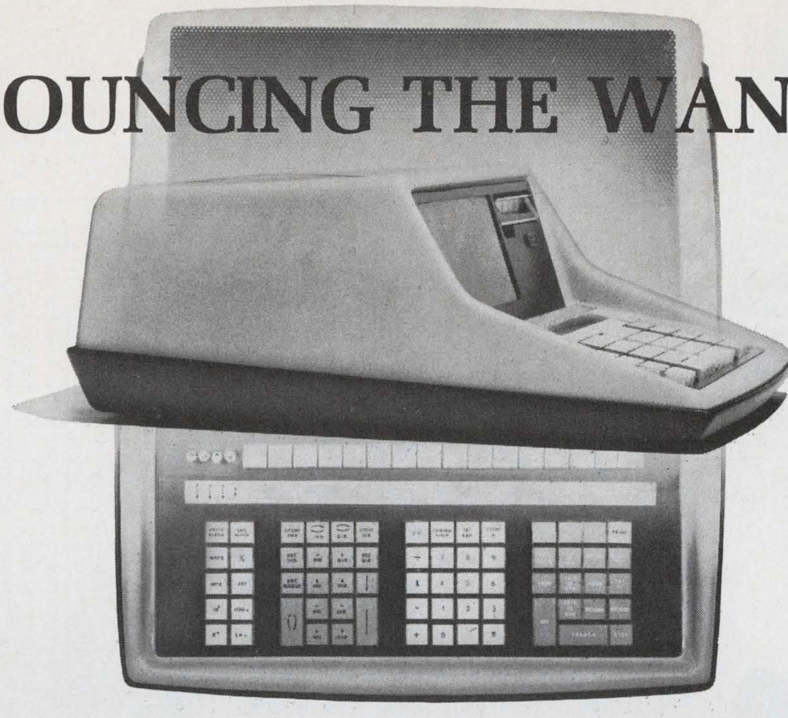
CIRCLE NO. 342

Teflon tape

Test the ruggedness of a new self-adhering Teflon tape that exhibits a high degree of chemical inertness and essentially zero-moisture absorption. An evaluation sample of the 2-mil film is now made available to design engineers. The new tape can be thermoset for greater resistance to commercial solvents. The Connecticut Hard Rubber Co.

CIRCLE NO. 343

ANNOUNCING THE WANG 700



...from any angle,

the most significant advance in calculator capabilities since the Wang 320.

960 Core-stored Program Steps.

120 Data Registers. Every register can add, subtract, multiply and divide.

Dual Nixie-type Display, 12 digits plus 2-digit (-98 to $+99$) exponent, each register.

Basic Keys for $+$, $-$, x, $\div$, $\sqrt{x}$, 1/x, $\text{Log}_{10}X$, Log_eX, e^x, $|X|$, INT(X), π.

Special Function Keys for SIN, COS, TAN, ARCSIN, ARCCOS, ARCTAN, SINH, COSH, TANH, ARCSINH, ARCCOSH, ARC TANH, Polar Conversion, Rectangular Conversion. (Others may be readily substituted.)

Commands for Loops, Branches and Subroutines. Unmatched power for matrix and array operations.

Programs Stored by Tape Cassettes; up to 10 blocks of 960 steps each.

Fastest Execution Time, approximately 300 μsec. for $+$ and $-$, 3.0 m sec. for x, 3.5 m sec. for $\div$, 15 m sec. for Log A, 35 m sec. for e^A.

Fully Self-contained with rear panel connector for forthcoming Selectric output writer.

Exclusive Integrated Circuit Design. First and only high-powered programmable calculator with IC's for more performance at less cost.

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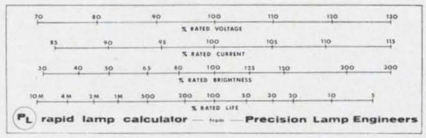
INFORMATION RETRIEVAL NUMBER 61

Design Aids



Lamp calculator

A rapid lamp calculator is included with a four-page brochure on miniature incandescent lamps. Current, candlepower and life can be computed from applied voltage using this four-scale nomogram. In addition, a full page is devoted to definitions and graphs that simplify the specification of miniature lamps. Precision Lamp Engineers.

CIRCLE NO. 348

Printed circuit chart

A die-stamped circuit chart shows how the thickness of conductors effects circuitry temperature at various voltage and current levels. GTI Corp., Dytronics Div.

CIRCLE NO. 345

Transducer data chart

A large summary chart lists the characteristics of standard surface-type temperature transducers. The chart describes over a dozen models and gives operating characteristics, accuracy ranges, sizes and general feature summaries. Trans-Sonics.

CIRCLE NO. 346

Conversion factors

A reference table for engineers in wall chart form includes common conversions such as inches to centimeters or watts to horsepower as well as many conversions that are difficult to locate in reference manuals. Some examples are atmospheres to kg/cm², cm/s to mph, ft³ to liters, microns to meters, and quintals to pounds. Precision Equipment Co.

CIRCLE NO. 347

RFI/EMI BROAD AND NARROW BAND EQUIVALENT TERMS

dBm	dBμV	Volts	Broadband Equivalent Signal Level* in dBμV/MHz for Indicated Receiver Impulse Bandwidth*: 10 Hz	100 Hz	1 kHz	10 kHz	100 kHz	1 MHz	10 MHz
+53	160	100	260	240	220	200	180	160	140
+48	155	56	255	235	215	195	175	155	135
+43	150	32	250	230	210	190	170	150	130
+38	145	18	245	225	205	185	165	145	125
+33	140	10	240	220	200	180	160	140	120
+28	135	5.6	235	215	195	175	155	135	115
+23	130	3.2	230	210	190	170	150	130	110
+18	125	1.8	225	205	185	165	145	125	105
+13	120	1.0	220	200	180	160	140	120	100
+ 8	115	.56	215	195	175	155	135	115	95
+ 3	110	.32	210	190	170	150	130	110	90
- 2	105	.18	205	185	165	145	125	105	85
- 7	100	.10	200	180	160	140	120	100	80
- 8	99	89 mV	199	179	159	139	119	99	79
- 9	98	79 mV	198	178	158	138	118	98	78
-10	97	71 mV	197	177	157	137	117	97	77
-11	96	63 mV	196	176	156	136	116	96	76
-12	95	56 mV	195	175	155	135	115	95	75
-13	94	50 mV	194	174	154	134	114	94	74
-14	93	45 mV	193	173	153	133	113	93	73
-15	92	40 mV	192	172	152	132	112	92	72
-16	91	35 mV	191	171	151	131	111	91	71
-17	90	32 mV	190	170	150	130	110	90	70
-18	89	28 mV	189	169	149	129	109	89	69
-19	88	25 mV	188	168	148	128	108	88	68
-20	87	22 mV	187	167	147	127	107	87	67
-21	86	20 mV	186	166	146	126	106	86	66
-22	85	18 mV	185	165	145	125	105	85	65
-23	84	16 mV	184	164	144	124	104	84	64
-24	83	14 mV	183	163	143	123	103	83	63
-25	82	13 mV	182	162	142	122	102	82	62
-26	81	11 mV	181	161	141	121	101	81	61
-27	80	10 mV	180	160	140	120	100	80	60
-28	79	8.9 mV	179	159	139	119	99	79	59
-29	78	7.9 mV	178	158	138	118	98	78	58
-30	77	7.1 mV	177	157	137	117	97	77	57
-31	76	6.3 mV	176	156	136	116	96	76	56
-32	75	5.6 mV	175	155	135	115	95	75	55
-33	74	5.0 mV	174	154	134	114	94	74	54
-34	73	4.5 mV	173	152	133	113	93	73	53
-35	72	4.0 mV	172	152	132	112	92	72	52
-36	71	3.5 mV	171	151	131	111	91	71	51
-37	70	3.2 mV	170	150	130	110	90	70	50
-38	69	2.8 mV	169	149	129	109	89	69	49
-39	68	2.5 mV	168	148	128	108	88	68	48
-40	67	2.2 mV	167	147	127	107	87	67	47
-41	66	2.0 mV	166	146	126	106	86	66	46
-42	65	1.8 mV	165	145	125	105	85	65	45
-43	64	1.6 mV	164	144	124	104	84	64	44
-44	63	1.4 mV	163	143	123	103	83	63	43
-45	67	1.3 mV	162	142	122	102	82	62	42
-46	61	1.1 mV	161	141	121	101	81	61	41
-47	60	1.0 mV	160	140	120	100	80	60	40
-48	59	.89 mV	159	139	119	99	79	59	39
-49	58	.79 mV	158	138	118	98	78	58	38
-50	57	.71 mV	157	137	117	97	77	57	37
-51	56	.63 mV	156	136	116	96	76	56	36
-52	55	.56 mV	155	135	115	95	75	55	35
-53	54	.50 mV	154	134	114	94	74	54	34
-54	53	.45 mV	153	133	113	93	73	53	33
-55	52	.40 mV	152	132	112	92	72	52	32
-56	51	.35 mV	151	131	111	91	71	51	31
-57	50	.32 mV	150	130	110	90	70	50	30
-58	49	.28 mV	149	129	109	89	69	49	29
-59	48	.25 mV	148	128	108	88	68	48	28
-60	47	.22 mV	147	127	107	87	67	47	27
-61	46	.20 mV	146	126	106	86	66	46	26
-62	45	.18 mV	145	125	105	85	65	45	25
-63	44	.16 mV	144	124	104	84	64	44	24
-64	43	.14 mV	143	123	103	83	63	43	23
-65	42	.13 mV	142	122	102	82	62	42	22
-66	41	.11 mV	141	121	101	81	61	41	21
-67	40	.10 mV	140	120	100	80	60	40	20

Rfi-emi conversion chart

Included with a capabilities brochure on a completely automated rfi/emi test facility is a handy chart that gives noise power densities equivalent to sinusoidal signals from -152 to $+53$ dBm. Also presented as voltage and dBμV for a 50π impedance, the noise-power densities are calculated for seven bandwidths from 10 Hz to 10 kHz. White Electromagnetics, Inc.

CIRCLE NO. 344

Switch wall chart

A rotary switch wall chart guide contains complete specifications on microminiature, miniature, and standard enclosed rotary switches. The new wall chart features a simple diagram showing how to order rotary switches according to your specific needs. Janco Corp.

CIRCLE NO. 349

Transistor chart

A new quick-reference guide to rf power transistors lists key parameters for 24 different units. A frequency vs power chart for the devices covers frequencies from 10 to 1000 MHz at power outputs up to 100 W, giving quick-reference frequency/power capabilities for each device. Package drawings are included. ITT Semiconductors.

CIRCLE NO. 350

Application Notes

Low-ohm measurement

A four-page illustrated application note briefly describes techniques used in the measurement of low resistances. The advantages of using an ac four-terminal technique for the measurement of resistances from 1 mΩ to 1000 Ω are described. In the ac four-terminal measurement, two terminals supply an ac constant current to the sample and two are used to measure the resultant voltage drop with an ac voltmeter. This technique eliminates thermal emfs and allows very stable measurements. Keithley Instruments, Inc.

CIRCLE NO. 351

Switching handbook

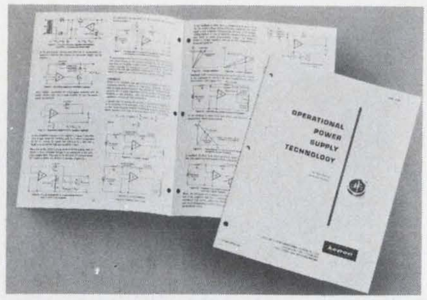
Designed for the systems engineer, a 40-page manual discusses switching as related to computers, communications, instrumentation, and automatic testing. Scanning, crosspoint switching and interfacing are emphasized. Such problems as interfacing three computers to a selection of two displays through multiple 144-line parallel paths are solved. As an alternative to solid state or reed switching arrays the use of new devices that can reduce system cost and size is described. Electronic Controls, Inc.

CIRCLE NO. 352

Microwave attenuators

Criteria for selecting microwave attenuators are discussed in a 12-page article appearing in a quarterly technical publication. The article presents the various trade-offs that may be made to obtain the optimum component at lowest cost. Included is a table of 89 fixed, 15 variable, and 4 step attenuators, which are compared in all significant parameters. The Narda Microwave Corp.

CIRCLE NO. 353



Operational power supplies

Just published, a 12-page monograph discusses the capabilities of modern dc regulators for the control of voltage or current. The paper reviews the operational analogy for power supplies and brings it up to date, with a thorough discussion of the input offset rating techniques by which regulators can be specified. There are 29 figures and photographs illustrating the application of feedback theory for the purpose of control. Kepco, Inc.

CIRCLE NO. 354

Digital memories

A guide to delay line types of serial memories presents the theory of operation and describes the capabilities and limitations of glass, quartz, and wiresonic type digital stores for specific applications. It lists factors that must be considered when choosing the correct type of ultrasonic store for buffer applications. Various tables provide additional data, such as delay shift versus temperature. Andersen Laboratories.

CIRCLE NO. 355

Gearmotor data

Can a product design engineer accept gearmotor nameplate ratings at face value when seeking a motor for a particular application? According to this newsletter, each manufacturer has his own set of rating conditions, so nameplate information on any specific gearmotor may be misleading as it relates to unit life and performance on the job. Bodine Electric Co.

CIRCLE NO. 356

Network analysis

How to determine network transfer and insertion characteristics over a 10 kHz to 32 MHz swept frequency range is described in a new 13-page application note. The note describes how a sweep signal generator and a phase/amplitude tracking detector work together to measure the gain/attenuation and phase response characteristics of networks and how these techniques are applied to the measurement of gain, insertion loss, envelope delay, and common-mode on a swept-frequency basis. Techniques for obtaining 100 dB dynamic range or 0.01 dB and 0.01° resolution, and for making log-log (Bode) plots are also described. Hewlett-Packard Co.

CIRCLE NO. 357

Crystal polishing

Step-by-step instructions on how to recondition fogged or scratched NaCl, KBr and CsBr windows are detailed in a 4-page illustrated folder. Techniques for cleaving and grinding crystals are described. Polishing methods detailed include the alcohol-felt technique and the aqueous solution-glass method. Procedures for handling transmission materials are also listed. Barnes Engineering, Inc.

CIRCLE NO. 358

Synchro standards

A 4-page illustrated bulletin describes procedures for determining the accuracy and the internal impedance characteristics of synchro and resolved standards at all angular setttings. Information given includes step-by-step procedures, test setup diagrams, equivalent circuit diagrams and recommended test equipment. Astrosystems. Inc.

CIRCLE NO. 359

sweeps 5 to 1500 MHz in 7.5 milliseconds flat!

We can supply a sweep generator with rally stripes on special order, but the frequency range and the sweep rate are standard.

Telonic's 2003 Sweep Generator will cover that entire band —1495 MHz— in a single sweep, or in any segment down to 0.02 Hz wide. You can instantly see response characteristics over all, or any portion, of a circuit's operating frequencies.

And don't overlook that word "instantly." If you're still in the habit of using a signal generator for point-to-point testing, it's time to upshift into swept techniques. Let your local Telonic rep show you the '69 floor models.

Catalog 70-A and Supplements contain complete descriptions on all Telonic Sweep Generators plus a full section devoted to "how-to" applications. Get your copy today.

Model 2003 Sweep/Signal Generator System

Frequency Range
(Seven different plug-in oscillators available) ...... .02 Hz-1500 MHz
Sweep Width
(F_1-F_2 or $F_c/\Delta F$) .... .02 Hz-1495 MHz
Frequency Marking
(Four different marker plug-ins available) ....Fixed or variable
Attenuation
(Eight attenuator plug-ins available) ....1 db to 109 db (50 or 75 Ω)
Sweep Rate
(Select from two rate plug-ins) ....0.001 to 60 sweep/sec.
Log Amplification
(One plug-in does it all) ....105 db dynamic range
Detection
(Two detector plug-ins available) ....P-P passive, 50 and 75 Ω
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(Two display processing plug-ins) .... Amplitude and marker tilt control

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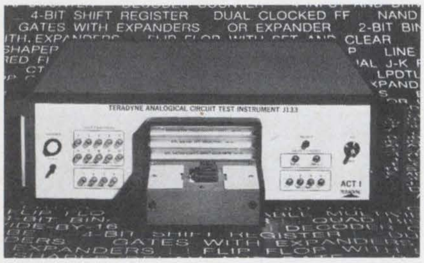
INFORMATION RETRIEVAL NUMBER 71

New Literature



IC testing

A new eight-page brochure on integrated-circuit testing by analog techniques discusses the economics of IC testing, the needs for logical and parametric testing, and the use of the firm's analog circuit test instrument. Teradyne, Inc.

CIRCLE NO. 365

Polyester film data

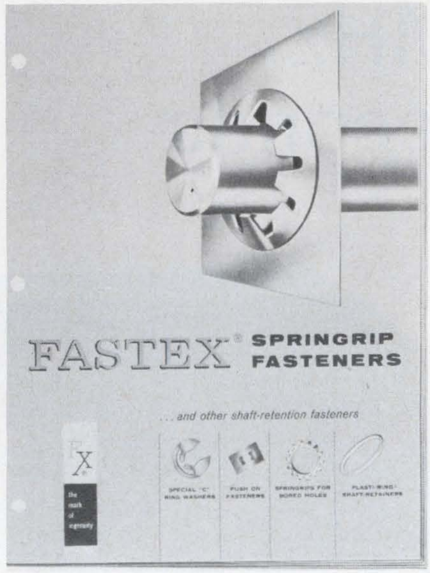
How to adhere polyster film to aluminum or copper foil, chipboard, cellulose acetate and to itself is explained in detail in a new technical bulletin. Emulsion and lacquer type adhesives that are commercially available for bonding polyester film are listed and related to specific applications. Methods of applying adhesives for flexible circuit laminates are also discussed in the eight-page bulletin. Celanese Plastics Company.

CIRCLE NO. 366

Plastic fasteners

A 12-page, two-color brochure provides detailed engineering data on a wide range of plastic fasteners including screws, nuts, washers, screw insulators and rivets as well as plastic-headed metal machine and self-tapping screws. In addition to details on numerous individual fastener types, the brochure furnishes a wealth of technical information on engineering properties of nylon and other thermoplastics. Data includes figures for both mechanical and electrical properties. Gries Reproducer Co.

CIRCLE NO. 367



Fasteners

An eight-page brochure describes standard fasteners of internal tooth design that are easily applied with a simple tool. No machining or other costly shaft preparations are involved. The cone-shaped high carbon steel fasteners slip easily over shafts, studs and rods, and are locked in place by strong spring tension. Illinois Tool Works, Inc.

CIRCLE NO. 368

Rotary switch catalog

A complete line of 1-in. diameter enclosed rotary switches is described in detail in a new 20-page catalog. Complete engineering data, specifications, dimension drawings, and code numbers are presented in a unique format that simplifies selection. An ordering guide with complete price lists is included. The ASM Corp.

CIRCLE NO. 369

Oceanographic connectors

Submersion-proof power connectors and environmentally sealed submarine connectors are described in a new six-page bulletin. Information for ordering the connectors is included. Amphenol Connector Div., The Bunker-Ramo Corp.

CIRCLE NO. 370

Selective plating

Principles, advantages and case histories relating to new selective plating techniques are detailed in a six-page brochure. The booklet describes a process that can plate strip material on a continuous basis at high speed. Burton Research Laboratories.

CIRCLE NO. 371

Silicons

The latest issue of the GE Silicone Digest (CDS-987) is available on request. The issue features three new GE product developments: higher strength, one-package RTV adhesive/sealants; heat-curing silicon potting and encapsulating compounds and new heat-cured silicon-rubber compounds with improved physical properties. Also included are articles on silicone applications. General Electric.

CIRCLE NO. 372

Pollution control

One section of a 10-page bulletin deals with the use of dissolved oxygen measurement to reduce costs in waste treatment and pollution control. For one example it cites aeration as the largest single operating cost in activated sludge treatment; it then points out how the use of polarographic oxygen sensors for direct in situ measurement can control this operation and prevent excess aeration. Illustrated with graphs, diagrams and photographs, the brochure also outlines specific application requirebents. Beckman Instruments, Inc.

CIRCLE NO. 373

A Page From The History of Surveillance

Geese, highly sensitive by nature to intrusion, were used by the ancients as an enemy detection device. They are credited with saving Rome from invasion by barbarians.

Applied Technology is making history today as a quick reaction developer and manufacturer of sophisticated electronic warfare equipment. Our ECM products are noted for providing maximum utilization, easy upkeep and easy checkout. They have been employed with considerable effectiveness in Vietnam and are credited with saving many lives.

If you would like to be part of tomorrow's ECM achievements, call or write Applied Technology. ATI is conducting a talent search for rare individuals with *A*bility, *T*alent and *I*magination. Needed are electronic engineers, designers and technicians.

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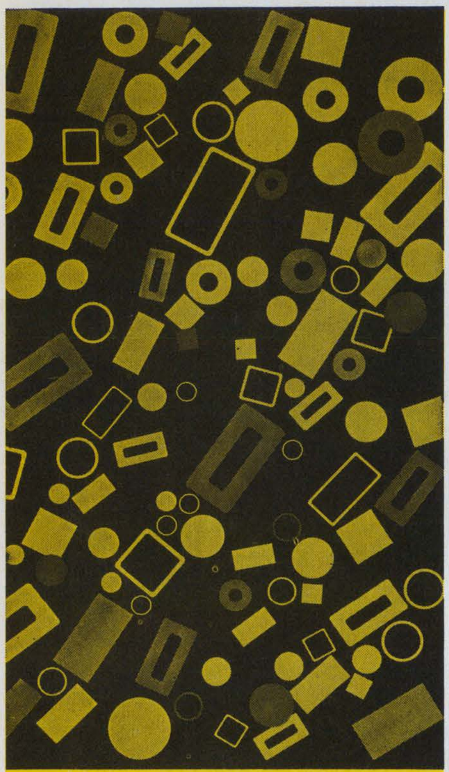


MOS/LSI brochure

A 44-page brochure describing MOS/LSI integrated circuits and other recent MOS IC products is now available upon request. The 8-1/2 by 11-inch reference guide provides a section on off-the-shelf MOS products and a second section on custom MOS arrays. Illustrative charts and diagrams accompany the text, which also gives specifications for a complete line of MOS circuits. Among the products, some of which are yet to be announced, are more than ten standard LSI circuits; and a representative cross-section of static and dynamic circuit designs to complement the LSI devices. Fairchild Semiconductor.

CIRCLE NO. 374

Dc-to-dc power supplies

A 12-page bulletin describes a complete line of power supplies for photomultipliers, scintillation counters, Geiger-Muller tubes, ionization gauges, solid-state detectors, channeltrons, CRTs, image intensifiers, nuclear particle detectors, electrostatic deflection plates, digital and analog integrated circuits and operational amplifiers. Optimized for minimum ripple and output changes with line, load and temperature variation, the compact power supplies are packaged to survive over a wide range of operating environments. Velonex, Inc.

CIRCLE NO. 375

Capacitor guide

A 68-page capacitor cross-reference is a handy tool for locating single, dual, triple and quadruple section replacement electrolytics quickly and easily. Units are listed in three different ways: the first permits selection by catalog number, the second is a complete listing by capacity, and the third is a complete electrolytic listing by voltage. There are three cross-reference sections, designed to solve selection problems. Also included is a complete listing by voltage of new wide-range tubular capacitors. Cornell-Dubilier Electronics.

CIRCLE NO. 376

Power supply catalog

A comprehensive 56-page catalog of power supplies, instruments and systems for laboratory, test equipment and OEM applications gives detailed specifications and prices and complete ordering information for more than 300 power supplies. The new catalog includes a convenient selection guide that lists all models, with specifications and features to facilitate customer selection. Also shown are several system applications. Lambda Electronics Corp.

CIRCLE NO. 377

Control computers

Two brochures that describe data acquisition and direct digital-control computer systems are available on request. This line of industrial control systems is designed to allow a knowledgeable user to set up and operate his own system. Both brochures provide system descriptions, function data, and software and application information. Honeywell Computer Control Division.

CIRCLE NO. 378

Motor-speed controls

A 28-page catalog on motor speed controls gives detailed information on many brands and types. It covers three lines of motor speed controls, the Reliance line, the Bodine line and the B&B line. Also listed are hundreds of variable speed motors that can be used with the controls. B & B Motor and Control Corp.

CIRCLE NO. 379

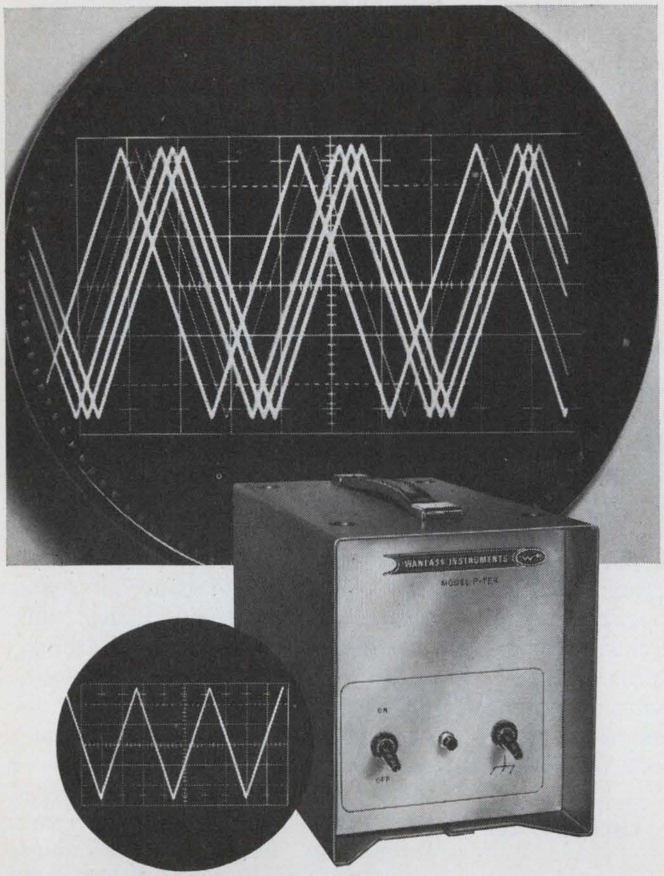
Power shears

Complete information on medium-gage capacity power squaring shears is offered in a 16-page bulletin. New accessories covered include a manual front-operated micrometer back gage and an automatic tripping device which increases output and assures consistently square cuts. Niagara Machine & Tool Works.

CIRCLE NO. 380

Take a Good Look

(You'll Never Have To See Traces Like These Again)



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Scope Conditioner
Eliminates AC Line Disturbances
From Your Oscilloscope

Merely plug your scope into SCOPAC. Let it provide the necessary noise filtering of 50 db to 1 MHz and line regulation to ¼%. You can proceed immediately with consistent, accurate oscilloscope readings. Gone are problems associated with jitter, zero-line stabilization, false triggering (top photo above), jumping off scale, erroneous signals and readings caused by normal plant or laboratory AC-line disturbances.

SCOPAC Model P-TEK operates all 300, 400 and 500 Tektronix scopes as well as those from Hewlett-Packard, Dumont and other scope manufacturers. Available off-the-shelf, priced at $375. Contact factory or local representative for literature.

See SCOPAC and PHASAC™, our new 1 to 3 phase converter, at IEEE March 25 in New York. Booths 4D11 and 4D13.

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- ☐ Digital Electronics
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INFORMATION RETRIEVAL NUMBER 74

Copper specifications

A 32-page copper-alloy specifications guide contains a section listing the most generally used alloys with specifications by the ASTM, ASME, SAE, GSA and others. Another section lists specs in numerical order and describes each alloy according to its grade, type, temper and anneal, etc. Also included is an alloy listing that gives nominal chemical compositions. Anaconda American Brass Co.

CIRCLE NO. 381

Pressure transducers

Pressure transducers, capable of withstanding severe environments and providing the latest advances in pressure measurement technology—from 1 psi to 10,000 psi—are described in a new general catalog. Detailed in the two-color catalog are absolute, gage, and differential pressure transducers, all designed to provide maximum reliability where high or low temperatures, high vibration and shock, and high pressure overloads are factors. Genisco Technology Corp.

CIRCLE NO. 382

Semiconductor devices

Listing performance data on a wide range of special semiconductor devices, a brochure gives specifications on a broad line of npn and pnp silicon triple-diffused epitaxial power transistors. Solid State Devices, Inc.

CIRCLE NO. 383

Industrial control

A free, illustrated catalog gives details on such products for the automotive field as electronic speedometers, hour meters, and others. It includes such industrial products as electronic counters, and maintenance meters for industrial applications. Engler Instrument Co.

CIRCLE NO. 384

Indicator lights

Catalog L-209 provides complete data, drawings and ordering information for momentary and alternate action switches. Described are new pushbutton caps that are available in a full range of colors. Low-profile, snap-in mounting bezels, with or without barrier, are available in a choice of four colors. Rectangular bezel units are interchangeable with most 4-lamp displays. The light source is the incandescent T-1-3/4 bulb, with midget flanged base in a range of voltages up to 28 V. Dialight Corp.

CIRCLE NO. 385

Automation computer

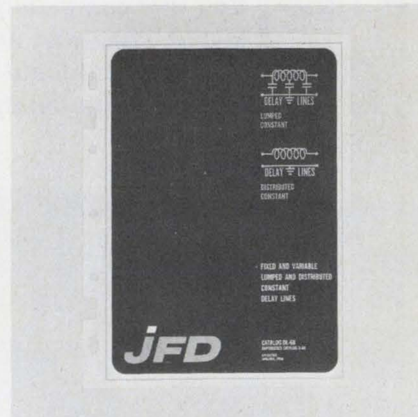
A 20-page technical brochure on an automation computer can assist system designers in configuring automatic control systems from functional off-the-shelf building blocks. The new brochure presents detailed information on the computer's organization, addressing, instruction repertoire and classes, software, I/0 systems, system interface units, fail-safe options, specifications and ordering information. Features of the processor's automation safety measures, and automation executive provisions are fully described and illustrated. General Automation, Inc.

CIRCLE NO. 386

Charge amplifier

Color-coded status indicator display, nonambiguous range-switching, multiple-level calibration and sine/random selection are among a broad array of user-oriented design features that are detailed in a six-page brochure on a new charge amplifier. The advanced-design charge amplifier also offers a choice of three different output levels, improved sensitivity range, low noise and wide frequency response in a single coordinated package. Complete electrical, environmental and physical specifications, optional equipment, accessories and prices of the model 2720 are included. Endevco.

CIRCLE NO. 387



Delay line catalog

Fixed, variable, lumped-constant and distributed-constant electromagnetic delay lines are described in a 12-page catalog. Virtually a manual for specifying delay lines, it gives definitions and formulas for delay time, risetime, pulse attenuation, pulse amplitude, characteristic impedance and bandwidth. Factors affecting cost are also discussed. In addition, the catalog covers a wide variety of standard delay lines and provides a form to facilitate design of custom units. JFD Electronics Co.

CIRCLE NO. 388

Relay buying guide

A 12-page brochure covering the selection of relays includes information on trade-offs in selection, including many cost-saving practices. A relay ordering checklist also is included to answer most questions asked in fitting a relay to a particular application. Cornell-Dubilier Electronics.

CIRCLE NO. 389

Computer careers

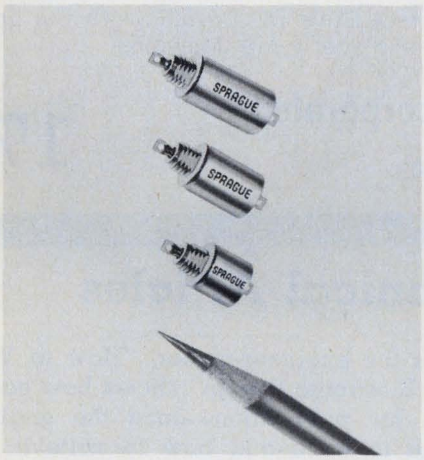
A 24-page booklet provides detailed information on careers in the design, production, and marketing of computers. It traces the rapid, continuing growth of the computer industry, explains the techniques of information processing, describes the types of job available and summarizes the qualifications. Business Equipment Mfr. Assoc.

CIRCLE NO. 390

Microwave devices

A new short-form catalog describes a line of high-power and medium-power traveling wave tubes, TWT amplifiers, backward-wave oscillators, solid-state devices and lasers. Separately printed catalogs are also available on the TWTA and laser product lines. Hughes Electron Dynamics Div.

CIRCLE NO. 391



Emi filters

A new series of subminiature emi filters for ac applications is described in a six-page brochure. The ceramic dielectric capacitor elements used in these filters have a low temperature coefficient for capacitance. A curve has been included in the engineering bulletin which illustrates the minimal effect of temperature on the insertion-loss characteristics over the complete operating range. Sprague Electric Company.

CIRCLE NO. 392

Quartz crystals

A listing of low and high frequency quartz crystals, in a range from 90 kHz to 210 MHz, is given in a new bulletin. Available in a range of 16 sizes and types of holders, the crystals are both standard and custom units that are suited for a wide variety of applications. The bulletin gives complete specifications and dimensional data. Tedford Crystal Labs.

CIRCLE NO. 393

Modular cabinetry

A 28-page catalog of modular cabinetry lists rugged cabinets for rack-mounting electronic equipment. The illustrated catalog covers four basic types of frames: straight front, slope front, wedge and sloping wedge. The catalog also details the wide range of options available in the line: plain and louvered panels and doors; individual and multiple bases; shelves and drawers, and fixed or retractable writing surfaces. Cabinets are offered in 100 optional colors. Honeywell Apparatus Controls Division.

CIRCLE NO. 394

Laminated metals

A six-page brochure describes how laminated metals offer engineers the opportunity to achieve production economy by eliminating the staking or welding of rivets. Case histories illustrate the application of laminates in electrical, electronic, appliance and automotive devices. Schematic drawings show laminated metals in sheet, strip, wire and tubing. General manufacturing specifications for each mill form are given along with suggested hardness ranges for common laminated sheet combinations. Improved Seamless Wire Company.

CIRCLE NO. 395

Microwave ICs

The 1969 edition of a 24-page component catalog lists several new product advances. Microwave integrated circuits are shown for the first time. Both ferrite and ceramic substrates are employed to realize fully integrated circulators, phase shifters, mixers and complete operating transmitters, as well as hybrid arrays that combine several functions. Also included are solid state signal sources, isolators, circulators, duplexers, phase shifters and equalizers. Sperry Microwave Electronics Div.

CIRCLE NO. 396

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ELECTRONIC DESIGN'S function is:

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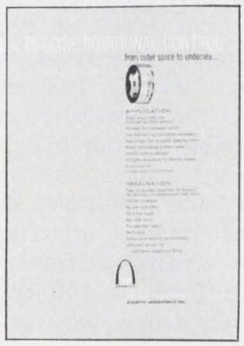
Design Data from

Free—Brushless Torque Motor Guide



A comprehensive guide to the Aeroflex line of Brushless DC Torque Motors, DC Moving Coil Torque Motors, DC Tachometers, DC Torquer/Tachometers and DC Torquer Amplifiers. Includes a concise, definitive evaluation of the "Brushless" concept, its benefits and application directions. Complete specification guide of typical types, related performance curves and a "Table of Conversion Factors" provide the Design Engineer of Direct Drive DC Devices with the graphic facts to make specifying decisions.

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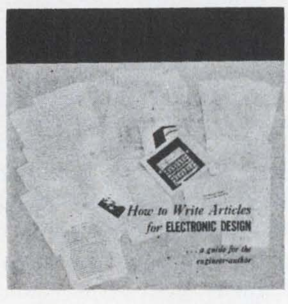
174

How To Write Technical Articles



A guide for the engineer-author, "How to Write Articles for Electronic Design" shows how easy it is to write for publication—once the engineer knows what to write and how to write it. The Author's Guide includes a complete run-down of the types of articles published by Electronic Design—plus detailed instructions on how to prepare technical articles and short special features. A MUST for every "would-be-writer" in the electronics industry. Send for your complimentary copy by circling the number to the right.

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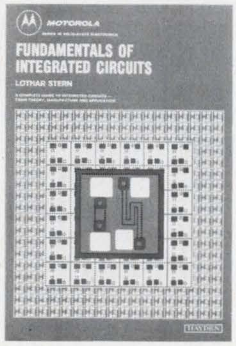
175

FUNDAMENTALS OF INTEGRATED CIRCUITS



A practical guide to integrated circuits, their theory, manufacture, and applications. This new guide by Lothar Stern offers compete, highly readable coverage of the various techniques of circuit fabrication, and their effect on circuit design and performance. As to marketing considerations, it compares the characteristics of the numerous IC structures devised to date in terms of economics and logistics. A volume in the **Motorola Series in Solid-State Electronics.** 198 pages, 7 x 10, illustrated. $8.95, clothbound. Send for 15-day examination copies.

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176

Manufacturers

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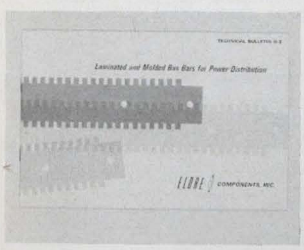
177

Bus Bars For Noise Reduction



A 16 page Technical Bulletin is now available, describing a new concept in power or signal distribution. Basic mechanical and electrical design principles, along with descriptive pictures and diagrams, are included in this bulletin. These compact buses can replace bulky cable harnesses and repetitive wiring for computer or modular application. This method of construction satisfies the demanding requirements of low inductance and resistance of high speed, solid state systems, while controlling electrical noises.

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INFORMATION RETRIEVAL NUMBER 85

Information Retrieval Service

All products, design aids (DA), application notes (AN), new literature (NL), and reprints (R) in this issue are listed here with Page and Information Retrieval numbers. Reader requests will be promptly processed by computer and mailed to the manufacturer within three days.

Cimron's new Word Generator gives you up to 16,320 bits—and you pay only by the word!

The message is simple: this all-IC Word Generator is the last word in pushbutton programming flexibility—but plug-in design insures that you don't have to buy a bit more than you can use. Up to nine plug-ins, each providing a serial word of data from 1 to 16 bits are available—and up to four repeat controls. These can be installed in combination to give you the precise output you want—fast, slow, or very complex. With four repeat controls, this word generator can deliver up to 16,320 bits—repeatable up to 225 times on a bit by bit, single word or continuous basis as selected. Digital period control has a range of 0.2 Hz to 5 MHz, continuously variable. RZ or NRZ modes; 10 ns rise and fall, 10 ns to 100 ms delay and width. By cascading repeat controls, repeats of up to 1,020 times can be achieved. As always, Cimron's *customer concern* gives you what you need at the lowest possible price. For details on Model 3903, write Cimron, Dept. C-124, 1152 Morena, San Diego, California 92110.

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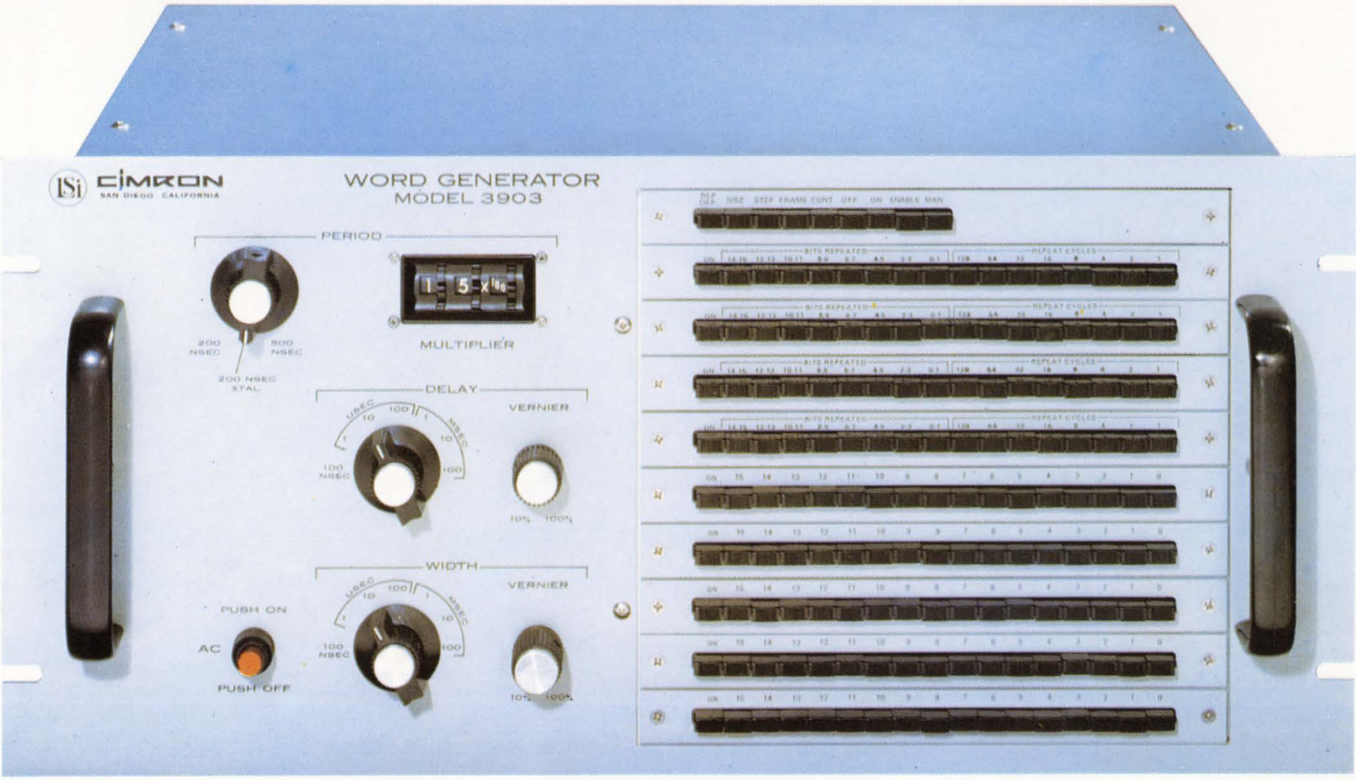
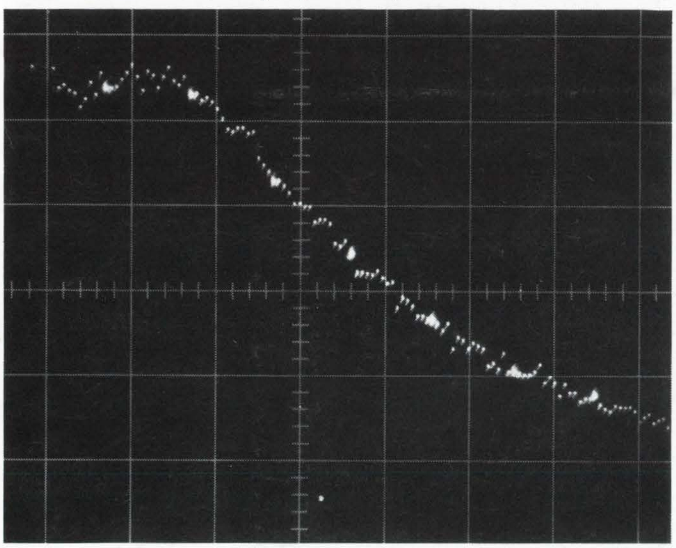


INFORMATION RETRIEVAL NUMBER 203

The RCA QUANTACON Photomultiplier First with a Gallium Phosphide Dynode— Offers Order of Magnitude Improvement in Electron Resolution

Electron Resolution Capability of photomultipliers formerly attainable.



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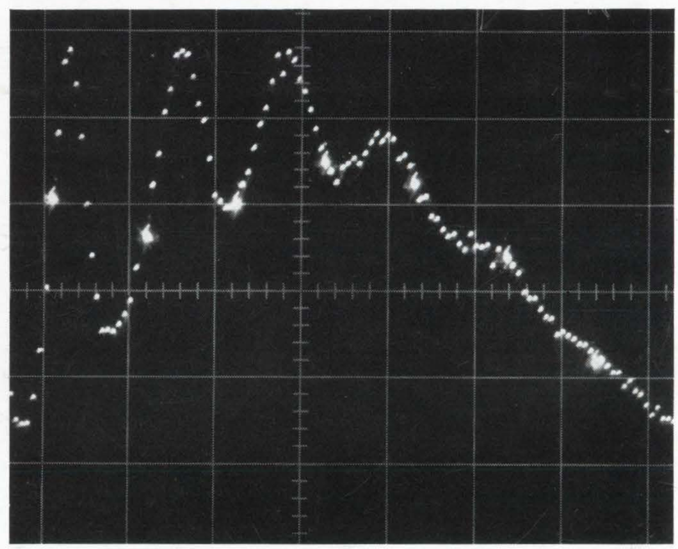
Pulse Height-Photoelectron Equivalents

Electron Resolution Capability of RCA — C31000D.



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Pulse Height-Photoelectron Equivalents

It's new . . . even revolutionary! It's the QUANTACON— a photomultiplier employing a new dynode material for extremely low-light-level applications, such as photon and scintillation counting, with a pulse height resolution so outstanding you can distinguish with ease single, double, triple, and quadruple photoelectron events.

Gallium Phosphide does it! Providing up to an order of magnitude increase in gain over conventional dynode materials, this gallium phosphide approach must be considered at the forefront of new photomultiplier designs for greatly improved low-light-level performance. In addition to improvements in electron resolution, Gallium Phosphide promises lower values of rise time and transit time in future photomultiplier designs.

RCA-C31000D is a 12-stage, bialkali, photocathode type photomultiplier utilizing Gallium Phosphide as the first dynode secondary emission material. At a cathode to dynode No. 1 voltage of 900 volts, the first dynode secondary emission ratio is typically 45.

For more information on RCA Photomultipliers and QUANTACON in particular, see your RCA Representative. For technical data, write: RCA Electronic Components, Commercial Engineering, Section No. Q-18C1, Harrison, New Jersey 07029.

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