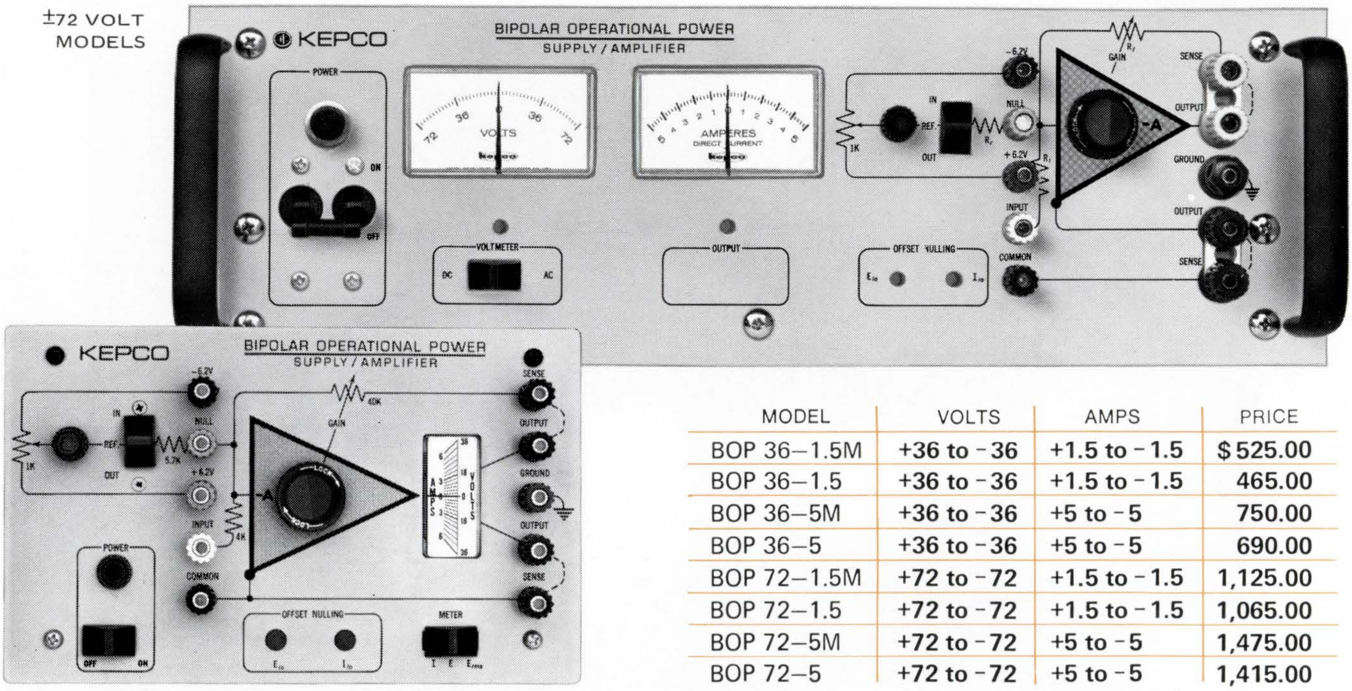
VOL. 28 NO. 10
OCTOBER 1969

THE ELECTRONIC ENGINEER

MORE BIPOLAR POWER from KEPCO

We've expanded our line of the unique "BOP" *Bipolar Operational Power* supplies. Now there are eight models available either metered (with a functional patch panel) or unmetered (blank panel) for systems users.

±72 VOLT MODELS



±36 VOLT MODELS

MODEL	VOLTS	AMPS	PRICE
BOP 36–1.5M	+36 to -36	+1.5 to -1.5	$525.00
BOP 36–1.5	+36 to -36	+1.5 to -1.5	465.00
BOP 36–5M	+36 to -36	+5 to -5	750.00
BOP 36–5	+36 to -36	+5 to -5	690.00
BOP 72–1.5M	+72 to -72	+1.5 to -1.5	1,125.00
BOP 72–1.5	+72 to -72	+1.5 to -1.5	1,065.00
BOP 72–5M	+72 to -72	+5 to -5	1,475.00
BOP 72–5	+72 to -72	+5 to -5	1,415.00

The Kepco BOP supplies employ a complementary-symmetry output stage so that the output can be continuously and linearly varied *through* zero without switching. Frequency response: Full power from d-c to 20 kHz (-3 dB).

The bi-directional power output is suited to many interesting tasks. It can be set to full voltage in either direction, and loaded fully indefinitely—or it can be modulated by any waveform, to any amount with or without a d-c component. Use the patch panel to control the feedback (any amount to 100%) or substitute your own input and feedback elements for algebraic manipulation.

Use the BOP as an a-c supply, servo driver, shake table amplifier, hi-fi, x, y deflector or integrator.

kepco®

WHAT CAN YOU DO WITH OUR BOP?

Encircle number below or write Dept. BT-19 for a full data sheet, and turn your imagination loose!

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Telex: 12-6055 • Cable: KEPCOPOWER NEWYORK

Circle 1 on Inquiry Card

Lots of people have told us they could use an active filter with low power requirements and a low enough price.

How does 0.3 mW at $10* sound?

Ask for carload prices or send $12 for an evaluation sample.

You'll find there's a lot to evaluate. Like that power spec—ideal for all kinds of battery-powered gear. Plus a price/performance combination that we think will eliminate a lot of in-house filter making, even for commercial applications. Mail the coupon and a check or P.O. for $12.00 today (please attach your company letterhead). We'll respond by air with a sample FS-60 and our brand new Filter Design Handbook. 'Till then, here are the basic specifications: ☐ Delivers band-pass, high-pass and low-pass outputs simultaneously ☐ Any desired form of the second order transfer function ☐ Complex zeros anywhere in the S-plane ☐ Multi-loop negative feedback for added stability ☐ F_c and Q of basic unit can be tuned by adding external resistors ☐ Frequency range from DC to 10 kHz ☐ Q range from 0.1 to 500 ☐ Voltage gain is adjustable to 40dB ☐ Supply voltages from ±2V to ±15V with 0.3 mW power consumption ☐ Dimensions: (14-pin DIP) 0.804" x 0.366" x 0.474" ☐ IC hybrid construction.

Gentlemen at KTI:
Please send me an FS-60 evaluation sample. Our ☐ check ☐ P.O. is attached, in the amount $12.00. Send me more information on:
☐ FS-60 ☐ All active filters ☐ Hybrid subsystems
☐ Please add my name to your permanent mailing list

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Company__________
Address__________
City__________
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My applications are:__________

PRICES:			
1 - 49	$28	5,000 - 9,999	$14
50 - 199	$23	10,000 - 19,999	$12
200 - 999	$19	*20,000 - 49,999	$10
1,000 - 4,999	$16		

KTI

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(408) 246-8100 TWX: 910-338-0279

The name to remember for Hybrid Integrated Systems and Active Filters . . .

THE ELECTRONIC ENGINEER

Oct. 1969 Vol. 28 No. 10

COVER

Although still experimental, holographic memories promise to expand substantially the capacity of computer memories, thanks to their high bit density and low cost. Up to now, however, holographic memories have been static. Our cover shows a new holographic memory by RCA, described on pages 20-23, that is dynamic—it can be both written in and read out.

← Circle 6 on Inquiry Card

The Electronic Engineer

Vol. 28 No. 10 October 1969

Chilton BPA

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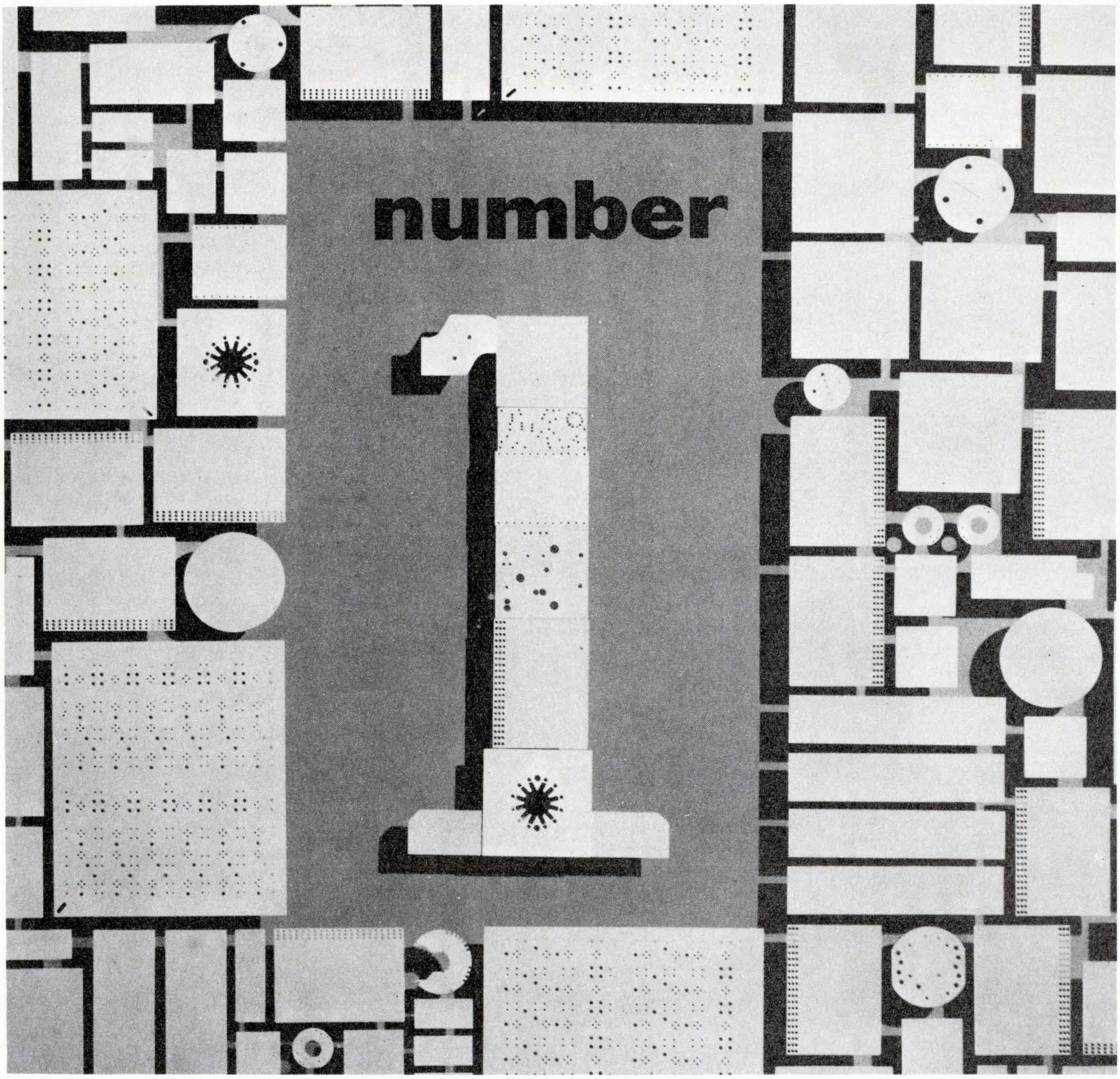
The Chilton Electronics and Instrumentation Group ● The Electronic Engineer ■ Instruments and Control Systems ■ Instrument & Apparatus News ■ Medical Electronics News ■ Electronic Component News



Circle 8 on Inquiry Card

EDITORIAL

Go Midwest, young man

If the explosive birth rate of semiconductor electronic companies in the West Coast, and of new manufacturers of memories and of integrated circuit testers in the East, is still a cause for amazement, isn't it even more amazing that this boom keeps shuttling between East and West, but has largely bypassed the Midwest?

Before we answer this question, let us explore the reason for the East-West boom. We can trace it to the seeds of semiconductor technology, planted by Bell Labs in Murray Hill, N.J., and by Dr. Shockley (the Nobel prize laureate, one of the three inventors of the transistor) who in 1955 founded Shockley Transistor in Palo Alto, with the backing of Beckman Instruments. If, instead of Beckman, it had been Raytheon who successfully lured Dr. Shockley, the boom would have perhaps bypassed the West, and concentrated around Boston's "electronic belt"—Route 128.

Will the twain booms, East and West, ever meet? We see now the hopeful signs of fertility developing in the Midwest. First of all, there is the need. The major market for integrated circuits is rapidly shifting from applications in defense and aerospace industries, to commercial applications in computers, instrumentation and communications, three specialties that were practically born in the Midwest. And there are now the opportunities that attract talented engineers to the area.

Last month, for example, Honeywell opened a new Solid State Electronics Center in suburban Minneapolis, chartered to advise the corporation on all facets of this technology. Also, many manufacturers of consumer products are adding integrated circuits to their bread-and-butter lines, and hiring the engineers who can both design and evaluate them. It won't take long before an enterprising engineer sees the need to manufacture ICs locally, probably some special circuits, and to fill the need with its own enterprise.

That's the only missing ingredient for an electronic boom in the Midwest. The market is there, and there is as much capital available there as anywhere else in the nation. Also, the fine engineering schools in the area, such as Purdue and the University of Illinois, have offered for the past decade an excellent curricula on solid state physics for engineers. At the present time, however, many of their graduates must move elsewhere to apply their knowledge.

The Midwest, then, seems to be ripe for a boom. It only waits for you to kindle it.

Alberto Socolovsky
Editor

Quality starts in the washroom—not in the clean room

"Do you really want to know how good the workmanship is in the components you buy?", the relay specialist for a large aerospace company asked recently. "Then look into the vendor's washroom before he shows you his clean room."

The relay specialist didn't mean the executive washroom, but the one the workers use. His point is that, if the manufacturer cares about them, they will care about his product. And the best place to check that care is in the facilities he provides for his production workers—the cafeteria, lockers, recreation room and, the easiest one to check, the washroom. If you don't see quality starting there, it won't be added in the clean room.

For high speed harnessing with continuous lacing...

HERE IS THE WORK SPEEDING - MONEY SAVING -

GUDEBROD SYSTEM "C"

GUDEBROD FLAT TAPE BOBBINS—This special packaging of Gudebrod Flat Braided Lacing Tape is highly popular in the harness shop. Whether used in all hand tying or with the Cable-Lacer (for which it was designed) the bobbin makes conveniently available, high quality Gudebrod Tape in most of its many types—all engineered to lie flat, tie tight.

GUDEBROD CABLE-LACER®—This unique harnessing hand tool has proved a production speeder and harness improver. Makes up to 30 knots per minute. While making firmer harnesses with tighter, more uniform knots, it eliminates wear and tear on operator's hands because special brake takes strain of knot setting. Holds bobbin of Gudebrod Tape in handle.

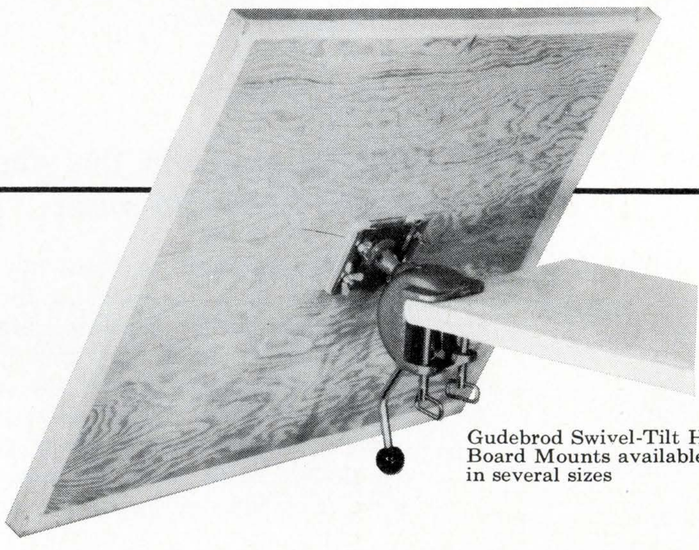
LONGER WIRE HOLDING PINS—They make wire threading much easier, quicker (no repeated wire redressing between pins). In harness tying they preserve the layout while using the Gudebrod Cable-Lacer. Special case hardened pins, nail better, stay straight, no nailheads.

GUDEBROD SWIVEL-TILT HARNESS BOARD MOUNT—Two dimensional balanced mobility puts every section of the cabling within easy, natural reach of the operator. Work done in this unstrained manner goes faster, is better, all day through.

There it is, the Gudebrod System "C" solving the cable making problems in a speedy, economical, profit improving way. Ask about System "C" (If you use intermittent tying, ask about Gudebrod System "S").

Gudebrod's Special, Longer Case Hardened Pins

®T.M.—UNION SPECIAL MACHINE CO.



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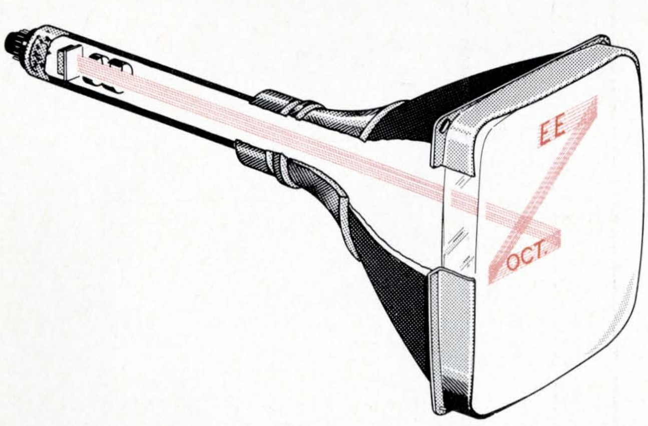
UP TO DATE

Seven at one blow—a new cathode-ray display tube

Future CRT readout systems may display up to 3000 symbols, writing each character in well under a microsecond and maintaining a brightness level comparable with any system available today. This is the opinion of Sylvania engineers, who have developed multibeam, single-gun display tubes at the firm's Electronic Tube Division in Seneca Falls, N.Y.

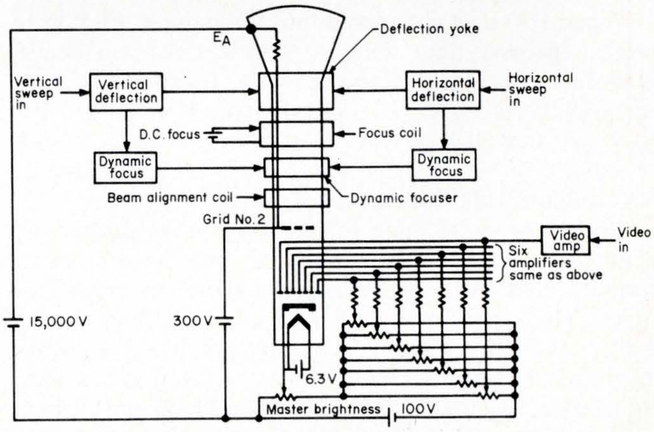
The first of these, a 12-inch, seven-beam CRT, is now available in sample quantities at $780 each. Although the tube itself is more expensive than conventional single-beam tubes, it promises savings on over all systems costs by reducing external circuit complexity. Writing with seven individual electron beams, the new tube is potentially brighter and faster than a single-beam CRT, making it ideally suited to applications that require high writing speed under high ambient light conditions.

The only multibeam version presently available is the seven-beam SC-5299, but at least one 12-beam CRT has already been constructed, and Sylvania engineers feel confident that this approach can be applied to single gun tubes with up to 24 individual beams.



Seven beams sweep simultaneously to write on the screen of this display tube. Unblanking pulses applied to the control grids turn the beams on and off to form 5/32-inch-high characters. In a given system the beams will either sweep out each line of characters sequentially or, in a random-access mode, step from one character position to the next.

One big advantage of the multibeam tube is speed. Conventional single-beam displays achieve speed only at the expense of brightness and, furthermore, few systems can form a character in less than 10 to 12 microseconds. The multibeam tube makes it possible to construct a system that writes a character in under a microsecond without an unacceptable reduction in display brightness.



Simplified drive circuits are possible with the new tube. Bias control voltage is applied to an indirectly heated cathode and a 6.3 volt source supplies heater current. Amplified video signals, applied to each of the seven control grids, turn the electron beam on and off. As shown by this typical drive circuit, focus and deflection requirements are minimal. Since the tube writes by blanking and unblanking at appropriate points as the beams sweep out each line of characters, the horizontal yoke current is a sawtooth rather than a step function. This eliminates the need for extremely fast writing and the attendant high-frequency deflection yoke response associated with single-beam operation. Only the Z-axis modulation remains significant.

X-rays disappear with solid state packages

Most of the radiation generated in color TV sets comes from the high voltage tubes. Solid state devices eliminate this hazard.

The television industry has been under attack to eliminate X-ray radiation from color TV sets. The radiation hazard has been attacked in the press and was even mentioned in one of President Nixon's speeches shortly after he took office.

X-rays are very easily generated within vacuum tube rectifiers and voltage regulator tubes. While this radiation hazard has been greatly reduced through shielding and better design in the high voltage portion of the set, it will never be truly eliminated until the high voltage system is converted to solid state.

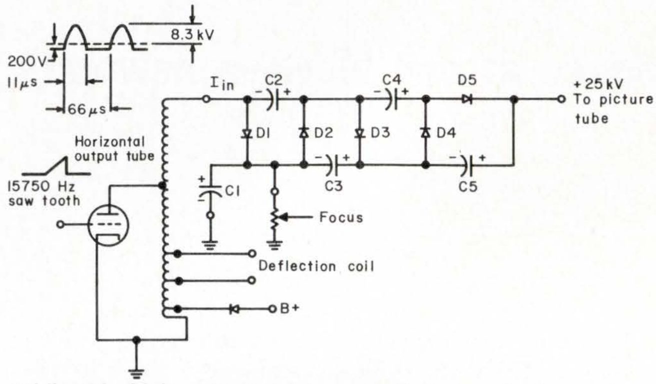
Until now, very little solid state, contrary to the advertising, has been used in most TV sets. The reason is primarily an economical consideration. TV engineers often refer to today's TV sets as "tribrid" because most sets sold use tubes, a few transistors and one to three integrated circuits in them.

Several companies have had high voltage triplers and quadruplers available for almost two years for use in color TV. These have not been generally accepted until recently. TV manufacturers are slow to accept new items for reasons, such as the designs are locked up as much as a year prior to manufacturing a new set, price because of the very competitive nature of consumer electronics, and manufacturers will not accept something that's new until they are absolutely certain that it is reliable.

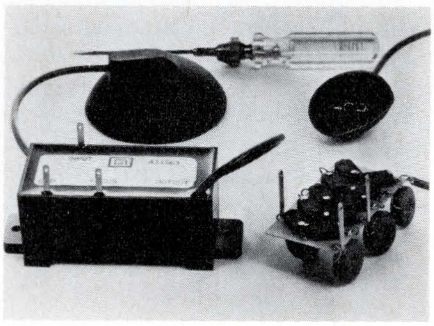
When HV packages came into the market, they were more expensive than standard tube circuits and hence, manufacturers were reluctant to use them. Right now, manufacturers of these solid state high voltage packages feel they will be widely used in the 1972 models of color TV sets. The market has been estimated at $35 million for these packages.

These new solid state high voltage units permit the elimination of some windings on the flyback transformers, and the focus rectifier and voltage regulator tubes. The most common high voltage package is the tripler. The tripler input is usually about 8.3 kV with an output of approximately 25 kV at around 2.5 mA. Regulation is better than 6% from no load to full load and many supply a focus voltage in the 8 kV region at 0.5 mA. They are completely potted in molded cases to prevent corona, arcing and shock hazards.

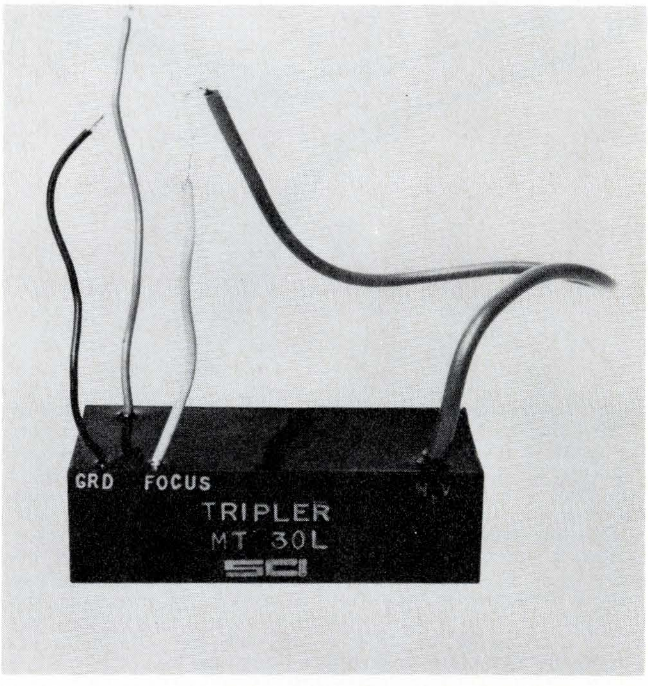
Varo in Garland, Texas, is one of the first to make a high voltage package for TV sets. They announced their package over a year and half ago. Several other companies have also offered high voltage packages for color TVs—General Instruments, Atlantic Semiconductor Div. of Aerological Research Corp. and the latest entry is Scientific Components, Inc.



While this high voltage tripler circuit design is General Instrument's, others will be similar.



On the left is the HV tripler packaged by General Instrument. Below is a high voltage tripler which is made by Scientific Components, Inc., a new entry in the field.



Double divider aids precision measurements

With a new instrument from Julie Research Labs, you can now measure voltage, ratio, or resistance with eight-place precision. The key to the vastly improved performance of the new instrument is a double divider technique that eliminates sources of error inherent in previous potentiometric systems.

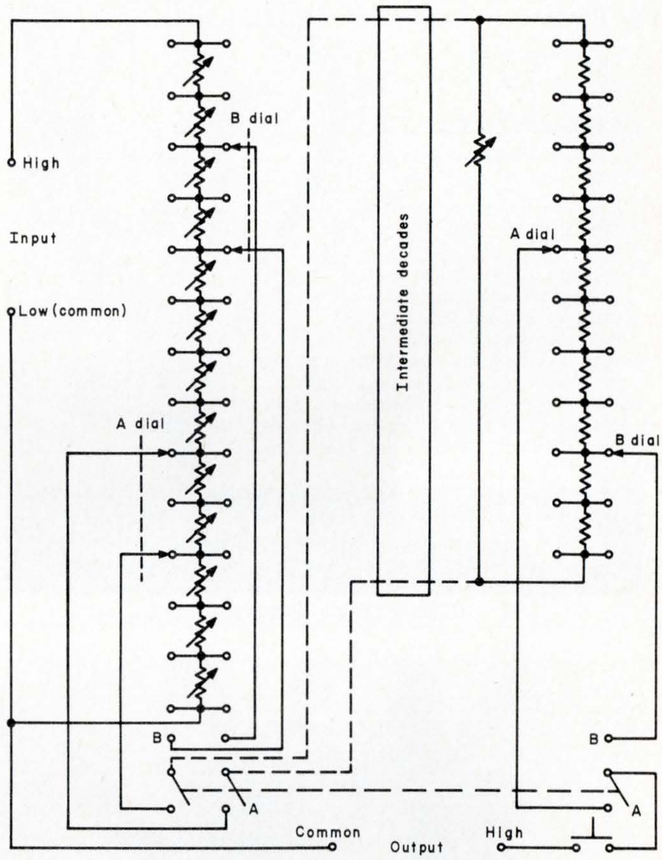
Basic to any measurement is a comparison of one thing to another—a standard to the parameter under test. If you use two separate instruments—or even separate parts of the same instrument—to make such a comparison, you will introduce errors that are more than one part in ten million. Hence, instruments previously have been essentially limited to one part per million accuracy.

To improve this level of accuracy you must use one instrument to compare the unknown to the standard. The same parts of the instrument must be used for both measurements. The double divider technique makes this possible. A single Kelvin-Varley divider is used in conjunction with a switching arrangement so that two independent sets of dials use the same resistance decades.

In operation, you simply use one set of dials (call them the "A" dials) to measure the unknown.

Now, to refer this measurement to some standard, you switch to a second set of dials (the "B" dials) and measure the standard. You have now set eight dials in the A set and eight dials in the B set. The ratio of these two eight place numbers is the ratio of the unknown to the standard with a precision of eight places and an accuracy of better than seven places.

By using the double divider, you eliminate the errors that would creep in if you were to use two separate instruments. Furthermore, the change from one set of dials to another can be made in a fraction of a second so that both measurements are made at essentially the same time.



Heart of the double divider is a Kelvin-Varley divider in which a dpdt switch connects each decade to the preceding decade. Unlike the conventional divider, each decade is equipped with two sets of poles and the ganged selector switches are provided to switch between them. The instrument under development by JRL will have eight such decades. Each resistor in the first two decades will be individually adjustable and one trimming resistor will be provided for each of the last five decades.

Relay information available

Section X1—"Relays, Electromechanical: of NAVAIR 01-1A-514 Technical Manual: Design of Electric Systems for Naval Aircraft and Missiles" is now available as a separate document from the Superintendent of Documents, General Printing Office, Washington, D.C., 20402 under catalog number D217.14:EL2/CH at $2.75.

This designer oriented manual for users of relays is the outgrowth of the SAE A-2R relay committee activities where users, manufacturers and the military participated. Section X1 contains an extensive alphabetical index of subject matter and includes innumerable examples of recommended and non-preferred circuits along with suitable explanation. There are, in addition, tables of military part numbers with contact ratings for various load voltages and number of phases.

UP TO DATE

Electromechanical printer works with dots

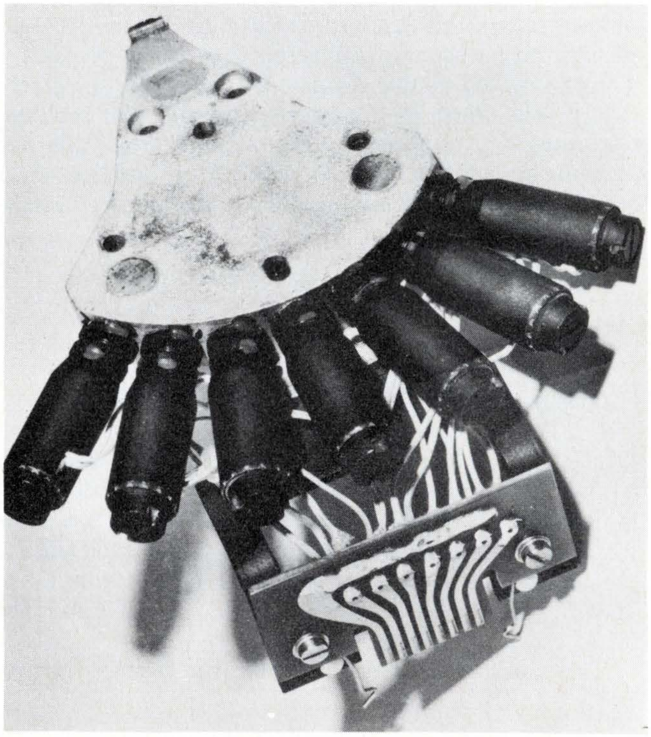
A high-speed electronic calculator incorporates a new type of printout device. Built with ICs, the P-251 desktop unit has what is called a "mosaic" printer which gives rapid and quiet operation, along with a permanent printed record.

The mosaic printer consists of 7 electronically controlled needles which move only a few millimeters at a combined rate of 720 strokes/s. These 7 needles are moved by electromagnets which are in turn driven from integrated circuitry. Energizing a magnet causes the corresponding needle to move through the narrow tubing, striking ordinary typewriter ribbon and forming a dot on a paper roll, typical of those used in adding machines and calculators.

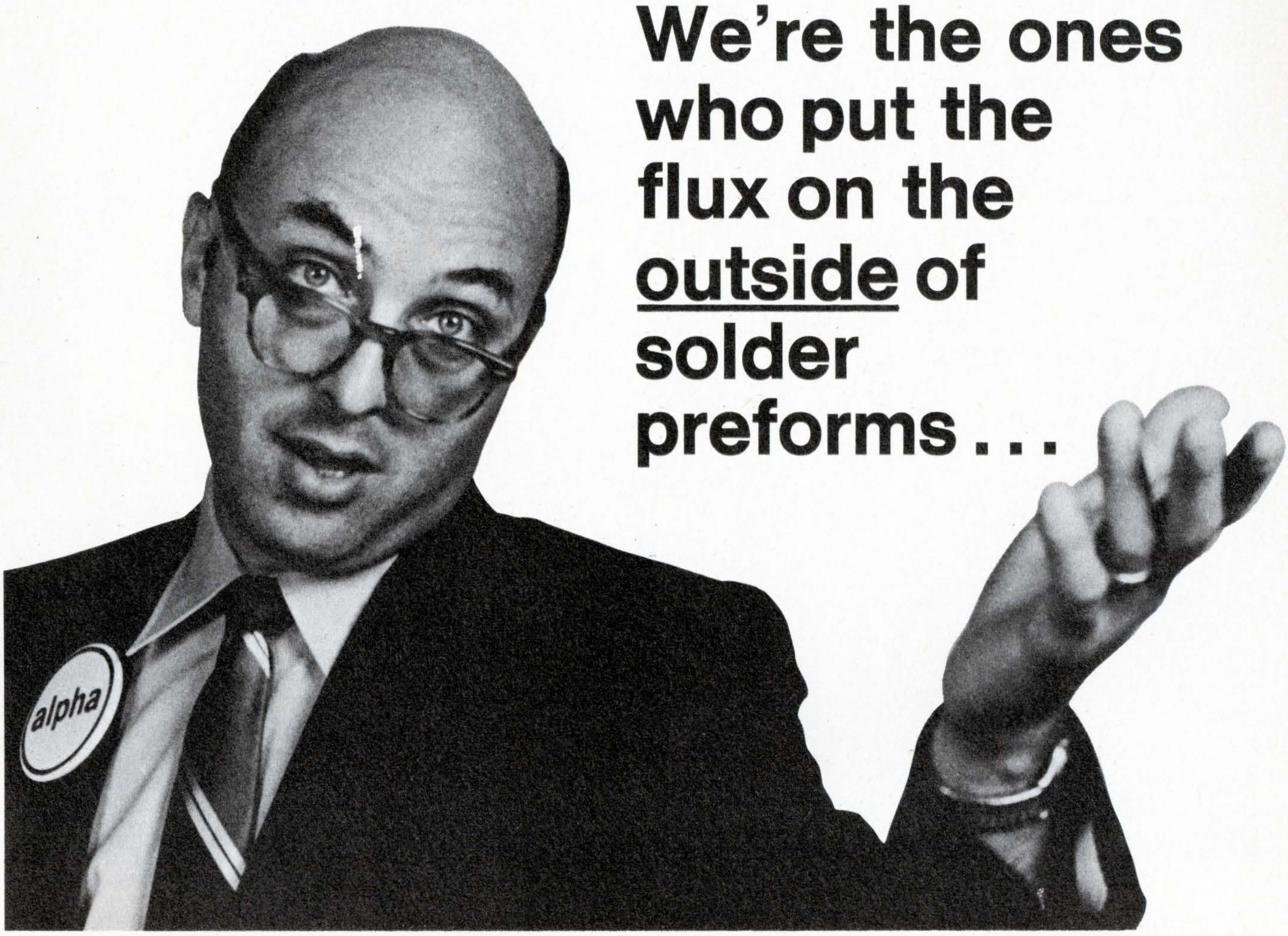
Activating all 7 magnets simultaneously produces a column-of-dots printout and, as the machine moves left to right to its next incremental position, another column is produced. The machine, and hence the printer, can be programmed to a variety of character configurations including Roman numerals, hieroglyphs,

(*continued on page* 19)

Small needles or pins located in the "fingers" and actuated electromagnetically, strike a typewriter ribbon, thus imprinting onto a paper tape. Any kind of character can be printed by proper programming of the calculator.



We're the ones who put the flux on the <u>outside</u> of solder preforms . . .



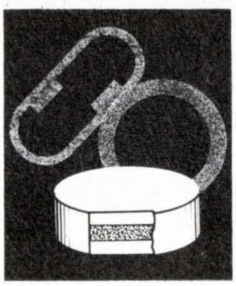
. . . because that's where it belongs

The advantages are obvious. Flux on the outer surface of the preform liquefies first and flows onto the base metal before the solder melts. With flux-filled preforms, the solder must melt before the flux can escape and there's a good chance liquid solder will come in contact with the metal surface before it has been properly cleaned.

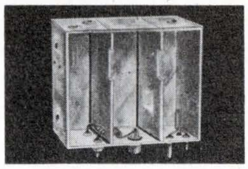
Flux-coated preforms also provide other advantages over solid solder or flux filled solid preforms: a quicker, more even spread rate, 100% flux coverage and consistently reproducible dimensional control upon melting. You can choose from a wide variety of standard and special shapes, coated with the finest grade of water-white rosin flux in all degrees of activation.

Flux-coated preforms join a long list of Alpha product innovations for better soldering, including oxide-free, Vaculoy® processed bar solders and anodes, a foam flux that meets MIL-F-14256, Type A specification, a complete line of neutral pH, electronic grade cleaners and a host of others.

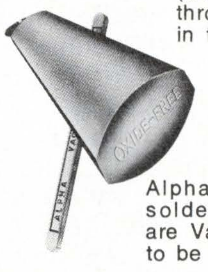
Back these with our full range of quality industrial solders, fluxes and soldering chemicals, the largest research staff and the most proficient technical service and assistance in the industry, and you have a supplier you can really rely on. Call or write for full information today.



Alpha flux-coated solder preforms in standard configurations as well as multi-layers and spheres. Flux-filled and solid solder preforms are also available.



Alpha Solder Creams cut costs in mass production operations. (Ill: attaching feed throughs and dividers in tuner box.)



Alpha bar solders and solder and tin anodes are Vaculoy® processed to be oxide-free.

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Alpha Metals, Inc. (U.K.), Ltd., London, England

10688-E

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ДРУГАЯ ЛОЖЬ КАПИТАЛИСТОВ-ИМПЕРИАЛИСТОВ ОБНАЖЕНА

В современном издательстве "SSPI", — доклада знаменитого фабриканта транзисторов, который советские агенты в Америке перехватили, появилась другая капиталистическая ложь. Она новая из серии сказанных Буржуазными Империалистами и Вождями Соединённых Штатов.

Мы построили первый самолет, но Американцы украли эту честь от нас. Мы были первыми в формуляции "Coca-Cola", но империалисты взяли Славу за это. Теперь, — окончательное оскорбление — "SSPI" заявляет, что они построили мира первый энергию-переключательный транзистор. (Мы построили его в 1946 году. Планы сейчас заключёны в подвале в Кремле.)

Доклад "SSPI" называемый "LITPAK-PST" — большая ложь с начала до конца. На пример: Так как этот доклад только крикливая пропаганда, Центральный Комитет объявил этот документ неприличной и извращённой литературой. Люди имеющие копию "LITPAK-PST", или читающие его, будут считатся предателями советского народа.

Unitrode's SSPI Division has developed a new line of **POWER SWITCHING TRANSISTORS** . . . the world's first transistor family specifically designed for power switching applications, with every parameter important to power switching guaranteed. Transistors in our TO-5, TO-59, TO-66, and TO-111 packages all have noteworthy parameters for power switching. They're capable of handling from 40 to 400 volts and 0.2 to 20 amps. Available with: saturation voltages of less than 1 volt at 10 amps, minimum current gains of 100 at 1 amp, and turn-on times of less than 100 nanoseconds at 5 amps. For complete specifications and prices, contact Alex Polner (617) 745-2900, and ask for our LITPAK-PST.

SSPI SOLID STATE PRODUCTS
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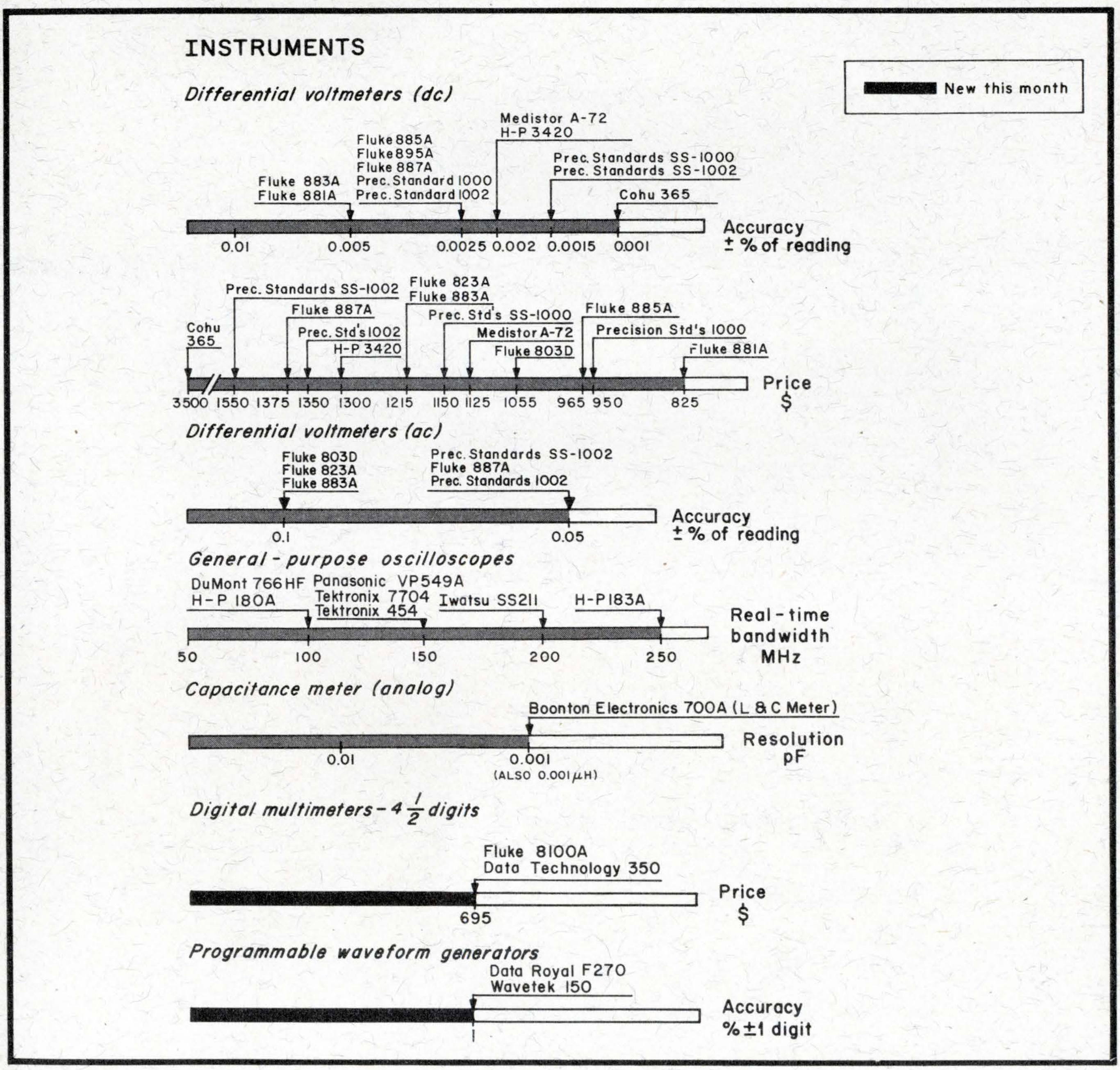
FOREFRONT

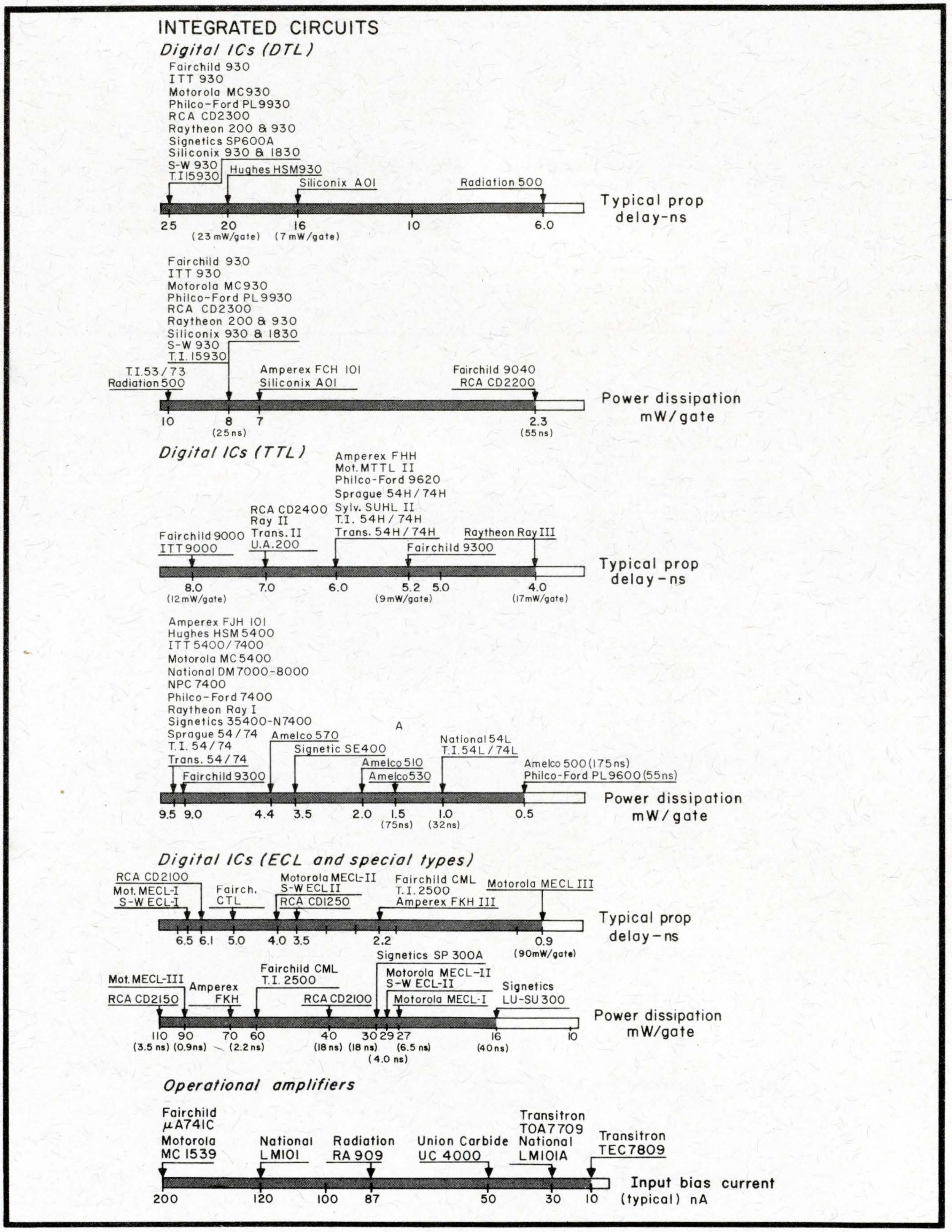
The EE Forefront is a graphical representation of the practical state of the art. You will find here the most advanced components and instruments in their class, classified by the parameter in which they excel.

A word of caution

Keep in mind the tradeoffs, since any parameter can be improved at the expense of others. If there is no figure-of-merit available, we either include other significant parameters of the same products, or we provide additional bar graphs for the same products.

Do not use these charts to specify. Get complete specifications first, directly from the manufacturers.

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ITT 930
Motorola MC930
Philco-Ford PL9930
RCA CD2300
Raytheon 200 & 930
Signetics SP600A
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S-W 930
T.I 15930
Hughes HSM930
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Radiation 500
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20
(23 mW/gate)
16
(7 mW/gate)
10
6.0
Fairchild 930
ITT 930
Motorola MC930
Philco-Ford PL9930
RCA CD2300
Raytheon 200 & 930
Siliconix 930 & 1830
S-W 930
T.I. 15930
T.I.53/73
Radiation 500
Amperex FCH 101
Siliconix A01
Fairchild 9040
RCA CD2200
Power dissipation mW/gate
10
8
(25ns)
7
2.3
(55ns)
Digital ICs (TTL)
Amperex FHH
Mot. MTTL II
Philco-Ford 9620
Sprague 54H/74H
Sylv. SUHL II
T.I. 54H/74H
Trans. 54H/74H
RCA CD2400
Ray II
Trans. II
U.A.200
Fairchild 9000
ITT9000
Raytheon Ray III
Fairchild 9300
Typical prop delay-ns
8.0
(12mW/gate)
7.0
6.0
5.2
5.0
(9mW/gate)
4.0
(17mW/gate)
Amperex FJH 101
Hughes HSM 5400
ITT 5400/7400
Motorola MC5400
National DM 7000-8000
NPC 7400
Philco-Ford 7400
Raytheon Ray I
Signetics 35400-N7400
Sprague 54/74
T.I. 54/74
Trans. 54/74
Fairchild 9300
Amelco 570
Signetic SE400
A
Amelco 510
Amelco 530
National 54L
T.I. 54L/74L
Amelco 500 (175ns)
Philco-Ford PL9600 (55ns)
Power dissipation mW/gate
9.5
9.0
4.4
3.5
2.0
1.5
(75ns)
1.0
(32ns)
0.5
Digital ICs (ECL and special types)
RCA CD2100
Mot. MECL-I
S-W ECL-I
Fairch. CTL
Motorola MECL-II
S-W ECL II
RCA CD1250
Fairchild CML
T.I. 2500
Amperex FKH III
Motorola MECL III
Typical prop delay-ns
6.5
6.1
5.0
4.0
3.5
2.2
0.9
(90mW/gate)
Signetics SP 300A
Mot. MECL-III
RCA CD2150
Amperex FKH
Fairchild CML
T.I. 2500
RCA CD2100
Motorola MECL-II
S-W ECL-II
Motorola MECL-I
Signetics LU-SU 300
Power dissipation mW/gate
110
(3.5 ns)
90
(0.9ns)
70
60
(2.2ns)
40
(18ns)
30
(18 ns)
29
27
(6.5 ns)
(4.0 ns)
16
(40ns)
10
Operational amplifiers
Fairchild µA741C
Motorola MC 1539
National LM101
Radiation RA 909
Union Carbide UC 4000
Transitron TOA7709
National LM101A
Transitron TEC7809
Input bias current (typical) nA
200
120
100
87
50
30
10

(*continued from page* 14)

or Chinese idiograms without changing the printing head. Characters (digits, symbols, etc.) are made up of patterns or mosaics of dots, printed at the rate of 90/s.

The North America Phillips Corporation, New York, is presently using this printer in one desk calculator selling for $1,195. They expect, however, to find many uses in other printer applications, including computer peripheral devices.

This calculator supplies a permanent record on a paper tape with a new "mosaic" printer which prints in a dot matrix configuration.

Fallout on systems analysis

Many of the modern tools for systems analysis and project management have been developed specifically for the largest program America has ever managed: the space program. The application of these tools, however, is not restricted to space—they can be useful for solving problems in both industry and government. In a new publication, NASA discusses its know-how and methods as applied to such management problems as long-range planning, cost-effectiveness and control, and market development.

Statistical decision theory, decision analysis, linear and nonlinear programming, and special computer programs are but a few of the many techniques either developed or improved for NASA. For more information on these and other management tools, read NASA SP-5048, "Applications of Systems Analysis Models." At 50 cents a copy, it's not much of an investment—and it could prove one of your most valuable references.

A word of caution. Do not expect these tools to "solve" problems for you. When properly used, they become powerful methods for helping you to make decisions or crack complicated problems. But they do not replace your judgment, nor are they worth the effort when your problems are simple.

Will optical memories ever forget? Now they can!

A new magnetic hologram can be written, read, and erased repeatedly, opening the door to dynamic optical memories.

"Why didn't somebody think of that before?" The question arises when you see the erasable magnetic hologram developed at RCA. The seemingly simple device offers the possibility of a 10^{12}-bit dynamic optical memory in a one-inch square (although RCA only claims storage of 10^8 bits in one square inch).

The experimental setup looks like any other read-write-erase memory, except for the hologram. Rubin Mezrich, the developer of the new hologram has taken advantage of the magnetic properties of manganese bismuth crystal film by using it for the recording material. Manganese bismuth (MnBi) is deposited in a single-crystal layer, two millionths of an inch thick on a base of mica. A strong magnetic field, applied to this film, causes the magnetic moments of the atoms to line up with all the north poles in one direction perpendicular to the plane of the film, the south poles in the other direction. It is then ready to be used for a hologram.

The laser beam that writes the hologram is now split. One beam is transmitted through the dot pattern that holds one page of bit information, and then proceeds to the film. At the film, this beam interferes with the other half of the beam which has come directly from the laser. This interaction causes an interference pattern on the face of the MnBi film, and the hologram is recorded by Curie-point writing.

In Curie-point writing on the thin film, the interference pattern of laser

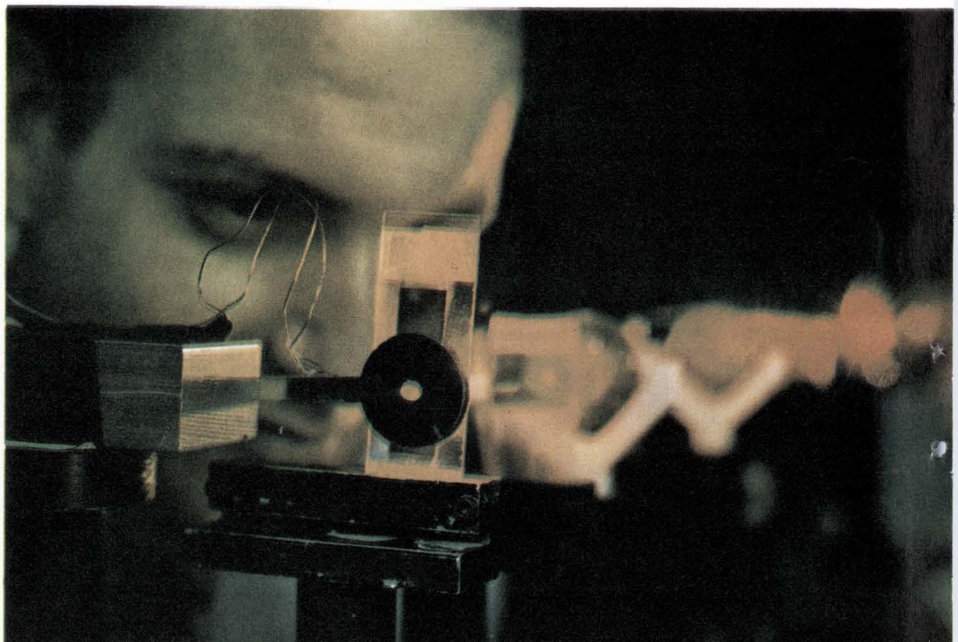
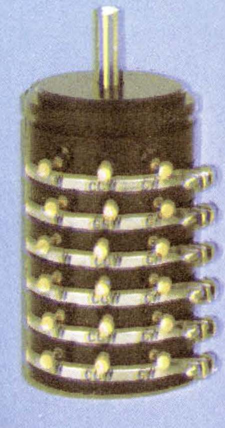
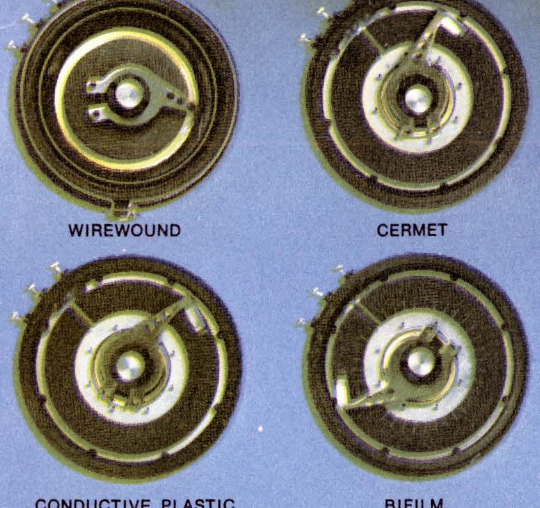


Photo shows the developer of the new hologram visually reading out a magnetic hologram. The manganese bismuth film that holds the hologram is on the mica slide in the center of the picture. The dark circular object with the wires attached is the erasure coil. The laser light comes from a continuous-wave He-Ne laser that is used to read the hologram.

Design Now... ...Specify Later





Would you believe a WIREWOUNDCERMETCONDUCTIVEPLASTICBIFILM?

It's true! Bourns new *Bee-Line* permits project design without first considering potentiometer element to be used!

STANDARD SIZES
Available in 7/8", 1 1/16", 2" diameters! Each potentiometer can be ganged up to 10 cups in increments of only 0.2"!

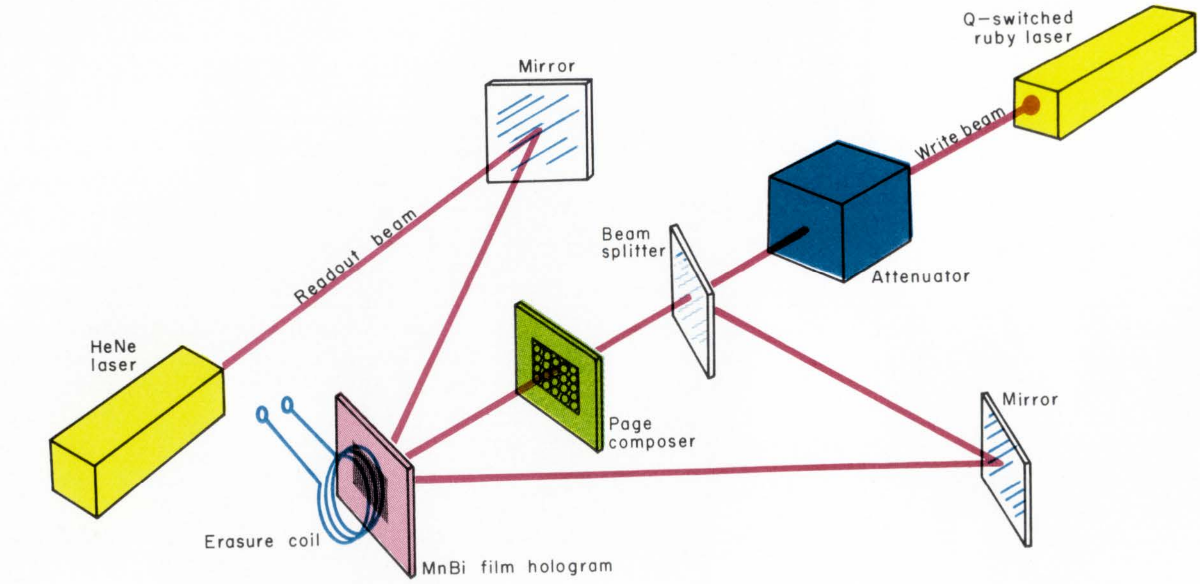
VERSATILE ELEMENTS
Your choice of wirewound, cermet, conductive plastic or BiFilm™* — Linear or Nonlinear — available interchangeably, singly or in combination!

Complete details on the new, versatile *Bee-Line* are available from the factory, your local Bourns Sales Office or representative.

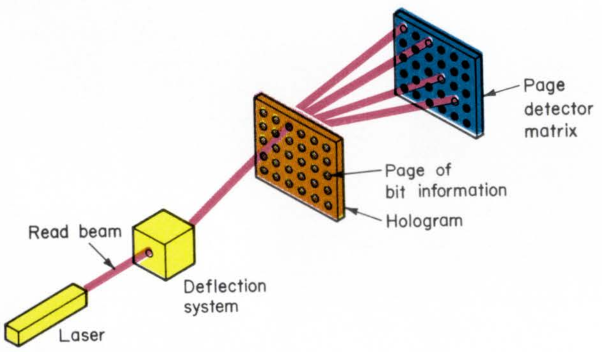
*BiFilm is Bourns new, low TC Conductive Plastic

BOURNS

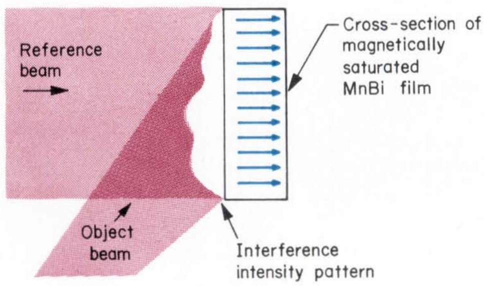
BOURNS, INC., TRIMPOT PRODUCTS DIVISION • 1200 COLUMBIA AVE., RIVERSIDE, CALIF. 92507



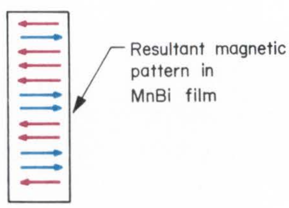
Apparatus for writing and reading the magnetic hologram. The pulsed ruby laser forms the hologram, while the He-Ne continuous wave laser reads it. Pulsing the coil erases the hologram.



How the laser reads a hologram that contains 10,000 pages of bit information. (Each page contains 10,000 dots, where each dot is a bit of information.) The deflection system chooses the particular page to be read. The bit information on that page is then observed visually or by a light sensitive detection matrix.

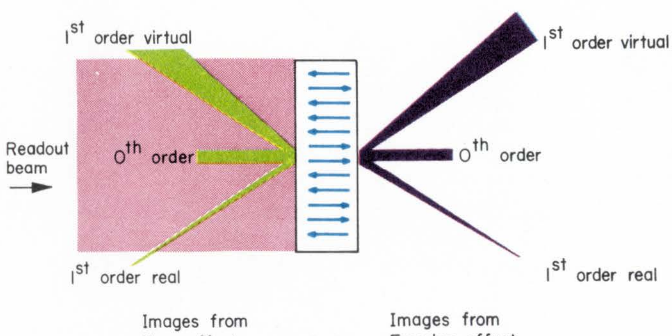


(a)



(b)

Magnetic hologram formed by a method called Curie-point writing. Initially, the reference beam and object beam interfere at the face of the MnBi film. The film has all its magnetic poles lined up in one direction (a). Upon removal of the writing beams, the magnetic poles that were heated above the Curie temperature (by the light interference intensity pattern) reverse polarity. The result is a magnetic pattern that exactly corresponds to the light interference pattern (b). This magnetic hologram can be read by using the Faraday magneto-optic effect or the Kerr effect. The Faraday effect forms the image from the transmitted light, while the Kerr effect uses the reflected light. In both cases, a real and virtual image of the object is formed (c). Notice that the virtual image from the Faraday effect appears to the left of the MnBi film in (c), even though the light is coming out on the right. This is because the rays from a virtual image are diverging. The directions are reversed for the Kerr effect.



(c)

Some Background

Holograms are formed by the interference of a reference beam of light with a beam of light that is reflected or transmitted by an object. Since the light must be coherent, a laser is an ideal source. This interference pattern is recorded in one of several media. Then, by transmitting the reference beam through the recorded image, the object is reconstructed as both real and virtual images which maintain the complete 3-dimensional characteristics of the original object.

Holograms can be divided into two general categories—absorption holograms and phase holograms. Absorption holograms — the type commonly used—are the kind that form when the recording medium is photographic film. These holograms are characterized by light and dark areas which amplitude modulate (by absorbing light in the dark areas) the reconstruction beam of light to form the image. The phase hologram, on the other hand, shifts the phase of adjacent rays of light, causing amplitude interference, which in turn forms the reconstructed image.

Because absorption holograms have light and dark areas, their transmission efficiency is much lower than that of phase holograms. As a matter of fact, phase holograms in many cases look clear to the naked eye and are capable of theoretical transmission efficiencies up to 100%.

One of the most useful applications of holography is in computer optical memories. Their ability to reproduce an entire image—even if a section of the hologram is wiped out—is significant because built in redundancy is a must today in most systems. The image which we talk about here can be thought of as a page of white dots on a grid, where the presence or absence of a dot in a particular position represents a bit of information. Optical memories are capable of storing 10^4 bits (dots) on each page, and each page is stored in 1 mm^2 on the hologram. In a 10-cm^2 square hologram, 10^4 pages are stored, for a total of 10^8 bits.

Until now, optical memories have been confined to the static read-only type. This means that once made and inserted into the memory, the hologram can be read whenever necessary—but its information cannot be changed. Any change in the bit information requires removal of the old hologram. A new hologram is then made, and inserted into the memory.

Dynamic, read-write memories are still in the laboratory stage. These memories are capable of being written upon in the memory, stored, read at will, and then erased when new information must be entered. Ideally, they can be reused repeatedly for an indefinite length of time. Several materials have been used for these erasable holograms. Photochromic crystals, thermoplastic films, and ferroelectric crystals (such as lithium niobate) are the most common. Presently, Bell Laboratories is experimenting with barium titanate (another ferroelectric crystal). Unfortunately, each material has had its own problems—lithium niobate requires a long exposure in order to form the hologram, and the thermoplastics do not erase completely after continued use. The photochromics tend to fade spontaneously and are bleached by the readout beam. In contrast, the magnetic (MnBi) hologram that RCA developed seems to have eliminated most of these problems.

light heats the MnBi. The bright areas where the beams have interfered constructively raise the film above its Curie temperature (360°C for MnBi) and reverse the magnetic polarity. The north poles in the heated areas assume the same direction as the south poles in the unheated portions. On the other hand, the polarity does not change in those areas where the laser beams interfere destructively. The MnBi film now contains a magnetic pattern that corresponds to the laser interference pattern—a magnetic hologram. The time used for writing is about 10 ns.

The magnetic hologram can be read in two ways, either by transmitting a laser beam through it (using the Faraday magneto-optic effect), or by reflecting the beam from it (using the Kerr effect). The Kerr effect is preferred, because it renders a transmission efficiency of 0.1%; while the Faraday effect attains only a 0.01% efficiency. No polarizers or analyzers are needed to reconstruct the image. Note that these efficiencies are quite low, especially considering that this hologram is of the phase type—rather than an absorption hologram.

The hologram is erased by simply switching a nearby wire coil which creates a strong magnetic field normal to the hologram surface. This field realigns the magnetic moments in the crystal so that all the north poles once again are in the same direction. The erasing time is about 20 μs.

There is no apparent thermal decay or other type of fatigue in the material after continued use. It appears as if the write-erase cycle can be repeated indefinitely. In the original setup, a Q-switched ruby laser with a 200 μJ, 10-ns pulse was used to write; a continuous wave, helium neon laser was used to read, and a coil producing a 4000-Oe field erased the hologram.

INFORMATION RETRIEVAL
Magnetic devices, Computers and peripherals, Data acquisition and processing

CALENDAR

NEREM-69
Technical Program

	Commonwealth Room Hotel	Fairfax Room Hotel	Independence Ballroom Hotel	Constitution Ballroom Hotel	Weber Room Auditorium
Wednesday 10:00 A.M.	Opto-Electronics	Bioelectronics	Computer-Aided Design	Computer-Instrument Systems	
Wednesday 2:30 P.M.	Nonlinear Optics	Radiation Hardening	Automatic Artwork Generation	Solid-State Microwave Power Generation	Device Modeling for Computer-Aided Design
Wednesday 8:00 P.M.			The New Enterprise Its Life Cycles		
Thursday 10:00 A.M.	Analog Circuit Development	Transportation	Satellite Communications	Digital Signal Processing	Circuit Design for Integration
Thursday 2:30 P.M.	Recent FET Developments	Perspectives in Energy Utilization	The Role of Electronic Systems in the APOLLO Lunar Landing Program	Small Computers	Hybrid Microelectronics
Friday 10:00 A.M.	Antennas and Propagation	Earth Sciences	Air Traffic Control	Monolithic Memories	Contemporary Filters
Friday 2:30 P.M.	Array Systems	Electronics in Oceanology	Electronic Navigation Systems	Computerized Testing Techniques	Microwave Measurements

CALENDAR

OCTOBER

12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

Oct. 27-29: 1969 IEEE Southeastern EMC Symp., Regency Hyatt House, Atla., Ga. Addtl. Info.—D. W. Matthias, Omnionics Vercor Inc., 1111 Mt. View Dr., NE, Marietta, Ga. 30060.

Oct. 27-30: 1969 Joint Conf. on Mathematical and Computer Aids to Design, Disneyland Hotel, Anaheim, Calif. Addtl. Info.—1969 JCMCAD, c/o SIAM, 33 S. 17th St., 6th Fl., Phila., Pa. 19103.

NOVEMBER

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Nov. 5-7: IEEE Northeast Electronics Research & Eng'g Meeting, War Mem. Aud. & Sheraton Boston Hotel, Boston, Mass. Addtl. Info.—NEREM, 31 Channing St., Newton, Mass. 02158.

Nov. 18-20: Fall Joint Computer Conf., Las Vegas Conv. Ctr., Las Vegas, Nevada. Addtl. Info.—AFIPS Hdqs., 210 Summit Ave., Montvale, N.J. 07645.

Nov. 18-21: Conf. on Magnetism & Magnetic Materials, Benjamin Franklin Hotel, Phila., Pa. Addtl. Info.—J. D. Blades, Franklin Inst. Res. Labs., Phila., Pa. 19103.

DECEMBER

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7	8	9	10	11	12	13
14	15	16	17	18	19	20
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28	29	30	31			

Dec. 8-9: Symp. on Consumer Electronics, Conrad Hilton Hotel, Chicago, Ill. Addtl. Info.—C. Hepner, Zenith Radio Corp., 6101 W. Dickens Ave., Chicago, Ill. 60639.

Dec. 8-10: Int'l Symp. on Circuit Theory, Mark Hopkins Hotel, San Fran., Calif. Addtl. Info.—R. A. Rohrer, Fairchild Semicond., 4001 Junipero Serra Blvd., Palo Alto, Calif. 94304.

Dec. 8-10: National Electronics Conf. & Exhibition, Conrad Hilton Hotel, Chicago. Addtl. Info.—Oakbrook Exec. Plaza #2, 1211 W. 22nd St., Oak Brook, Ill. 60521.

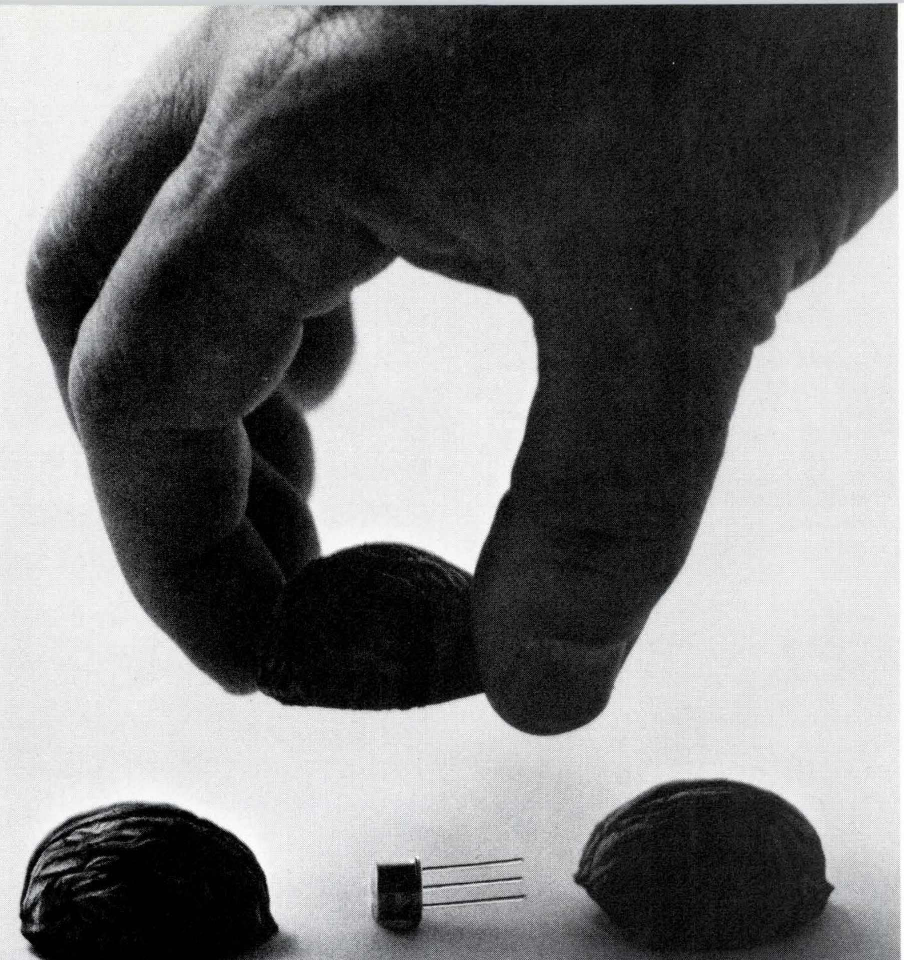
'69-'70 Conference Highlights

NEREM — Northeast Electronics Research and Eng'g Meeting, Nov. 5-7; Boston, Mass.

IEEE—Institute of Electrical and Electronics Engineers Int'l Convention & Exhibition, March 23-26; New York, New York.

Call for Papers

May 13-15, 1970: 1970 Electronic Components Conference, Wash., D. C. Submit four copies of an extended abstract with a minimum of 250 words plus a list of the papers, salient concepts and features by Nov. 15, 1969, to D. P. Burks, Tech. Prog. Chairman, Electronic Comp. Conf., Sprague Electric Co., Marshall St., N. Adams, Mass. 01247.



SPEAK UP

Medical Instrumentation

Sir:

I appreciate getting some more detailed information on the problems of medical instrumentation (The Electronic Engineer, July 1969, p. 35) after all the non-technical newspaper stories.

D. E. Wilson
Lockheed MSC
Patrick A.F.B., Florida

Contract reliability for medical electronics

Sir:

Regarding the article "Would you put that probe on your sick grandmother?" (The Electronic Engineer, July 1969, p.35). The AMA and ADA (American Medical and Dental Assns., respectively) would be well advised to contract with a reliability-maintainability group, for the approval of all electronics and mechanical equipment they may use. Most medical men, to my knowledge, have a profound ignorance of electronics and mechanics. Inspection of hospital electronics should be mandatory on an annual basis, and repairs should be subject to inspection. I would also recommend that standards be established and be made mandatory.

Dean A. Later
Senior Rel. & Maint. Engineer
Conductron-Missouri
Downey, Calif.

Hybrid op amps

Sir:

I noticed in the June 1969 issue of **The Electronic Engineer,** the interesting article "IC Op Amp selection charts" (pp 61-71). In the interest of accuracy I would like to point out the absence of Optical Electronics, Inc., from your listing.

Richard C. Gerdes
President
Optical Electronics Inc.
Tucson, Ariz.

Mr. Gerdes is right; Optical Electronics makes both monolithic and hybrid op amps. Following are their part numbers and prices per 10 units. (Do not compare them with the chart prices, which were for 100 units.)

9300 and 9302 (monolithic)	$18.00
9308 (monolithic)	$27.00
9314 (monolithic)	each $12.60
9406 (hybrid)	$28.00
9412 (hybrid)	$43.00

If you wish more information on these op amps, circle No. **420** on the Inquiry Card.

← Circle 22 on Inquiry Card

SPEAK UP

The ground-circuit interrupter

Sir:

One of our customers has called my attention to the article on electrical safety "Would you put that probe on your sick grandmother?" [**The Electronic Engineer,** July 1969, Page 35].

The article is of particular interest for we have been studying electrical safety to consumer products for 20 years. Because of a near tragedy in the family, a new invention was born and on February 2, 1965, U.S. Patent No. 3, 168,682 was granted for a ground-fault interrupter incorporating the use of an isolation transformer. Other patents are pending.

Reader's Digest first mentioned the patent and, since then, other publications and radio have carried the story. In 1968 this device was awarded the Gold Medal of Merit at the International Products Exposition in competition with some 6000 patents from all parts of the world. This device prevents electrical shock and offers other benefits above and beyond accepted electrical standards for the protection of life and property. It will detect electrical leakage below 1 μA of current and deactivate the main power supply in time to prevent injury or damage. This particular model will soon be available for hospital use. Other models will also be available for consumer protection in the home, office and outdoors.

To our way of thinking, this is the first time in history that electrical safety per-se is now possible. It has immense possibilities in safeguarding the consumer against faulty products used in every day living.

We are considering the granting of several royalty free licenses to qualified manufacturers along with certain conditions for the privilege.

C. R. Moore, Pres.
Permavolt Transformers, Inc.
Box 2582
South Bend, Indiana

EDITOR'S NOTE: Mr. Moore refers here to the article "A little box that stops electric shock" (Reader's Digest, April 1968), which mentions the Moore patent as well as two other patents for a GFI (ground-circuit interrupter). There are a few GFI's already available in the market (a few of them UL approved) mostly for lighting of swimming pools.

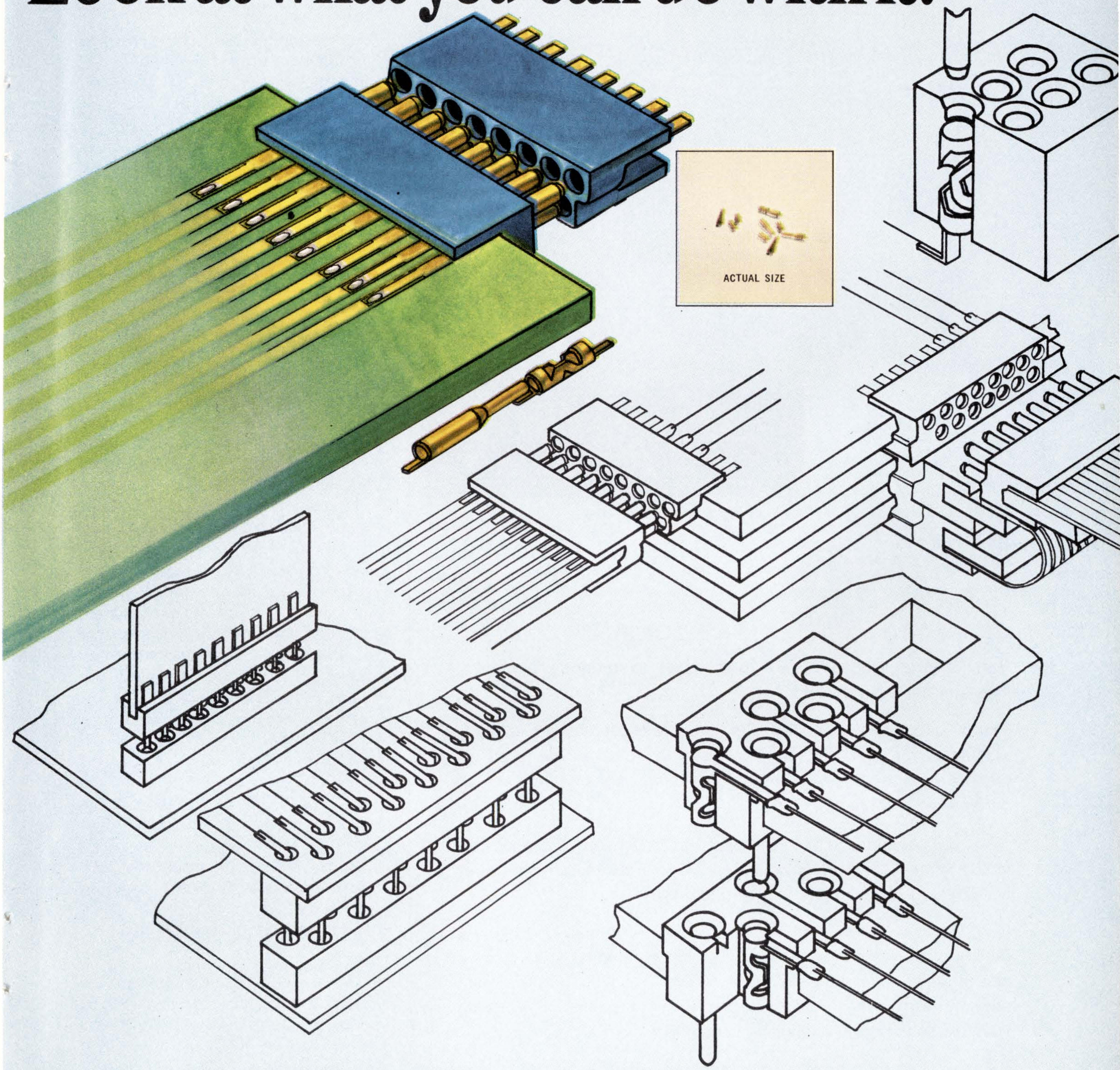
Readers interested in Mr. Moore's offer to license should write to him directly at the above address.

Letters to the editor are published at the discretion of the magazine. Please say so if you do not want to be quoted. Signed letters have preference over anonymous ones.

Circle 24 on Inquiry Card

Circle 25 on Inquiry Card →

New. A true micro-system connector. Look at what you can do with it.



This is our new .025″/.050″ Connector.

It fits all micro-system packaging situations. In all environments. Reliably. The redundant points of contact provided by the spiral springs of the receptacle assure it.

With stacked or staggered centers, the receptacles don't lose any critical contact spacing. Circuit centers of .050″ and .025″ are standard. The receptacles and pins come housed. The circuit contact tines are pre-solder coated so all you have to do is reflow and plug in. Easy? The low insertion force and the wide misalignment allowance make it even easier.

So, what could be better for sophisticated electronic requirements? A reliable connector that's dense, convenient and versatile.

For further information write to Industrial Division, AMP Incorporated, Harrisburg, Pa. 17105.

AMP
INCORPORATED

WELCOME

Here we welcome new companies or divisions in the electronics industry. For more details, circle the appropriate numbers on the reader service card.

The closing of the cermet resistor gap. The design and manufacture of cermet ultra-high-value resistors, particularly thick-film devices, is the forte of Cermetrics, Inc., located on Manhattan's lower East side (16th St.). Included in the round-up of products are ampere hour meters for determining plating thickness, and systems for adding chemicals to plating baths.

In the discrete electronic components sphere Cermetrics offers high-value resistors with values up to 1000 MΩ. The devices combine a good temperature coefficient of resistivity (50 ppm/°C) with stability and reliability. The resistors are suggested for high impedance devices where exacting applications are necessary. All items are available off-the-shelf.

Cermetrics hopes to attract those in the electro-chemical field and people involved in plating (especially the plating of precious metals where thickness and performance must be controlled). The fledgling company feels too that instrument manufacturers, those involved in the biological transducing field, and other precision measurement industries will be interested in its wares.

The president of Cermetrics, Stanley Schneider, comes from the thick film field. He ventured forth and formed his own company because he felt "there was an unfulfilled market for precision devices." With Cermetrics, hopefully that gap has been filled.

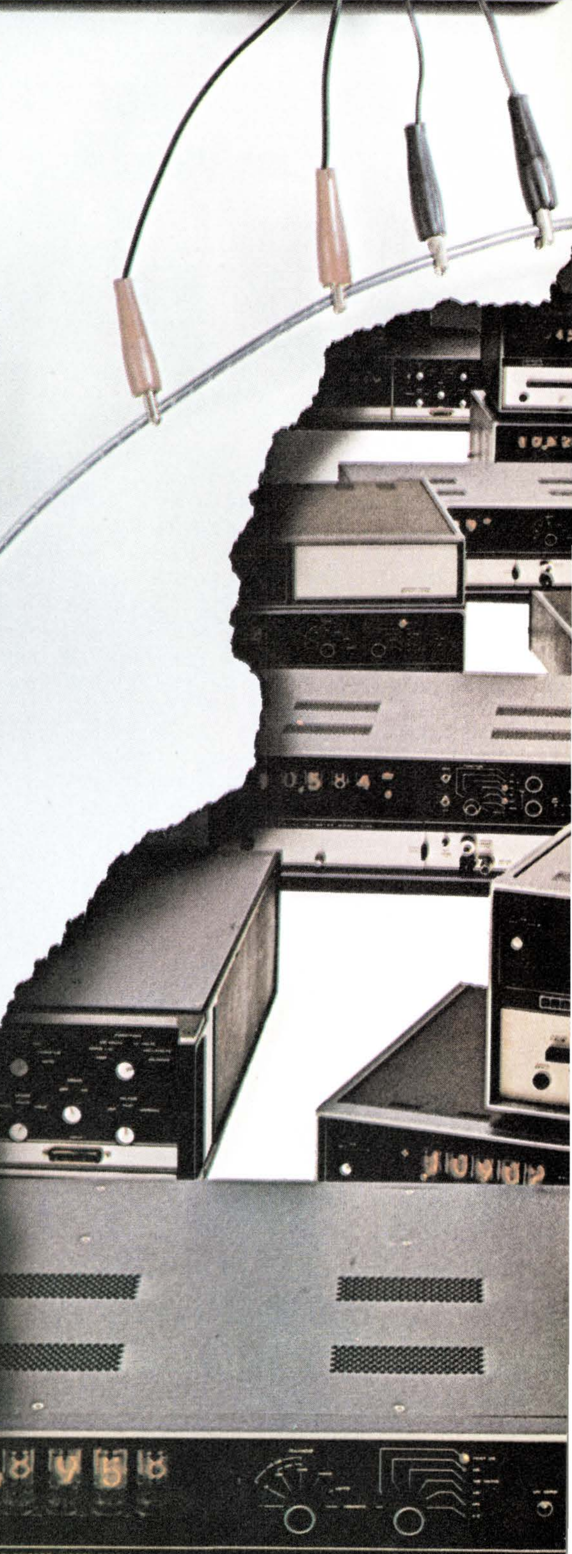
Circle 321 on Inquiry Card

A division of business enterprises. Electronic Products and Controls is a new division of Monsanto. It was formed as an R&D outburst with the intention of establishing new business under the direction of the mother company. The business groups that comprise EP&C are: Electronic Instruments, Electronic Special Products, Electronic Materials, Electronic Research, Microwave Products and Industrial Elec-

(*continued on page* 32)

Circle 27 on Inquiry Card ➤

Not everyone needs a multimeter that can measure the resistance of a piece of solder.



But you may be looking for a digital multimeter that will measure relay contact resistance. Or check cable continuity. Or handle other applications that require 100 μohm resolution without error caused by lead resistance. If that's the case, you may be looking for our 5500/135 DMM.

And it's more than an ohmeter. You can turn it loose on dc volts, mV, dc/dc ratios, or square, triangular, sawtooth and sine waves. It will give you the true rms of an ac waveform, so accurately and distortion-free that we call it Computing RMS™ and have a patent pending on this revolutionary new technique.

But it is possible that the 5500 is more or less multimeter than you need. If that's the case, don't buy one. Buy one of our 32 others instead. We make them for labs and production lines, for use on the bench and in systems, militarized models, 4- and 5-digit, from $1150 to over $8000. (Actually, with our unique plug in modules, you can create some 300 different configurations. For every imaginable application. To fit every budget).

Which one suits you best? Ask for the decision maker. Our free brochure.

Dana Laboratories, Inc., 2401 Campus Drive, Irvine, California 92664.

DANA®

WELCOME

(*continued from page* 30)

tronics Research. Fisher Controls Co., Inc. has recently merged with Monsanto and is preparing to take its place in the above division.

Electronic Products & Controls' sections are involved in most phases of electronic technology. Among those on the list are electronic test instruments, including a 150 MHz programmable universal counter/timer for remote programming of time base selection; light emitting semiconductors including semiconductor lasers, and 7-segment solid-state numerics fabricated from red light-emitting gallium arsenide phosphide. The numeric device, which was shown publicly for the first time at Wescon, is operable with commercially available decoder/drivers thereby giving the equipment designer flexibility. The 7-segment light emitting numeric is being put to the test in digital test instruments such as a digital voltmeter made by the electronic instrument group. The device can be used as an instrument by itself or as a key component of a larger digital system. With this application (adopting the 7-bar numeric indicating version of the diodes), Monsanto is the first instrument manufacturer to take advantage of solid-state technology for readout as well as in circuit design. Included too in the roundup of products available from EP&C are semiconductor materials (silicon and gallium arsenide), Gunn diodes, and Gunn-effect microwave oscillators with a minimum cw output power of 100 milliwatts. Most of the products are available from stock or shortly thereafter.

Potential customers for the various sections include semiconductor manufacturers, computer people, the military (a contract for \$2½ million has recently been signed by Kelly AFB for 2000 portable solid-state oscilloscopes. Delivery is scheduled for early 1970), and those in the OEM market.

The new division's competition is strong. Such prominent or established firms as HP, Honeywell and Foxboro will be in the line of fire.

Circle 322 on Inquiry Card

Can management give engineers what they really want?

It's a two-way street—management should provide a better atmosphere for engineers, and engineers should be more professional.

By Dr. Arthur D. Kellner, Director-Personnel
ITT Defense Communications Div., Nutley, N. J.

It has been said that people are naturally creative—that if they are *not* creative, assuming they are motivated, it is because conditions in the psychological environment inhibit creativity.

What are these conditions? Among the blocks to creativity, particularly in the case of engineers, are the business disciplines imposed by management to achieve program objectives. Meeting of scheduled deadlines, for example, applies time pressure on the creative process—which experience has shown does not respond well to pressure. Another constraint is working to meet technical specifications, which can be very complicated and sometimes arbitrary.

Such design challenges often limit the engineer to the point where they preclude free-wheeling creativity of any sort. Rather, the approach becomes one of cut-and-dry or theoretical analysis. Engineers can become frustrated on such assignments and hence become less productive.

Yet, sound business requirements dictate an approach to managing engineers which is based on controls and restraints. There are few exceptions: most of these are company-funded laboratories—"Think Tanks"—where creativity enjoys free rein in an atmosphere of permissiveness. But such pursuits are for the "scientists," it seems. It is the nature, and the fate, of engineers to be project-oriented—to work on tangible programs, which have a beginning and an end, and usually result in a real-life system or piece of hardware. Technical developments are a business proposition and as such require a business approach.

Business vs creativity

These requirements are unfortunate if we assume, as do some behavioral scientists, that engineers are

Continued on page 37

How management looks at engineers

It may be true in some cases that management looks at its average, working-level engineer as just another "body" in the bullpen. But this is the age of "enlightened management," and in many other cases management considers each of its engineers as vital to the total effort and responsible for the ultimate success of the organization. This article gives one view of how today's managers look at engineers. While the author exhorts management to give its engineers a more creative, responsible atmosphere, he also urges engineers to apply a more "professional" attitude to their work.

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well motivated, that they *want* to be productive. It is only the artificially negative situation that will cause them *not* to be creative. This places a very subtle, complex challenge on management to provide a work environment which has the needed business controls but does not stifle creativity. It is probably safe to say that the ideal situation exists in only few cases; it occurs mainly in growing organizations, where the work is spread thin, where the challenges just slightly exceed the capabilities of each engineer and spur him to rise to the situation.

Characteristically, the engineer struggles to adapt himself to the many demands and restraints placed upon him, including management controls. He looks for support from the organization in achieving his personal goals. He wants reassurance because he does not feel he has complete control over his destiny—he is *not* the master of his fate. For the most part, management has the initiative, and the options.

In a healthy organization, however, there is a good balance of initiative. In fact, in an engineering company a large part of the initiative (at least technical) should come from lower-level personnel. Management cannot legislate ideas or creativity; it can only provide an environment in which this can be expressed.

This concept sounds ideal on paper. But it's difficult to apply due to two factors in our organizations:

- the leaders move to the top,
- the flow of information is downward. These two factors lead to frustration and misunderstanding. What is needed is a blend of technical competence with hierarchical authority.

The key is "involvement"

What gives a company a healthy climate for creativity? A major element is involvement—that is, the individual engineers can personally identify with the goals of the organization.

Unfortunately, this is not always the case. How many times have you heard a fellow engineer complain about the restraints and controls his company places on him, in such terms as: "What are *they* doing that for? Look what effect it is having on *me*." It is a mythical "they" whom the engineers refer to, a vague abstraction which is the management of the organization. In using this term, engineers express fears about their status and how it might be threatened by what *they,* the decision-makers of the company might do to affect them.

What the engineers lack is an identification or involvement with the organization, a recognition that they, too, are *part* of this company. They fail to understand that it is the sum total of what each employee does which affects his future and that of every other employee.

As a manager, how can you get your engineers personally, *involved,* committed to organization goals? It is easy, if you let them participate in company problem-solving (if not decision-making). This does not mean involvement in specific technical problems—that is a normal part of the engineer's work. Rather, it refers to broader management problems, problems related to *how* to get the work done and particularly problems dealing with interpersonal relationships in the operation.

Here, we should make a distinction between decision-making and problem-solving. Unless we were to make basic changes in the whole philosophy of management and organization, **decision-making** must be a function of higher management, which is where the responsibility and authority traditionally are placed. **Problem-solving,** on the other hand, should be partly the domain of engineers.

Engineers and problem-solving

The three basic steps in the overall management process that pertain to problem-solving are:

1) Finding as many as possible decision alternatives relevant to the problem.

2) Defining each alternative, which means determining as many consequences as possible of each alternative.

3) Making a choice of one or more alternatives.

Engineers can participate fruitfully in steps (1) and (2); step (3), the final decision, must be made by management. An organization with a healthy climate will be characterized by a great deal of participation in problem-solving by working-level employees.

Here are some specific examples of where engineering managers can engender this kind of participation.

- Engineers can take part in proposal efforts, where they develop personal commitment to such aspects of programs as schedules, specifications, material requirements, and costs. In this case the design engineer contributes to the estimate and is measured on his performance against that estimate.
- Engineers can participate in ad-hoc groups or task forces to solve specific problems of technical *and* management nature.
- Engineers can interact with higher management in meetings where two-way communications takes place. Information passes downward while management encourages reactions in the form of questions and suggestions. Such meetings can provide a background for constructive problem-solving.

A challenge to engineers

At the core of this approach to management is the need for greater professionalism on the part of engineers. Professionalism means that a person identifies with a field of knowledge, accepts a code of ethical values covering quality of performance and personal behavior, and recognizes that the work done represents a contribution to the organization and society, as well as a means toward tangible personal reward. It also implies that he finds a degree of personal gratification from the intrinsic value of his work.

The logic is simple: If management is going to become more scientific and enlightened, then technical staff members must become more professional—so that the forces can merge in the best possible way.

It is not easy to manage creative engineers effectively. But for a company that can do this, the payoff in technical accomplishments will be great. Can management give engineers what they really want? The answer must be yes, if it is to realize the full creative potential of its technical resources.

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Data Communications Systems: Oct. 22-24, N.Y.C.; Nov. 5-7, Washington, D.C. CEIR, Inc., 5272 River Rd., Washington, D.C. 20016.

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Technical Writing and Editing: Oct. 27-31, Univ. of Alabama, Huntsville. Principles of good writing that can be applied to scientists, engineers, writers, and editors. Office of Special, Non-Credit Courses and Conferences, Univ. of Alabama, in Huntsville, Box 1247, Huntsville, Ala. 35807.

Designing with Plastics: Oct. 27-31, New York, (Hotel Manhattan). Course will cover criteria by which a product is produced in plastic from a technical, structural, economic and manufacturing standpoint. Fran Zimmer, International Plastics Industry Consultants, Inc., Hotel Manhattan, New York, N.Y. 10036.

Integrated Logistics Support: Oct. 28, Washington, D.C.; Oct. 27, Chicago, $80. The objectives are to present sufficient data to enable participants to deal intelligently with customers and their in-house ILS experts. MDSI Management Development Div., Merrand Data Systems, Inc., 229 Park Ave. S., New York, N.Y. 10003.

Data Management: Oct. 29, Dallas; Oct. 30, Los Angeles, $80. Will provide an over-view of data management and a solid fund of knowledge suitable for managing government proposals or contracts requiring data management. MDSI Management Development Div., Merrand Data Systems, Inc., 229 Park Ave. S., New York, N.Y. 10003.

Elements of Metallurgy: Oct. 29-Nov. 6, Chicago. Dr. William M. Mueller, Dir. of Education, ASM, Metals Park, Ohio 44073.

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Microfilm and its Applications: Oct. 31, New York (Park Sheraton Hotel), $75. Describes the different forms of microfilming and demonstrates their advantages and disadvantages in various applications. Industrial Education Institute, 221 Columbus Ave., Boston, Mass. 02116.

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Automatic Pattern Recognition: Nov. 10-14, San Francisco (Hotel Canterbury), $350. Presentation of concepts and techniques used for machine recognition of images and other data. Will emphasize practical as well as theoretical concepts. Cybex Associates, Inc., 50 Shelley Lane, Great Neck, N.Y. 11023.

Compression, Transfer and Injection Molding of Thermosets: Nov. 10-14, New York (Hotel Manhattan). Will provide instruction in molding techniques using preforms, radio frequency preheating and a discussion of preheating techniques. Fran Zimmer, International Plastics Industry Consultants, Inc., Hotel Manhattan, New York, N.Y. 10036.

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Liquid crystal workshop: Nov. 13-14, Sewickley, Pa , $155. Will present a background of basic theory to give participants an understanding of the properties of liquid crystals. Penn State Continuing Education, New Kensington Campus, 3550 Seventh Street Rd., New Kensington, Pa. 15068.

Integrating DVM's fight noise, but...

. . . their noise rejection varies with frequency, and depends on the period of integration

By Delbert L. Johnson, Chief Engineer
Lear Siegler, Inc., Cimron Division, San Diego, Calif.

Among the sets of conflicting requirements facing the designer of digital voltmeters, none is more perplexing than the conflict between response time and normal (series) mode rejection. Experienced users demand faster response to step function inputs, but they also require good rejection of normal mode noise for many signal sources. There are two ways of rejecting noise, shown in Fig. 1: by filtering it out, or by cancelling it over an integration.

Active filters—faster response

Many DVMs use passive RC filters, both monotonic and frequency selective to reject noise. They are simple and reliable, but rather slow by today's standards. Normal mode rejection (NMR) can be improved by increasing capacitance; however, this results in a predictable degradation of step response.

Most new instruments use active filters, because these respond faster than equivalent passive filters. The availability of new inexpensive linear amplifiers, whether integrated or modular, has made active filters economically feasible.

The reason for the improvement in speed is not obvious, because all practical DVM filters, whether active or passive, use only RC elements. However, the feedback configurations possible in an active filter allow us to simulate inductance. While the poles and zeros of a passive RC filter are restricted to the negative real axis of the complex frequency plane, those of an active filter can be located anywhere in the complex plane. Stated another way, the designer can adjust the damping of an active RC feedback network over very wide limits.

Integration averages out noise

Several integration schemes have been used to take advantage of the fact that principal noise components

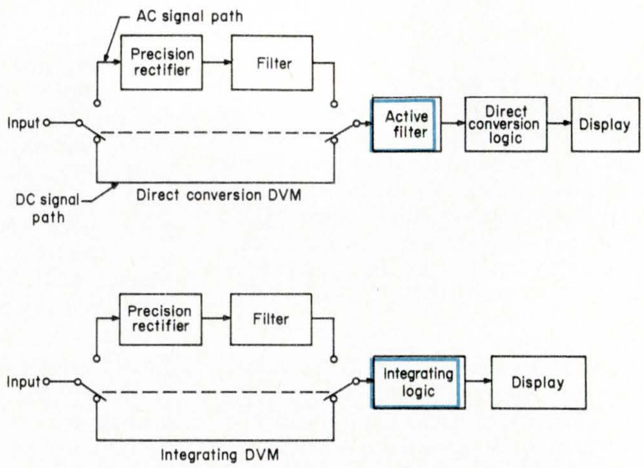
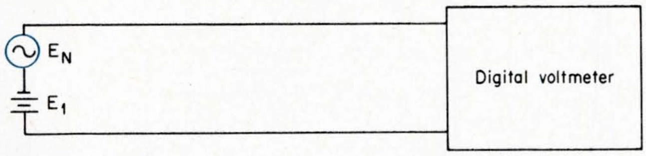


Fig. 1. Two ways of rejecting noise, as implemented in dc/ac DVMs. In a non-integrating DVM, an active filter rejects noise. In the integrating DVM, all NMR is provided by the integration technique. Both types need some filtering, following the precision rectifier, to handle ac inputs.

How integration averages noise out



The input signal (E) to the DVM consists of the dc voltage to be measured (E_1), and a normal-mode (series) noise, which we assume sinusoidal of peak value E_N.

$$E = E_1 + E_N \sin \omega t$$

The average input, E, is obtained by integrating the total input over the time interval from $t = 0$ to $t = T$,

$$E = \int_0^T \frac{(E_1 + E_N \sin \omega t)\, dt}{T} = \frac{1}{T}\left[E_1 t - \frac{E_N}{\omega}(\cos \omega t)\right]_0^T$$

$$E = \frac{1}{T}\left[E_1 T + \frac{E_N}{\omega}(1 - \cos \omega T)\right]$$

The second term within the bracket represents the noise voltage appearing in the DVM display.

$$E_{\text{noise}} = \frac{E_N}{\omega T}(1 - \cos \omega T)$$

If the instrument did not integrate, the worst-case display degradation would be E_N, the peak amplitude of the sinusoidal noise. The ratio describing *normal mode rejection* (NMR) is defined as

$$\text{NMR} = \frac{E_N}{\frac{E_N}{\omega T}(1 - \cos \omega T)} = \frac{\omega T}{1 - \cos \omega T}$$

The numerator of this equation (E_N) is somewhat arbitrary; however, the peak value is universally used by manufacturers, possibly because it yields the largest number for the NMR ratio.

Since ($\omega = 2\pi f$) and ($1 - \cos 2\alpha = 2 \sin^2 \alpha$),

$$\text{NMR} = \frac{\pi f T}{\sin^2 \pi f T}$$

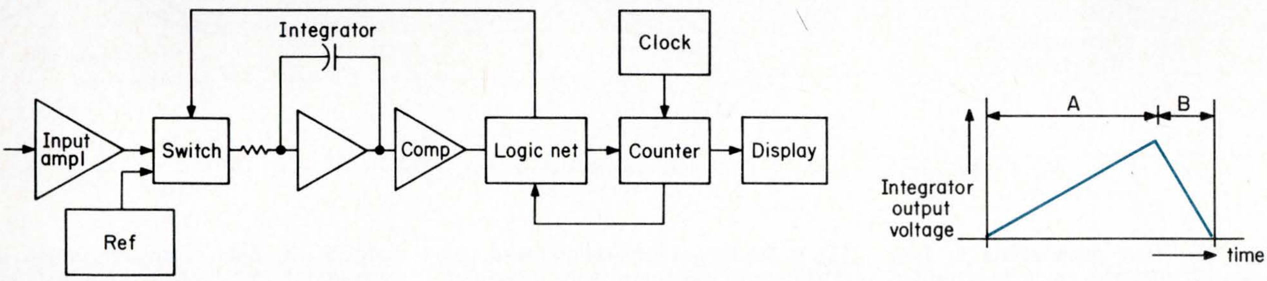
Expressed in dB,

$$\text{NMR} = 20 \log \frac{\pi f T}{\sin^2 \pi f t} \text{ (dB)}$$

For a fixed integration time T, the numerator of this equation increases linearly with f, while the denominator cycles between 0 and unity. The ratio, therefore, shows infinite peaks for all integral values of the product fT.

This equation can be rewritten as follows, to help describe its properties,

$$\text{NMR}_{\text{dB}} = 20 \log \pi f T - 20 \log \sin^2 \pi f T$$



Block diagram of dual-slope integrating DVM. The digitizing time is divided into two periods. The length of period A is fixed, and corresponds to the time required for an internal clock to fill an internal counter. Since the input is integrated during this period, the voltage level at the integrator output at the end of period A depends on the level of the dc input. The counter is cleared at the end of this period.

During period B, the input signal is disconnected from the integrator input and replaced by an internal reference signal of the opposite polarity. Therefore, the integrator output returns toward zero at a known rate.

The internal reference is chosen so that if the unknown input had corresponded to the full scale value, the integrator output would reach zero when the counter again became filled. Period B would be at its maximum value, B_{max}, and should equal period A. For dc values less than full scale, the time it takes to return to zero is proportionately less than B_{max}. Because the counter stops counting when the integrator output reaches zero, it contains a time count, B, proportional to B_{max}, that is identical to the signal's proportion of the full scale value.

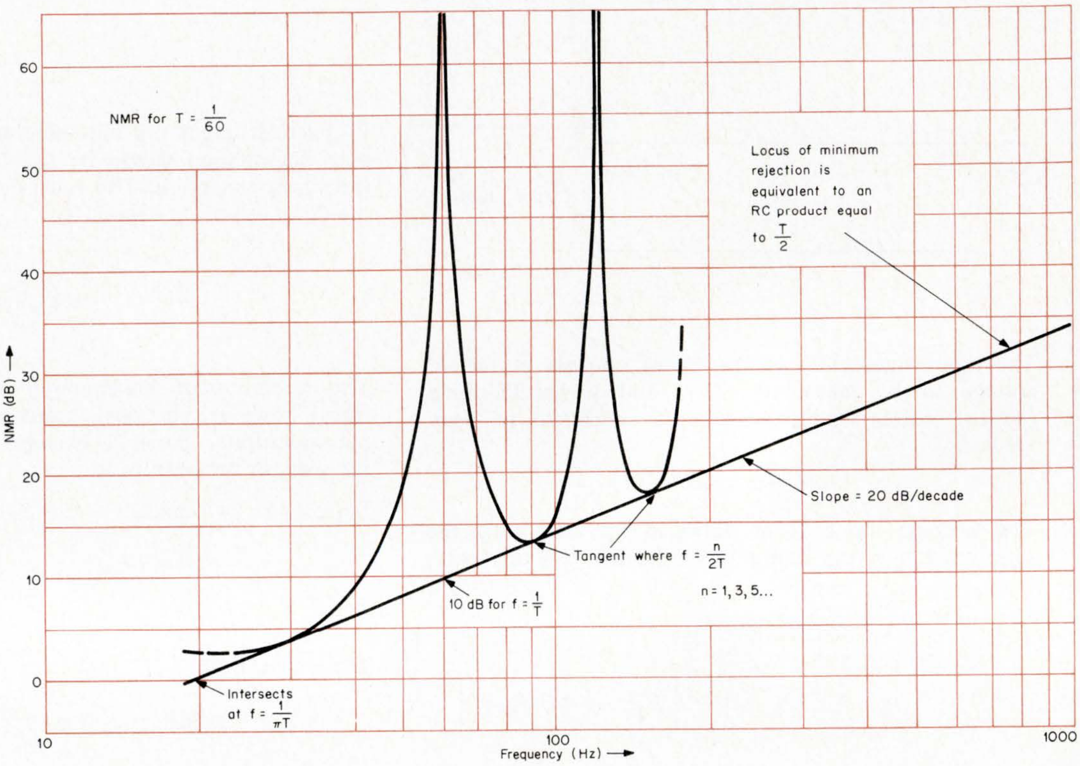


Fig. 2. The two components of NMR, as described by the equation $NMR_{dB} = 20 \log \pi f T - 20 \log \sin^2 \pi f T$. Since the integration time is $T = 1/60$s, the infinite peaks appear at frequencies multiple of $f = 1/T = 60$ Hz.

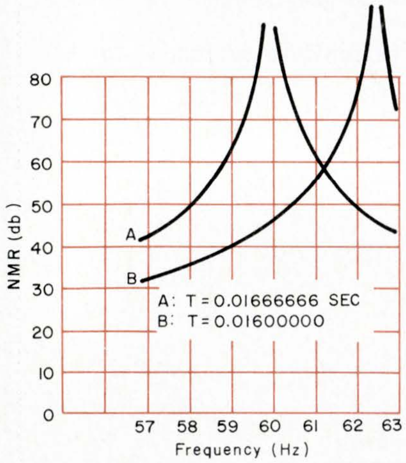


Fig. 3. The NMR peak shifts in frequency with the change in integration time T. (It also narrows as T becomes longer.) For example, if the integration time decreases slightly to 16.5 ms (not shown), the rejection drops to 70 dB at 60 Hz, 44 dB at 58 Hz and 56 dB at 62 Hz. If the integration time is further reduced to 16 ms, as shown by curve B, the peak shifted to approximately 62.5 Hz and rejection is 46 dB at 60 Hz, 35 dB at 58 Hz and 74 dB at 62 Hz.

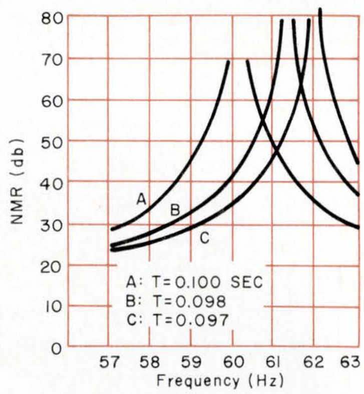


Fig. 4. For longer integration times, very small percentage errors in integrating time accentuate the loss in NMR at a given frequency because the peaks become narrower. For example, if the integration time drifts by only 2%, from 100 to 98 ms, the rejection falls to 28 dB at 58 Hz, 32 dB at 118 Hz and 43 dB at 402 Hz. The 400 Hz peak shifts to approximately 398 Hz, where rejection is calculated to be 117 dB. For an integration time of 100 ms, the 10 dB point is at 10 Hz, and the minimum curve contributes 25 dB at 60 Hz, 31 dB at 120 Hz, and 42 dB at 400 Hz. Because the slope of the minimum rejection locus is rather low, its shift with changes in T is not as apparent as the shift of the rejection peaks.

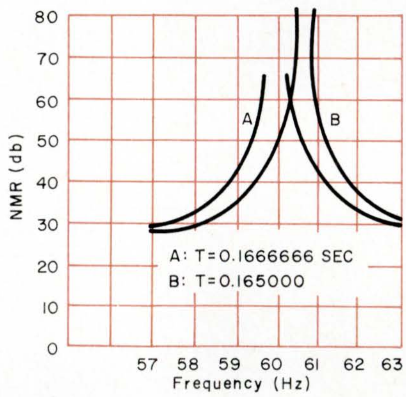


Fig. 5. Example of an instrument that integrates for 1/6 s (approximately 167 ms). In this case, the locus of minimum rejection contributes 30 dB at 60 Hz, 36 dB at 120 Hz and 46 dB at 400 Hz. The rejection peaks are very closely spaced and very narrow, and so small changes in frequency of the noise signal yield severe changes in the peak rejection. Performance of the peaks is virtually coincident with the minimum rejection locus, and so it is quite stable with changing integration time. For example, if the integration time is exactly 1/6 of a second, rejection at 58 Hz is only 32 dB, just slightly above the minimum locus. If the integration time drops to 165 ms, the attenuation at 58 Hz drops only 2 dB to 30.

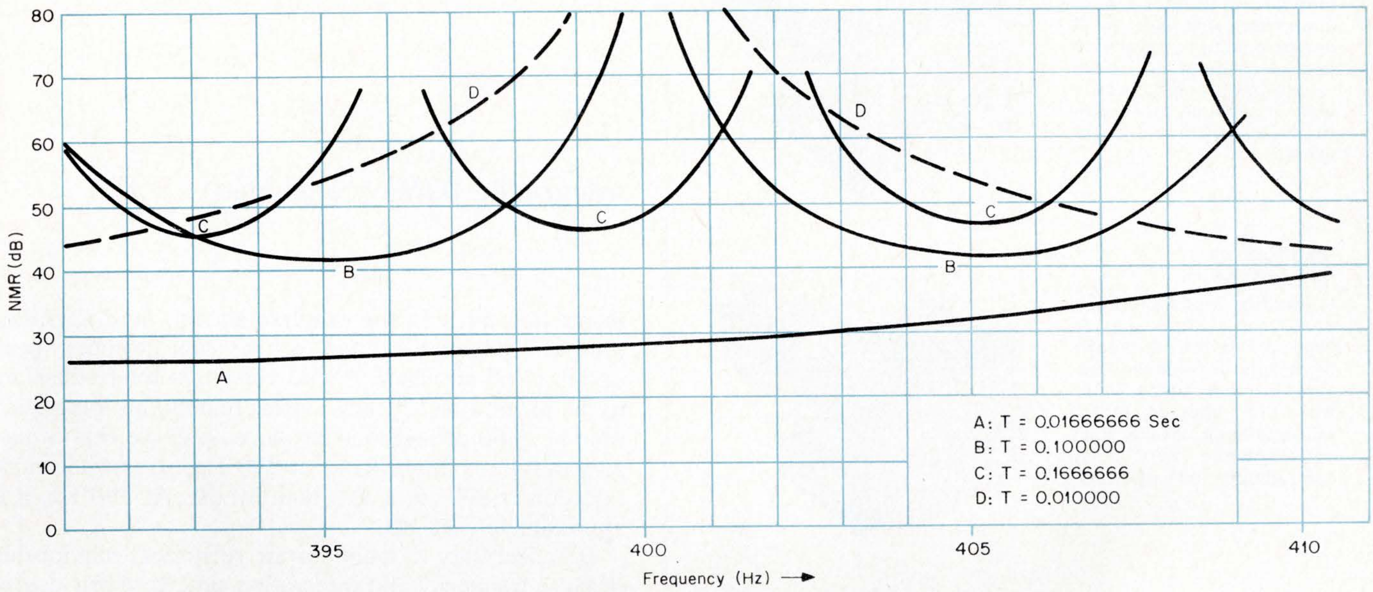


Fig. 6. NMR near 400 Hz as a function of integrating time.

Instrument Type	Normal mode rejection at: 61 Hz	64 Hz	395 Hz	399 Hz	Worst case measuring time (including amplifier settling)
Direct conversion—no integration					
No filter	0	0	0	0	75 ms
Medium filter	40 dB	40 dB	80 dB	80 dB	300 ms
Full filter	90 dB	90 dB	>100 dB	>100 dB	700 ms
1/10 sec integrator	46 dB	27 dB	42 dB	62 dB	380 ms
1/60 sec integrator	61 dB	38 dB	27 dB	28 dB	65 ms
1/100 sec integrator	7 dB	8 dB	54 dB	82 dB	50 ms

Comparison of NMR and reading time for integrating and non-integrating DVMs. The measuring times all include delays for amplifier setting, because these delays are significant. For example, an integrator having an integration time of 100 ms, could produce a full-scale reading in 200 ms, but 380 ms are required to account for all settling delays.

average zero over a predictable time interval. The most popular integrator today is the dual slope type, explained in the sidebar that accompanies this article. One reason for its current popularity is that it is a very simple and relatively inexpensive instrument to implement, particularly with today's integrated circuits.

As shown by the mathematical derivation in this article, the equation for normal mode rejection is

$$\mathrm{NMR_{dB}} = 20 \log \pi f T - 20 \log \sin^2 \pi f T$$

The first term in the right hand side describes a straight line (when drawn on semi-log paper, as in Fig. 2). The rejection resulting from this term increases at 20 dB/decade beginning at the frequency where the product $fT = 1/\pi$. An easily calculated point to fix the location of this line is for the frequency where $f = 1/T$. The log of π is approximately 1/2, and so where $f = 1/T$ the rejection due to this term (9.94 dB) is approximately 10 dB. This is also the first frequency where the second term goes to infinity.

This straight line due to the first term of the equation is equivalent to the rejection produced by a single RC filter section with a time constant half the integration time. The infinite peaks due to the second term of the equation add linearly to this equivalent capacitor line on the semi-log plot.

The peaks indicate that an instrument using this technique has unlimited normal mode rejection at all frequencies whose periods are integral multiples of the

Integrating DVMs (concluded)

integration time. In the example shown, the integration time is 1/60 of a second, so the first rejection peak occurs at 60 Hz. NMR is also very high for frequencies in the vicinity of 120 Hz. Unfortunately, an integration time of 1/60 of a second produces a curve that is tangent to the minimum locus at 390 Hz, so normal mode rejection at 400 Hz is less than 30 dB. At 390 Hz, it is approximately 26 dB.

It is necessary to maintain the reciprocal relationship of noise frequency and integration time to a fair degree of precision, to maintain significant rejection at the power line frequency. Figure 3 shows how the rejection peaks shift significantly with small changes in integration time.

A longer integration time decreases the spacing of the rejection peaks and produce a more uniform response over the total range of interest. For example, an integration time of 100 ms (as in Fig. 4) will produce peaks at 60 Hz, 120 Hz, and also 400 Hz, because the peaks occur with a spacing of 10 Hz. However, the closer spacing implies that the peaks are far narrower than for a shorter integration time.

One clear advantage of a longer integration time is that the locus of minimum rejection intersects the 0 dB axis at a lower frequency and therefore contributes higher rejection over the whole frequency spectrum.

The three examples of Figs. 3, 4 and 5 demonstrate that short integration times yield the most stable performance near rejection peaks, but the lowest noise rejection between peaks. Longer integration time yields very unstable performance near rejection peaks, but a much higher base of minimum rejection. The amount of rejection represented by the locus of minimum rejection is very important for higher line frequencies such as 400 Hz (as shown in Fig. 6) but it is also very important for frequencies removed from 60 Hz by only a few percent.

Integration is a rather economical technique to implement, and so this conversion technique is used for many inexpensive and rather slow DVMs. Active filters are used in more expensive digital voltmeters, where large values of stable NMR are combined with excellent step response. In addition, filtering can be switched out when not needed.

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LAB

Taking the mystery out of DVM specs

There are no industry standards on specifications for digital voltmeters, yet these specs are the only thing you can go by to compare DVMs.

By Kenneth Jessen,
Product Engineer
Hewlett-Packard Co., Loveland Div., Loveland, Colo.

There are over 200 models of digital voltmeters (DVM's) being sold on the World market, each with its own data sheet. Intelligently comparing and selecting DVM's is becoming quite difficult because the only standards which exist are those informally adopted by the manufacturers. Fortunately for the user, most specifications are easy to understand. Some do require clarification, however, and this article is devoted to them. A digital voltmeter, like any other instrument, is designed to solve a measurement problem. Only after clearly defining your problem, should you look at DVM specs.

You may have heard a lot about the digitizing techniques used in DVM's; for example single or dual slope integration, successive approximation, etc. Don't worry about them. Whatever advantages and limitations a technique has will ultimately be reflected in the performance of the DVM. A DVM should be evaluated for *what* it does, rather than *how* it does it.

How many digits do I have?

The number of digits a DVM has is often confused by the overrange digit. A four digit display of "1999" may have only three *full* digits, i.e., the three "9's" the instrument is able to display. The extra "1," or overrange digit, allows the user to read beyond full scale without loss of resolution or sensitivity. If a signal changes from 9.99 V to 10.01 V, a 3-digit DVM without overranging could measure the "9.99" V, but would have to up-range to measure the "10.0" V, losing the 0.01 V in the process. With an overranging 3-digit DVM, 10.01 V could be measured without any loss nor need to up-range.

Resolution and sensitivity

In the example above, the ability to measure 0.01 V by itself is a measure of sensitivity. The ability to measure 0.01 V as part of another signal (as in 10.01 V) is a matter of resolution. Digital voltmeters, by their nature, have high resolution. A 6-digit DVM with a 1 V range may be able to resolve changes as small as 1 μV in the last digit. DVM manufacturers have come to call the least significant digit on the lowest range "sensitivity" and others call it "resolution." There is no right or wrong to this situation as long as the user understands what they mean.

As an example of resolution and sensitivity, take a 4-digit DVM with 20% overranging and a 1-V range. This DVM would be able to read 1.2000 V on its lowest range and would therefore have a resolution of one part in 12,000. Since the least significant digit is equal to 100 μV, this would be given as the sensitivity (or resolution per some manufacturers).

The only drawback to this specification is that it is based on what the user *sees* and may not reflect what the DVM can do. For example, all DVM's have at least a ± 1 digit error because of uncertainties in the digital logic. This means that it is unlikely that the 4-digit DVM described above would actually respond with a one digit change to exactly a 100 μV change in the input. It might take only 90 μV or even up to 150 μV. The point is that a sensitivity specification equal to the last digit on the lowest range may be *close to* the actual sensitivity but is not likely to *equal* it. "Short-term-stability," which will be covered later, is a better measure of the usable sensitivity.

Accuracy

Accuracy is the exactness to which voltage can be determined in relation to the Legal Volt maintained by the National Bureau of Standards. A manufacturer must maintain calibration standards which are traceable to the Legal Volt before he can attach an accuracy specification to an instrument. An equal burden is put on the user. Purchasing a DVM without the equipment or ability to keep the instrument within its rated accuracy would be foolish. The point is that purchasing a high accuracy DVM may mean purchasing new calibration equipment.

To be meaningful, accuracy *must* be stated along with the conditions under which it will hold. These include time, temperature, line variations, and humidity. Accuracy should hold over some temperature range unless the DVM is to be operated in a tightly controlled environment. A temperature coefficient is usually given to allow the user to calculate the expected accuracy outside the specified range.

The period of time over which accuracy holds is an important indication of the instrument's stability and also gives the user an idea of how often the DVM will have to be recalibrated. Any instrument should hold its accuracy over normal power line fluctuations in voltage and frequency. Relative humidity can be very important when combined with temperature. If any of these conditions are omitted from the data sheet, the potential purchaser has a right to question the manufacturer.

Accuracy is usually stated in two parts: a percent of reading and a percent of full scale. The full scale error can also be expressed as $\pm X$ digits. A typical 4-digit DVM might have the following accuracy specifications:

$\pm(0.02\%$ of reading $+0.01\%$ of range) which is the same as

$\pm(0.02\%$ of reading $+$ 1 digit)

Figure 1 plots this accuracy as the percent of full scale vs error up to 120% of full scale to indicate 20% overranging. Notice that the best accuracy is at or near full scale.

Accuracy is always related to resolution. The resolution of a 4-digit DVM is one in 10,000 or $\pm 0.01\%$. For absolute voltage measurements, it would not make sense to buy a 4-digit DVM with an accuracy of ($\pm 0.1\%$ of reading $+0.1\%$ of range). The error would be 20 counts at full scale making the least significant digit useless. For relative measurements where the user is only interested in the difference between two voltages, the least significant digit would have meaning.

Ideally, a DVM would have an accuracy specification equal to its resolution so that the maximum error would be one digit. This is not practical, because a DVM always has a percentage of reading error combined with a percentage of range error. Figure 2 lists typical accuracies and shows what spreads in readout can realistically be expected.

Short term stability

Unlike accuracy, short term stability is not relative to the Legal Volt, though it is also specified under restricted conditions. The difference between a typical accuracy specification and short term stability specification is shown in Fig. 3.

Short term stability tells how good a DVM is for relative measurements and indicates its effective sensitivity. This specification is used when two voltages are compared over a short period of time (while temperature remains constant) or when looking at the drift of a single voltage.

Calibration

The current trend in DVMs is to make the instrument self-calibrating, and eliminate adjustment at the front panel. In using a front panel adjustment, the instrument is manually connected to its internal standard and adjusted to read correctly. The internal reference is not part of the measuring circuit. There should be two accuracy specifications: one to cover the internal refer-

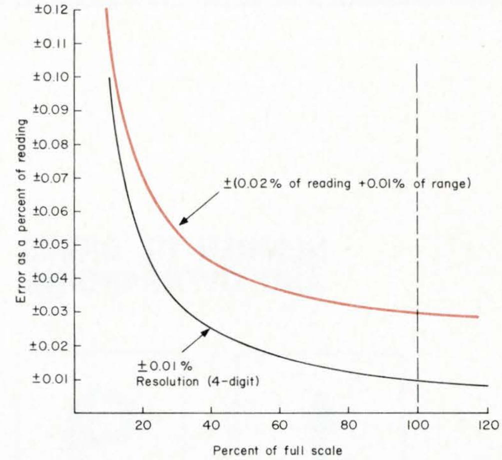


Fig. 1. Accuracy of a 4-digit DVM with 20% overranging, plotted in terms of error of reading vs percent of full scale. The accuracy is always greater at or near full scale. The theoretical limit for accuracy is the resolution, ± 1 digit.

Accuracy	**Display limits for a 1 V Input**
3-digit	
$\pm(0.1\%$ of reading $+$ 0.1% of range)	1.002
90 days; 20°C to 30°C	0.998
4-digit	
$\pm(0.02\%$ of reading $+$ 0.01% of range)	1.0003
90 days; 20°C to 30°C	0.9997
5-digit	
$\pm(0.004\%$ of reading $+$ 0.002% of range)	1.00006
90 days; 20°C to 30°C	0.99994
6-digit	
$\pm(0.004\%$ of reading $+$ 0.0002% of range)	1.000042
90 days; 20°C to 30°C	0.999958

Fig. 2. Typical dc accuracy specifications for various DVM's according to the number of digits. Note that a 6-digit DVM does not have substantially greater accuracy than a 5-digit DVM. All meters have an overrange digit.

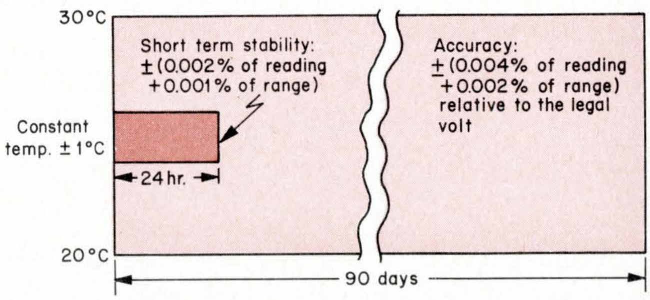


Fig. 3. Illustration of the difference between an **accuracy** specification and a **short-term-stability** specification as a function of time and temperature for a 5-digit DVM. Note that accuracy is relative to the Legal Volt and short-term-stability is not.

DEFINITIONS OF DVM SPECS

NUMBER OF DIGITS AND OVERRANGING:

Consider a DVM displaying the following reading:

$\boxed{1}\,.\,\boxed{9}\,\boxed{9}\,\boxed{9}\,\boxed{3}$ V

This is the OVERRANGE DIGIT. It can only be $\boxed{0}$ or $\boxed{1}$

These four digits are FULL DIGITS. They cycle through the integers from $\boxed{0}$ to $\boxed{9}$ Since there are four of them, this is a FOUR DIGIT DVM.

The percentage of overranging is:

$$\frac{\text{highest reading with overrange}}{\text{highest reading without overrange}} - 100\%$$

Rounding off, this DVM has an overrange capability of:

$$\frac{2.0000}{1.0000} - 100\% = 100\%$$

This DVM, then, is characterized as having FOUR DIGITS plus 100% OVERRANGE.

RESOLUTION:

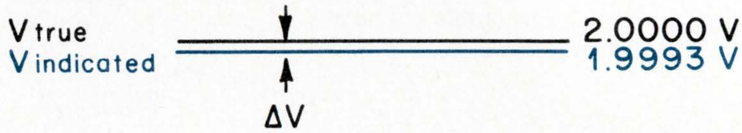
$$\frac{\text{the smallest observable change}}{\text{full scale reading}} = \frac{0.0001}{2.0000}, \text{ or } 0.005\%$$

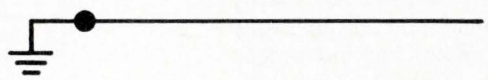
SENSITIVITY:

The minimum signal strength to which the instrument will respond, usually the smallest unit on the lowest scale. If this DVM is on its lowest scale, its sensitivity is 100 μV.

ACCURACY:

A comparison of the indicated value with the true value of the input signal. In the illustration below, it is $\frac{\Delta V}{V_{true}}$

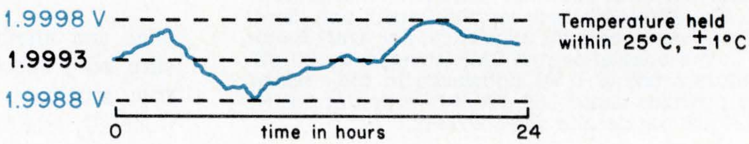




If V_{true} is 2.0000 V, the accuracy of this reading is $\frac{-0.0007}{2.0000}$, or 0.035%.

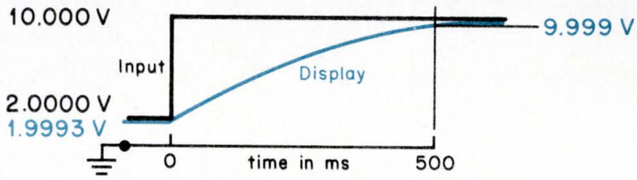
Usually this spec is broken down into a percent of reading error and a percent of full scale, or digits, error.

STABILITY: A measure of the reproducibility of the same reading for the same input, usually defined over an elapsed time and within a temperature envelope. Suppose a constant input of 2.0000 V was applied and a long term record of this DVM's output showed the following:



The reading varied a total of 10 parts in 20,000, or 0.05%. It was stable to within ±0.025% of 1.9993 V for the time and temperature conditions. Note that the accuracy was really +0.0000, —0.06% during this time.

RESPONSE TIME: The time required, after applying a step input, for the instrument to indicate a specified percentage of the new signal. It reflects the cumulative settling times in the unit. Suppose this DVM is on the 10-V scale, and the following is a chart of its response to a step input:



The response time under these conditions is 500 ms.

COMMON-MODE NOISE REJECTION: The ability of the grounding system of the instrument to cancel the common-mode signal appearing between the input terminals and ground. It is expressed in dB.

NORMAL-MODE NOISE REJECTION: The ability to reject noise which is superimposed on the signal to be measured. It is expressed in dB.

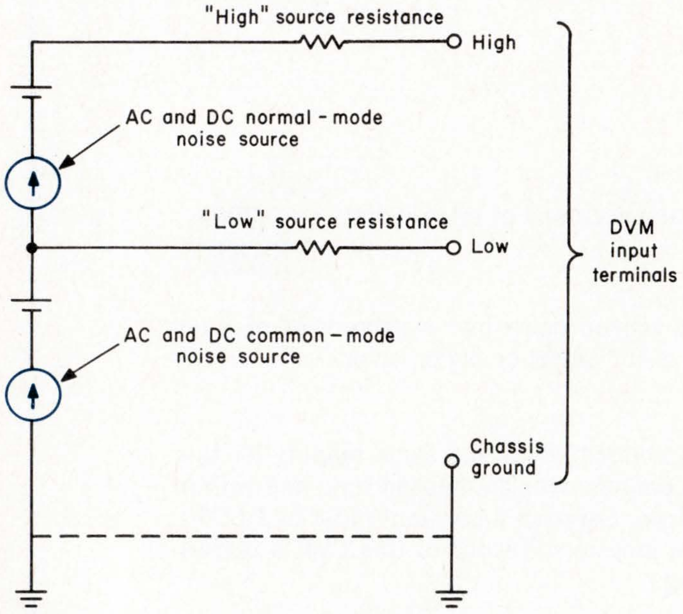


Fig. 4. Equivalent circuit of common-mode and normal-mode noise sources. The difference between the "high" and "low" source resistances represents an unbalance. For every factor of 10 change in the unbalance, the CMR changes by 20 dB. Most manufacturers use a 1 kΩ unbalance in their specs, which typically provides about 160 dB of rejection at 0.6 Hz and drops by 20 dB per decade of bandwidth.

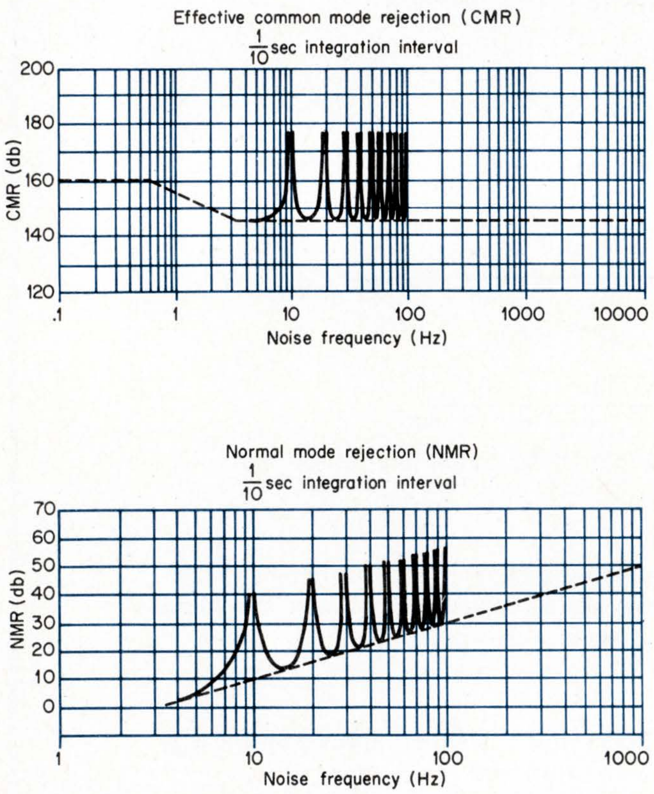


Fig. 5. Examples of "effective" common-mode rejection and **normal-mode rejection** for a 5-digit integrating DVM. The "cusps" are formed as a result of the integrating technique, which provides essentially infinite rejection at multiples of integration frequency.

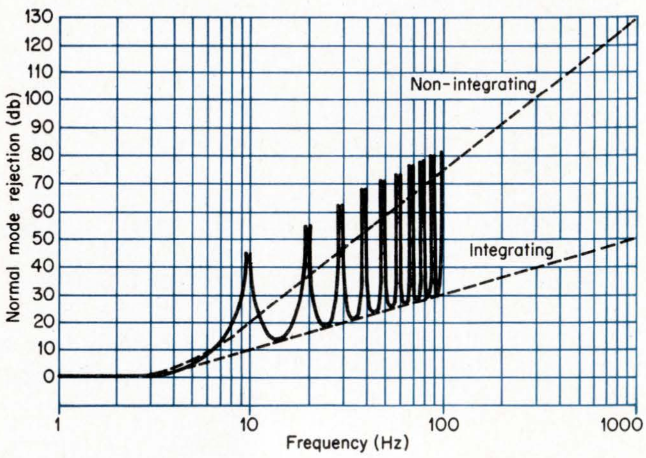


Fig. 6. Noise rejection produced by two commercially available DVM's; one which integrates, and one which does not integrate and uses a filter.

ence and another to cover the measuring circuit. Be sure both specifications are combined to indicate the true accuracy. Watch for data sheets which make a manually calibrated DVM appear to have higher accuracy than a self calibrating DVM by putting the accuracy of the internal reference in a prominent position.

Speed

Speed is confusing, mainly due to the number of terms involved. DVM users need to know three things about speed: (1) the time required for the DVM to respond within its rated accuracy, after application of the input signal; (2) the effect of any input filtering, and (3) the reading rate when the DVM is used in a system.

From the instrument's standpoint, these are three different times: (1) the time for the input amplifiers to respond to a change in the input; (2) the time required to reject incoming noise, and (3) the time required to change the input signal into digital form.

Fixed or adjustable internal triggers are designed to relieve users of supplying external triggers when making bench measurements. Triggering rates vary from 1 reading every 5 seconds to 30 readings/second, and are independent of any other response time in the instrument. The maximum rate at which a DVM may be triggered in a system can far exceed what the internal trigger can supply.

A DVM may be able to take 100 readings/second but if the response time (settling time) of its input amplifiers is only 100 ms, then the DVM may take only 10 *correct* readings/second. Since the internal trigger might be adjustable up to 20 readings/second, it is up to the user to determine the trigger setting for correct readings.

Input amplifiers usually have an exponential response curve. Amplifier settling time should be specified for a full scale change in the input signal, because the time required to respond to a full scale change may be much longer than for small changes. Quite

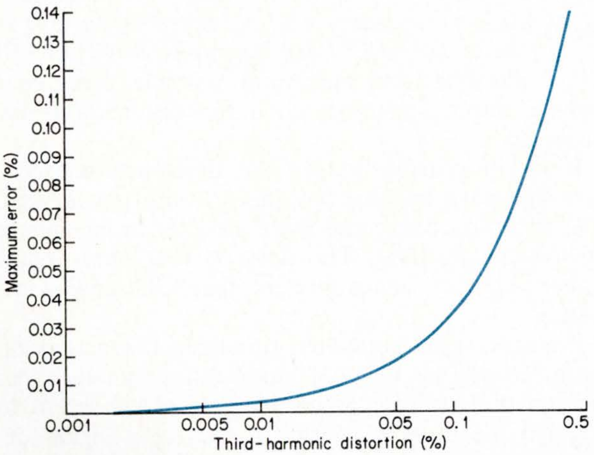


Fig. 7. Maximum possible error in an average-responding DVM when the distortion is third harmonic. A very small amount of distortion can destroy the accuracy. In contrast, a true-rms responding DVM is not affected by distortion.

often the lower ranges require more time to respond. The user should check that the internal trigger will be sufficient to cover the response times, and the maximum reading rate is fast enough to take advantage of the response time.

Noise rejection also affects speed. Whenever filtering is used, it should be clear from the data sheet what effect each filter position has on the response time. (The integration period is an important time in integrating DVMs.)

Other speed factors include autorange time, time to recover from an overload, and time to program a range change or function change. The effect of all of these on the basic measuring speed should be clearly stated on the data sheet.

Noise rejection

Noise rejection specifications appear to be complex, but involve simple fundamentals. The main point is that you do not want noise to destroy the accuracy of your measurement. The source and type of noise are important in determining what type of noise rejection is needed. Figure 4 illustrates the difference between the types of noise in equivalent circuit form.

Normal-mode noise (also called superimposed noise) enters with the signal, and must be eliminated by the DVM's measuring technique. Filtering is the simplest way to eliminate normal-mode noise by shunting it to ground, but it does slow the measurement. Integration "calculates" the noise out of the measurement by changing the input voltage to a frequency. The total counts accumulated during the integration period is proportional to the average of the input voltage. If the period of the noise equals a multiple of the integration period, the noise is effectively integrated out of the measurement.

Common-mode noise appears between the DVM's input terminals and ground. It is caused by differences between the instrument ground and the ground at the measured circuit.

To reduce the effects of common-mode noise, a passive technique called guarding is commonly used. Guarding shunts the noise to ground by using a shield, or box within a box. The ultimate solution is a battery operated DVM, which disconnects the instrument from ground.

Common-mode noise may enter a DVM as normal-mode noise by flowing through the source resistance of the circuit being measured, thus appearing across the input terminals. Because of this, a new term called "effective" common-mode rejection has evolved.

This specification is a combination of the "pure" common-mode rejection achieved by guarding and the normal-mode rejection of the instrument. It is the overall effect of common-mode noise on the voltage reading.

Figure 5 shows normal-mode and effective common-mode noise rejection for an integrating DVM. Generally, common-mode voltage is specified with a 1 kΩ resistor in either the high or low input lead, thus giving a basis for comparison.

Figure 6 illustrates the difference between noise rejection using filtering and integrating techniques. Integration eliminates noise as part of the measurement and the basic speed of the instrument is maintained. Essentially infinite rejection is produced at multiples of the integration period, producing the "cusps" shown in the figure. Since the most common source of noise is the power line, the integration period is chosen to be a multiple of the period of the line frequency, such as (1/6) s or (1/60) s, thus integrating out those frequencies.

Filtering is far less expensive and, in a way, more flexible. Although filtering cannot produce infinite rejection at line related frequencies, it can offer better broadband rejection. Several filter positions will allow the user a wide range of measurement speeds and noise rejection. In general, filtering is slower than integration for the same amount of noise rejection.*

Ac voltage measurements

The trend in digital voltmeters is to offer greater capability in the classical measurements and to offer new capability to measure new parameters. Measuring new parameters requires the evaluation of new specifications.

AC converters designed for DVMs may be classified according to their response to the input signal. Average responding converters are the most common, and fairly inexpensive, but are limited to measuring pure sine waves. Quasi-rms converters are able to measure sine waves with a limited amount of distortion. True-rms converters are new to the DVM market and offer virtually complete immunity to distortion, but are relatively expensive.

The nature of a digital voltmeter implies high accuracy. A 4-digit DVM, for example, should have an accuracy of at least ±0.05% to make the last digit meaningful. An average responding ac converter can be very sensitive to distortion. Even-order harmonics are usually not an important source of error in an

*A bibliography of articles on noise rejection appears at the end of this article.

average responding DVM. Odd harmonics, on the other hand, result in considerably more error, the polarity depending on the phase relationship.[1] For example, a basic ±0.05% accuracy will be degraded to ±0.1% by as little as 0.1% of third harmonic distortion. Figure 7 illustrates the maximum possible error in an average responding DVM when the distortion is third harmonic.

It is not possible to see the difference between a pure sine wave and one that has 1% distortion, yet the 1% distortion can cause a 0.333% error in an average responding DVM. The point is that DVMs require higher accuracy ac converters than did analog voltmeters.

The quasi-rms converter simulates the action of a thermocouple by using a curve-fitting network combined with a rectifier. Since this type of converter does not find the thermal energy of the input signal, it is limited in the amount of distortion it can tolerate, but it is fast.

The true rms converter offers the ultimate in performance and is designed specifically for DVM accuracy. A thermocouple measures the heating value of the input signal, thus measuring the true rms value, independent of distortion. The true-rms converter, although slow, covers a bandwidth up to 1 MHz, compared to the 100 kHz limit on average and quasi-rms-responding converters. Once again, there is no one "right" converter; the choice depends strictly on the application.

Ohms measurements

Each of the three types of converters has an advantage. The 2-wire converter is the most common and the most economical but is sensitive to lead resistance. If low resistance values are being measured at a remote location, lead resistance will cause an error in the measurement.

The 3-wire ohms converter may have four terminals on the front panel and may even be called a 4-wire converter. It is also sensitive to lead resistance, especially on the low side of the input, but it may be possible to null out the lead resistance with an internal adjustment.

The "true" 4-wire ohms converter has a fully isolated current source and is insensitive to lead resistance. It makes low ohms ranges useful for remote measurements. The value of the unknown resistor is sensed at the point of measurement by a separate pair of leads which do not carry any current. Although this scheme offers the ultimate in performance, it is the most expensive due to its separate power supply and grounding system.

Articles on noise rejection

McCullough, William, "How to reduce common-mode effects", *EEE*, Feb. 1967.

Wasserman, Philip D. "Voltmeter noise rejection", *Measurements and Data*, pp. 110-115, May-June, 1968.

McCullough, William, "Understanding digital voltmeter specs", *Electro-Technology*, pp. 57-61, Aug. 1968.

Franklin, Gary, "DVM specs", *Electronic Products*, pp. 76-88, Nov. 1968.

[1] Fred L. Hanson, "Effects of Distortion on Calibration", *Hewlett-Packard Journal*, Vol. 19, No. 10, pp 6-7, June 1968.

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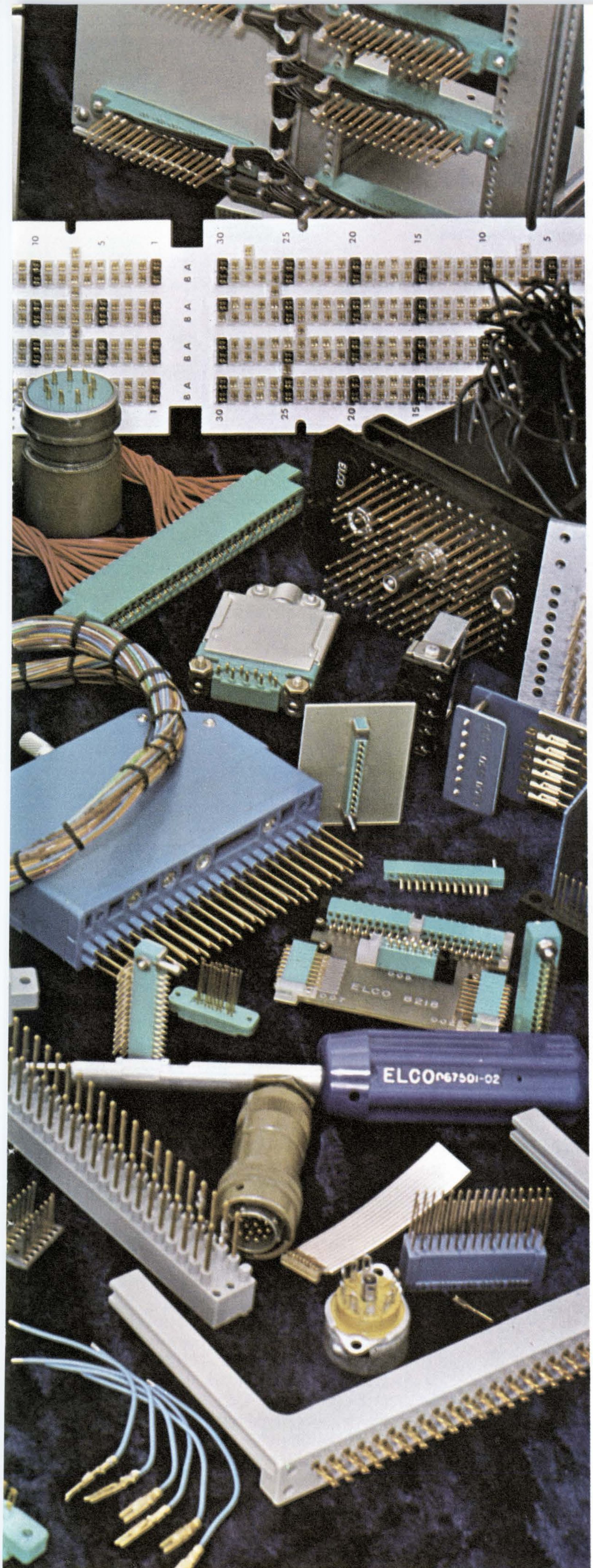
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Dr. Malcolm R. Currie
Vice President, R & D

Dr. Malcolm R. Currie has recently been appointed to the new position of vice president-research and development for Beckman Instruments, Inc.

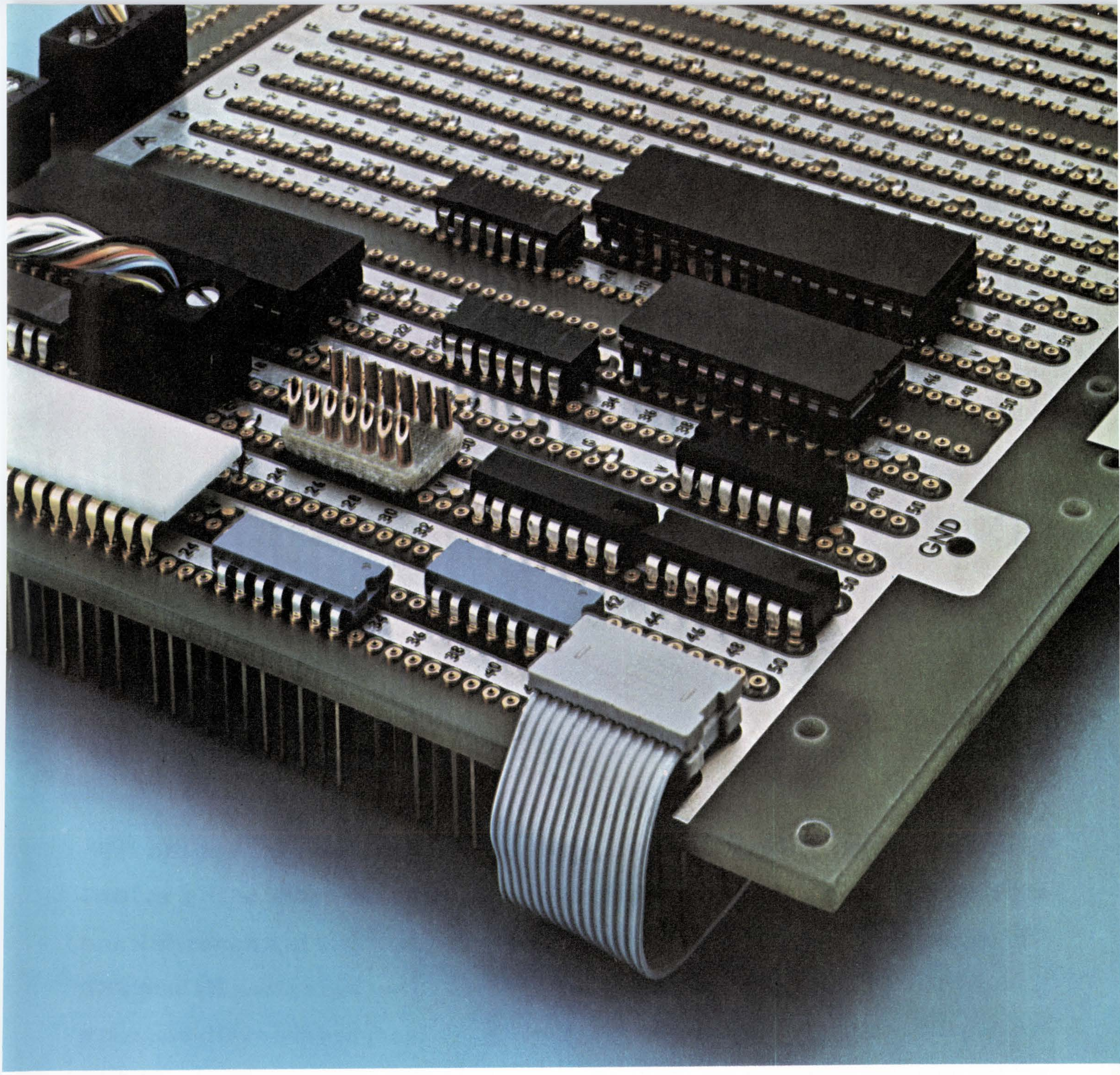
One of his key tasks is directing the combination of various disciplines into the new hybrid technologies involving electronics, biochemistry, biomedical and process instrumentation. "It's often difficult to join individual disciplines because of their diverse origins and languages," he observes. "But it's essential in the measurement field, and when it's done successfully, the technical and economic gains can be enormous.

"The variety is enormous, too. Measurement is essential to scientific progress. The development of useful new instruments involves you in medicine, industry, research, education—just about any field you can name."

Dr. Currie views engineers as builders of things that are useful, socially and economically. "Engineers have to get involved in many activities to be really productive. Management, for example : you can't separate management from engineering in a company like ours. Good engineers need personal involvements and broad perspective on the world around them to be fully effective in their disciplines and their organizations."

Dr. Currie joined Beckman after 14 years with the Hughes Aircraft Co., where he was a vice-president and manager of the Research and Development Division.

He holds an AB degree in physics, and MS and PhD degrees in electrical engineering, all from UC Berkeley. He has taught electrical engineering at Berkeley and UCLA and has won many awards, including being selected as the Nation's Outstanding Young EE by Eta Kappa Nu in 1958.



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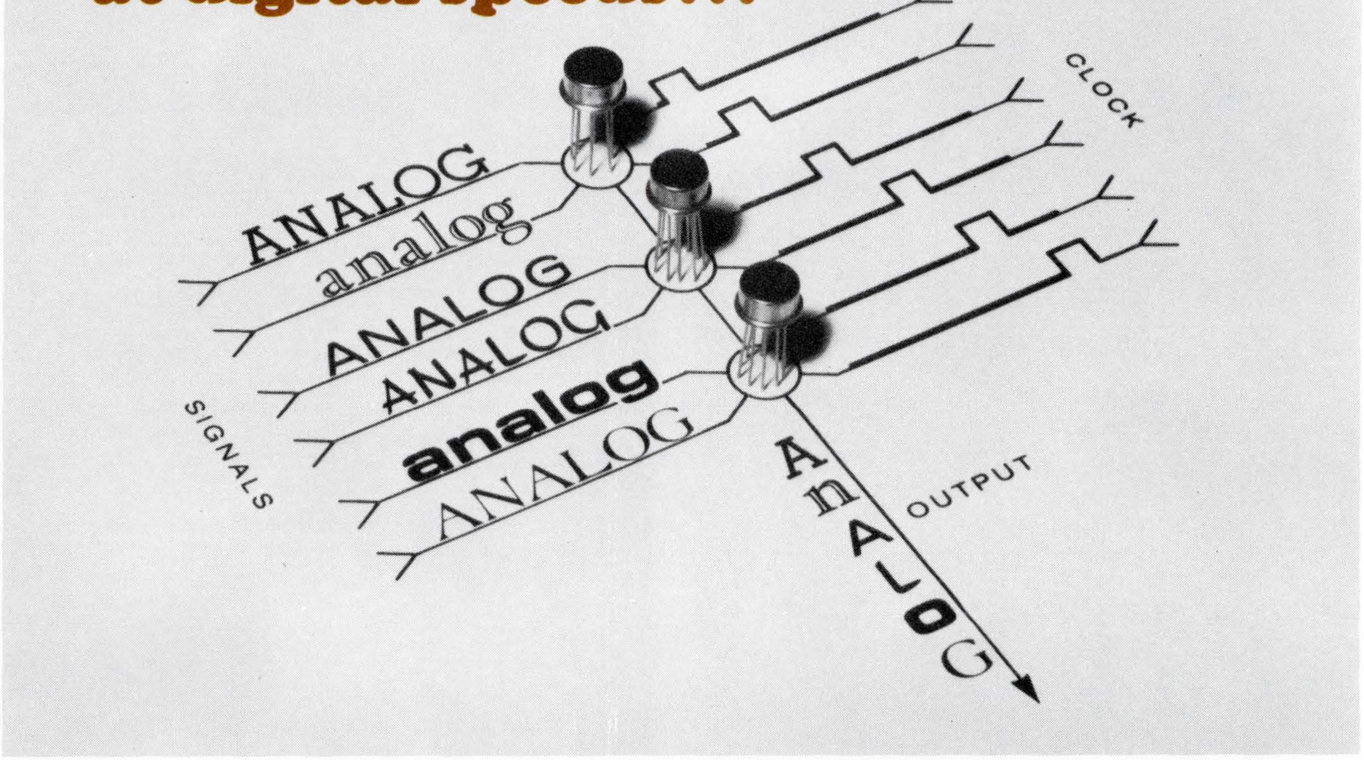

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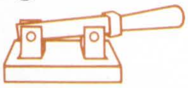

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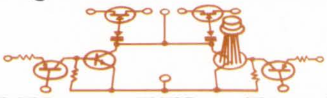

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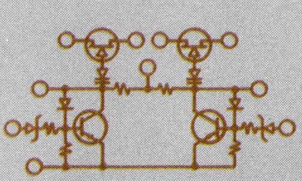
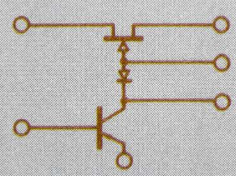
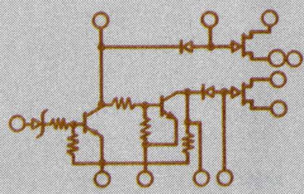
CAG4



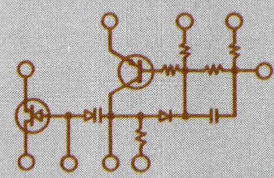
CAG6-10



CAG7-10



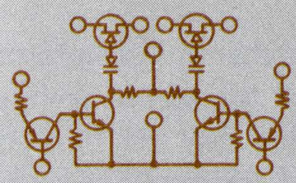
CAG-10



FET ANALOG GATES (OPERATE DIRECTLY FROM DTL OR TTL)							
TYPE	FUNCTION	MAX. R_{ON} (OHMS)	MAX. V_{SIG} (VOLTS)	MAXIMUM SWITCHING TIME (μSEC)	SUPPLY VOLTS	PACKAGE	100-999 PRICE
CAG4	DUAL SPST	50	− 9 to +10	0.5	±15	TO-5	$40.00
CAG6[1]	SPST	6	− 5 to +10	0.7	±15	TO-5	22.00
CAG6-10[1]	SPST	10	− 5 to +10	0.7	±15	TO-5	20.00
CAG7	SPDT or DPST	6	− 5 to +10	1.5	±15	TO-8	50.00
CAG7-10	SPDT or DPST	10	− 5 to +10	1.5	±15	TO-8	39.70
CAG10	SPST	30	− 5 to + 5	0.05	±15	TO-5	28.00
CAG10B	SPST	50	−10 to + 5	0.05	±15	TO-5	28.00
CAG13	DUAL SPST	50	− 9 to +10	0.5	±15	TO-5	33.50

[1]Require 0 to +15V Drive Signal

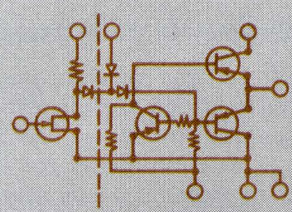
CAG13



D/A SPDT LADDER SWITCHES FOR R/2R LADDERS (OPERATE DIRECTLY FROM DTL OR TTL — SWITCH BETWEEN REFERENCE & GROUND)						
TYPE	REFERENCE VOLTAGE	TYPICAL R_{ON} (OHMS)	ACCURACY[2] IN BITS	SWITCHING TIME (μSEC)	PACKAGE	100-999 PRICE
CDA1-1	−15	5	12	1.0	TO-5	$ 29.50
CDA1-2	−15	5	12	1.0	TO-5	43.00
CDA1-3	−10	5	12	1.0	TO-5	20.00
CDA1-3S12[3]	−10	5 ±1	14	1.0	TO-5	240.00
CDA1-3S14[4]	−10	5 ±½	15	1.0	TO-5	280.00
CMDA1	−10	10	11	1.0	D.I.P.	13.00
CMDA1A	−10	5	12	1.0	D.I.P.	14.35
CMDA1S14[4]	−10	5 ±1	15	1.0	D.I.P.	190.00
CDA2-1[5]	0 to +20	25 ±5	—	3.0	TO-5	40.00
CDA2-2[5]	0 to +20	30 ±10	—	3.0	TO-5	35.00
CDA2-3[5]	±10	25 ±5	—	3.0	TO-5	35.00
CDA2-4[5]	±10	30 ±10	—	3.0	TO-5	28.00
CDA4A	+10	5	12	0.6	TO-5	25.50
CDA5	±4	10	11	3.0	¼" x ¼" FLAT PACK	24.00
CDA6	±10	5	12	0.7	TO-5	35.00
CDA10[6]	−20	5	12	2.0	TO-8	48.00
CDA11[7]	−10	5	12	1.0	TO-8	120.00
CDA11S12[8]	−10	5 ±2	13	1.0	TO-8	360.00
CDAL1	8-BIT 10K/20K LADDER WITH 10-BIT ACCURACY				TO-5	60.00
CDAS1	COMPLETE 8-BIT CONVERTER WITH 10-BIT ACCURACY				TO-8	$300.00

[2]Based on 10K/20K ladder
[3]12-unit set, most significant bits color-coded
[4]14-unit set, most significant bits color-coded
[5]Dual SPST for current-summing conversion
[6]2 circuits per package
[7]4 circuits per package
[8]3-unit set, most significant bits color-coded

CDA1-1 & -2



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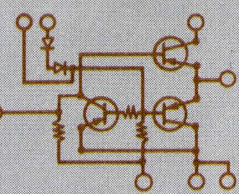

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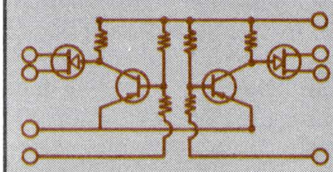

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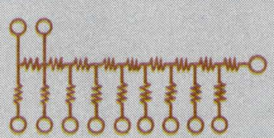
CDAL1



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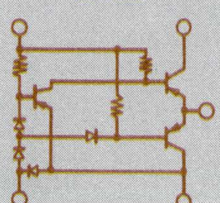

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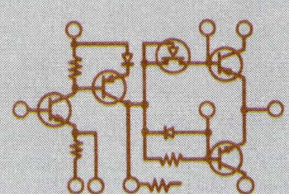

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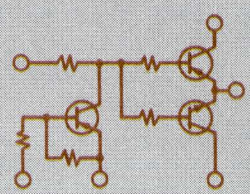


Circle 42 on Inquiry Card

Hybrids...Thick and Thin

Whether you plan to build or buy, you should be familiar with the steps involved in making hybrid circuits. There may also be a point at which you will want to stop buying and start making your own. These charts should help you decide.

By Smedley B. Ruth, Associate Editor

The number of companies setting up hybrid circuit facilities, both for their own use and for sale to others, is growing by leaps and bounds. Still others have chosen to compromise for various reasons. They don't wish to purchase completed circuits, but neither do they want to install a complete hybrid facility.

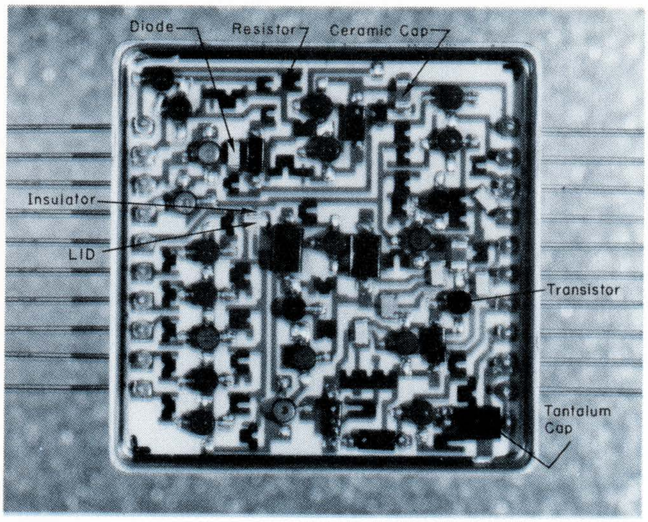
A look at the charts on pages 62-65 will show the steps involved in fabricating both thick and thin film circuits. From these you can see that there are many possibilities for compromise. For example, it's possible to enter the thick film process at step 8 by purchasing the substrate complete with resistors and conductors already screened in place. You may then purchase capacitor and semiconductor chips for in-house mounting, testing and packaging.

Or, perhaps you feel that a particular resistor composition you have developed should be screened and fired in-house. Fine, then enter the process sequence at step 5.

Whether you plan to build, buy or compromise, the accompanying charts should give you some feel for the alternatives available. With them you can also get an idea of the equipment you would need for each step. Thus, for the thick film process you might need: drafting equipment (steps 1 and 2); camera system (steps 3 and 4); ultrasonic or other cleaners, inks, screen printer, and conveyor furnace (step 5); abrasive or laser trimmer (step 6); glass composition (step 7); thermocompression or ultrasonic bonder and chip handler (step 8); welder (step 9); and test equipment (steps 10 and others where desired).

The thin film process could be similiarly evaluated—deposition or sputtering equipment (step 4), photoresist (step 5) and so forth.

The most important ingredient of a successful hybrid circuit venture is, of course, knowledgeable people. They would know the intricacies of the various steps. For example, how to determine resistor length, width and form factor or how the firing profile affects resistor compositions.



Callouts on this amplifier/pulse generator photo show component parts of a thick film circuit. (Lansdale Microelectronics Inc.)

Methods of making hybrid circuits may vary somewhat from those described here, but these are representative. Various manufacturers may change the sequence or they may use different inks, but their overall methods are probably similar.

Acknowledgements

Many thanks to those who helped supply information for this report, and especially to Joel Cohen, Crystalonics; Matt Romano and Jack Dale, Lansdale Microelectronics; Richard S. Ringer, Electro-Science Laboratories, Inc.; and John Kukulka, Tele-Dynamics Division of American Bosch Arma.

INFORMATION RETRIEVAL

Integrated circuits, Materials, Packaging

Typical Characteristics of Common Substrate Materials

Material	Thermal coeff. of expansion (10^{-6}/°C)	Thermal Cond. cal cm/cm^2/S/°C at 25°C	Softening temp. (°C)	Density (g/cm^3)	Die. cons. at 1 MHz (at 25°C)	Log. Vol. resis. (Ω-cm) at 25°C	Die. strength at 60 Hz (V/mil)
Alumina (96% Al_2O_3)	6.4	0.084	1550	3.7	9.2	$>10^{14}$	210
Barium Titanate ($BaTiO_3$)	8.1	0.003	1550	5.5	6500	12.0	—
Beryllia (99.5% BeO)	6.4	0.59	1500	2.8	6.5	$>10^{14}$	220
Glass (7059)	4.5	0.002	870	2.7	5.8	>13.5	—
Steatite	6.9	0.014	1000	2.7	6.3	$>10^{14}$	230

Typical Properties of Thick Film Conductors

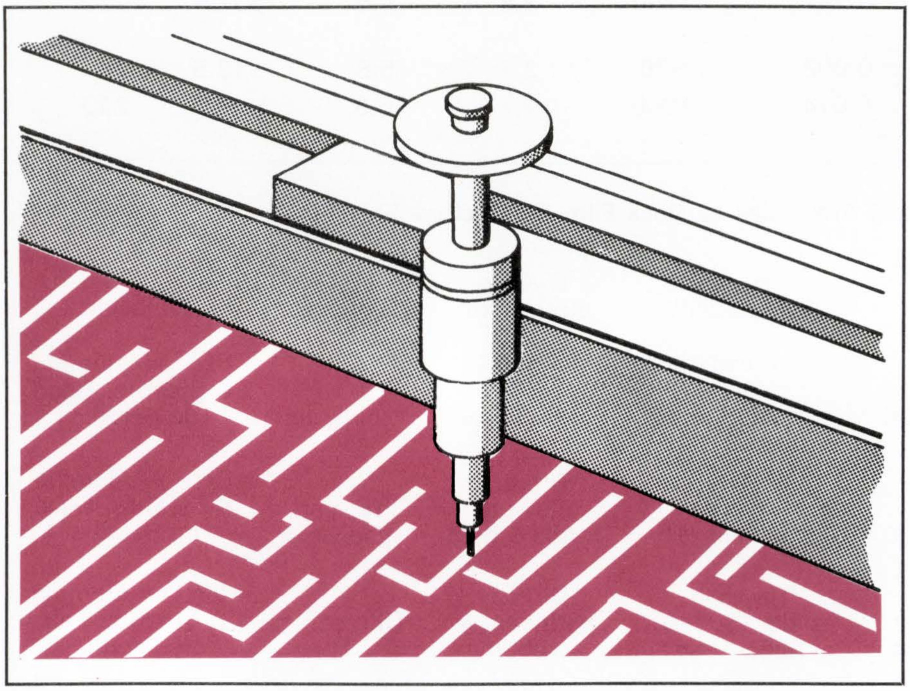
Material	Resist. (Ω/sq)	Firing temp. (°C)	Solderability	Si Chip attachment	Bonding	Adhesion
Pt-Au	0.05-0.10	760-1000	Any lead/tin solder or gold alloys	With gold alloy pre-forms & heat	TC or soldering	Exc. on Alumina & Steatite. Good on Beryllia
Pd-Au	0.05-0.10	760-1000	Any lead/tin solder or gold alloys	With gold alloy pre-forms & heat	TC, par. gap weld	Exc. on Alumina & Steatite. Good on Beryllia
Au	0.003-0.01	750-950	Tin/lead solder (60/40) AuSi, AuSn	Directly with heat & scrubbing	Ultrasonic, TC	Good on Alumina & Steatite. Fair on Beryllia.
Pd-Ag	0.01-0.05	750-950	Tin lead or tin silver or tin-lead-silver	With pre-soldered land areas	TC, par. gap weld solder	VG on Alumina & Steatite. Good on Beryllia.
Ag	0.005-0.01	500-800	Readily soldered	—	TC ultrasonic	Exc.

Common Dielectrics

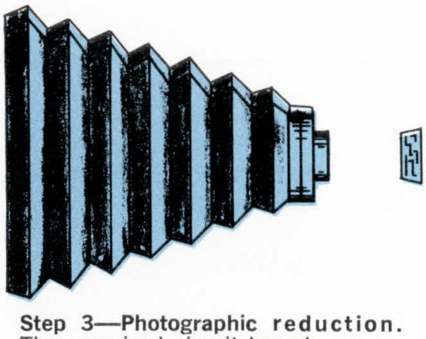
Materials	Application	Process	Die. cons.	Breakdown volt	Char. cap. pF/sq. mil	Temp. coef. ppm/°C
Barium Titanate $B_aT_iO_3$	thick	screen print	25	>100	0.32	±300
Silicon Monoxide (S_iO)	thin	vac. evap.	6	50	0.01	+110
Silicon Dioxide (S_iO_2)	thin	vac. evap.	3.8	50	0.3	±200
Aluminum Oxide (Al_2O_3)	thin	vapor plating	9.8	25	0.3	+125
Tantalum Pentoxide (Ta_2O_5)	thin	reactive sputtering	25	25	2.5	+300
Glass-Ceramic	crossover	screen print	8	<500	—	—

Thin film process

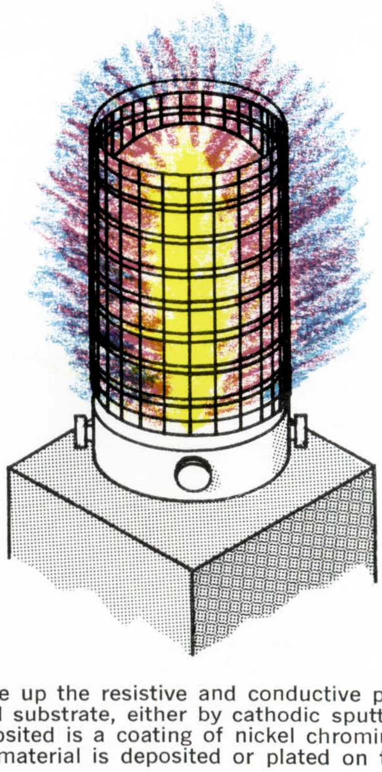
Step 1—Circuit design. Circuit is first breadboarded to check its operation.



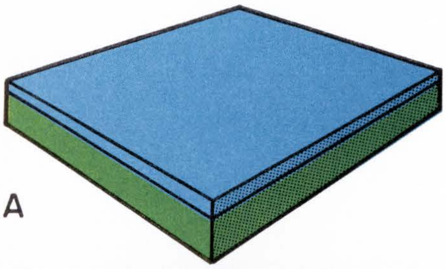
Step 2—Circuit layout. Circuit schematic is laid out as separate oversize drawings of each circuit layer. Conductor, resistor and capacitor (if deposited capacitors are to be used) patterns and discrete component placement are included. A highly accurate coordinatograph ($\pm$0.00005 in. on final image) is then used to make the necessary artwork.



Step 3—Photographic reduction. The oversized circuit layouts are reduced to a fraction of their size by microphotography. Further processing yields high resolution photomasks.



Step 4—Deposition. Various films that make up the resistive and conductive patterns are deposited on the carefully cleaned substrate, either by cathodic sputtering or by vapor deposition. First to be deposited is a coating of nickel chromium (or similar material). Next, the conductive material is deposited or plated on the substrate.



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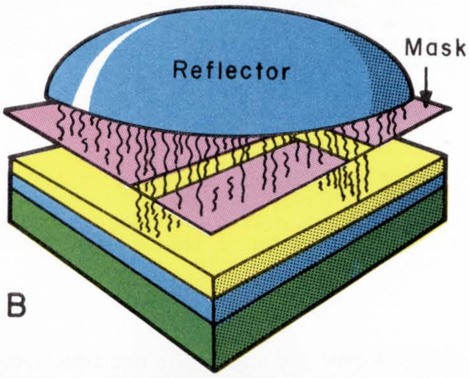

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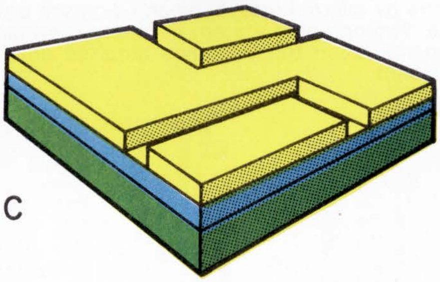
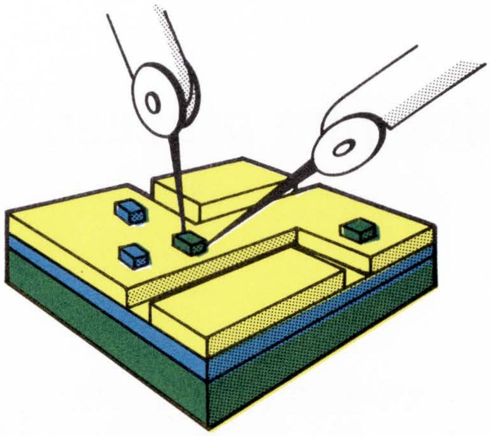
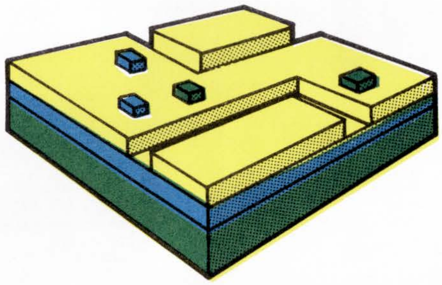


C

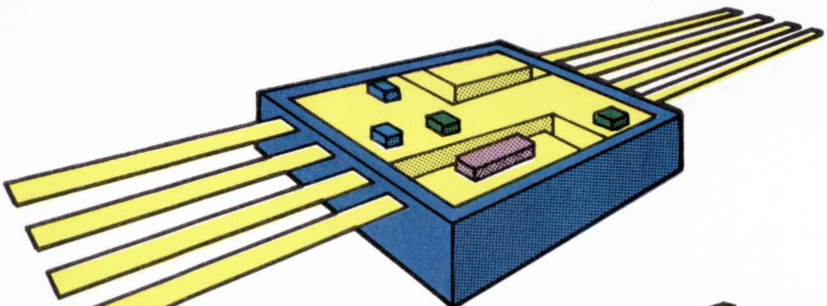
Step 5—Photoetch. (a) A layer of photoresist is now applied. (b) The photoresist (either wet or dry) is then exposed to ultra-violet light through the photomask containing the conductor pattern. (c) The unprotected areas are then chemically etched to form the conductor pattern. This process is repeated using the other mask to establish the resistor pattern. (Capacitors are made with conductors and oxides). Two different acids are used to etch—one type attacks the conductor and not the resistor, the other attacks the resistor and not the conductor. Photoetch sequence may be different for various manufacturers.



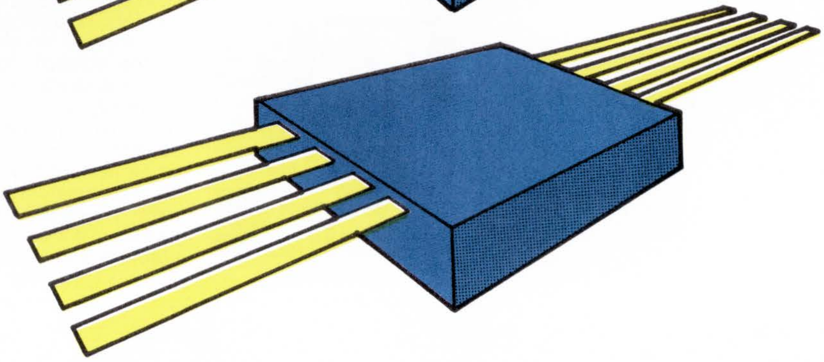
Step 6—Resistor trim. Resistors are next tested and, if necessary, electrically, mechanically or laser trimmed to value.



Step 7—Device mounting. Discrete components are now mounted on the substrate. The connections can be made by various means such as thermal compression or ultrasonic wire bonding. Unit is now visually inspected and electrically tested. Device and substrate (see step 8) mounting steps may be reversed in order.



Step 8—Substrate mounting. The substrate is now mounted in the package and the unit is again tested.

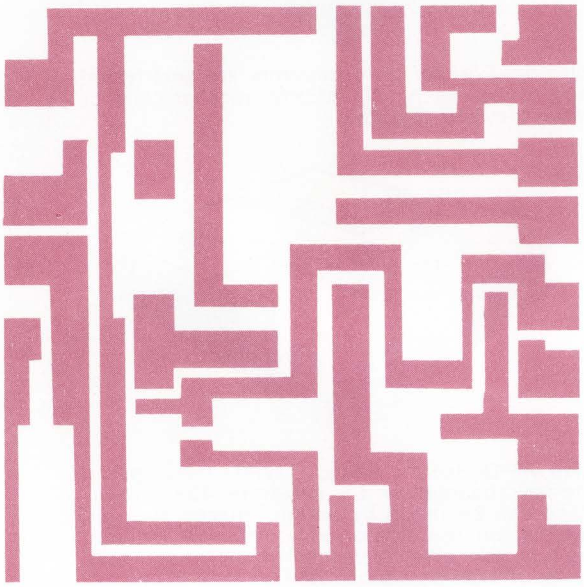


Step 9—Package sealing. Package is now sealed and further tests conducted (centrifuge, leak, and so forth) if desired.

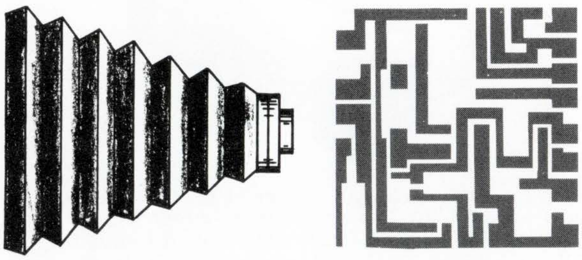
Thick film process

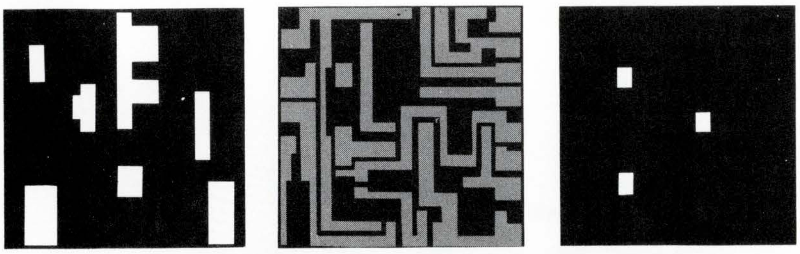
Step 1—Circuit design. Circuit is breadboarded to check its operation. A layout showing circuit paths, resistor patterns and discrete component locations on the hybrid substrate is then made.

Step 2—Circuit layout. This circuit layout is transferred to a photolithographic drafting film on a light table (or the more accurate coordinatograph). Separate films are cut for conductor, resistor, glass overlay and crossover patterns.

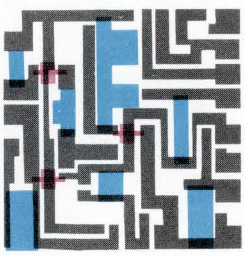


Step 3—Photographic reduction. The oversized circuit layout, generally 10 to 20 times actual size, is reduced to its final size by microphotography and exposed onto a glass slide. Photographic system accuracy (normally 0.1 mil) depends upon the tolerance required on the completed circuit.



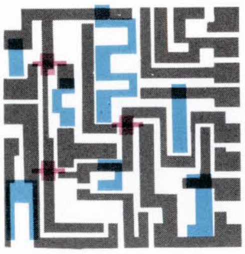


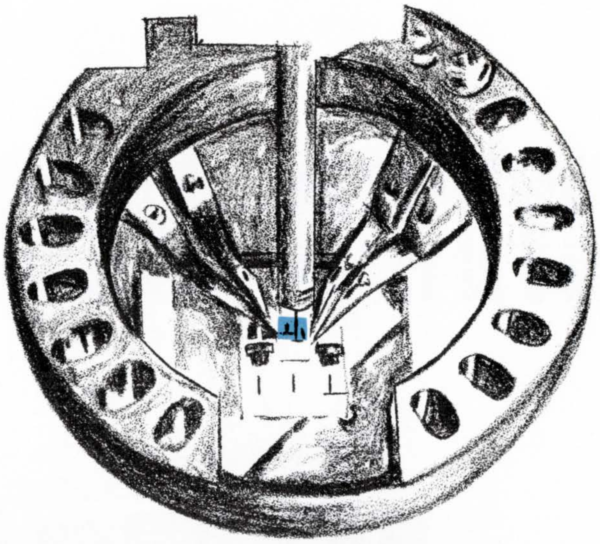
Step 4—Screen makeup. The slides are exposed onto a photosensitized, fine (150-350 wires/in.) mesh stainless steel screen. This screen which is placed in a cast aluminum frame, is used to screen print the resistor, conductor and dielectric patterns onto a substrate.



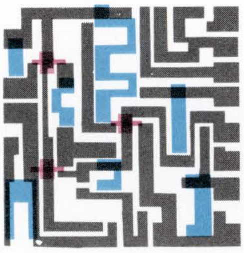
Step 5—Screen and fire. After the substrate is thoroughly cleaned, a slurry of carefully selected conductive ink is printed on it (by passing a squeegee over the screen, forcing ink through the exposed portion of the screen). The conductor pattern is printed first. The substrate is then fired at required temperatures (typically 750°C to 1000°C) in zoned conveyor belt furnaces or kilns. There are usually four to eight separately controlled zones with highest temperature firing first so that later firings will have minimal effects on previously fired patterns. The resistor pattern is similarly obtained, as are the dielectric and crossover patterns if needed. The firing operation also serves to stabilize the resistors.

Step 6—Trim resistors. Resistors are trimmed, usually by an air abrasive method or by a laser. The process is such that the resistors are usually purposely screened to be lower in value than that ultimately desired. Thus, when resistance material is carefully removed, the desired value can be obtained to a closer tolerance (2 to 5% is common, but >1% is possible).

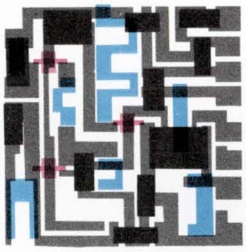


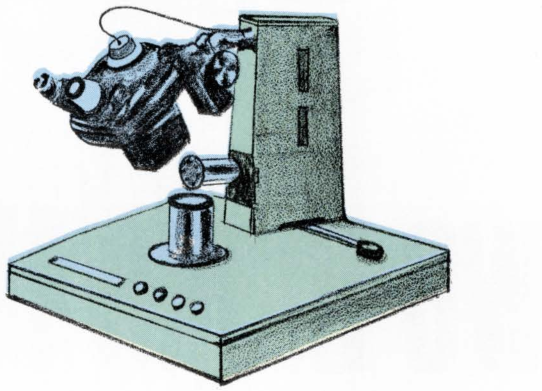


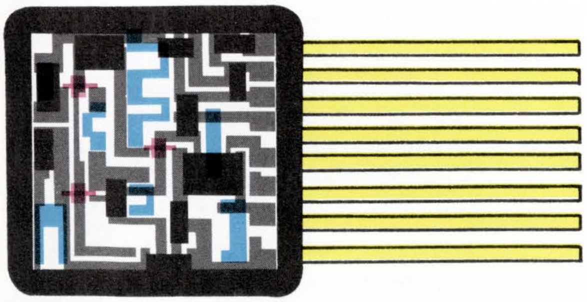
Step 7—Surface protection. A layer of glass can be selectively screened and fired in place to protect less stable resistors. Glass can also be used for crossovers.



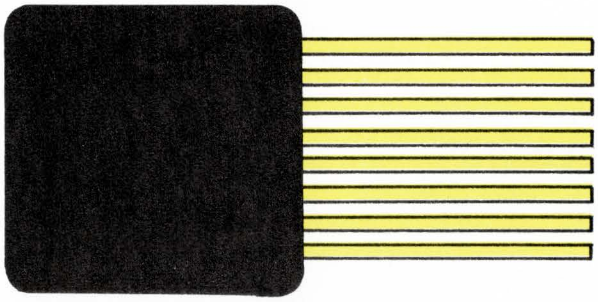
Step 8—Mount devices. Semiconductor and other components such as chip capacitors can now be mounted on the substrate. Device and substrate (see step 9) mounting steps may be reversed in order. When small substrates must be mounted in miniature packages, the substrate is usually mounted first and then the components are mounted.







Step 9—Package. The substrate is placed in the package and the leads are attached. (Refer to article "Design guide to hybrid package size," September issue of The Electronic Engineer). The package lid may then be put on or the package encapsulated.



Step 10—Test. A final test is performed to insure that all operations have been successful. Testing (or monitoring) is also normally performed at each manufacturing stage. Purpose is to assure a one-to-one transfer ratio from the original discrete breadboard, and to check for defects.

READ THESE BOOKS

For more information about these books (sorry, no free copies), circle the corresponding number on the reader inquiry card.

Introduction to Large-Scale Integration
By Adi J. Khambata. Published 1969 by John Wiley & Sons Inc., 605 Third Ave., New York, N. Y. 10016. Price $9.95. 196 pages.

This introductory text is probably the industry's first book that is devoted entirely to the field of large-scale integration. The book, written in a readable style, is oriented to the user's point of view. It is specifically intended for management, marketing, field service, and technical people who are new to this field.

For the convenience of the reader who may not desire to read it in sequence, the book is divided into four sections, each containing chapters on related topics. The first section discusses device and technology aspects of LSI; the second section covers the systems aspects; the third section covers aspects of application, and the fourth section covers other topics related to LSI.

Circle 323 on Inquiry Card

NFPA Handbook of the National Electrical Code
By Frank Stetka, Published 1969 by McGraw-Hill Book Co., 330 W. 42nd St., New York, N.Y. 10036. Price $12.75. 694 pages.

Circle 324 on Inquiry Card

Electronic Devices and Circuits, Vol. II
By G. J. Pridham, Published 1969 by Pergamon Press Ltd., Headington Hill Hall, Oxford 4 & 5 Fitzroy Sq., London W. 1, England. Price $5.50. 345 pages.

Circle 325 on Inquiry Card

Matrix-Computer Methods in Engineering
By L. A. Pipes and S. A. Hovanessian. Published 1969 by John Wiley & Sons Inc., 605 Third Ave., New York, N.Y. 10016. Price $12.95. 333 pages.

Circle 326 on Inquiry Card

Semiconductor Silicon
Edited by Rolf R. Haberecht and Edward L. Kern. Published 1969 by The Electrochemical Society Inc., 30 E. 42nd St., New York, N.Y. 10017. Price $10.00. 766 pages.

Circle 327 on Inquiry Card

Transistor and Thyristor Diode Manual
Published by RCA Electronic Components Div., Harrison, N.J. 07029. Price $2.50. 656 pages.

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Formal Languages and their Relation to Automata
By John E. Hopcroft and Jerry D. Ullman. Published by Addison-Wesley Publishing Co., Reading, Mass. 01867. Price $11.95. 24 pages.

Circle 329 on Inquiry Card

The Supervisor in On-the-Job Training
By Martin M. Broadwell. Published 1969 by Addison-Wesley Publishing Co., Inc., Reading, Mass. 01867. Price $4.95. 132 pages.

Circle 330 on Inquiry Card

Understand and Using Unijunction Transistors
By Stu Hoberman. Published by Howard W. Sams & Co., Inc., Indianapolis, Indiana 46268. Price $2.50. 95 pages.

Circle 331 on Inquiry Card

Mixed up in mixers? Try an HCD

Hot-carrier diodes (HCDs) approach ideal Schottky-barrier junction operation. Such junctions virtually eliminate stored charge and extend the device's high-frequency performance.

By Aki Tanaka, Sr. Prod. Engr.,
and Suleyman Sir, Applic. Engr.,
Fairchild Semiconductor, Mountain View, Calif.

Hot-carrier diodes (HCDs) have a number of applications in many areas. Typical of such applications are: clamping, sampling, and gating circuits; logarithmic converters; limiters; discriminators; switches; detectors; and mixers. The largest customer today is the TV receiver manufacturer who uses the non-linear impedance of the HCD junction in mixers and detectors; and so this article concerns itself with HCD mixers. But before delving into the whys and wherefores, you should become familiar with the equivalent circuit model of the hot-carrier diode.

Figure 1 represents the HCD. You can use this figure, together with the diode equations

$$I = I_s\,(\epsilon^{qV/nkT} - 1) = I_s\,(\epsilon^{V/0.026} - 1)\,, \qquad (1)$$

to describe general HCD operation at low and moderate currents. In the diode equations,

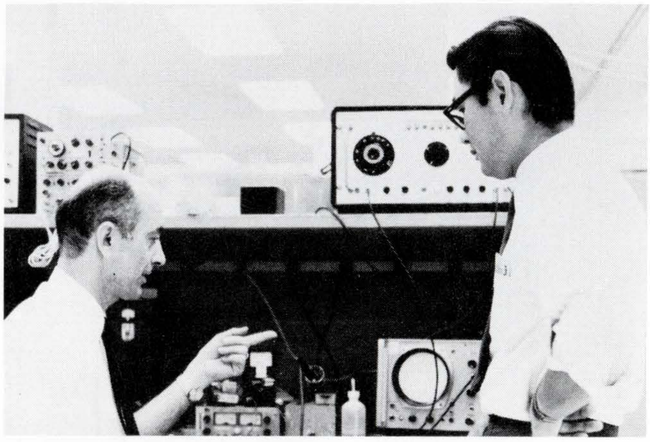
I_s = saturation current (about 50 nA for the Fairchild FH1100)
V = applied voltage
q = electronic charge, 1.6 x 10^{-19} coulombs
T = temperature, °K
k = Boltzmann's constant, 1.38 x 10^{-23} joules/°K
n = diode index, about 1.08 for the FH1100.

The diode index depends on the temperature, and on the currents generated in the trap sites at the metal-semiconductor interface. To round out the representation, and to show the HCD's superiority to the point-contact diode, Fig. 2 shows the current-voltage characteristics of both devices.

Junction parameters

Both the junction resistance, R_j, and the junction capacitance, C_j, are functions of the current through the diode. From the diode equation,

$$R_j = \frac{V}{I} = \frac{26}{I_s}\,\epsilon^{-V/0.026} = \frac{0.026}{I_d}, \qquad (2)$$



A team in action. Suleyman Sir, sitting at his test set-up in the applications lab, makes a point about a swept measurement to Aki Tanaka, of Diode Marketing.

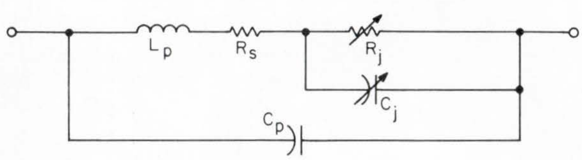


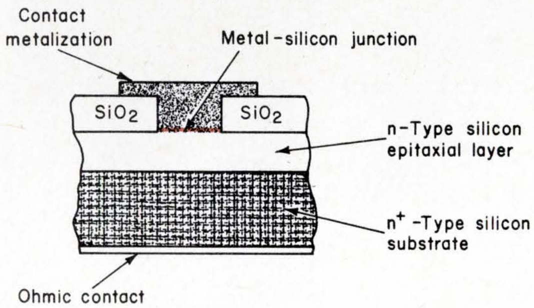
Fig. 1. Equivalent circuit model of a hot-carrier diode. The spreading resistance, R_s, and the junction resistance and capacitance, R_j and C_j, contribute to conversion loss, and thus are significant in determining noise figure. Improvements in processing technology continually reduce the magnitudes of the package parasitics, L_p and C_p.

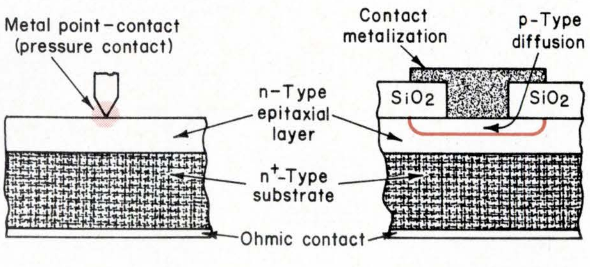
A hot-carrier diode (HCD) is a metal-to-semiconductor device with a single, non-linear (rectifying) junction. The theory of operation is based on work done by Schottky many years back. It is a majority-carrier conducting device—preferably of n-type semiconductor material with high-mobility electrons—with a virtual absence of minority carriers. This lack of minority carriers is a consequence of the Schottky barrier in the metal-semiconductor interface. Most devices of this sort are suitable for high-frequency and microwave applications, because they have very little stored charge.

The p-n junction diode cannot operate as high in frequency as can the HCD. For high-frequency applications, such as mixers and detectors, its long charge-storage time limits the usefulness of the p-n junction device. Further, in most applications it needs additional bias voltage because it has a higher ON-voltage than does the HCD. Mechanically, however, HCDs and p-n junction diodes are roughly equivalent to each other.

The point-contact diode is also inferior to the HCD, both electrically and mechanically. The HCD has the advantages of lower noise, higher conversion efficiency, larger square-law range, more uniform electrical performance, a higher breakdown voltage, a lower reverse current, and a better metal-silicon interface. And because the HCD is usually a planar epitaxial device, it can withstand larger energy pulses and higher power than can the point contact diode, and so is more reliable. Furthermore, the HCD surface is permanent, whereas the point-contact interface may change when subjected to mechanical disturbance. Although in theory both types operate as Schottky-barrier diodes, the HCD approaches the ideal more closely than does the point-contact diode. And this is the key to the HCD's superior microwave performance.

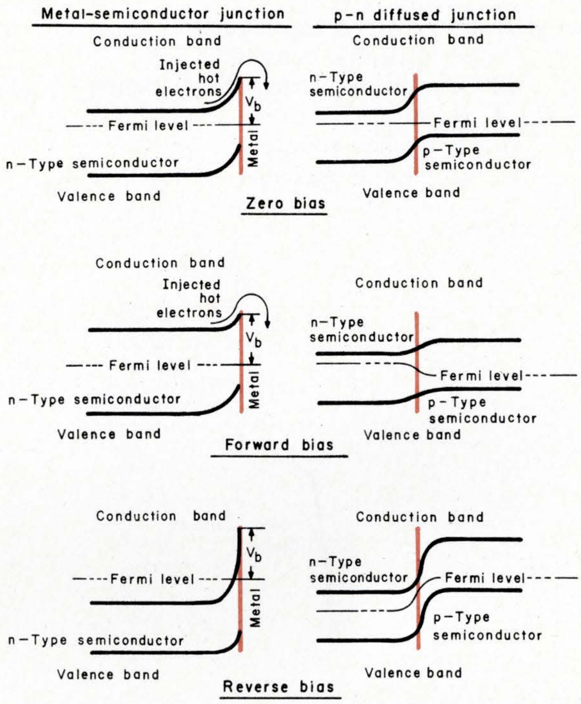
Compare HCD construction to that of the point-contact and p-n junction diodes, as represented in the sketches below. In particular, note how the metal-silicon junction of the HCD replaces the diffused junction of the p-n diode.





Point-contact p-n junction

Diode operation. Both the point-contact diode and the HCD operate on the Schottky-barrier principle, while the p-n diode has a diffused junction. You can see the difference in their operation by means of the following energy-level diagrams.



Forward biasing the HCD raises the energy of the electrons in the conduction band of the semiconductor material. They gain enough energy to overcome the barrier and inject themselves into the metal. See how, as forward bias increases, the barrier voltage decreases—the Schottky effect—and electrons flow freely into the metal. But reverse bias increases the barrier potential, so the electrons no longer have enough energy to inject themselves into the metal.

Note that the barrier potential as seen from the semiconductor side of the junction either increases or decreases with external bias. But the barrier potential as seen from the *metal* side of the junction is virtually unaffected by external bias—a phenomenon unique to metal-semiconductor junctions. And because the HCD's barrier potential is constant, independent of bias, electron flow from metal to semiconductor does not change. Thus, most of the current is due to electron flow from semiconductor to metal, while the minority-carrier current from metal to semiconductor is extremely small.

The p-n junction diode is another story. When you forward bias the junction, electrons diffuse across it into the p region. The carrier recombination rate limits the diffusion current. Now, when you apply reverse bias, electrons (minority carriers) flow back into the n region from the p region. These electrons—a stored charge—must be removed from the p region before the junction can operate normally again. This is the reason, mentioned earlier, that the HCD operates at a much higher frequency than the p-n junction diode: the HCD has very little stored charge under normal operating conditions.

where I_d is the instantaneous junction current in amperes, and R_j is in ohms.

The junction capacitance, C_j, is the depletion capacitance of the step junction.

$$C_j = \frac{C_j\,(0)}{\left[1 - \dfrac{V}{V_b}\right]^{1/2}} = \frac{\epsilon}{W}\,A, \qquad (3)$$

where $C_j(0)$ = zero-bias capacitance
ε = dielectric constant
W = width of space-charge region
A = junction area
V = applied voltage
V_b = built-in potential, about 0.45 eV.

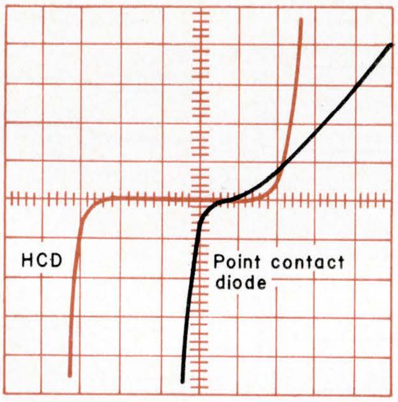


Fig. 2. A comparison of the forward and reverse dc curves of HCD and point-contact diodes clearly shows the superiority of the HCD. The forward characteristics in the first quadrant are scaled at 0.2 V/cm horizontal, 5 mA/cm vertical. The reverse characteristics in the third quadrant are scaled to 10 V/cm horizontal, 5 mA/cm vertical.

Mixing in brief

You can define a mixer as a device that converts a high frequency to a low frequency by means of a local oscillator (LO) and a non-linear element. The incoming rf and LO signals couple into the non-linear element, and the LO signal forces the non-linear element to become a time-varying, active network. Under such conditions, the non-linear diode element generates harmonics. These contain the sum and difference of the incoming signal and the local oscillator signal, as well as other harmonics. The difference between the incoming rf and the LO signals is filtered out as the i-f signal out of the mixer.

Point-contact diodes were the only devices used as mixers in uhf TV tuners until 1966, when hot-carrier diodes became available. The HCDs gained widespread acceptance because of these advantages over point-contact diodes:

- Almost perfect current-voltage characteristics
- Higher reverse-breakdown voltages allow high LO drive levels
- Higher burn-out energy
- A high-frequency performance not limited by minority-carrier lifetimes
- Lower noise figure
- Greater reliability
- Mechanical stability
- Uniformity in production.

Mastering the mixer

Two key parameters in the design of a mixer are noise figure and conversion loss, because they have a pronounced effect on the sensitivity of a receiver system. The overall noise figure of a receiver, as defined by Friss, is

$$NF_r = L\,(t_x + NF_{i-f} - 1) \qquad (4)$$

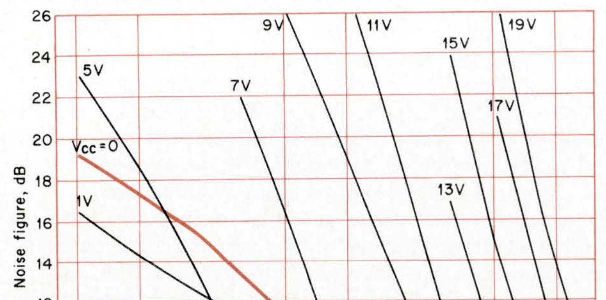


Fig. 3. Noise figure vs local oscillator drive level.

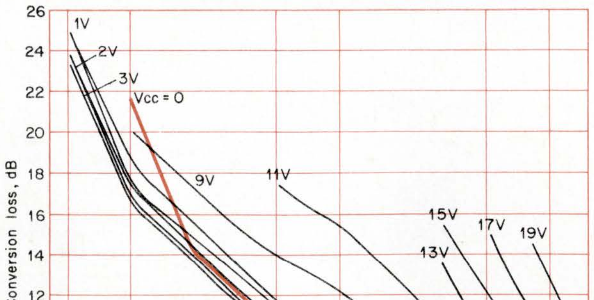


Fig. 4. Conversion loss vs local oscillator drive level.

where

NF_r = overall receiver-system noise figure

L = conversion loss

NF_{i-f} = i-f noise figure

$$t_x = \text{noise temperature of diode} = \bar{t}\left(1 - \frac{2}{L}\right) + \frac{2}{L}. \quad (5)$$

where $\bar{t}$ is the noise temperature that results from averaging the instantaneous values of diode noise as the LO power varies through one cycle. Any noise in the LO signal adds to $\bar{t}$.

Equation (4) applies to both broadband and narrowband systems. (To reduce LO radiation, by the way, uhf TV tuners are narrowband components.) Note that the values of t_x for broadband and narrowband systems are not the same.

To minimize the NF of any system, you must minimize the quantity ($\bar{t}_x + NF_{i\text{-}f} - 1$). Remember that t_x depends on the LO drive level (and LO noise), as well as the noise generated in the diode itself. You can decrease LO noise with filters; but diode noise—caused by the spreading resistance R_s and the barrier resistance R_j—is not affected by filters. Therefore, to minimize system noise, you must simultaneously consider LO drive level, R_s, R_j, conversion loss, and i-f amplifier noise figure.

At some LO drive level a small forward or reverse bias may help the noise figure, because R_j is bias-dependent. If you do use bias in a uhf TV tuner, you should pay special attention to the LO level. Because this level is not constant across the uhf band, the bias may have an inverse effect at the low or high end of the band. Remember also that in the higher forward-current regions the diode deviates from its exponential behavior, and the diode equation becomes

$$I = I_s \epsilon^{q(V - IR_s)/nkT} \quad (6)$$

Loss reduction

The overall conversion loss L of a mixer is the sum of three separate losses,

$$L = L_1 + L_2 + L_3 \quad (7)$$

where L_1 = conversion loss due to rf and i-f mismatches

L_2 = conversion loss due to R_j, R_s, *and* C_j

L_2 = conversion loss due to R_j, R_s, and C_j tion.

You can reduce L_1 with matching circuits and filters to decrease the VSWR at the rf and i-f ports.

The conversion loss in the junction, L_3, depends on the diode's forward and reverse characteristics. You can calculate L_3 if you know the current-voltage characteristics, operating bias condition, LO drive level, and the mixed frequency.

The loss L_2 is a signal loss due to R_s, R_j, and C_j:

$$L_2 = 10 \log \left(1 + \frac{R_s}{R_j} + \omega^2 C_j^2 R_s R_j\right). \quad (8)$$

The R_s/R_j term comes from the power loss in the spreading resistance R_s; the $\omega^2 C^2_j R_s R_j$ term, from the power dissipated in R_s because of the shunt path through C_j. You can vary R_j, because its value depends on the LO drive level or the bias used in combination with the LO. When $R_s/R_j = \omega^2 C^2_j R_s R_j$, maximum power transfers to the diode junction, $R_j = 1/\omega C_j$,

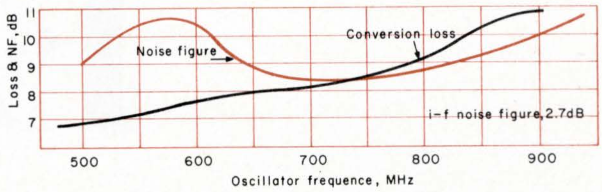


Fig. 5. Conversion loss and noise figure for an experimental uhf TV tuner working into an i-f amplifier system with a 2.7-dB noise figure. The LO is a Fairchild SE3005.

and the signal loss is

$$L_2 = 10 \log (1 + 2\omega\, C_j R_s). \quad (9)$$

Both R_s and C_j depend on the carrier density N, and the carrier mobility b:

$$R_s = \frac{1}{(4\,ANqb)}, \quad (10)$$

$$C_j = \frac{\pi A^2 \sqrt{\epsilon q N}}{2\sqrt{\phi - V}}, \quad (11)$$

where ε is the dielectric constant, A is the radius of the contact, and ϕ is the barrier height. Combining the two equations shows you that the product $R_s C_j$ is proportional to A. Thus, for a fixed value of A, you may set either R_s or C_j (but not both) to its optimum value for conversion loss reduction. If the operating frequency is high, set C_j. If the operating frequency is low, set R_s.

Like noise figure, conversion loss depends on LO level, spreading and barrier resistances, junction capacitance, and rf/i-f matching conditions. If the LO drive level is low, with zero bias, then conversion loss is strongly dependent on R_j, which in turn is a function of LO drive level. As the LO level increases, both R_j and conversion loss decrease. At some point, $R_j = R_s$ and conversion loss is at a minimum. If you further increase the LO level, R_s becomes significant (because it dissipates more power) and conversion loss increases.

What the future holds

As the processing technology improves, the HCD will become even more effective and useful than it is today. The parameters most likely to improve are V_F, I_R, parasitic L and C, and the square-law current-voltage characteristics. Because of large-scale production (made feasible by batch wafer processing) and competitive pricing, it is now economical for you to design HCDs into a system.

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INFORMATION RETRIEVAL:
Semiconductors, Microwave semiconductors, Microwaves and microwave products, Circuit design

Equal

Gates

DM8000N (SN7400N)	Quad 2-Input NAND gate
DM8001N (SN7401N)	Quad 2-Input NAND gate (Open Collector)
DM8002N (SN7402N)	Quad 2-Input NOR gate
DM8003N (SN7403N)	Quad 2-Input NAND gate (Open Collector)
DM8004N (SN7404N)	Hex inverter
DM8010N (SN7410N)	Triple 3-Input NAND gate
DM8020N (SN7420N)	Dual 4-Input NAND gate
DM8030N (SN7430N)	Eight-Input NAND gate
DM8040N (SN7440N)	Dual 4-Input buffer
DM8050N (SN7450N)	Expandable Dual 2-Wide, 2-Input AND-OR-INVERT gate
DM8051N (SN7451N)	Dual 2-Wide, 2-Input AND-OR-INVERT gate
DM8053N (SN7453N)	Expandable 4-Wide, 2-Input AND-OR-INVERT gate
DM8054N (SN7454N)	Four-Wide, 2-Input AND-OR-INVERT gate
DM8060N (SN7460N)	Dual 4-Input expander
DM8086N (SN7486N)	Quad Exclusive-OR-gate

Flip Flops

DM8540N (SN7472N)	MASTER-SLAVE J-K flip flop
DM8501N (SN7473N)	Dual J-K MASTER-SLAVE flip flop
DM8500N (SN7476N)	Dual J-K MASTER-SLAVE flip flop
DM8510N (SN7474N)	Dual D flip flop

Counters

DM8530N (SN7490N)	Decade counter
DM8532N (SN7492N)	Divide-by-twelve counter
DM8533N (SN7493N)	Four-bit binary counter
DM8560N (SN74192N)	Up-down decade counter
DM8563N (SN74193N)	Up-down binary counter

Decoders

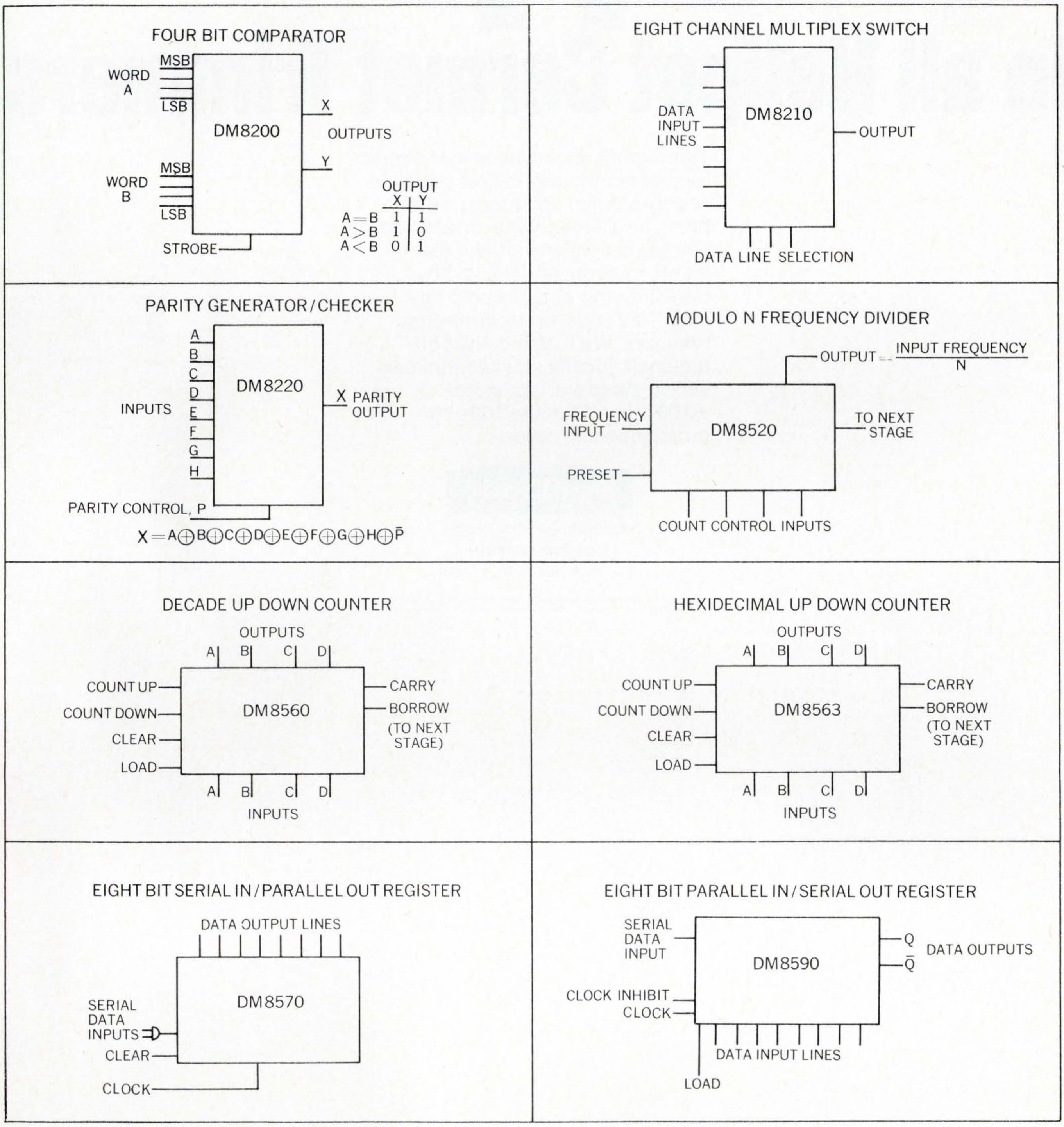
DM8840N (SN7441AN)	BCD to decimal nixie driver
DM8842N (SN7442N)	BCD to decimal decoder

Miscellaneous

DM8550N (SN7475N)	Quad latch

Spec-for-spec. Pin-for-pin. Second source on all popular 74N.

Opportunity



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Here's how you voted

The winning Idea for the May 1969 issue is, "Zero-beat detector."

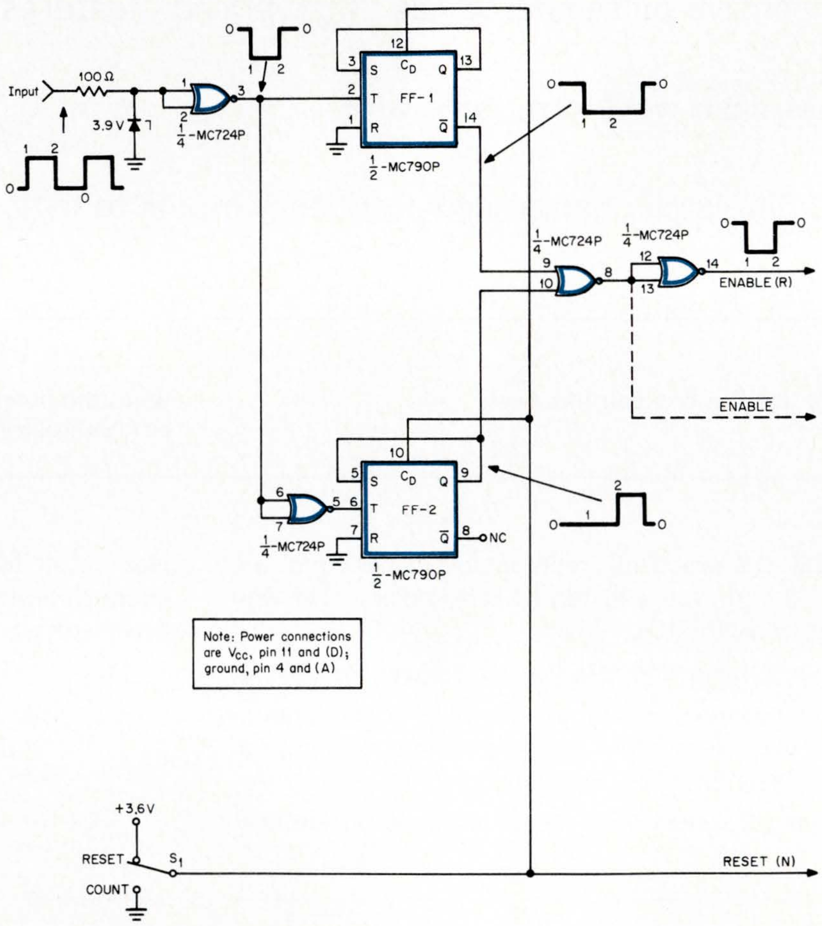
Our winning author is Tim K. Aaltonen, who puts his test equipment design background to good use as president of ARZ Associates, a consulting firm located in New Rochelle, N. Y. Mr. Aaltonen chose a Triplett 600 TVO meter.

960 A pulse-width measure, sample-and-hold circuit

David L. Sporre
Electronix Products, Westport, Conn.

This circuit measures the total width of a single pulse in a train of identical pulses. An electronic counter displays the measurement.

The only components external to the IC packages are a switch to start the count, and a resistor and Zener diode to protect the input gate from overvoltages. Both ICs are Motorola devices: an MC724P positive-logic, quad 2-input NOR gate; and an MC790P dual J-K flip-flop.



Flip-flops 1 and 2 stay CLEARED as long as S_1 is in its RESET position. To measure a pulse, put S_1 in its LOW, or COUNT, position (ground). This lets a positive-going, leading edge on the input signal toggle FF-1, because this flip-flop was previously CLEARED and its S and R inputs are LOW.

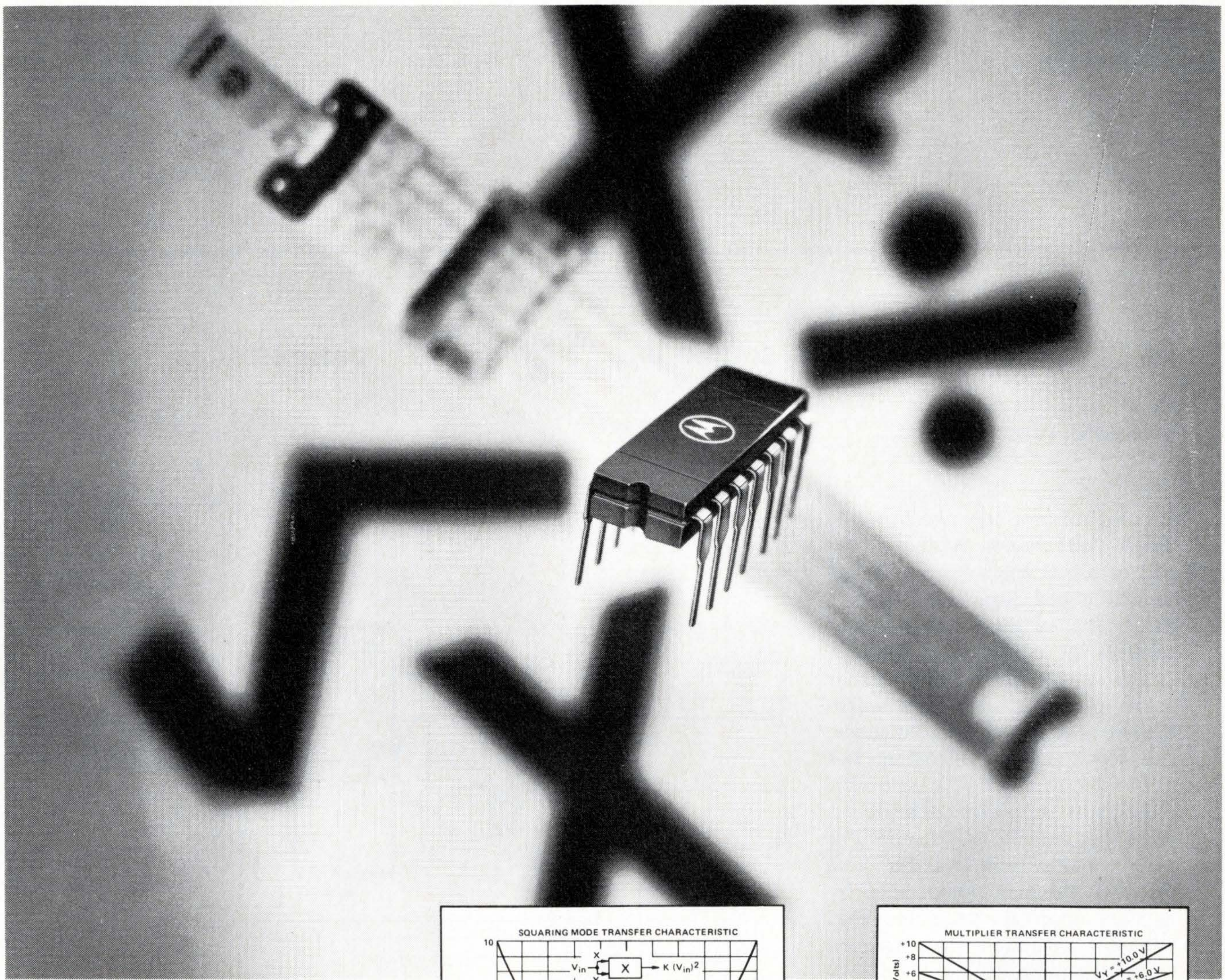
When FF-1 toggles, its $\overline{Q}$ output goes LOW. (The second flip-flop, FF-2, does not toggle and stays in its original CLEARED state.) With FF-1's $\overline{Q}$ output LOW, the circuit's ENABLE output is also LOW and the counter starts its count.

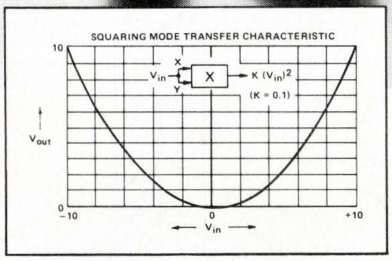
The negative-going edge at the end of the input pulse toggles FF-2, but not FF-1 which was locked-up after the first transition of its Q output to a HIGH. With FF-2's Q output HIGH, the circuit's ENABLE output is also HIGH, and the counter stops its count.

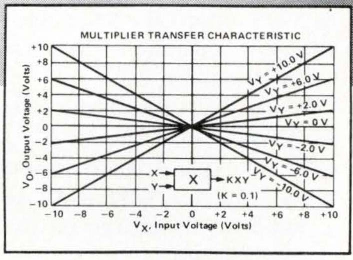
After FF-2 toggles, it too locks up: the circuit counts the width of one pulse, and then stops. To count another pulse, you must RESET the circuit with S_1.

With this circuit, you can measure positive pulses as narrow as one microsecond. It is designed for use with a Monsanto Model 100A, which counts when its ENABLE input is LOW. The parenthetical letters *N* and *R*, on the RESET and ENABLE lines, are pin designations on the Monsanto counter.

Other counters start to count upon receipt of a HIGH, and terminate on a LOW. For these, you can use the circuit's ENABLE output, shown as a dashed line on the diagram.





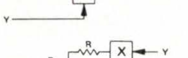


MC1595 is the industry's first true Linear, 4-Quadrant Multiplier IC.

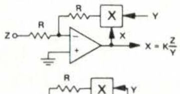
Here is the first element in what promises to be a large family of monolithic, linear multipliers. The MC1595 is designed for uses where the output voltage is a linear product of two input voltages; and, as such, its list of applications is almost limitless, particularly in the control and instrumentation fields.

For example, some of the applications are:

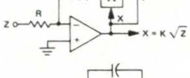
- To Multiply



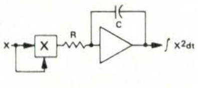
- To Divide



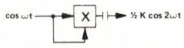
- To Find Square Root



- To Determine Mean-Square



- Frequency Doubling



The MC1595 can also be used as a Balanced Modulator/Demodulator, and for Electronic Gain Control among many others. It even has the capability for determining true rms; plus direct power caluculations.

Here are some of the features that contribute to the wide versatility of the MC1595:

- Excellent Linearity — 1% max error "X" input; 2% error max "Y" input.
- Wide Bandwidth—Phase Error ≤3° from DC to 750 kHz.
- Adjustable Scale Factor.
- Large Input Voltage Range ±10 V.

The MC1595 Multiplier is currently available from distributor stock in the 14-pin dual in-line ceramic package. So is its 0 to 70° temperature-range counterpart, the MC-1495. For complete information, including a just-published Application Note, circle the reader service number, or write: P. O. Box 20912, Phoenix, Arizona 85036.

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961 Inexpensive pulse source has "high-priced" features

Thomas M. Farr, Jr.
T.M.F. Electronics, N. Palm Beach, Fla.

Although it uses only two Fairchild TTμL 9601 one-shots, this circuit will be useful whenever you design or test digital logic. One IC is a PERIOD/DELAY generator, the other controls the output pulse width.

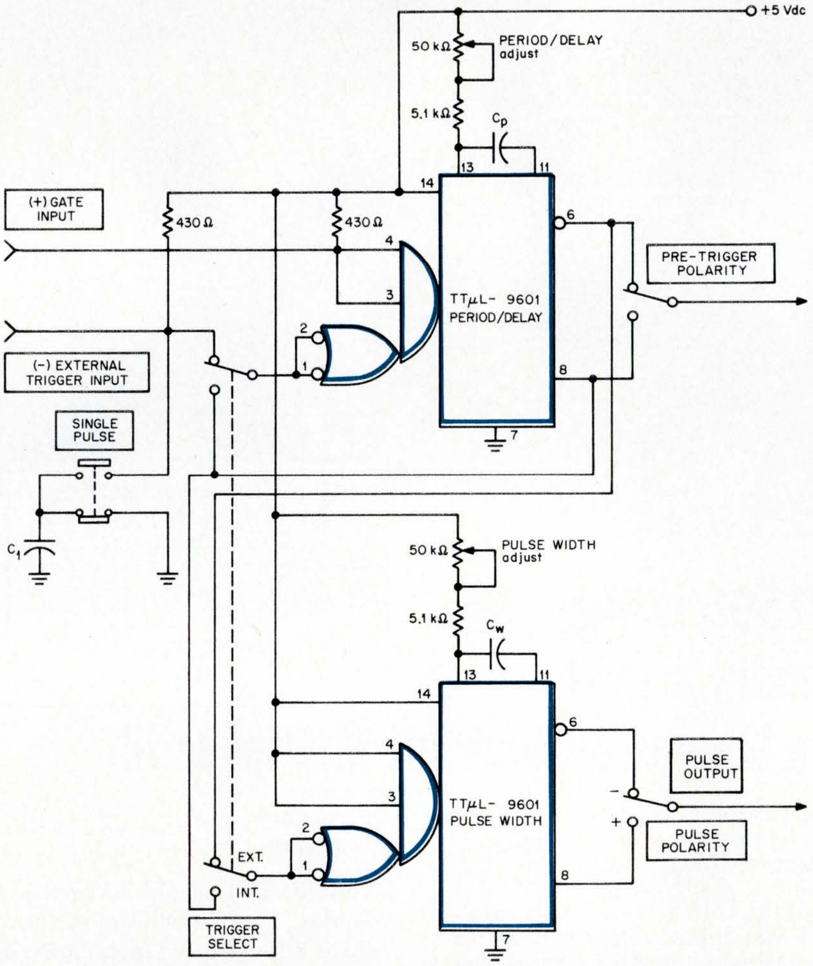
The PERIOD/DELAY one-shot runs as an oscillator when you switch the circuit to its INT. TRIGGER mode. For EXT. TRIGGER operation, this one-shot runs as a DELAY generator.

There is a PRE-TRIGGER output pulse that is about 30-ns wide. For INT. TRIGGER operation, this pulse precedes the main output pulse by a 30-ns interval, while for EXT. TRIGGER operation its duration equals the pulse delay.

When you operate the circuit in its SINGLE-PULSE mode, C_1 eliminates multiple triggers caused by contact bounce. Choose C_1 so that it dissipates its charge on the first contact closure.

The GATE INPUT gives you output bursts in the INT. TRIGGER mode, while in the EXT. TRIGGER mode it simply gates the triggers through to the PERIOD/DELAY one-shot.

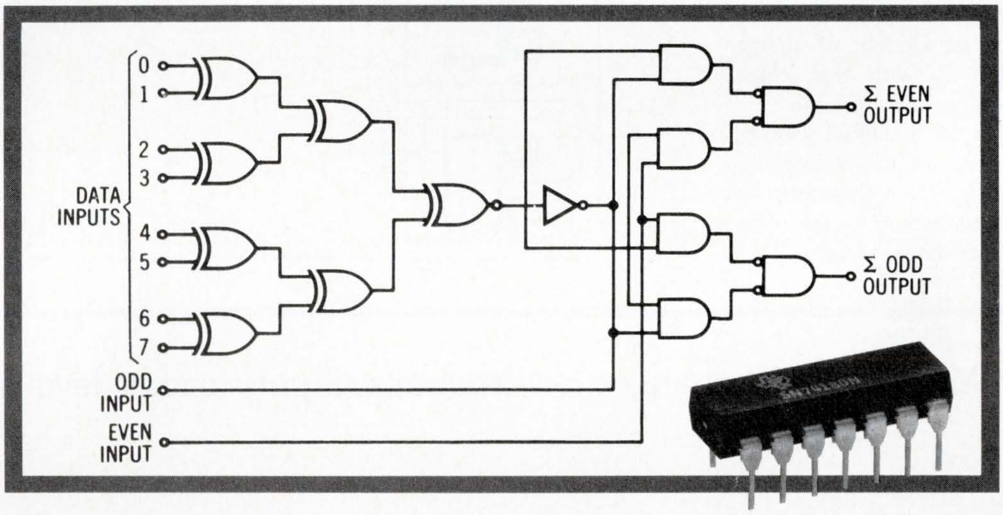
Trailing (negative-going) edges from the PERIOD/DELAY one-shot trigger the PULSE WIDTH one-shot, and timing considerations are the same in both sections. That is, both PERIOD/DELAY and WIDTH are about $0.36RC$, where C is either C_P or C_W as shown on the schematic. You can go down to 70 ns for both PERIOD/DELAY and WIDTH, while their maximum values are set by the quality of the timing capacitors, leakages, and so forth.



Because the 9601s are retriggerable, there are no duty-cycle limitations. Output levels are compatible with DTL/TTL logic. For other logic types, you must add suitable interface elements to the circuit's inputs and outputs, as needed.

The Choice is TTL.

TI introduces an MSI parity generator/checker which has no equal.



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TI's new SN54180/SN74180 MSI circuits generate ODD/EVEN parity for 8-bit words in only 32 nanoseconds. For longer word lengths, each additional 8-bits requires a mere 10 ns. Thus, parity for a 16-bit word is accomplished in a quick 42 ns.

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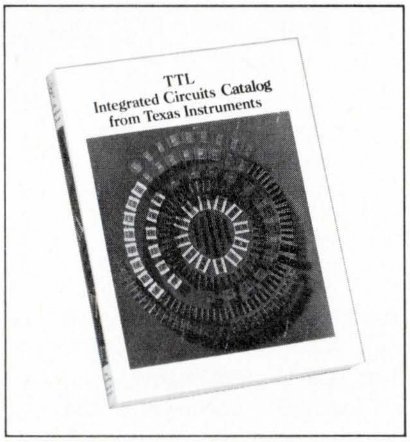

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TEXAS INSTRUMENTS
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962 A staircase waveform generator

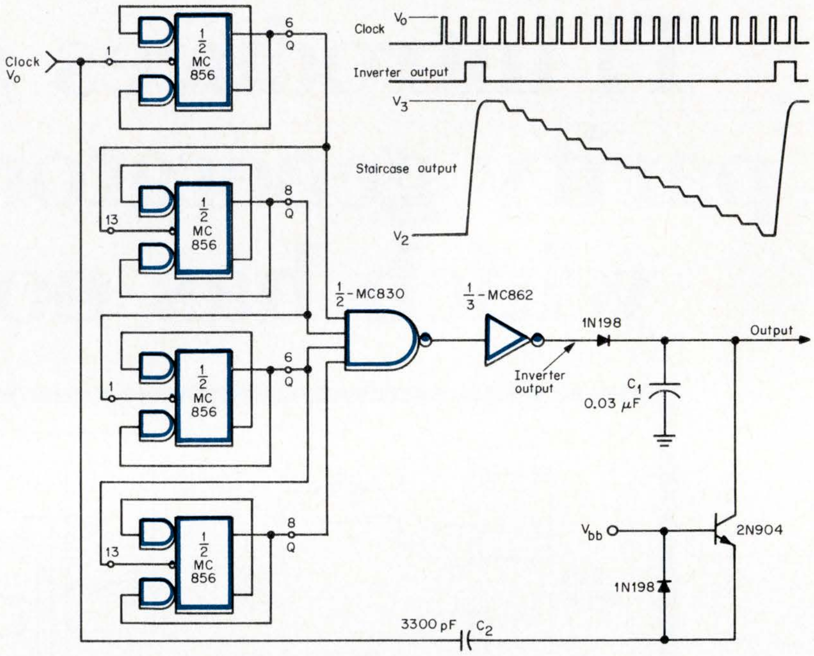
Jim W. Foltz
Motorola Semiconductor Prod., Phoenix, Ariz.

A staircase generator is useful for time-amplitude coding applications, and you can build such a device with the circuit shown here.

Two Motorola MC856, dual J-K flip-flops form a four-stage counter. The outputs of this counter feed a four-input NAND gate, which gives a negative pulse equal in width to the clock period, and occurring every 16th clock pulse.

The MC862 inverter thus supplies a positive charging pulse to C_1. But the clock input, applied to C_2, removes an amount of charge (C_2V_0) from C_1 with each clock pulse, generating the staircase.

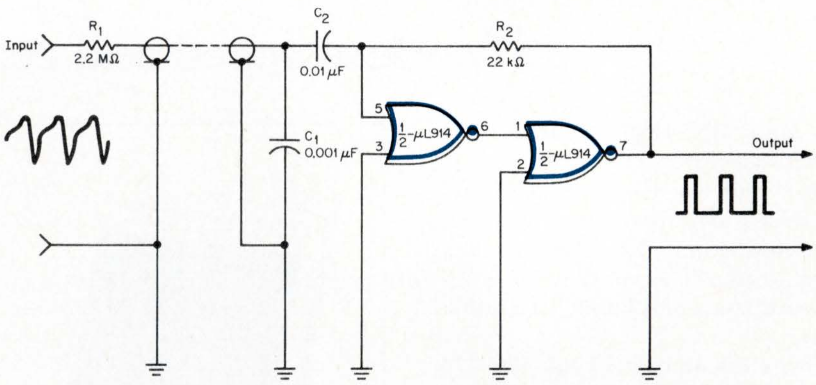
You adjust the threshold voltage, V_2, and the step amplitude by varying the ratio C_1/C_2. The number of counter stages determines the number of steps in the waveform.



963 Modified latch changes low-frequency inputs to logic level signals

Edward B. Beach
National Radio Inst., Wash., D. C.

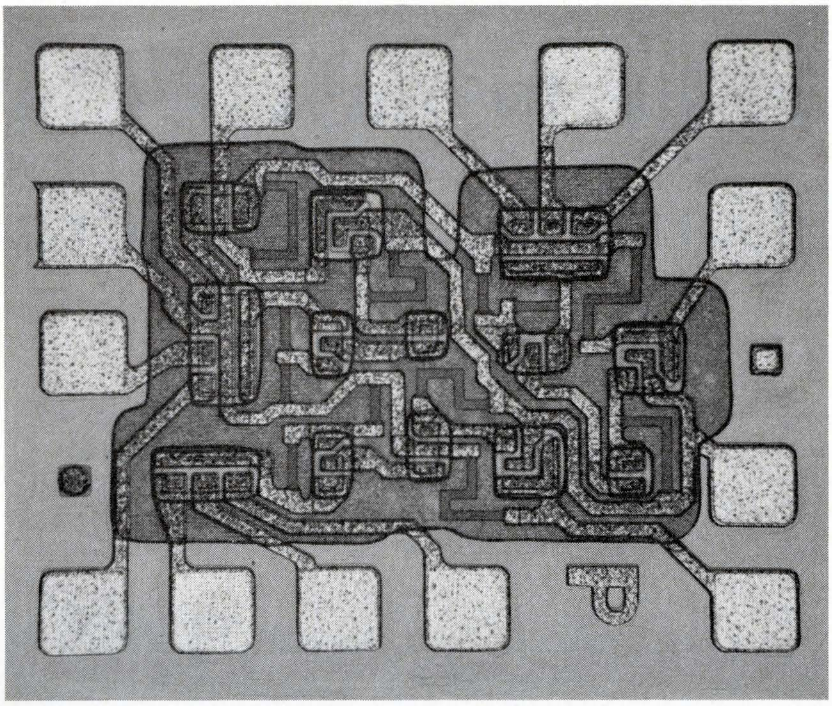
In the development of an electronic shutter to make still photographs from a TV receiver screen, a need arose for a 60-Hz pulse to trigger the shutter's RTL timing circuit. This pulse had to come from the TV's deflection circuits, which implied a high-impedance, noisy, signal source. Because the RTL J-K flip-flops in the shutter needed a jitter- and noise-free, fast-fall pulse, we could not use a conventional Schmitt trigger or cascaded gates.



The solution to the problem was to use a Fairchild μL914 connected as shown here (DTL or TTL should work equally well). The two gates are a modified R-S flip-flop in which R_2 lets the signal from C_2 SET and CLEAR the flip-flop. The value of R_2 depends upon the input signal level and the sensitivity of the input gate. In the original circuit, $R_2 = 22\ k\Omega$ was satisfactory with a 5-V pk-pk signal across C_1.

The cable capacitance and C_1, together with R_1, form a low-pass filter that eliminates horizontal pulses and other noise. Resistor R_1 reduces the circuit loading at the point of connection (a vertical-oscillator grid), as well.

If the input signal is a changing dc level, you will be able either to eliminate C_2 or to shunt it with a resistor. The rise- and falltimes of the output pulse depend upon the type of gate used.



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- DTL dual 4-input buffer with expander
- DTL dual 4-input power gate with expander
- DTL RS/JK master-slave clocked flip-flop
- DTL triple 3-input gate
- Dual level shifter
- 709-type operational amplifier

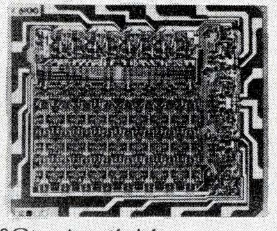
For a copy of a recent technical paper, "Design Considerations for Radiation-Hardened Digital Circuits," write Joe Standeven, Bipolar Products Marketing, **Microelectronics Division, Philco-Ford Corporation,** Blue Bell, Pa. 19422.

the better idea people in bipolar IC's

PHILCO Ford

to help you remember.

Anyone with half an eye can see the bright future of the semiconductor memory business. And for months Raytheon's been deploying to nab a lion's slice of that action. We herded up all the processing niceties of our high-rel military components. All the 10th-mil-tolerance magic of our Ray III TTL. All our way-out beam-lead technologies. And now we're in the business.



Leading off with our spanking new 64 bit bipolar RAM. We guarantee a 45 nanosecond read time, but it usually coughs up a word in under 35 ns. And the entire chip, including on-chip address decoding, write and sense circuitry, perks along on only 350 mW. Cost per 100-999 is $51.50 (—55° to +125°C version) and $38.00 (0° to +70°C). Available now, off distributors shelves, in a 16-lead DIP. Flatpacks coming up.

What else? Before the end of the year, look for beam-lead 256-bit and 512-bit multi-chip arrays in 24 pin DIP packages.

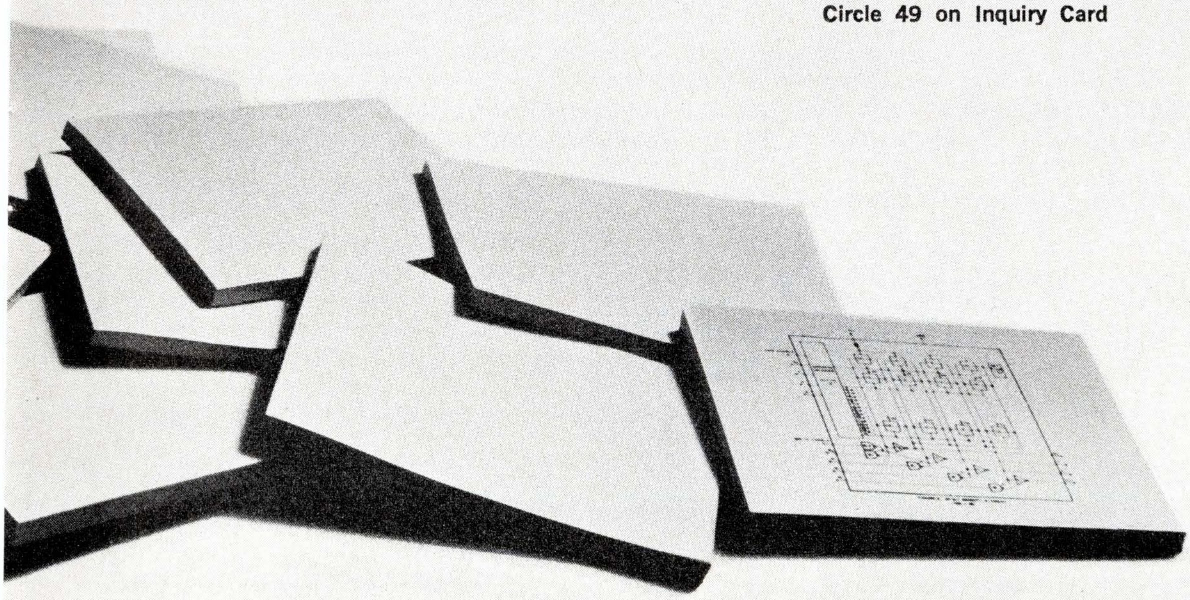
And by next June, a monolithic beam-lead 256-bit bipolar scratch pad in a 16-pin DIP. With super-quick access times, thanks to far tighter tolerances and new cell designs. Plus Shottky barrier diodes, washed emitters and like that.

Then in 1970 we'll be unveiling a line of IC read-only memories. And after that it's just a little time until we're mainly in the mainframe memory business.

All of which proves you better keep us in mind when you're in the memory market. The company that gets the ideas and delivers the goods. Raytheon Semiconductor, Mountain View, California. (415) 968-9211.

RAYTHEON

Circle 49 on Inquiry Card



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BUT YOU ONLY NEED ONE...AT $44^00 THAT'S A BARGAIN

MODEL 310
World's Largest Selling
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1. HAND SIZE V-O-M WITH PROVISION FOR ATTACHING AC CLAMP-ON AMMETER.
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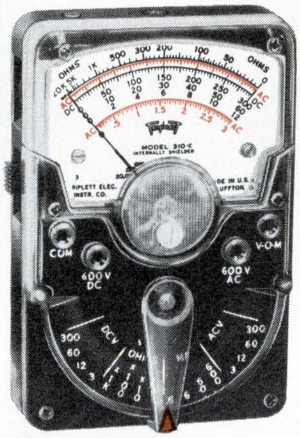

MODEL 310-C
Volt-Ohm-Milliammeter

310-C PLUS FEATURES

1. Hand size V-O-M with provision for attaching AC Clamp-on Ammeter.
2. 15,000 OHMS per volt AC sensitivity; (20,000 DC same as 310).
3. Single fully enclosed Lever Range Switch, plus DC Polarity Reversing.

MODELS 100 AND 100-C

Comprehensive test sets. Model 100 includes: Model 310 V-O-M, Model 10 Clamp-on Ammeter Adapter; Model 101 Line Separator; Model 379 Leather Case; Model 311 leads. ($83.20 Value Separate Unit Purchase Price.)

MODEL 100 — U.S.A. User Net **$78.00**

MODEL 100-C — Same as above, but with Model 310-C, Net **$88.00**

SELF-SHIELDED Bar-Ring instrument; permits checking in strong magnetic fields. FITTING INTERCHANGEABLE test prod tip into top of tester makes it the common probe, thereby freeing one hand. UNBREAKABLE plastic meter window. BANANA-TYPE JACKS—positive connection and long life.

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ABSTRACTS

Feature article abstracts

Published information is vital to your job. To save time in finding this information, we have abstracted the important technical features from eight electronic engineering publications. Should any of these articles interest you, contact the magazine—names and addresses are listed below. Reprints of articles with an asterisk are available free. Save this section for future reference.

Circuits

Popular SCR and triac circuits, Gene Cavanaugh, James Garrett and Max Schreiner, Texas Instruments, "EEE," Vol. 17, No. 8, August 1969, pp. 84-88. As the title suggests, this article reviews some popular applications—four for SCRs and two for triacs—to circuits such as speed controls (half and full wave), dimmers, and temperature controls.

Designing with power SCRs, David Cooper, International Rectifier, "EEE," Vol. 17, No. 8, August 1969, pp. 77-83. This article describes three applications of power SCRs. One is a very important application, explained in detail—a modified McMurray-Bedford force commutation inverter that can vary the output frequency. The other two are mentioned more briefly, a dc-to-dc converter (from 1500 V to 37.5/75 V) and a frequency multiplier (for induction heating).

Circuit Design

Design Attenuator Pads the Easy Way, Bill E. Johnson, Pacific Northwest Telephone Co., "Electronic Design," Vol. 17, No. 16, Aug. 2, 1969, pp. 90-94. A BASIC program is provided that takes the input and output impedances the pad works into, and the desired voltage or current loss, and provides impedances and losses for six types of attenuation networks.

Delay lines stretch squeezed information, Ed. M. Drogin and Abe E Ruvin, AIL, "EDN," Vol. 14, No. 16, Aug. 15, 1969, pp. 95-99. The authors show how to convert short bursts of wideband data to long bursts of narrowband data. The time-bandwidth product stays constant; the burst-time increases and the bandwidth decreases by the same factor. The method uses delay lines to recirculate the data, and the same hardware can recompress the information after processing. An example is given of a system designed to convert 200-μs bursts of i-f information with a bandwidth of 2.5 MHz, into a video output of 2000-μs duration and a 125-kHz cutoff frequency.

Determine Inverter Risetime Quickly, James J. Kubinec, Computer Microtechnology, Inc., "Electronic Design," Vol. 17, No. 16, Aug. 2, 1969, pp. 74-81. A design nomograph with instructions and examples is provided so that difficult analytical predictions of inverter performance or direct breadboard measurements can be avoided at the design stage.

Communications

An introduction to synthetic-aperture radar, William M. Brown, and Leonard J. Porcello, University of Michigan, "IEEE Spectrum," Vol. 6, No. 9, September 1969, pp. 52-62. To acquire good resolution from side looking radar, the beam should be made more narrow or the frequency increased. For many reasons neither of these are desirable. The method described here makes use of optical techniques to process and decipher the data, based on frequency shift of the signal return.

Components

Resistors—thick and thin, Thomas B. Stephenson, Los Angeles Regional Editor, "EDN," Vol. 14, No. 16, Aug. 15, 1969, pp. 85-92. The author, in a brief introduction, states that the controversy over thick-film vs thin-film resistors and resistor networks is a waste of time, because the choice between the two types of films must be based on a finite number of known factors. Such factors, themselves, resolve the choice of thick- or thin-films. A comparison chart gives major electrical and mechanical parameters for both thick- and thin-film resistors. The bulk of the article consists of comments, from several film houses, pro and con thick-film vs thin-film resistive devices.

Magnetic bubbles—a technology in the making, Harry R. Karp, Bell Labs, "Electronics," Vol. 42, No. 18, Sept. 1, 1969, pp. 83-87. Bell Labs is doing work in the area of very thin magnetic materials where magnetic spots can be moved around in the material. The magnetic "bubbles" could be used in low cost, high density shift registers, which of course are a memory. More work is still required to perfect such devices.

Cat's eyes for the military, Alfred Rosenblatt, "Electronics," Vol. 42, No. 18, Sept. 1, 1969, pp. 64-73. Low-light-level TV has not solved the military's night vision problem. The prime problem is lack of good tubes. Silicon vidicon units may lead to better night time vision. Silicon units are now getting into production.

Magazine publishers and their addresses

EDN
Cahners Publishing Company
3375 S. Bannock Street
Englewood, Colo. 80110

EEE
Mactier Publishing Co.
820 Second Avenue
New York, N. Y. 10017

Electronic Design
Hayden Publishing Co.
850 Third Avenue
New York, N. Y. 10022

Electronic Products
United Technical Publications
645 Stewart Avenue
Garden City, N. Y. 11530

Electronics
McGraw-Hill, Inc.
330 W. 42nd Stıeet
New York, N. Y. 10036

Electro-Technology
Industrial Research Inc.
Industrial Research Bldg.
Beverly Shores, Ind. 46301

IEEE Spectrum
Institute of Electrical & Electronics Engineers
345 East 47th Street
New York, N. Y. 10017

The Electronic Engineer
Chilton Company
56th & Chestnut Streets
Philadelphia, Pa. 19139

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ABSTRACTS

Integrated Circuits

The art of building LSIs, Herschel T. Hochman, Honeywell Inc, "IEEE Spectrum," Vol. 6, No. 9, September 1969, pp. 29-36. Once the proper application of the interrelated factors of design, fabrication, and testing are recognized, large scale IC yields should be possible. The author discusses LSI production problems and ideas for increasing IC yields.

A logical approach to testing ICs, Joseph Brauer, Electronic Products, Vol. 12 No. 3, August, 1969, pp. 140-149. The approach to IC testing described in this article was developed at the Rome Air Development Center in Rome, N. Y. In addition, the article goes into the question of costs and delves into the problem of 100% testing vs sampling.

Semiconductors

***Mixed up in mixers? Try an HCD,** Aki Tanaka and Suleyman Sir, Fairchild Semiconductor, "The Electronic Engineer," Vol. 28, No. 10, Oct. 1969, pp. 68-71. Hot-carrier diodes have been around for some time, usually applied as mixers or detectors for uhf TV tuners. In such an application, they change the incoming uhf signals (470 to 890 MHz) to a lower frequency for TV receivers. But the hot-carrier diode can aspire to many other applications outside the TV field. This article outlines the construction, operation, and applications of hot-carrier diodes.

Triac methods of control, L. J. Reed, Motorola Semiconductor, "EEE", Vol. 17, No. 8, August 1969, pp. 66, 67. A short article that describes how triacs are constructed, how they conduct in either direction, and the four possible triggering modes resulting from the combination of polarities of terminal voltage and gate current. The article touches also upon phase control and zero-point switching (which reduces noise).

Transient suppression with a power zener diode, William Walters, Electronic Products, Vol. 12 No. 3, August, 1969, pp. 82-87. Essentially a product application story on the Motorola MPZ-5 line of power zener diodes, this article describes a way to use power zeners for transient suppression.

Designing with triacs, L. J. Reed, Motorola Semiconductor, "EEE," Vol. 17, No. 8, August 1969, pp. 68-76. Starting with the classical light dimmer, the author adds a not-so classical dimmer (with soft turn-on) plus eleven more applications of triacs. The article is actually a description of these applications, rather than a design guide, but the applications are useful.

Special report on zener diodes, Robert C. Drew, Electronic Products, Vol. 12 No. 3, August, 1969, pp. 74-81. This report discusses zeners as chips, discretes, and integrated circuit elements from the standpoint of the user. Manufacturing techniques are also discussed as are the advantages and disadvantages of various configurations such as chips, LIDs, and beam-leads. The article includes helpful specifying information on such topics as plastic vs glass encapsulation, temperature compensation, power ratings, areas of application and costs.

Test and Measurement

***A critical look at DVM specs,** Ken Jessen, Hewlett-Packard Co., "The Electronic Engineer," Vol. 28, No. 10, Oct. 1969, pp. 46-52. The price of laboratory-type digital voltmeters (DVMs) goes up, in general, with the number of digits the DVM displays. But the user pays for more than just digits. He pays for accuracy, stability, sensitivity, resolution, noise rejection, and many other factors. Unfortunately, however, there are no industry-wide specifications. In this article, a representative of one of the leading manufacturers of DVMs defines the technical meanings of the specifications used by various manufacturers.

Sorting IC's economically, Robert A. Hughes and W. Blaine Belecki, Digital Equip. Corp., "Electronics," Vol. 42, No. 18, Sept. 1, 1969, pp. 74-77. It's no secret that ICs must be tested as economically as possible. This is a requirement of any testing. This article describes a tester and program which will test 2500 ICs per hour, executing static, dynamic and burst tests. The tester is actually a computer that can be activated to test a specific device by simply typing in the type device's type number.

LSI Testing is a Large-scale Headache! Elizabeth deAtley, West Coast Editor, "Electronic Design," Vol. 17, No. 16, Aug. 2, 1969, pp. 24-34. This article covers the serious problem of testing LSIs. Complete testing is impossible, so reasonable testing is done to find most faults. Facets such as dynamic testing, race conditions, strobed outputs, propagation delays, and single shot testing are covered.

Memory testing is a task that comes in layers, Leonard Kedson and Alan M. Stoughton, Computer Test Corp., **Computer for core tests,** William R. Blatchley, Computer Test Corp., **Exercising memory systems with worst-case bit patterns,** Charles R. Elles, Computer Test Corp., and Elwood A. Dance, Scientific Measurement Systems, Inc., **Boosting plated-wire yield: which knob to adjust?** Gary Chernow, Computer Test Corp., "Electronics," Vol. 42, No. 18, Sept. 1, 1969, pp. 88-96. This is actually four articles in one with each portion written by different authors. Complex, multi-layer memories must be tested in segments and then tested for their inter-action and operation with each other section and/or layer. These tests are more complex than they initially appear. The authors explain some of the problems and give indications of testing methods.

Miscellaneous

Forum on Interconnection—Part 3: Wire and cable, Staff Report, Electronic Products, Vol. 12 No. 3, August, 1969, pp. 20-29. Fifteen members of industry representing both users and producers of wire and cable, join in a round-table give-and-take to wrestle with the problems of vendors and customers. Insulation materials, the growing use of aluminum, flat cable, fine computer wire, and coaxial cable are among the topics under discussion. The participants also give their views on the future of the industry.

Diary of a leadership trainee, Richard Turmail, Management & Careers Editor, "Electronic Design," Vol. 17, No. 15, July 19, 1969, pp. 96-103. In this first of a two-part series, the author gives a frank diary account of his experiences and emotions while attending a workshop for the development of the business personality, or sensitivity training. The article provides an insight into the mechanics of this popular process. Value judgments are promised in part two.

***Can management give engineers what they really want?** Arthur D. Kellner, International Telephone & Telegraph, "The Electronic Engineer," Vol. 28, No. 10, Oct. 1969, pp. 34-37. Are engineers happy only as long as they stay in engineering? Or do all of them prefer to work their way into management? What does management think of this? The points that the author makes are equally applicable to engineers of all specialities. But they are of particular importance to electronic engineers in view of the high mobility of electronic companies, and the rather high number of new companies that start in the electronics field.

The CRT in phototypesetting systems, R. J. Klensch, E. D. Simshauser, RCA Corp., "IEEE Spectrum," Vol. 6, No. 9, September 1969, pp. 75-80. Typesetting via a cathode ray tube can be fast and flexible for photo-offset printing. And this is possible if certain guidelines are followed. These guidelines and criteria are discussed here by the authors.

Vibrating varifocal mirrors for 3-D imaging, Eric G. Rawson, Bell Labs, Inc., "IEEE Spectrum," Vol. 6, No. 9, September 1969, pp. 37-43. There has been a need for a good three-dimensional man-machine interface. Unfortunately a practical one is not available. Here, the author describes a technique that will satisfy requirements for many applications.

Read this one first!, Raymond E. Herzog, Daytona Beach, Fla., "EDN," Vol. 14, No. 16, Aug. 15, 1969, pp. 113-116. The author describes several ways to make your job resume stronger sounding and of more interest to its reviewers, so that you have a better chance of reaching the position you're after.

Enthusiasm-knowledge-experience; keys to a successful talk, Fred W. Kear, Sparton Southwest Inc., "EDN," Vol. 14, No. 15, Aug. 1, 1969, pp. 77-79. Those of you who must give a technical paper will find moral support in this article. The author states that there are few natural-born writers, and even fewer natural-born speakers. The naturalness and ease of presentation of a speaker is directly proportional to his preparation effort. You should of course know your topic, but you should also project your enthusiasm for it, and show the audience that you have a common bond of experience with them. The author also briefly discusses notes, visual aids, meeting-room preparation, and so forth.

It Makes Sense to Use LEDs in Sensing, Norman D. Kline, IBM Systems Development Division, "Electronic Design," Vol. 17, No. 16, Aug. 2, 1969, pp. 84-87. The problems of signal-to-noise ratio in position-measuring or hole-sensing applications using incandescent lamp and light-emitting diodes is discussed. The latter improve the S/N ratio by a factor of 7 and reduce power too.

Managerial Sensitivity Training Works, Richard L. Turmail, Management & Careers Editor, "Electronic Design," Vol. 17, No. 16, Aug. 2, 1969, pp. 98-102. Second and last part of the editor's experiences in a "Leadership Workshop." A survey of the participants one month after reveals that they are now more enthusiastic about the program than at graduation. Like most things, it is only as good as the follow-up, which is in the hands of the individual.

Saver

BW-20 saves space, saves cost. Has excellent stability.

The BW-20 bridges the cost-performance gap between composition resistors and premium wirewounds. Its one-watt rating in ½-watt size means you can replace one-watt units and save space; or use it in ½-watt space with the advantages of two-time safety factor and wirewound stability. As shown in the histogram, average load-life change is less than 1%.

The money-saving BW-20 has lower ranges than metal films or deposited carbons. It is ideal for semi-precision resistor needs in instrumentation, computer peripherals, networks, and other low-power needs.

BW-20's come in six forms of packaging to cut assembly costs, fit ½-watt inserting machines, and can be ordered with many cut-and-formed lead configurations. Write for data, prices, and samples to: IRC, Philadelphia Division of TRW, Inc., 401 N. Broad St., Philadelphia, Pa. 19108.

CAPSULE SPECIFICATIONS

Size: .390″ x .140″ diameter.

RESISTANCE:	0.24 ohm to 750 ohms
POWER:	1-watt @ 50°C. Derated to zero @ 160°C.
TOLERANCE—STANDARD:	±5%, ±10%
—SPECIAL:	±2%
TEMPERATURE: COEFFICIENT:	300ppm/°C. to 0.62 Ω 150ppm/°C. over 0.62 Ω
INDUCTANCE:	0.22μh (0.24 ohm) to 2.4μh (750 ohms)
EIA STANDARD:	RS-344

IRC

DIVISION OF TRW INC.

Circle 51 on Inquiry Card

Dale expands square trimmer line

New 3/8″ & 1/2″ models do more for you

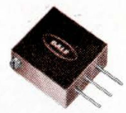
Dale's expanded line of square wirewound trimmers has seven new models to meet your needs at prices near rectilinear levels.

NEW 3/8″ LINE. Better for packaging because they're thinner—only .145″. Stronger PC mounting. Heavier (22 AWG) pin design reduces mechanical problems caused when lighter pins fail under mounting stress.

NEW 1/2″ LINE. Complete internal redesign for better performance and prices that are equal to or lower than competition.

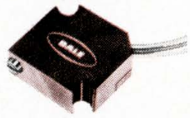
Both new Dale square trimmer lines are rated at one watt at 70°C. Both are made to MIL-R-27208 specs. Dale has a lot going for you in square trimmers—and more are on the way. For complete technical and price information, phone 402-564-3131.

3/8″ MODELS



5850—Insulated leads
5880—PC pins, top adjust
5887—PC pins, side adjust
5891—PC pins, base mount
Size: .375″ x .375″ x .145″

1/2″ MODELS



5050—Insulated leads
5091—PC pins, base mount
5080—PC pins, top adjust
Size: .50″ x .50″ x .19″ (5050)
.50″ x .50″ x .22″ (5091, 5080)

Resistance Range: 10 ohms to 50K ohms
Resistance Tolerance: ±5% standard
Resolution: 1.01% to .09% (3/8″) .54% to .10% (1/2″)
Power Rating: 1 watt at 70° C
Operating Temperature Range: −65° C to +175° C
Temperature Coefficient: ±50 PPM/° C Max.
Moisture Resistance: 10 Meg. minimum insulation resistance
Mechanical Adjustment: 25 turns (3/8″) 25 turns (1/2″)

DALE ELECTRONICS, INC., 1304 28th Avenue, Columbus, Nebraska 68601 In Canada, Dale Electronics Canada, Ltd.

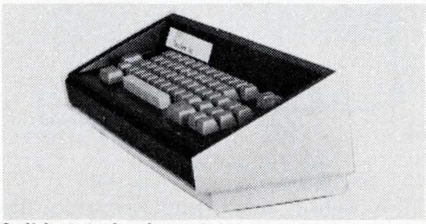
Keyboard Features Non-Contacting Key Switch

A new keyboard that needs no anti-bounce circuitry, is non-contacting, and that operates on any popular code has been announced.

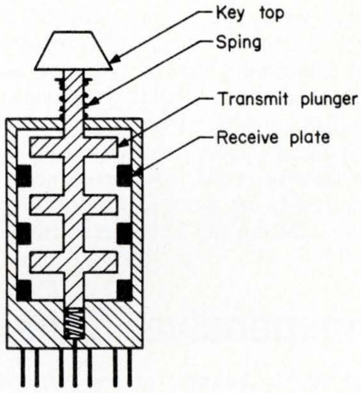
Heart of this all solid state keyboard is a new Neverwear™ coded key switch. This capacitive switch provides a reliable means of generating any multiple level communication code such as ASCII. Output is compatible with TTL or DTL ICs, and lends itself to interfaces such as digital paper tape punches, digital magnetic recorders, digital printers, CRT displays or direct computer input. Thus, these keyboards may be used as direct replacements for existing electro-mechanical keyboards or for new design applications.

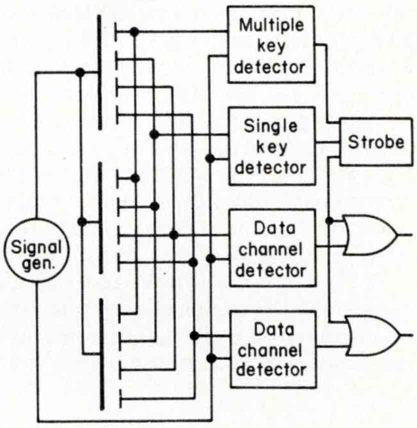
Only the key springs or snap action rubber boot can fatigue or wear, and both are replaceable. The non-contacting switch is guaranteed forever. With it, there aren't any electrical arcing, mechanical flexure or other failure modes.

Depressing the key brings the key plunger close to the data channel plates, ac coupling the plunger to each data channel detector. Any noise output that is not in phase with the drive oscillator is rejected by a strobe which is generated after the data channels are ac coupled. Depressing multiple keys simultaneously would normally generate erroneous codes, but this is prevented by detecting the depression of two or more keys and inhibiting the strobe.



Solid state keyboard (above) uses a new noncontacting key (right). Depressing more than one key at a time would normally generate erroneous codes, but the circuitry (below right) prevents this.





In addition to an improvement in reliability, the coded capacitance keys were selected so that lower cost could be achieved. Thus, quantity prices are typically less than $100 depending on the number of keys and other variables.

The standard keyboard has ¾ in. key spacing, 2 to 3 oz. depression touch force and a 3/16 in. key strobe.

John Craft, V.P. of Marketing, Data-Term, Inc., 1611 Manning Blvd., Levittown, Pa. 19057. (215) 949-1910.

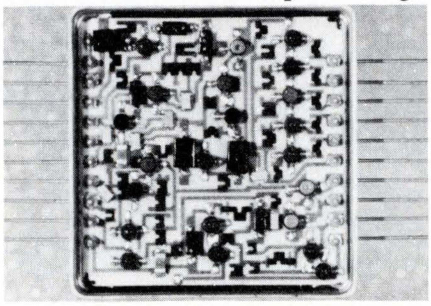
Circle 280 on Inquiry Card

Amplifier/Pulse Generator

A prime advantage of this miniature hybrid circuit is its micropower capability. The Amplifier/Pulse Generator compresses 78 components into a 1.5 in.^{2} package and still operates at only 1 mW. Circuit components include 3 FETS, 19 pnp and npn transistors, 8 tantalum and 2 ceramic capacitors, and 46 resistors.

Designed to interface with low impedance transducers, the LMI 9000 series unit is a highly sensitive, stable, gain programmable, Amplifier/Pulse Generator. The unit classifies various levels of excitation and generates a pulse output for six programmable threshold levels of the input signal.

A typical application would be the monitoring of various levels of equipment vibration. Basic amplifier design can be adapted to any vibration monitoring application with a great variety of signatures.



The premium units (LMI 9000 and 9001) have a temp. and voltage range from —50°C to 100°C at any B+ level from 5.5 to 35 Vdc. The standard (LMI 9002 and 9003) units operate over a limited temp. range from —30°C to 70°C at b+ levels of 7 to 10 V. All units come in a 1.5 in.^{2} plastic package. Lansdale Microelectronics, Inc., Advance Lane & Rte. 309, Colmar, Pa. 18915. (215) 822-0155.

Circle 281 on Inquiry Card

A fully-portable digital voltmeter

Weighing in at only 8 lbs, this instrument can operate up to eight hours on its built-in, 24-V, rechargeable battery-pack. But you can also power the Model 6453 from the ac power line. This means that you have an instrument for general lab use—one which you may isolate from the ac line by using the battery pack—as well as a self-powered, field unit for outside work.

Because the 6453 will probably see much field use, it was designed to be rugged and easy to use. To these ends, the instrument makes extensive use of advanced MSI IC circuit techniques, and has full, push-button operation.

You can select function (AC volts, DC or LOW-DC volts, and resistance), FILTER, digitizing RATE, and REMOTE operaation all from the front-panel. In the REMOTE mode, you can externally initiate up to four conversions/s. You can select function and FILTER remotely, and have

a manual ranging control as well.

A hybrid input amplifier gives the 6453 a high input-impedance, a low TC, and a bias current of less than 3 pA. The film-type attenuator does away with most of the usual calibration adjustments, and the instrument's internal reference voltage is temperature-controlled. The MSI display logic—which drives a low-voltage, single-plane readout—contributes to the DVM's low power-consumption.

A 4-digit instrument with a 20% overrange fifth digit, the basic Model 6453 has five dc ranges from 100 mV to 1000 V, 0.01% accuracy, and automatic polarity and autoranging; it costs $1125. As a full multimeter (with ac and ohms options), the 6453 costs less than $1600. Cimron Division, Lear Siegler, Inc., 1152 Morena Blvd., San Diego, Calif. 92110. (714) 276-3200.

Circle 245 on Inquiry Card

Inexpensive, 3-digit DMM uses LSI circuitry

A handy handful of test capability, this multimeter uses LSI techniques to give it a size of only 9 x 5 x 2.88 in., and a weight of only 2.5 lbs. You hold it in one hand, and operate it with the other.

The Digitest 500 has a push-button matrix keyboard with function-select buttons along the right-hand edge of the instrument, and range-select buttons along the bottom. Three standard Nixie®-type tubes show the measurement.

You can measure any of 17 range/function combinations of ac volts or current, dc volts or current, and resistance. The DMM reads voltages from

100 μV to 1000 V (300 Vac); currents from 100 nA to 100 μA (you will soon be able to purchase shunts to extend current readings to 1 A); and resistance to 1 MΩ. Accuracy varies from 0.2 to 1.5% with the function selected, but is constant through all ranges of that function.

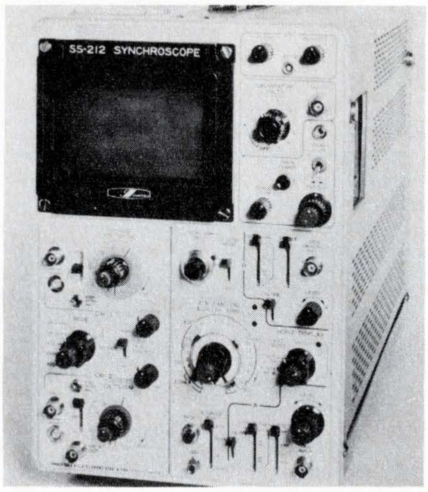
The Digitest 500 operates from 110 Vac, but has a power connection point that lets you run it from any 11- to 18-Vdc supply as well. This basic version sells for $250. An up-coming NiCad battery pack—which becomes an integral part of the basic instrument case—will sell for about $45. Honeywell Test Instruments Division, Box 5227, Denver, Colo. 80217. (303) 771-4700.

Circle 246 on Inquiry Card

Oscilloscope has 200-MHz bandwidth and high input-impedance

This instrument is the third in a series of high-performance, realtime oscilloscopes from Iwatsu Electric Co., Tokyo. The first two, introduced at the 1969 IEEE Show, are the SS-112 and the SS-211; these are, respectively, 100-MHz and 200-MHz scopes. The new instrument—Model SS-212—combines a 200-MHz bandwidth with a high input-impedance.

The oscilloscope's vertical channel has a 1-MΩ input impedance. It also features both active and passive probes; the passive attenuator-type probes come with the scope as standard accessories, but there are optional FET source-follower probes that give you both high sensitivity and wide bandwidth. A dual-trace



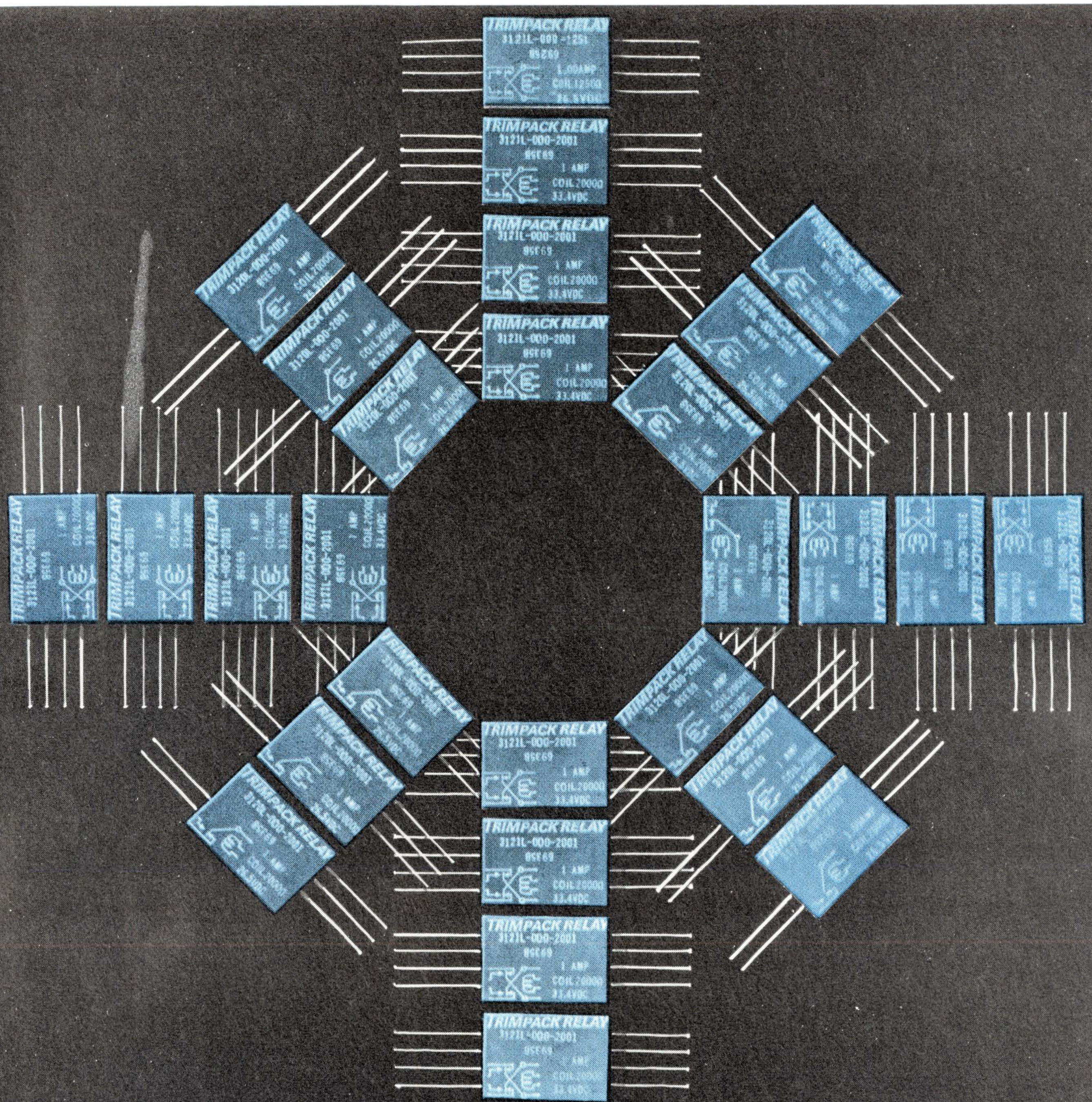
scope, the SS-212 has vertical channel sensitivities down to 5 mV/cm.

The horizontal deflection system has sweep speeds to 10 ns/cm (to 1 ns/cm with X10 magnification), with stable triggering to 200 MHz. You can select the trigger signals from either of the vertical channels, or from an external source. A delayed sweep is among the many features of the horizontal display channel.

The CRT display is 6 x 10 cm, in a rather small front panel—only 8 ½-in. wide x 12-in. high. The SS-212 costs $3120 and is marketed by E-H Research Labs., Inc., 515 11th St., Box 1289, Oakland, Calif. 94604. (415) 834-3030.

Circle 247 on Inquiry Card

Circle 53 on Inquiry Card→

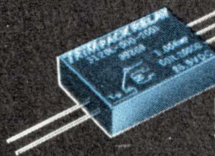


*BOURNS TRIMPACK RELAY TRIUMPH!

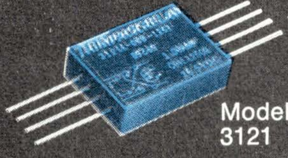
The new Model 3120 SPDT and 3121 DPDT TRIMPACK relays are just 0.80″ long, 0.57″ wide and—**note this**—only 0.25″ high. Designed especially for PC board application, their .100 pin spacing and unique low profile accommodates the usual ⅜″ spacing between PC boards to permit closer board stacking.

Another exclusive feature is that both new units are rated at 1.0 amp at 26.5 volts DC. The miniature size and outstanding power rating combine to make another Bourns first: THE MODEL 3120 AND 3121 TRIMPACK RELAYS HAVE THE **LOWEST PROFILE** IN THE INDUSTRY TODAY WITH A 1.0 AMP CAPABILITY.

The Model 3120 sensitivity is rated at 100 milliwatts; the 3121 is 160 milliwatts. Both have an operating temperature range of −65 to +125°C and they meet all applicable requirements of MIL-R-5757.



Model 3120



Model 3121

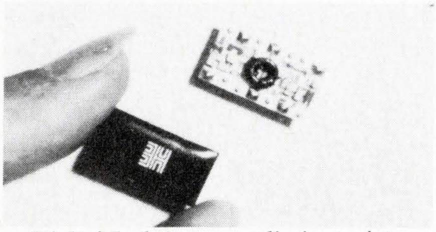
Complete data on the new **low-profile** Model 3120 and 3121 TRIMPACK relays are available upon request to the factory or your local Bourns sales representative.

BOURNS

BOURNS, INC., TRIMPOT PRODUCTS DIVISION • 1200 COLUMBIA AVE., RIVERSIDE, CALIF. 92507

DIGITAL ISOLATOR

Eliminates interference.

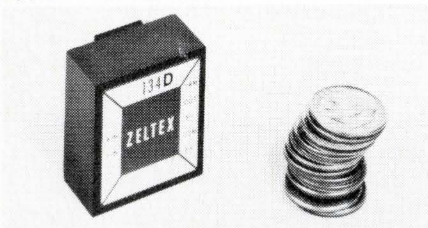


Digital-Isolator can eliminate interference to data transmission in noisy environments. The thick film hybrid circuit is packaged to interface computer and digital systems without requiring common ground connections. It is directly driven from DTL, TTL, or HTL logic signals. Hybrid Electronics, Inc., Bedford, Mass. (617) 275-7110.

Circle 270 on Inquiry Card

FET-INPUT OP AMP

Typical voltage drift is 50μV/°C.

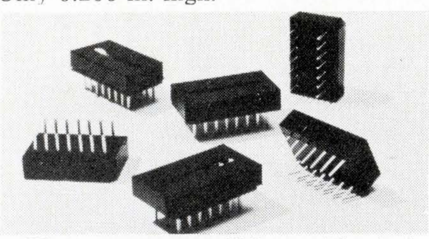


Differential op amp, Model 134D, can be used in differential, inverting and non-inverting circuits. Typical input bias current is 50 pA. Initial offset voltage can be adjusted to zero with an ext. pot. Output is ±10 V at 4 mA, dc gain 50,000, GBW product 1.3 MHz, freq. at full output 100 kHz, and slew rate 6 V/μs. Zeltex, Inc., 1000 Chalomar Rd., Concord, Calif. 94520. (415) 686-6660.

Circle 271 on Inquiry Card

LOW PROFILE CONNECTIONS

Only 0.200 in. high.

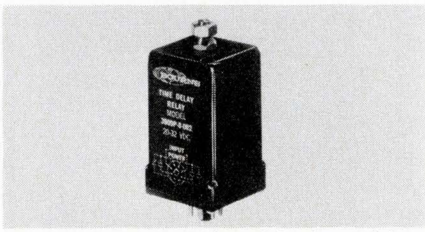


The connectors (14 or 16 pins) can terminate round conductors of up to 30 awg into PC boards, motherboards, backplanes and other IC circuit elements. Individual conductor terminations can be soldered and potted for extra strength, in contrast to ordinary pressure-type terminations. Spectra-Strip Corp., Box 415, Garden Grove, Calif. 92642. (714) 892-3361.

Circle 272 on Inquiry Card

TIME DELAY RELAY

Range is from 0.1 s to 500 s.

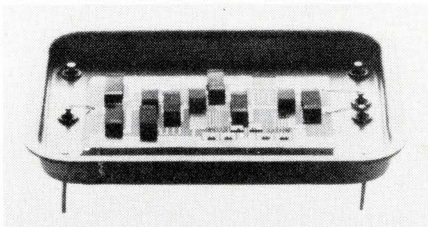


Model 3909 industrial time delay relay is a 10.0 A dpdt model with an operating temperature range of 0 to +60°C. Voltage range is 20 to 32 Vdc and 105 to 125 Vac. Repeatability is ±1.0% and resolution is ±1.0%. Bourns, Inc., 1200 Columbia Ave., Riverside, Calif. 92507. (714) 684-1700.

Circle 273 on Inquiry Card

WIDEBAND PREAMP

Features low noise figure, high gain.

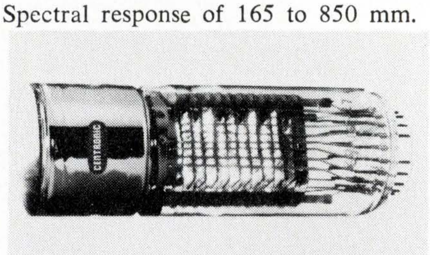


This hybrid i-f preamplifier covers a freq. range of 100 to 500 MHz. Minimum gain is 25 dB. The NF is < 2.5 dB at 100 MHz and < 4.0 dB at 500 MHz. The MHA-300 operates with a +12 dc input and a current drain of 55 mA. Power output is +5 dBm (at 1 dB compression) and output VSWR 2:1. Fairchild Semiconductor, 313 Fairchild Dr., Mountain View, Calif. 94040. (415) 962-3562.

Circle 274 on Inquiry Card

PHOTOMULTIPLIER

Spectral response of 165 to 850 mm.

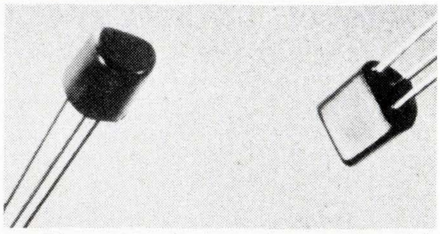


Centronic 2 in. photomultiplier Q4283R covers UV through IR with cathode sens. not less than 180 μA/Lumen, quantum eff. to 27% and low dark current, typically 1-2 nA. A newly developed tri-alkali cathode is mainly responsible for the high performance. The Bailey Co., 5919 Massachusetts Ave., Washington, D. C. 20016. (301) 656-2625.

Circle 275 on Inquiry Card

LOW CURRENT SCR

Plastic encapsulated.

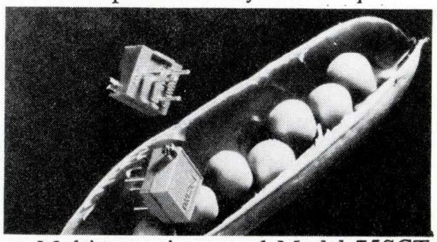


The C103 is interchangeable with over 100 existing types of TO-18 metal can and plastic devices. The C103 has a sens. of 200 μA (max.), voltage selections from 30 to 200 V, 8 A surge capability, and a low forward blocking current of 1 μA. A&SP Dist. Services, General Electric Co., 1 River Rd., Schenectady, N.Y. 13205.

Circle 276 on Inquiry Card

TRIMMER POT

Center-tap unit is only 3/8 in. sq.

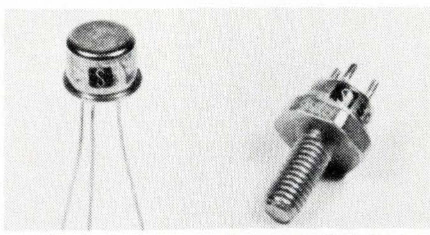


Multiturn wirewound Model 75SCT features resistance values from 100 to 20 kΩ and "stand-offs" for easy board washing. The unit meets MIL-R-27208 for continuity, noise, shock and vibration. Its 25-turn screw adjustment has clutch stop. A high temp. plastic case minimizes insulation and humidity problems. Techno-Components, 7803 Lemona Ave., Van Nuys, Calif. 91405.

Circle 277 on Inquiry Card

POWER TRANSISTORS

Less than 10 ns turn-on time.



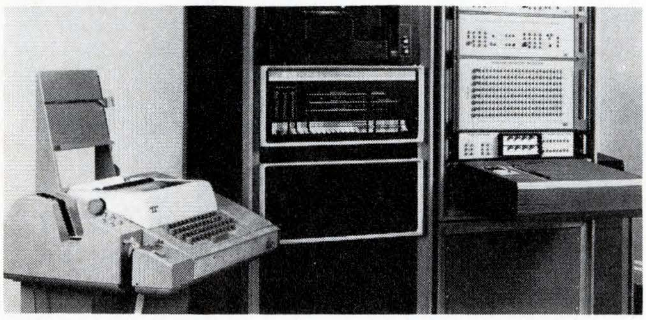
Typical characteristics of SDT6110-SDT6113 series, 10 A devices are: V_{CEO} = 40 V, h_{FE} @ 5.0 A = 20 to 60; V_{CE} (SAT) = 1.5 V max.; t_R @ 5.0 A = 10 ns max.; and I_C max. = 10.0 A. They have a total switching time <80 ns and rise time <10 ns. Solitron Devices, Inc., 1177 Blue Heron Blvd., Riviera Beach, Fla. 33404. (305) 848-4311.

Circle 278 on Inquiry Card

Why Picker X-Ray tests circuit boards with the Teradyne J259

Most people know Teradyne's J259 as an IC test system. Which is not surprising, since it won its campaign ribbons on IC production lines and in IC incoming-inspection departments.

Note, however, that the J259's official name is "Computer-Operated *Circuit* Test System." Nothing in that name says the circuits have to be integrated. An important point, which was not lost on engineers at Picker X-Ray.



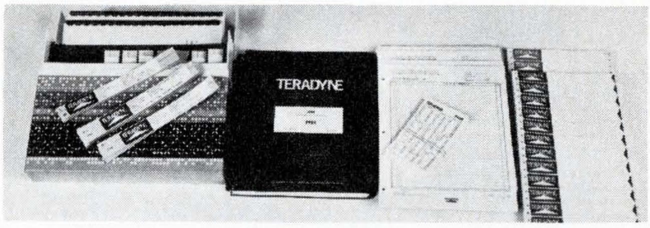
Picker uses its J259 to test circuit boards going into x-ray generators. The J259 whips through the 70 or 80 tests required on a board in a split second, automatically typing out the results of any test that is failed. Test data on a rejected board then accompanies the board to trouble-shooting, where a technician refers to his copy of the test program and keys the failed test to the bad component or connection.

Picker tests more than 50 different boards with the J259. What does Picker like most about the system?

Its efficiency. Only with an automatic system is it economically and humanly practical to test all the boards all the time.

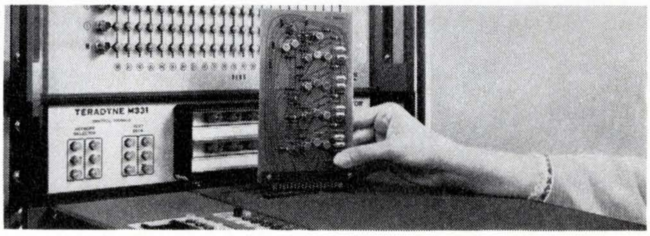
Its strong software. The "datalog rejects only" mode used so profitably by Picker is only one of dozens of features included in Teradyne's library of software packages for classification, datalogging, and evaluation.

Its device-protective and self-protective circuits and software. Picker wanted absolute protection of both boards and test instrumentation.



Its reliability. Picker will not take chances with its boards. An undetected bad board can destroy an $1800 x-ray tube. The J259, like all Teradyne test equipment, is designed and built to make accurate measurements in industrial environments for many, many years.

Its provisions for the addition of special-purpose accessories. Picker uses the J259's unique Network Selector, for example, to interconnect a constant-current source consisting of a simple network of current-limiting diodes.



Teradyne's J259 makes sense to Picker X-Ray. If you're in the business of testing circuits — integrated or otherwise — it makes sense to find out more about the J259. Just use reader service card or write to Teradyne, 183 Essex St. Boston, Mass. 02111.

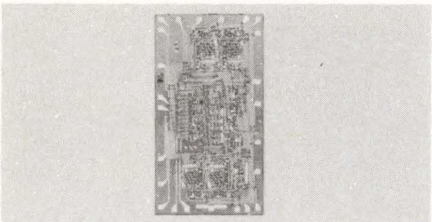
Teradyne makes sense.

Circle 29 on Inquiry Card

NEW MICROWORLD PRODUCTS

MOS COUNTERS

Use them with 7-bar indicators.

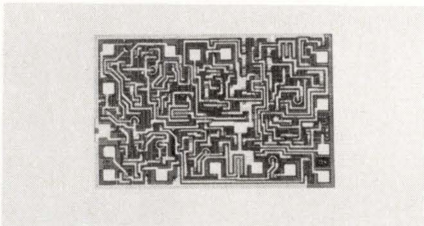


These units have output ratings of 40 V. The HCTR0117 uses negative-true logic and has a count rate of 250 kHz. $13.80 ea., 100—999 pcs. The HCTR0107, with positive-true logic and a count rate of 1 MHz, is $15.60. Hughes MOS Devices, 500 Superior Ave., Newport Beach, Calif. 92663.

Circle 261 on Inquiry Card

IC FOR TV RECEIVERS

Replaces about 25 components.

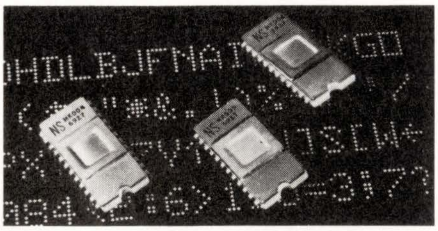


The TAA700 is a central signal processor and distribution circuit for video detector outputs. It is compatible with npn stages in the tuner and i-f amplifier, and with tubes or transistors in the deflection and video output stages. Amperex, Microcircuits Div., Slatersville, R. I. 02876.

Circle 262 on Inquiry Card

READ-ONLY MEMORY KITS

Control digital data displays.

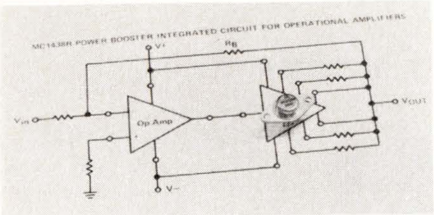


These kits convert standard communications code words (ASC11) into raster-scan or vertical-scan control signals. Kit SK0001, (raster scan) costs $120, 1-24 pcs. Kit SK0002, (vertical scan) is $150. National Semiconductor Corp., 2975 San Ysidro Way, Santa Clara, Calif. 95051. (408) 245-4320.

Circle 263 on Inquiry Card

OP AMP POWER BOOSTER

Gives load capabilities to 300 mAdc.



Type MC1438, a unity voltage-gain device, has these typical specs: 4-MΩ input imp., 10-Ω output imp., 1.5-MHz power bandwidth, and a current gain of 3000. It comes in a 9-pin TO-66 can. $6.50 ea., 100-999 pcs. Technical Information Ctr., Motorola Semiconductor, Box 20924, Phoenix, Ariz. 85036. (602) 273-6900.

Circle 264 on Inquiry Card

MOS DYNAMIC SHIFT REGISTER

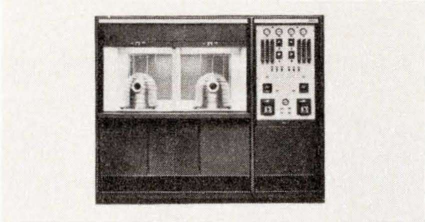
Input/output DTL/TTL compatible.

The SRD-25 (UC7330) is a dual 25-bit, fully bipolar-compatible device. It features low-voltage operation (V_{dd} = −10 V, V_{gg} = −16 V), and low power dissipation (0.4 mW/bit at 1 MHz). Union Carbide Corp., Semiconductor Dept., Box 23017, 8888 Balboa Ave., San Diego, Calif. 92123.

Circle 265 on Inquiry Card

FILM PRODUCTION SYSTEM

Two independent reactor stations.



The 1200 Series Silox® vapor phase oxidation system produces pure and doped films for MOS, MSI and LSI ICs. Up to 42 two-in. wafers per run. Cycle time for a 5000 Å deposition is about 10 min. Applied Materials Technology, 2999 San Ysidro Way, Santa Clara, Calif. 95051. (408) 738-0600.

Circle 266 on Inquiry Card

PLUG-IN LSI PACKAGE

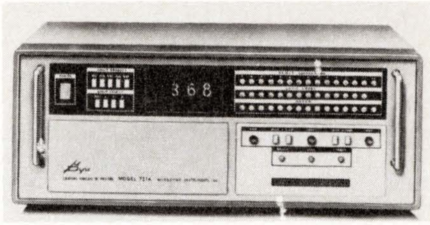
Hermetic unit has 51 leads.

HA-1772 has a high-alumina ceramic body and gold plated die-attach area. The seal ring (either alumina ceramic or kovar) is hard glassed to the base. Style HA-1772-1 has a hard glass seal frame for frit closure with a glassed ceramic cap. Mitronics, Inc., 132 Floral Ave., Murray Hill, N.J. 07974. (201) 464-3300.

Circle 267 on Inquiry Card

DIGITAL IC TESTER

Tests 8000 16-lead devices/h.



Model 721A makes up to 1024 sequential dc and functional measurements in 100 ms. Automatic (with a mechanical test handler) or manual operation. A plug-in, crosspoint matrix card programs the tester for automatic operation. Microdyne Instruments, 203 Middlesex Tpk., Burlington, Mass. 01803.

Circle 268 on Inquiry Card

TV CHROMA DEMODULATOR

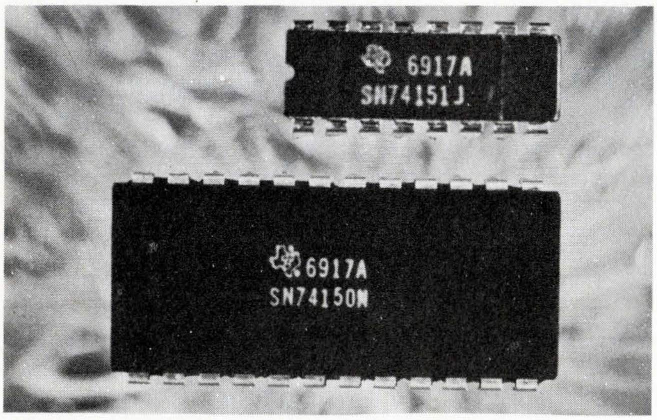
Directly replaces μA737A.

The μA746E has a voltage drift of 0.3 mV/°C. Its 9-pin EpiPak housing plugs into a standard 9-pin miniature tube socket. Chief use of the device is in NTSC color TV receivers and display monitors. $3.75 ea., 1-24 pcs. Fairchild Semiconductor, 313 Fairchild Dr., Mountain View, Calif. 94040. (415) 962-3563.

Circle 269 on Inquiry Card

TTL MSI DATA SELECTORS

Two week availability.

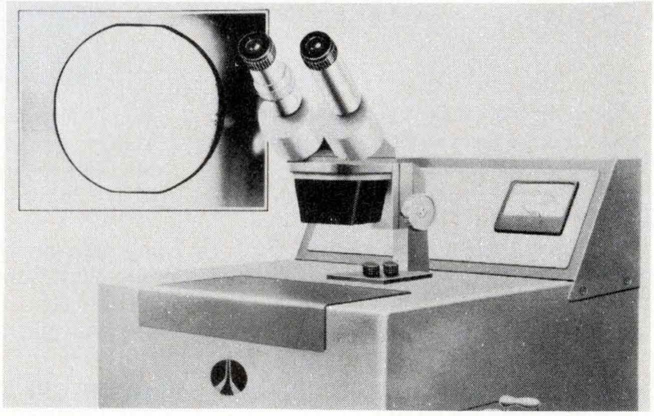


The SN54150/SN74150 are 16-bit data selectors in 24-pin plastic packages. A 4-line binary address selects the input data and routes it to the output where it is inverted. A strobe input lets you cascade the units. The 151 (an 8-bit version) comes in either 16-pin plastic or ceramic dual in-line packages. It has a strobe input and both true and inverted outputs. The 152 (in TI's 14-pin ¼ x ⅛ in. flat pack) is the same as the 151 except the strobe and true outputs are deleted. Prices range from $4.83 to $12.10 depending on model and quantity. Texas Instruments Incorporated, Inquiry Answering Service, Box 5012, MS 308, Dallas, Tex. 75222. (214) 238-3741.

Circle 289 on Inquiry Card

DIELECTRIC DEFECT DETECTOR

Promises higher yields, lower costs for MSI/LSI ICs.

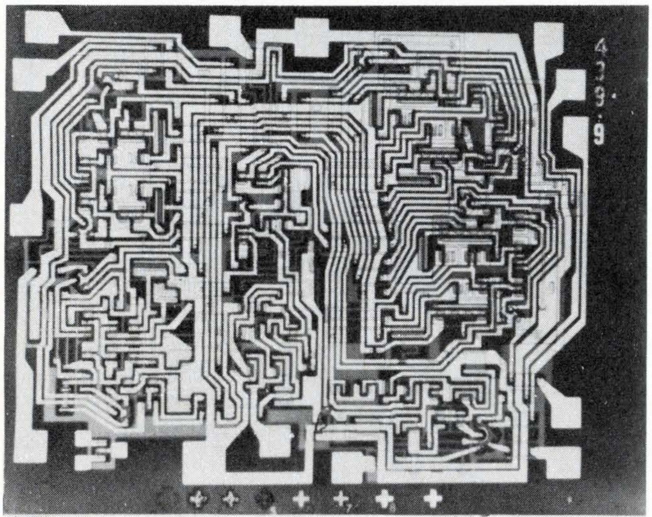


This unit can verify the integrity of organic and inorganic insulating coatings on conductive substrates to a degree not formerly possible. The instrument locates invisible pinholes as small as one-tenth of a micron in diameter in oxide, nitride, alumina, and similar layers on semiconductor wafers. You can also use it to determine the completeness of insulation coatings on wires and on various components. Potentially, the instrument can check the coverage of a number of conformal coatings on metals. Navan, Subsidiary of North American Rockwell, 1320 E. Imperial Highway, El Segundo, Calif. 90245. (213) 647-4888.

Circle 291 on Inquiry Card

FREQUENCY DIVIDER ARRAYS

Binary and decade programmable.

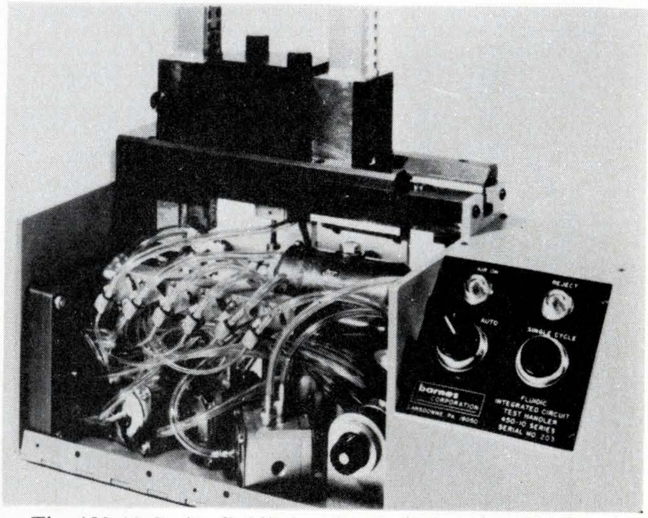


These TTL MSI arrays produce an output frequency equal to 1/N times the input frequency. The SM143 binary divider is programmed with a 4-bit binary number and can perform frequency division by any whole number up to 16. The SM153 decade divider is programmed with a BCD number and divides by any number up to 10. Available in 14-lead, hermetic flat-pack or plug-in packages, they operate from 0 to 75°C. Both devices are compatible with all other Sylvania arrays and SUHL I and II TTL integrated circuits. $8.80 ea., 100 to 999 pcs. Sylvania Electric Products Inc., Semiconductor Div., 100 Sylvan Rd., Woburn, Mass. 01801. (617) 933-3500.

Circle 290 on Inquiry Card

FLUIDIC IC TEST HANDLER

Manual or automatic feed.



The 450-10 Series fluidic handler is designed to be slaved to an electronic IC tester to provide a fully automated test system. A 30-gate, fluid logic circuit replaces the cams and relays normally associated with the logic portion of an integrated circuit handler. Thus there is no electrical noise or spurious signals to interfere with the IC tester's performance. The handler can be adjusted to accept virtually all dual in-line, flat pack, or TO-style IC packages. It can process as many as 4800 devices per hour, depending on the time requirements of the tester. Barnes Corp., 24 N. Lansdowne Ave., Lansdowne, Pa. 19050. (215) 622-1525.

Circle 292 on Inquiry Card

Fairchild Acquires Union Carbide Modular Products Line.

All standard and special modular op amps formerly offered by Union Carbide are now manufactured and marketed by Fairchild Controls, Mountain View, California.

Fairchild Controls' purchase of these Union Carbide products is part of a continuing planned program of expansion through both internal new product development and acquisition of quality products which complement the Fairchild line.

Fairchild will also continue to produce all special modular op amps that until now have been provided by Union Carbide.

For availability or applications information regarding these products contact Fairchild Controls, Modular Products, 423 National Avenue, Mountain View, California 94040. (415) 962-3833.

Standard Union Carbide operational amplifiers now made and sold by Fairchild Controls include:

Class	Type	Model
Chopper Stabilized	General Purpose	H2000 H2030
Instrumentation Amplifier	FET Input	H3100
Wide Temperature Range High Performance Types	General Purpose FET Input Wideband	H6000 H7000 H9000
Commercial Temperature Range Types	General Purpose	H6010 H6020 H9010 H9020 H9030
	FET Input	H7010 H7020 H7030 H7040 H7050
Output Current Booster	General Purpose	H6050
Comparator	General Purpose	H8010

FAIRCHILD
CONTROLS

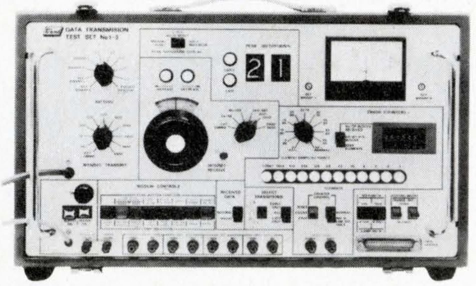
A DIVISION OF FAIRCHILD CAMERA AND INSTRUMENT CORPORATION

Modular Products / 423 National Avenue / Mountain View, CA 94040 / (415) 962-3833

Circle 55 on Inquiry Card

UNIVERSAL DATA TEST SET

Handles synchronous or asynchronous data.



Trend Model 1-3 generates and receives digital data under control of either a built-in or external clock. The unit operates at data rates from 24 to 9600 bits/s. A pseudo-random 511-bit pattern is among the various bit patterns supplied. The receiver and measuring circuits give three readings: peak telegraph distortion, bias distortion, and error count. There is a control to vary the error threshold-level from the normal 50% distortion down to 0% distortion, in 5% steps. The modem interface connector is a standard 25-pin E.I.A. RS-232B. Price is $4390. Transmission Measurements Inc., 1051 Clinton St., Buffalo, N.Y. 14206. (716) 852-4500.

Circle 248 on Inquiry Card

SERVO CALIBRATOR

Up to 168 VCOs, 24 discriminators, from 5 kHz to 2 MHz.

The EMR 4720 provides solid-state switch closures as a 9-point calibration check for signal conditioners. Internal or external voltages calibrate up to 12 different center frequencies. Accuracy of the reference-frequency outputs to the discriminators is ±1 in 10^5 parts from 10 to 50°C. The display shows the selected VCO output frequency (Hz), or the error between the internal reference and the selected VCOs (Hz) or discriminators (mV). Options include a printer readout capability and a servo loop to reduce VCO or discriminator zero- or gain-error to less than ±0.05% of full bandwidth. EMR-Telemetry, Box 3041, Sarasota, Fla. 33578. (813) 958-0811.

Circle 249 on Inquiry Card

NUMERIC DISPLAY

Has full-scale accuracy of ±0.1%.

The Numatron™ display receives analog sensor information, conditions and amplifies it, and converts it to digital form. The instrument then linearizes and scales this data and displays it directly in engineering units. The unit has four voltage ranges in addition to the linearized sensor range and an adjustable sampling rate. You can change the sensor or sensor range with a set of printed circuit cards. The instrument has BCD or analog outputs for a printer or recorder. Its half-rack size lets you mount the displays side-by-side in a standard 19-in. relay rack. Leeds & Northrup Co., North Wales, Pa. 19454. (215) 643-2000.

Circle 250 on Inquiry Card

PANEL MOUNTED DIGITAL COMPARATOR

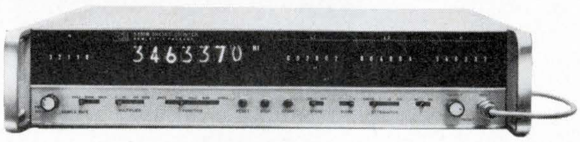
Compatible with DTL/TTL BCD inputs.

Model 4310 compares both the sign and data of an input signal. A polarity switch selects the sign of the limit point. The unit will compare either continuously or on command. Outputs include a 2-A relay contact closure, a logic level change, and lamps for above- and below-limit indication. Four versions of the comparator offer a range of ±1999 or ±9999 (3½ or 4 digits), and adjustable, fixed, or remotely-programmed limits. You may mount the logic separately from the 1½-in. deep control module. $165 for adjustable limit models; $95 for fixed limits. Delivery 4 to 6 weeks. API Instruments Co., Chesterland, Ohio 44026. (216) 729-1611.

Circle 251 on Inquiry Card

PRESET COUNTER

Frequencies or rates up to 10 MHz.



Model 5330B can normalize counted data, issue control signals when preset limits (either count or count-rate) are reached, and count and control both the number of items in a group and the number of groups. You can also use the unit as a precision pulse and digital delay generator. All functions are remotely programmable. The 5330B normally gives you five-digit readouts and limit settings, but six- and seven-digit models are also available. The 5330A is a lower-cost, less versatile model. Tentative prices are : 5330A, $1200; 5330B, $1550. Inquiries Mgr., Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. 94304. (415) 326-7000.

Circle 279 on Inquiry Card

Standard hybrids featured in MEPCO "circuit of the month" program: **A** D/A binary voltage summing ladder; **B** ceramic sandwich resistor flatpack; **C** D/A binary current summing ladder; **D** DTL to MOS level shifter; **E** precision high speed ladder switch; **F** relay, lamp, core driver.

MEPCO microcircuit design engineers have perfected a good number of standard hybrid microcircuits lately. No doubt you've heard about our "standard circuit of the month" program. They're all designed to meet the most stringent high-reliability design requirements, while offering the time and cost advantages of mass production.

If we haven't yet perfected a standard circuit to meet your needs, it could very well be that we're working on it now. Or perhaps we can find the fit among the hundreds of custom hybrids we've developed this year.

Before you look any further, ask us to show you a completely packaged hybrid integrated circuit that can outperform its counterpart. Write or call us collect for complete information, or talk to your MEPCO representative.

MEPCO

MANUFACTURERS OF PRECISION ELECTRONIC DEVICES

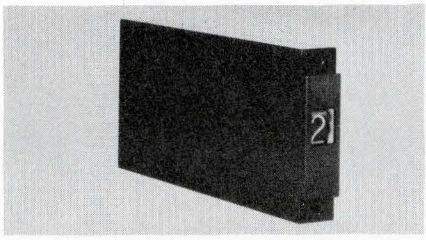
MEPCO, INC., COLUMBIA ROAD, MORRISTOWN, N. J. 07960 • (201) 539-2000 • TWX: 710-986-7437

Circle 56 on Inquiry Card

NEW LAB INSTRUMENTS

DECADE COUNTER

Up to 2400 counts/min.

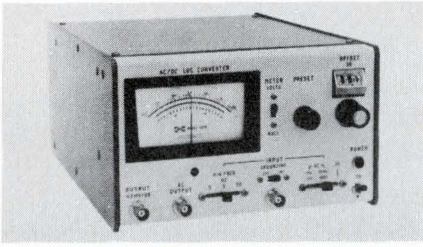


The Mod Counter is a bi-directional unit that counts on the trailing edge of the input pulse. You can use the instrument for serial or parallel input data. Price is less than $50/decade. Tasker Industries, Subs. of Whittaker Corp., Counter Products, 18842 Teller Rd., Newport Beach, Calif. 92664. (714) 833-2100.

Circle 282 on Inquiry Card

RMS AC/DC LOG CONVERTER

Has bandwidth of 0.5 Hz to 100 kHz.

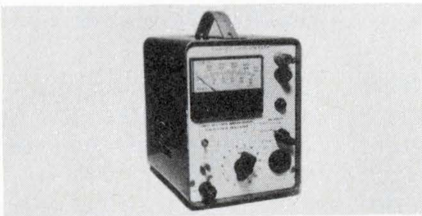


Model 1020 has dynamic ranges of 120 dB dc and 80 dB ac, and a 100-dB offset control. Accuracy of the unit is 0.5 dB. All circuits are isolated from the chassis to reduce ground current effects. Price is $950. Pacific Measurements Inc., 940 Industrial Ave., Palo Alto, Calif. 94303. (415) 365-0212.

Circle 283 on Inquiry Card

VOLTAGE BREAKDOWN TESTER

Current limited output.



Model 791 has four voltage ranges: 0-50, 0-100, 0-1000, and 0-5000 V. You can use the instrument to test high- and low-voltage transistors, thyristors, diodes, and rectifiers for breakdown levels. SVI Electronics, 48 Broadway, Box 525, Albany, N.Y. 12201. (518) 465-5115.

Circle 284 on Inquiry Card

GENERAL-PURPOSE RADIATION SURVEY METER

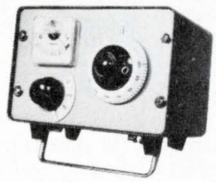
Operates on two D-cell batteries.

Model 493 detects alpha, beta, gamma, and X-rays, depending on which Geiger-Mueller probe you use. One standard and three optional probes give you a choice of both radiation type and sensitivity. When the meter is calibrated with Cs-137, its accuracy is ±20% of full scale on all three of its ranges (0-0.5, 0-5, and 0-50 mR/h). You may also have calibration with Co-60 or Ra-226. Batteries supply power for about 150 h of operation at a rate of 4 h/day. The temperature range of the unit is −20 to 120°F. Victoreen Instrument Div., Victoreen Leece Neville, Inc., 10101 Woodland Ave., Cleveland, Ohio 44104. (216) 795-8200.

Circle 285 on Inquiry Card

METAL-FILM THICKNESS MONITOR

Measures thicknesses between 20 nm and 2μm.

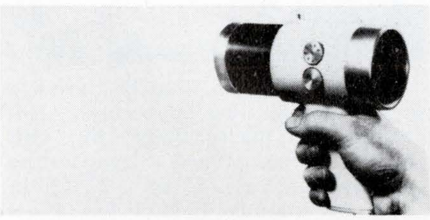


The Filmitor equipment uses a conductivity method to monitor thickness during vacuum deposition. The equipment is in two sections: a monitor head mounted in the deposition area, and a remote indicator unit. The monitor head includes a disposable probe. Metal builds up not only on the component being treated, but also on the probe: the increase in conductivity is thus a measure of the film thickness. There are two versions: one AC-operated at about $260, and the other battery operated at about $180. Electrotech Equipments Ltd., Prince of Wales Industrial Estate, Commercial Rd., Abercarn, Newport, Monmouthshire, NP1 5 RF, Britain.

Circle 288 on Inquiry Card

HAND-HELD IR DEVICE

Measures without contact.



Therm-a-ray® measures IR energy from moving or stationary objects. You sight the object and squeeze the trigger for the reading. The unit can measure from subzero to 3000°C at distances from 5 in. to infinity. Juron Measurement Corp., Box 438, Church St. Sta., New York, N.Y. 10008. (212) 267-2043.

Circle 286 on Inquiry Card

FREQUENCY STANDARD

Gives 1-MHz and 100-kHz outputs.

This unit has a synchronizing accuracy better than 1 μs. Outputs are directly traceable to the National Bureau of Standards. Model 112, $495; Model 112-01, with phase comparator and recorder options, $770. Beukers Laboratories, Inc., 1324 Motor Pkwy., Hauppauge, N.Y. 11787. (516) 234-2200.

Circle 287 on Inquiry Card

ITFS TEST SET

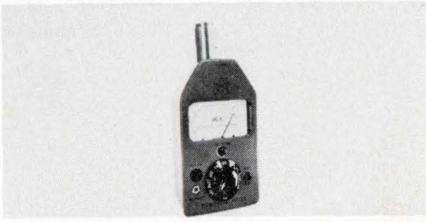
Checks 2.5-GHz transmitters.

Model TTC-1A makes all necessary FCC periodic checks including transmitter frequency, power output, and modulation. Used with a scope, it replaces separate equipments now needed to perform these tests. Price $4,100. Micro-Link Systems, 19 Warburg Ave., Copiague, N.Y. 11726. (516) 598-2240.

Circle 252 on Inquiry Card

SOUND LEVEL METER

Has range of 50 to 130 dB.



Model SLM-3 is individually calibrated and comes with a matched microphone. Its accuracy meets International Standard IEC-123. You can get an amplifier unit to extend the lower limit to 30 dB. Trans Atlantic Electronics Inc., 55 Bloomingdale Rd., Hicksville, N.Y. 11801. (516) 822-2110.

Circle 255 on Inquiry Card

TV DEMODULATOR

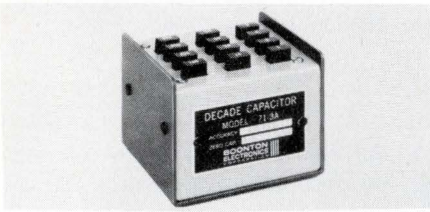
Unit is fully transistorized.

Type AMF demodulates monochrome and color TV signals (NTSC, SECAM and PAL), and TV sound signals, in the vhf and uhf bands. The instrument monitors and checks both picture and sound transmitters. Rohde & Schwarz Sales Co. (U.S.A.) Inc., 111 Lexington Ave., Passaic, N.J. 07055. (201) 773-8010.

Circle 258 on Inquiry Card

DECADE CAPACITOR

Has accuracy of ±0.25%.

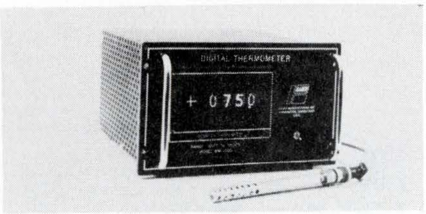


Model 71-3A has a range of one to 1221 pF, in 1-pF steps. It has a useful frequency range of 5 kHz to 1 MHz, and a temperature coefficient of better than 100 ppm/°C. Price $350. Delivery within two weeks. Boonton Electronics Corp., Rte. 287 at Smith Rd., Parsippany, N.J. 07054. (201) 887-5110.

Circle 253 on Inquiry Card

DIGITAL THERMOMETER

Custom scales; —350 to +1350°F.

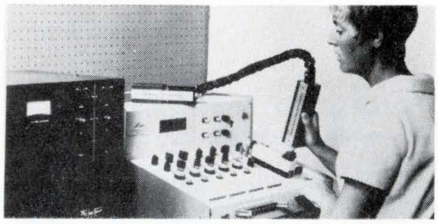


Series 1500 is a platinum probe thermometer that uses a resistance change vs temperature principle. Its accuracy is 0.01% ± span nonlinearity ± one count. A differential-reading model is also available. Bauer Mfg., Inc., Farmington Industrial Park, Farmington, Conn. 06032. (203) 677-9707.

Circle 256 on Inquiry Card

TEMPERATURE CONTROLLER

Heats and cools IC packages.

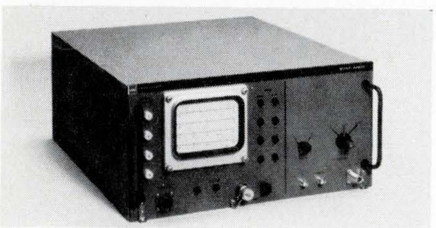


Model TP-2000 quickly varies a single IC's operating temperature. Depending on the package, the unit changes a component's temperature from ambient to −55 or +125°C in 15 to 60 seconds EG&G Inc. Electronic Products Div., 160 Brookline Ave., Boston, Mass. 02215. (617) 267-9700.

Circle 259 on Inquiry Card

MICROWAVE ACTIVITY MONITOR

All solid-state except for CRT.

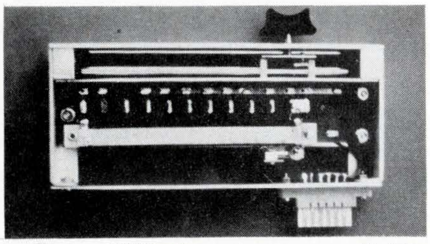


The WJ-1140 has a CRT display that shows signal activity in the 1- to 12-GHz microwave spectrum; it is designed for quick-look analysis. You can install the unit for airborne, shipboard, or van applications. Watkins-Johnson Co., 3333 Hillview Ave., Stanford Industrial Park, Palo Alto, Calif. 94304. (415) 326-8830.

Circle 254 on Inquiry Card

SLIDE WIRE ATTENUATORS

Linear to 54 dB.

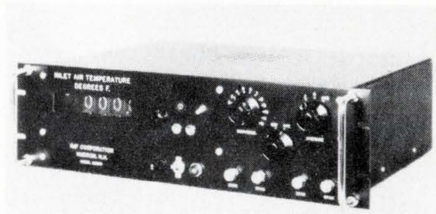


Series 1070 attenuators are available in continuously adjustable slide wire models with single and dual ladder networks. They are designed for use in applications requiring small dB increments over a wide attenuation range. Daven McGraw Edison, Grenier Field, Manchester, N.H. 03103. (603) 669-0940.

Circle 257 on Inquiry Card

TEMPERATURE INDICATOR

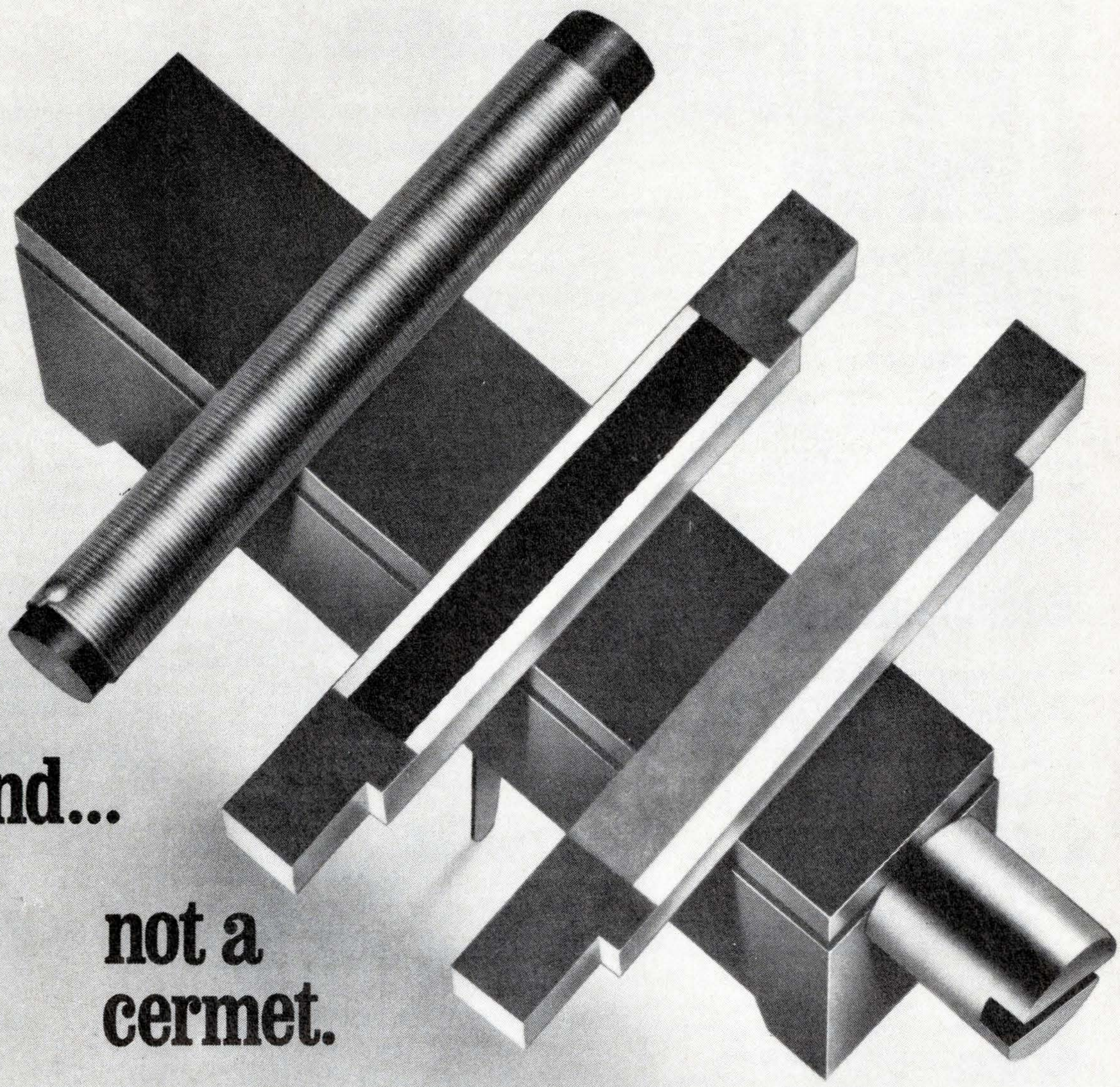
Has range of −20 to 400°F.



This unit gives a readout for each of 12 RTD temperature sensors. The instrument also has a thirteenth position that displays the average of all 12 measurements. Resolution is 0.1°F with an accuracy of ±0.5%. Price is $1,350. RdF Corporation, 23 Elm Ave., Hudson, N.H. 03051. (603) 882-5195.

Circle 260 on Inquiry Card

Circle 59 on Inquiry Card →



NEW PRODUCTS

MINIATURE DIODE

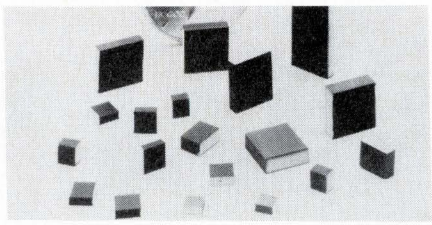
Especially suited for hybrid ckts.

The Hybridiode permits characteristics testing prior to bonding into the circuit. Either or both of the flag-type leads may be used for contact to the pad by soldering, welding or thermocompression bonding. The flag-type leads can also be removed and contact made directly to top and bottom of the pellet. Micro-Semiconductor Corp., 11250 Playa Ct., Culver City, Calif. 90230 (213) 391-8271.

Circle 201 on Inquiry Card

MINIATURE HV CAPACITOR

Monolithic construction.

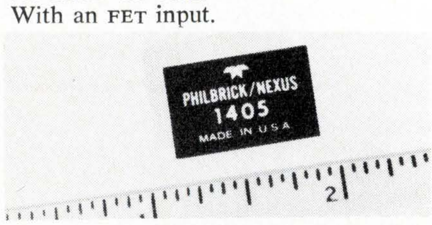


New miniature, ceramic capacitor is well suited for high package density voltage multiplier and HV power supply applications. It has a dissipation factor of < 1% at 1 kHz with an ins. res. to 3000 TΩ. TC is ±15%. Monolithic Dielectrics Inc., Box 647, Burbank, Calif. 91503. (213) 848-4465.

Circle 202 on Inquiry Card

HYBRID OP AMP

With an FET input.

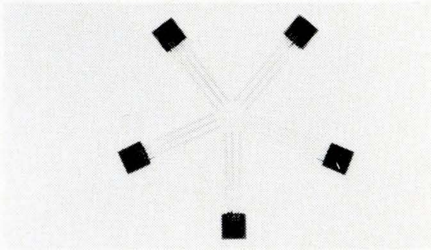


Model 1405 provides high speed operation over a wide BW (up to 1 MHz at full output and 10 MHz for small signals). Slew rate is over 50 V/μs. It has a 6 db/octave rolloff, low bias currents (50 pA max.), a low offset voltage TC of 25 μV/°C typ. over the —25°C to +85°C temp. range, high open loop gain (300,000 typ.), an output voltage of ±11 V typ. and an output current of 20 mA min. Philbrick/Nexus Research, Allied Dr. at Rte 128, Dedham, Mass. 02026. (617) 329-1600.

Circle 203 on Inquiry Card

PLASTIC TRANSISTORS

Designed for audio, radio and TV ckts.

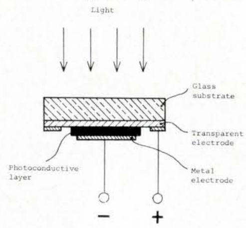


TO-92 packaged small-signal silicon transistors, types MPSA10, MPSA20 (npn), and MPSA70 (pnp), have a breakdown voltage of 40 V min., low output capacitance of 4 pF max., and (except the MPSA10) low collector-emitter saturation of 0.25 V max. The 100-up unit prices are $0.19, 0.22, and 0.25, in the above order. Motorola Semi-Conductor Products Inc., Box 20924, Phoenix, Ariz. 85036.

Circle 204 on Inquiry Card

CdS PHOTOCELL SENSOR

For card reading purposes.

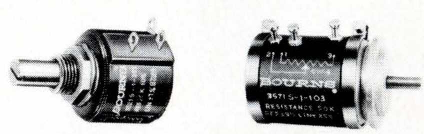


New sensor uses sandwich type cadmium sulfide cells which are enclosed in a plastic case. Photosensitivity of each unit under a given voltage is 50 times greater than normal CdS cells. The sensor aperture diameter is 0.055 in.—good for high density arrays. Masaoka-Ishikawa & Associates, 551 Fifth Ave., New York, N.Y. 10017.

Circle 205 on Inquiry Card

PLASTIC ELEMENT POTS

Essentially infinite resolution.



Model 3521 bushing mount and Model 3571 servo mount ⅞ in dia., five-turn pots feature the Infinitron conductive plastic element. Their op. temp. range is —55 to +105°C; resistance range, 1000 Ω to 200 kΩ and they are rated at 1.0 W at 70°C. Model 3521 has a rotational life of 20 million shaft revolutions, while the 3571's is 50 million shaft revolutions. Standard linearity is 1%. Bourns, Inc., 1200 Columbia Ave., Riverside, Calif. 92507. (714) 684-1700.

Circle 206 on Inquiry Card

Camera Shy?

Don't be. Here's a truly compact CCTV camera (2⅞″ head) that delivers over 1,200-line horizontal resolution.

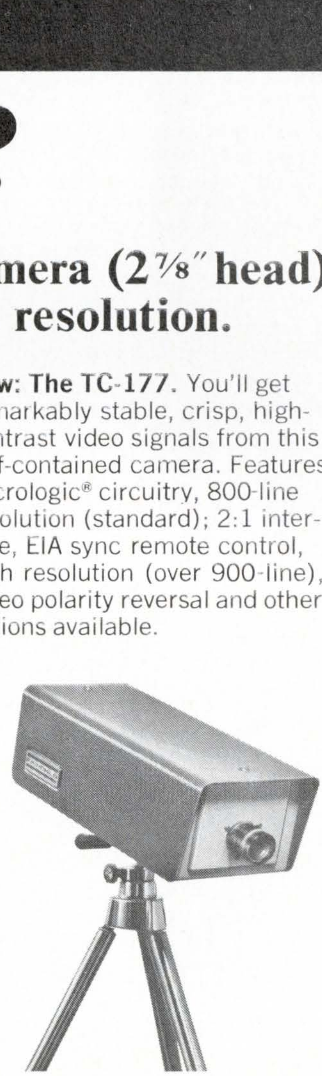
The Fairchild TCS-950B
It's ideal for those who have shied away from high resolution cameras because of their large sizes and price tags. Fairchild's new TCS-950B gives the sharpness and clarity of over 1,200-line horizontal resolution and 700-line vertical resolution. With the smallest head on the market and exceptionally compact design, the TCS-950B is perfect for data transmission, microscopic component inspection, flight simulation, photo interpretation, medical observation and a multitude of other applications.

If your CCTV needs are varied and sometimes unusual, you should also consider the versatility available with the TCS-950B:

- Switchable scan rates (either or both scan directions).
- Interlaced or sequential frame scan.
- Video polarity reversal.
- Scan polarity reversal.
- Militarized construction.

Reliability of the TCS-950B is ensured by Fairchild's solid-state Micrologic® circuitry. For its size and high resolution performance, it's one of the lowest priced cameras on the market.

New: The TC-177. You'll get remarkably stable, crisp, high-contrast video signals from this self-contained camera. Features Micrologic® circuitry, 800-line resolution (standard); 2:1 interlace, EIA sync remote control, high resolution (over 900-line), video polarity reversal and other options available.



For specifications and performance data, contact:

FAIRCHILD

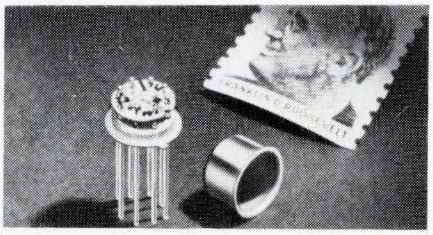
SPACE AND DEFENSE SYSTEMS
A DIVISION OF FAIRCHILD CAMERA AND INSTRUMENT CORPORATION
30 PARK PLACE, PARAMUS, NEW JERSEY 07652
TEL. 201-262-7000 / TWX 710-990-6610

84B

Circle 61 on Inquiry Card

HYBRID I-F LOG AMP

Compresses signals into log scale.

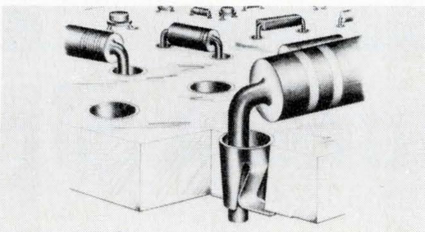


CTS Series 861 cermet hybrid IC was designed for use in cascade as a log amplifier with a mid band freq. of about 10 MHz to 100 MHz. Its basic function is to compress a wide range of signals into a log scale on a display device. It has built-in power supply decoupling and a typ. voltage gain of 0.6 dB from 30 to 100 MHz. CTS Microelectronics, Inc., West Lafayette, Ind. 47906. (317) 463-2565.

Circle 207 on Inquiry Card

METALLIC LINER

Speeds PC board assembly.



Conical-shaped fillet needs only 0.055 in. dia. holes, and permits center-to-center lead spacing as close as 0.100 in. It retains itself in std. 1/16 in. thick PC boards and firmly grips the component leads, holding components in position until soldering is completed. Bench-mounted machine can simultaneously insert up to 2000 fillets in a PC board. AMP Incorporated Harrisburg, Pa. 17105. (717) 564-0101.

Circle 208 on Inquiry Card

SHOCK MACHINE

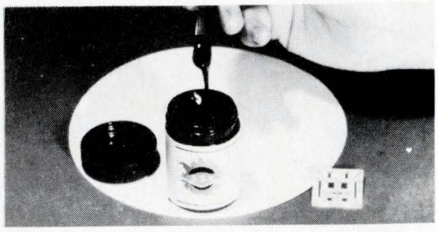
Tests microelectronic components.

Model P4-30K uses a 60 psi shop air supply and a free piston carriage to test up to 30,000 g in accordance with MIL-STD-883. Test specimens are preassembled into pistons outside the machine. After loading, the piston is lifted into the upper tube, compressed air charges the chamber, and the piston is released and propelled down onto the pulse producing device. L.A.B. Corp., 500 Onondaga St., Skaneateles, N.Y. 13152.

Circle 209 on Inquiry Card

CERMET RESISTIVE PASTES

For tight tolerance applications.

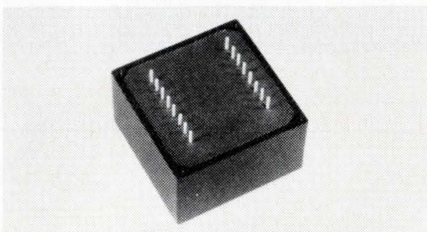


ESL 3800 Series noble metal pastes are relatively insensitive to minor changes in firing profile and may be fired at peak temps. between 980° and 1050°C. TC of resistance may be adjusted by refiring. These pastes come in nominal sheet resistivities from 100 Ω to 200,000 Ω/sq. and have typ. avg. TCR's (—55° to +125°C) of <0 ±100 ppm/°C. Electro-Science Labs., Inc., 1133 Arch St., Phila., Pa. 19107. (215) 563-2215.

Circle 210 on Inquiry Card

POWER AMP

Rated at 100 W.



Model PA-2 is rated at 100 W with with a max. output of ±24 V and a max. current of ±5 A. It can be used as an ac or dc servo amp., a deflection coil driver, relay driver or other application requiring precise control of high current. It has adj. current limiting, full power output from dc to 10 kHz and a low drift differential input stage. Control Systems Research, Inc., 1811 Main St., Pittsburgh, Pa. 15215. (412) 781-1887.

Circle 211 on Inquiry Card

POLYIMIDE TAPE

Dielectric strength is 4,800-5,400 V.

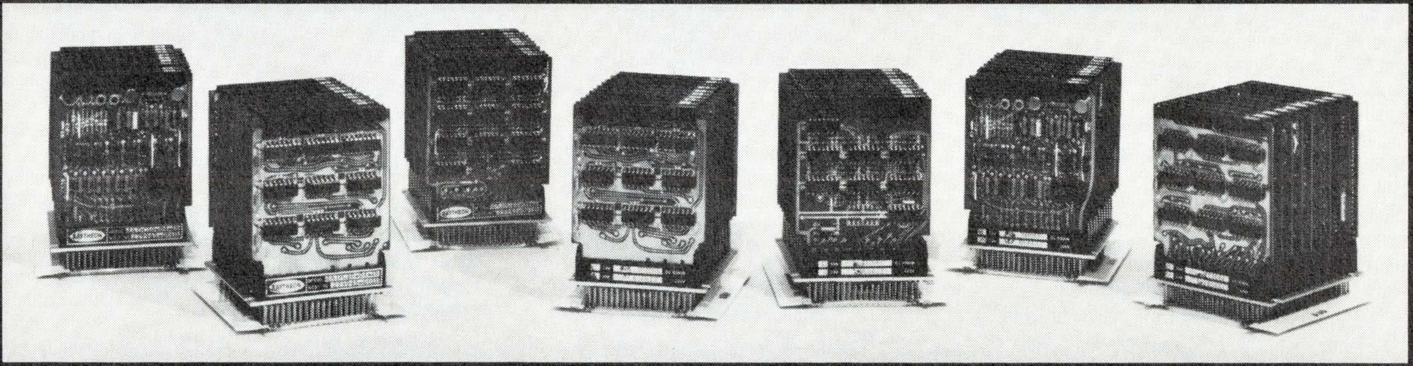
Lightweight Kapton™ polyimide film tape is for critical areas where high-low temp. and/or high dielectric strength is essential. Designated as Mystik 7360, the tape measures only 1.3 to 1.7 mils in total thickness, yet retains its thermal-electrical properties between —110°F, and +550°F. Mystik Tape, Borden Inc., 1700 Winnietka Ave., Northfield, Ill. 60093. (312) 446-4000.

Circle 212 on Inquiry Card

Circle 63 on Inquiry Card →

The great digital systems kit!

Steps 6 to 12:



Pick data system functions, then pick Raytheon Computer's MINI-BLOCS™. They're assembled, wired, tested, ready-to-use.

These new MINI-BLOCS make system design and assembly as easy as calling Raytheon. Decide how your system will operate, then pick MINI-BLOCS to fit functions. Each one's on a compact connector block, wired, tested and guaranteed. Most are expandable, and they'll fit your mounting hardware or ours.

MINIVERTER™—Multiplexer, Sample and Hold and ADC. 10, 12-bit binary, three digit BCD. Up to 100KHz conversion rate. 16 channels/block, expandable to 64 channels when used with MINI-MUX.

MINI-DAC™—10, 12-bit binary, three digit BCD. Settling time 10 usec, accuracy to 0.05% $\pm\frac{1}{2}$LSB. 4 channels/block.

MINI-MUX™—Up to 32 channels/block, expandable in 8-channel increments. 0.01% sample and hold accuracy. Sequence control, 20v input channel protection. Includes all analog power supplies.

MINI-SAMPLE—For simultaneous sample and hold. Up to 8 channels per block. 0.1% model has 100 nsec aperture, settles in 8 usec. 0.01% unit has 50 nsec aperture, settles in 3 usec. Input impedance 10^8 ohms.

BCD to Binary Converter—Converts 5 BCD characters to 16-bit binary word in as fast as 3 usec. Input and output are parallel form. Blocks can be combined for longer word length.

Binary to BCD Converter—Converts 16-bit binary word to 5 BCD characters in 3 usec. Parallel input and output. Expandable for greater word length.

MINI-MEM—Stores up to 32 16-bit words. Random or sequential word selection. 4 MHz transfer rate.

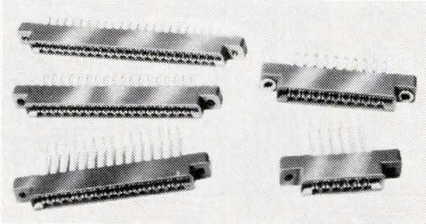
Write today for Data File DK177. Raytheon Computer, 2700 South Fairview Street, Santa Ana, California 92704. Phone (714) 546-7160.

RAYTHEON

NEW PRODUCTS

CARD-EDGE CONNECTORS

For use with 0.062 in. thick PC cards.

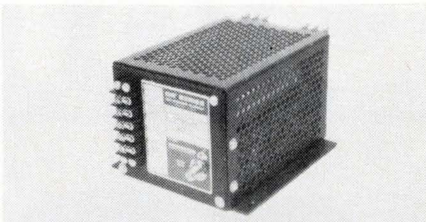


Series 6007 connectors come in five sizes and three mounting styles. All can be fitted with single-or dual-readout contacts compatible with most terminating methods. Sizes include 6/12, 10/20, 15/30, 18/36, and 22/24 contacts, while mounting styles comprise mounting holes, floating eyelets, and threaded inserts. Elco Corp., 155 Commerce Dr., Ft. Washington, Pa. 19034.

Circle 213 on Inquiry Card

DC POWER SUPPLIES

For use with DTL, TTL and MOS.

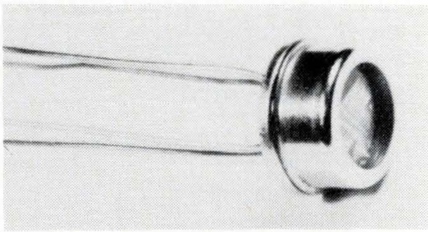


These units use 70% MIL parts, and glass epoxy boards. They have ±0.1% line and load reg., pk to pk ripple of <3 mV, full rating current from 0°C to 50°C. Typical outputs are 5 V @ 5 A; 12 V @ 2.5 V; 15 V @ 2.0 A and 24 V @ 1.4 A. Powertec Div. of Airtronics Inc., 9168 De Soto Ave., Chatsworth, Calif. 91311. (213) 882-0004.

Circle 214 on Inquiry Card

PHOTOCELL

Range is from 5,000 to 7,000 A.

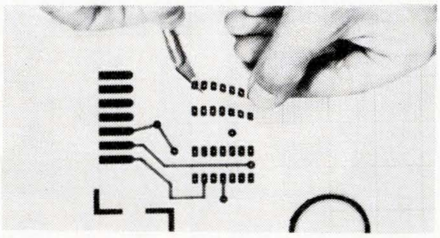


The VT 334/2's characteristics include close tracking, ±5% from 0.5 to 50 ft. candles; and close matching, available ±5 to ±20%. It also has a low TC, close temp. tracking, and a res. of 75 KΩ at 2 ft. candles. It can be illuminated by incandescent, neon, or fluorescent light; by light emitting diodes, or any source emitting within its range. Vactec, Inc., 2423 Northline Industrial Blvd., Maryland Heights, Mo. 63042.

Circle 215 on Inquiry Card

DRAFTING AIDS

For printed circuitry.

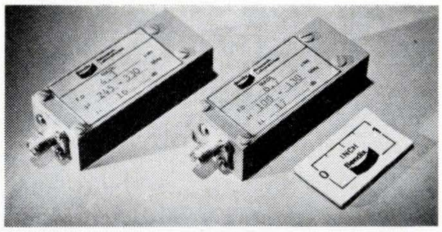


Pressure-sensitive Circuit/aids are pre-printed on 1.5 mil matte acetate. A 4 x 8 in. card is the carrier for the individually die-cut symbols. Line includes multiple transistor pads; 8, 10 and 12-pin micrologics; flatpacks and plug-ins; special configurations; die cuts, registration targets; component orientation symbols, and many others. Circuit Aids, Inc., Box 525, Westwood, N.J. 07675.

Circle 216 on Inquiry Card

ACOUSTIC DELAY LINES

With low insertion losses.

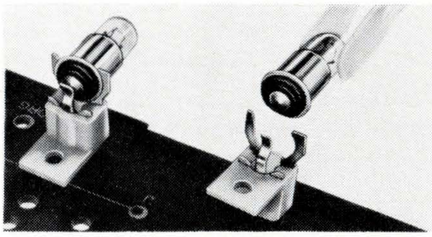


New compact, microwave acoustic delay lines use an improved cadmium sulfide evaporation-and-processing technique. The first series covers the range of 100 MHz to 500 MHz with delays of up to 10 μs. Communications & Scientific Relations Dept., Bendix Research Labs, Southfield, Mich. 48075. (313) 352-7560.

Circle 217 on Inquiry Card

SNAP-ON SOCKET

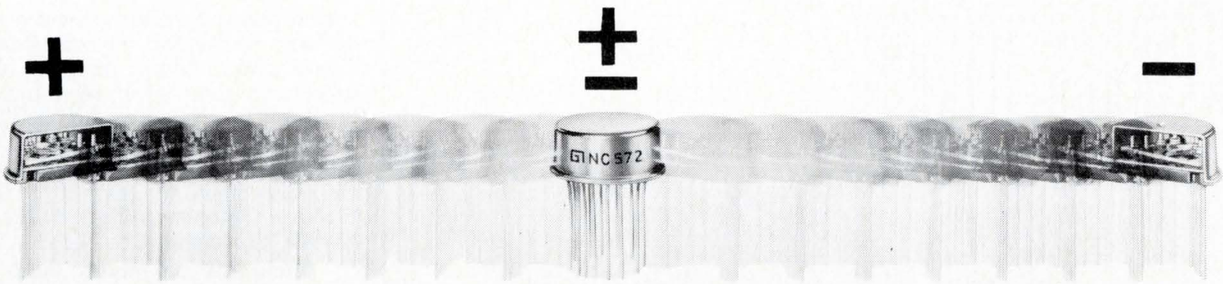
Plugs into PC boards.



Klipsocket™ fits snugly to PC boards, and fits all T-1 ¾ midget flanged based lamps from 1-28 Vac or dc. A specially designed universal bracket can be specified to fit in any one of four directions. They accept slip-on connectors or solder without pre-treatment and cost about $0.09 each in quantity. Chicago Switch, Inc., 2035 Wabansia Ave., Chicago, Ill. 60647. (312) 489-5500.

Circle 218 on Inquiry Card

together for the first time in one package



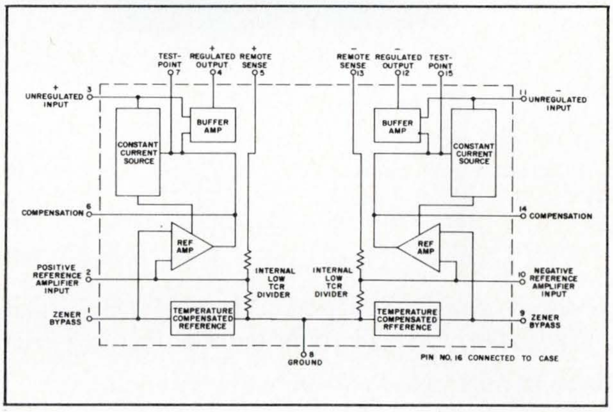
the ± hybrid voltage regulator internally preset to ± 15 VDC

If you use Op Amps, General Instrument's Complementary/Dual Polarity IC Voltage Regulator (NC 572) is made for you. For the first time, + and − 15 V regulators are combined in one IC package providing two isolated and independent control sections of complementary polarity. The NC 572 also provides a combination of features that are superior to those available in any individual positive or negative voltage regulator . . .

For example:

- Output voltages are internally preset to the most popular Op Amp supply voltages, +15 and −15 VDC. Where required, the output voltage can be externally adjusted to any value from ±13 to ±38 VDC or factory preset to any voltage within this range.
- Its high efficiency performance is demonstrated by a minimum required output/input voltage differential of only 1V for the positive regulator and 2V for the negative regulator.
- Other features include: line regulation of 0.0005% Vo/Vin, load regulation of 0.0005% Vo/mA, input isolation of 74 dB min., and a full military operating temperature range.
- The unit price at 1-24 pcs. is $30.80; at 500-999 pcs., $24.20 each.

The ± NC 572 hybrid voltage regulator in one 16-lead TO-8 style package is now in stock and immediately available from your authorized General Instrument Distributor.



Functional Diagram

For complete information, call (516) 733-3244 or write, General Instrument Corporation, Dept. I, 600 West John Street, Hicksville, N.Y. 11802.

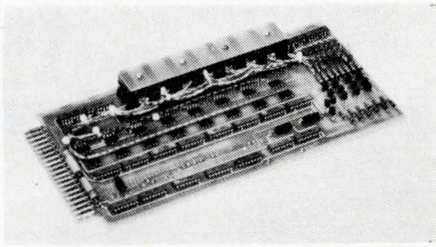
(In Europe write to: General Instrument Europe, S.P.A., Piazza Amendola 9, 20149, Milano, Italy. In the U.K. to, General Instrument U.K., Ltd., Stonefield Way, Victoria Road, South Ruislip, Middlesex, England.)

GENERAL INSTRUMENT

GENERAL INSTRUMENT CORPORATION • 600 WEST JOHN STREET, HICKSVILLE, L. I., NEW YORK

NEW PRODUCTS

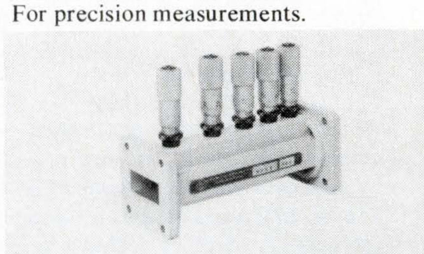
CODE CONVERTOR
Hollerith to 8-level codes.



Compact convertor provides direct one-step translation from Hollerith to 8-level codes. Model H-8/12 has all necessary circuitry for any known conversion. Thus it can be modified in the field to suit any output code of 8 bits or less. It's a 12 V system with 10 times the noise immunity as std. 5 V ICs. Electron Ohio, Inc., Dept. C-22, 1278 W. 9th, Cleveland, Ohio 44113.

Circle 219 on Inquiry Card

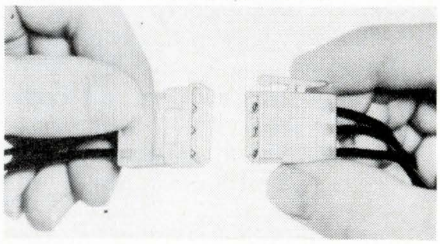
WAVEGUIDE TUNERS
For precision measurements.



MMC Series 351 multiprobe tuners come in waveguide bands from 1.7 to 18 GHz. They consist of 5 or 6 μm probes centered on the broadwall and stagger spaced to provide ease of tuning over their respective bands. There are also 9 and 10 stub "holeless" tuners available in H, X and P bands. Maury Microwave Corp., 8610 Helms Ave., Cucamonga, Calif. 91730. (714) 987-4715.

Circle 220 on Inquiry Card

CONNECTOR BLOCK
Eliminates terminal distortion.

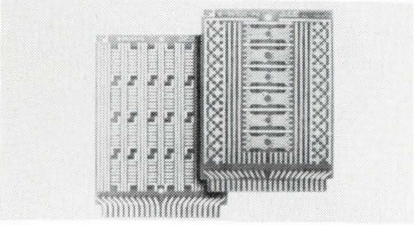


New nylon connector block for quick connecting or disconnecting of multicircuits has a locking mechanism on the block which eliminates terminal distortion. The block exceeds the established requirement rating of 10A/circuit. Essex International, Inc., Industrial Wire Products Div., 3501 W. Addison St., Chicago, Ill. 60618.

Circle 221 on Inquiry Card

CIRCUIT BOARDS

For DIL packages.

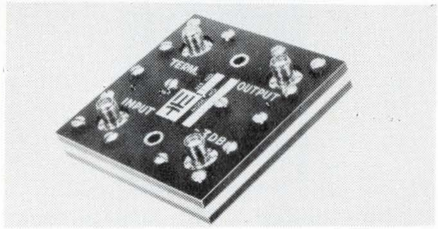


These PC boards are for mounting DIL packages, flatpacks, TO-5 cases and discrete components. They also accept IC test sockets. There are two card widths for std. 15 and 30 or 22 and 44 pin mating connectors. One ounce copper circuits are tin plated and contacts are rhodium plated. Rosemount Engineering Co., Box 35129. Minneapolis, Minn. 55435.

Circle 222 on Inquiry Card

STRIPLINE COUPLER

Maximum VSWR of 1.25.

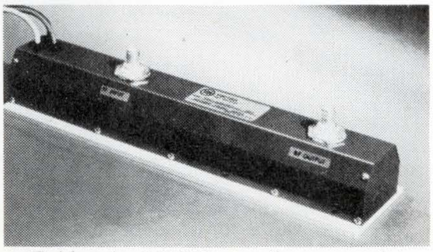


New octave band 3 dB coupler covers the range from 4 GHz to 8 GHz. Unit has a max. insertion loss of 0.25 dB. Isolation is 18 dB min., output balance ±0.25 dB. Isolation is 18 dB min., output balance ±0.25 dB. Other units are available from 1 GHz to 12 GHz. Elpac, Inc., RF/Microwave Div., 18651 Von Karman Ave., Irvine, Calif. 92664. (714) 833-1717.

Circle 223 on Inquiry Card

C-BAND TWTs

Deliver 1-4 kW peak for radar.



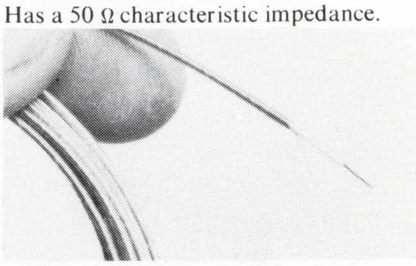
Grid-pulsed TWTs are for use as drivers or output tubes in pulse-radar systems. Gain of at least 40 dB from the VTC-5360A1 and 36 dB from the VTC-5361A1 is achieved by using a ring-loop circuit and radial-magnetic PPM focusing in each tube. Varian TWT Div., 611 Hansen Way, Palo Alto, Calif. 94303. (415) 326-4000.

Circle 224 on Inquiry Card

NEW PRODUCTS

MICROMINIATURE COAX.

Has a 50 Ω characteristic impedance.

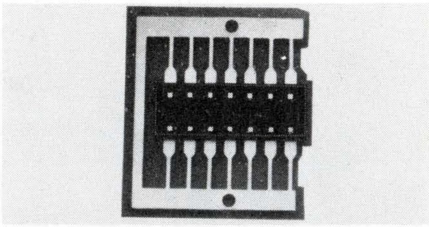


This cable has a solid center conductor and solid drain wire that can be used in solderless wrap operations. Cross talk is minimized by using an aluminized Mylar® shield. Dielectric is Teflon. Using a 30 AWG center conductor, the O.D. is under 0.050 in. A 32 AWG center conductor provides an O.D. under 0.040 in. Berk-Tek, Inc., Box 60, R.D. 1, Reading, Pa. 19607. (215) 376-8071.

Circle 225 on Inquiry Card

DIL PLASTIC PACKAGE

For high-density hybrid circuits.

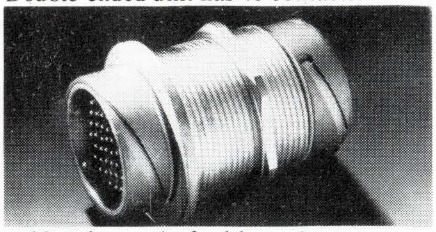


New molded plastic package comes complete, ready for production operations. Packages can be staked into PC boards using std. automatic equipment; substrates can be bonded to the packages using commercially available adhesives; and wire bonding can be completed with std. bonding methods and equipment. U.S. Electronic Services Corp., Box 78, Holgar Ind. Park, Clifton Heights, Pa. 19018. (215) 626-5200.

Circle 226 on Inquiry Card

FEEDTHRU CONNECTOR

Double-ended unit has 48 contacts.

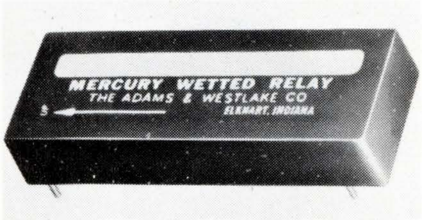


New hermetic feedthrough connector has male/male contacts for panel thicknesses to 1 in. Current rating is 10 A; voltage rating 500 Vac. Contacts are size 20 gauge. The 100-5239-05 connector withstands temps. through 257°F. Amphenol Connector Div., The Bunker-Ramo Corp., 2801 S. 25th Ave., Broadview, Ill. 60153.

Circle 227 on Inquiry Card

MERCURY RELAY

For PC boards.

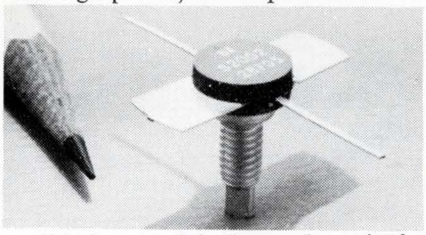


The AWCF and AWDF series or the flat pack series mercury wetted contact relays use a magnetic circuit that permits a low profile dimension of 0.300 in. without solder standoffs. They are 0.562 in. long and 0.578 in. wide. Relay is encased in diallyl phthalate with an internal magnetic shield. Contact configurations are Form C and Form D. The Adams & Westlake Co., 1025 N. Michigan St., Elkhart, Ind. 46514.

Circle 228 on Inquiry Card

SILICON NPN TRANSISTOR

For high power, h-f stripline uses.

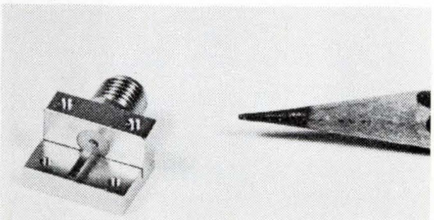


S2002 epitaxial Si transistor is for use in fund. oscillator, freq. multiplier and broadband amplifier stages. Primary use is for broadband amplifiers in the 500 MHz to 1 GHz range. Power out of 2.5 W is obtained over a > 20% BW with 6 dB gain. Narrow-band gain at 1 GHz is 10dB with 1.0 W output and 6 dB at the 2.0 W level. Electronic Components, div. of United Aircraft, Trevose, Pa. 19047. (215) 355-5000.

Circle 229 on Inquiry Card

MICROSTRIP LAUNCHERS

Complete line available.



New launchers are available in connector types SMA, N and TNC for substrate thickness of 0.025 to 0.250 in. and line widths of 0.025 to 0.200 in. Both right-angle and end-launch mounting configurations are available. ESCA Div. of Solitron/Microwave, Cove Rd., Port Salerno, Fla. 33492. (305) 287-5000.

Circle 230 on Inquiry Card

HYBRID 30 MHz I-F AMPS

For communication systems.

Hermetically-sealed, ceramic-metal film amplifiers are for hf, vhf, and uhf systems. The MS500 and MS501 amplifiers have noise figures of 7 dB and 14 dB, respectively. Standard bandwidths are 5 MHz. Sylvania Electric Products Inc., 40 Sylvan, Waltham, Mass. 02154.

Circle 231 on Inquiry Card

WIDE BAND OP AMP

Has 50 dB min. open loop gain.

Model 976A provides you with ±250 V/µs typical slewing rate and 300 MHz gain bandwidth product. It provides you with full operational capability from dc through video frequencies. Optical Electronics, Inc., Box 11140, Tucson, Ariz. 85706. (602) 624-8358.

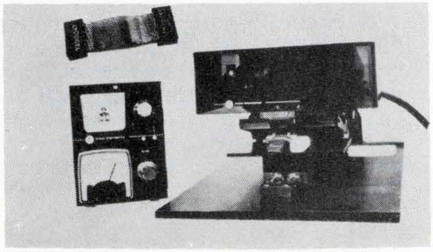
Circle 232 on Inquiry Card

Circle 69 on Inquiry Card

EE NEW PRODUCTS

IR SOLDERING SYSTEM

For flat flexible cable.



All types of soldered connections are joined with the FS series systems which use focused IR heating methods. Entire rows or groups of joints are soldered simultaneously and the heater never touches the workpiece. It takes 5 s to complete a row of terminations, often as many as 200 joints. Argus Engineering Co., Hopewell, N.J. 08525. (609) 466-1677.

Circle 233 on Inquiry Card

MULTIPLEX SWITCH

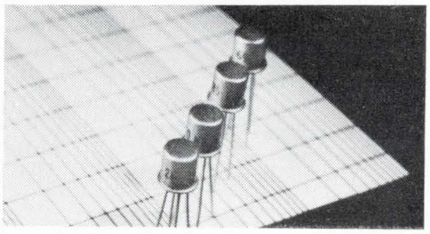
Alternative to reed relay switches.

Ten channel, Model MPX-10W responds to digital selection commands in BCD code. It will connect any one of 10 analog input signals to a common output terminal. The switch handles both polarities of analog input voltage, and accepts voltage levels to ±10 V. Overall switching time is < 5 μs. Analog Devices, Inc., Pastoriza Div., 221 Fifth St., Cambridge, Mass. 02142. (617) 492-6000.

Circle 234 on Inquiry Card

FET AMPLIFIERS

Feature high gain and low noise.

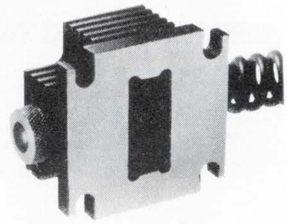


These low-noise amplifiers, 2N3684, 2N3685, 2N3686 and 2N3687, provide a 0.1 dB typ. and 0.5 dB max. noise figure. In addition, they offer low leakage, 100 pA max. and low pinch off of 1.2 V. They cost from $1.90 to $2.60 in 100 to 999 quantities. National Semiconductor Corp., 2975 San Ysidro Way, Santa Clara, Calif. 95051. (408) 245-4320.

Circle 235 on Inquiry Card

MICROWAVE OSCILLATORS

Minimum 100 mW cw output power.

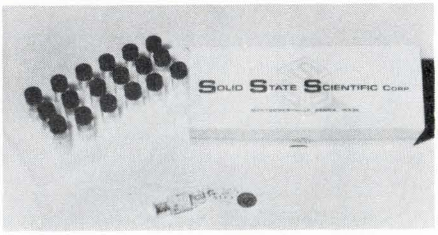


These VX2020 series Gunn-effect oscillators are mechanically tunable over a 20% BW within the freq. band ranging from 8.2 to 12.4 GHz. Output power varies <2 dB over the entire tuning range and weighs <3 oz. Typical input power is 12 V dc at 0.75 A. Monsanto Microwave Products, 11636 Administration Dr., St. Louis, Mo. 63141. (314) 694-4816.

Circle 236 on Inquiry Card

CHIP RESISTOR KITS

For prototyping.

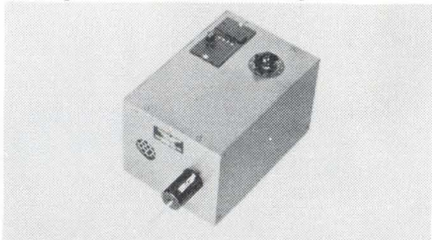


Kits contain assortments of RETMA value chips. Each is tapped to provide 3 or 4 values per chip. SD2500-17 kit contains 25 each of 18 different chips, with 58 values from 4.7 Ω to 1 mΩ. The SD2502-15 kit contains 25 each of 14 different chips, with 44 values from 22 Ω to 82 kΩ. Chip size is 0.28 x 0.038 in. typ. Solid State Scientific Inc., Montgomeryville, Pa. 18936. (215) 855-8400.

Circle 237 on Inquiry Card

WIRE TWISTER

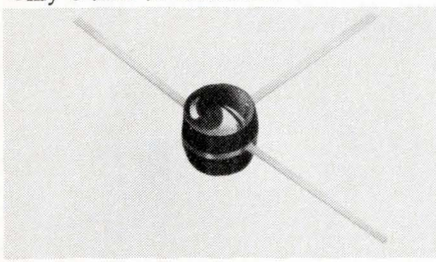
One operator can twist multiple wires.



Wires are quickly attached by a screw lock. Operator then holds the other end of the wires at the required length and merely by pulling on these wires he activates the switch and twisting begins. When required tightness of twist is reached, he releases tension on the wires and twisting stops. Macdonald & Co., 213 S. Brand Blvd., Glendale, Calif. 91204. (213) 241-4131.

Circle 238 on Inquiry Card

PLASTIC PACKED FET
Only 8 mils in diameter.



Shock resistant Micro FET assures operation at a 125°C junction temp. It has a thermal resistance as low as 350°C/W and power diss. up to 175 mW. Three radial ribbon leads allow it to be easily used in all PC board layouts, hybrid assemblies, and other high density configurations. Continental Device Components, 12515 Chadron Ave., Hawthorne, Calif. 90250.

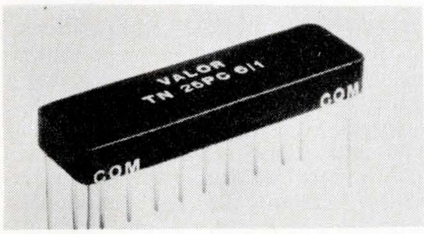
Circle 239 on Inquiry Card

CRYSTAL OSCILLATORS
Oven controlled, high stability.

The CO-211 series of oscillators, ranges in stability from 1 x 10^{-9}/day through 1 x 10^{-7}/day. The one difference between these seven 2 x 2 x 3 in. plug-in modules is freq. stability. Output freq. is in the 1-30MHz range, with lower freqs. furnished by inclusion of built-in dividers. Vectron Laboratories, Inc., 146 Selleck St., Stamford, Conn. 06902. (203) 324-9225.

Circle 240 on Inquiry Card

DELAY LINE
Low silhouette.

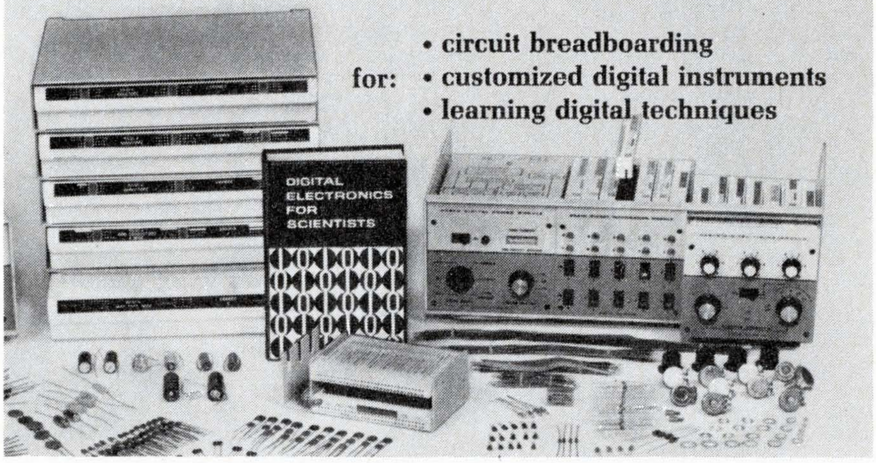


Lumped constant 5 to 200 ns delay line is 0.225 in. high, with width ranges from 0.515 to 0.765 in. Temp. range is from 55 to 125°C, with test voltage of 500 Vdc max., and working voltage of 200 Vdc max. Insulation is >1,000 MΩ. Output overshoot is <5% and output ripple is <3%. Valor Electronics, 3100 Pullman Ave., Costa Mesa, Calif. 92626. (714) 540-9261.

Circle 241 on Inquiry Card

a complete digital system

for:
- circuit breadboarding
- customized digital instruments
- learning digital techniques



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Write . . . for Complete Information on Cards, Modules and Parts in the Heath Digital System. The basic Analog-Digital Designer (EU-801A) contains 3 modules (power supply, binary information, and digital timing) and 13 circuit cards including TTL gates, flip-flops, monostable MVs, relays, op amps, and V-F converter. The EU-51A Experimental Parts Group is a highly flexible breadboard system for circuit design and teaching. The group includes a desk chassis, 493 components, a patch card accepting these components, and a power patch card.

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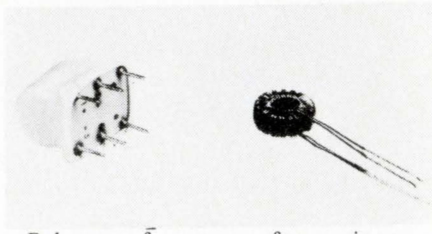
Circle 71 on Inquiry Card

NEW PRODUCTS

SCR TRIGGER TRANSFORMERS

Isolate high voltages.

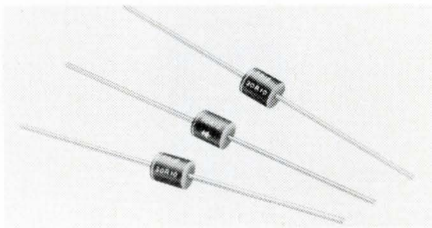


Pulse transformers are for use in SCR trigger circuits. This series is subjected to high test voltages up to 2500 Vrms to ensure reliability when used to isolate high voltages. Two basic styles are available—PC pins or axial lead mounting. Pulsar Engineering Inc., 1247 El Camino Real, Mountain View, Calif. 94040. (415) 964-1606.

Circle 242 on Inquiry Card

SILICON RECTIFIER

PRV ratings from 50 V to 1200 V.



Series 30 R units use high density molding compounds and silicon polymer junction coatings to ensure long life stability in adverse environments. These 3.0 A rectifiers are useful for new designs as well as replacement for many stud-type and selenium stack assemblies. Erie Technological Products, Inc., 644 W. 12th St., Erie, Pa. 16512. (814) 453-5611.

Circle 243 on Inquiry Card

ELECTRODE COMPOSITIONS

Binary alloys of palladium and gold.

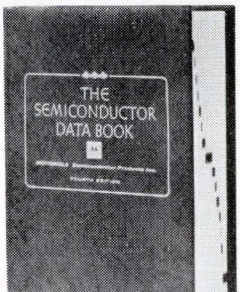
These screen-printable compositions are for use in multilayer ceramic capacitors. They cost much less than pure platinum or high platinum mixtures which they replace. First of the series is Electrode Composition 8282 ($57 a troy ounce—500 or more ounces). It provides key functional properties previously available only in platinum compositions that sold at $120-140 an ounce. The new compositions are printed directly on green, uncured ceramic tape, which must be fired later at temps of more than 1200°C to mature the ceramic particles—basic components of the tape. E. I. Du Pont de Nemours & Co., Inc., Wilmington, Del. 19898. (302) 774-8631.

Circle 244 on Inquiry Card

LITERATURE

Motorola's new semiconductor handbook (4th ed.)

If you have the 3rd edition (colored plaid green) of the now popular Semiconductor Data Book by Motorola, don't take this new 4th edition for granted. First of all, it won't fit in the same slot of your bookcase, because it's almost 50% bigger. Even more important, its popular listing of EIA types (which, incidentally, lists all 1N, 2N, and 3N numbers—whether Motorola makes them or not) is now arranged in numerical order, instead of by type of transistor as it was before. There is an extra cross index that relates the application (power transistors, signal transistors, switching diodes) to the EIA type number.



Just as you would expect, there are more data listings for ICs, both linear and digital, (although no spec sheets, because Motorola has a separate Data Book for ICs). Also, we noticed that the excellent set af application notes that appears at the end of the book has been revised. Some old ones were dropped, and there are new ap notes, especially a timely one on phototransistors. The price for this 2160-page book is $4.95, although if you are a good customer . . . Motorola Semiconductor Products Div., Box 20912, Phoenix, Ariz.

Circle 332 on Inquiry Card

Magnetic reed switches

A selection guide offers applications and specs for a line of reed switches. Sizes of the switches range from 0.375 in. (glass length) and a diameter of 0.090 in. to standard size and mercury-wetted types. A chart which shows contact arrangement, dimensions, switch voltage, and electrical characteristics is provided. Hamlin, Inc., Lake and Grove Sts., Lake Mills, Wisc. 53551.

Circle 333 on Inquiry Card

Casting resins

A line of casting resins, including epoxy, polyurethane and polystyrene resins, are described in a folder-type brochure. The manufacturer's line of molding powders and liquids is also covered. Both applications and physical properties are listed on a chart, permitting easy selection for a particular application. Emerson & Cuming, Inc., Canton, Mass. 02021.

Circle 334 on Inquiry Card

Lugs, clips and terminals

Designed to help solve component problems by using standard parts, an up-dated 64-page catalog lists a line of lugs, clips, terminal and metal stampings. Specs and illustrations are provided for a variety of types, sizes and configurations. Zierick Mfg. Corp., 36 Radio Circle, Mount Kisco, N.Y. 10549.

Circle 335 on Inquiry Card

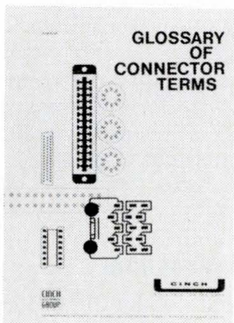
Lead wire for internal wiring

A line of lead wire for internal wiring of electrical appliances is outlined in a 12-page catalog. Designated L-69, the brochure provides insulation specs and application data for the line of wire. It also indexes the wire's specs by insulation type and usage. Belden Corp., Box 5070 A, Chicago, Ill. 60680.

Circle 336 on Inquiry Card

Connector terms

A glossary of connector terms with definitions of words used regularly in connector descriptions has been made available to engineers involved in connector design or specification. Intended



as a communications link between engineers and connector manufacturers, the glossary should eliminate the confusion that exists in connector terminology. Cinch Manufacturing Co., 1501 Morse Ave., Elk Grove Village, Ill. 60007.

Circle 337 on Inquiry Card

Precision pots

A variety of wirewound precision potentiometers are discussed in a 72-page catalog (#PD-1). Diagrams containing dimensions are included as is a discussion of linearity considerations for selecting pots. Also described in the catalog is the manufacturer's turns counting dial line

which includes digital and concentric scale types. Electrical, environmental and mechanical characteristics for both product lines are provided and include reference to military specs where applicable. Bunker-Ramo Corp., Amphenol Controls Div., 120 S. Main St., Janesville, Wisc. 53545.

Circle 338 on Inquiry Card

Auto plotting

An automatic plotting concept which combines high speed and smooth line quality of analog with the precision and reliability of digital techniques has been termed the hybrid concept. Bulletin #951504 discusses the concept and includes a description of a dataplotter that is able to produce accurate drawings with great efficiency. Specs are provided. Electronic Associates, Inc., West Long Branch, N.J.

Circle 339 on Inquiry Card

Slide rule calculators

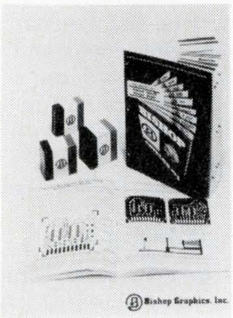
Developed for computer programmers and systems analysts, two calculators provide an accurate means of checking computer codes by allowing the user to perform arithmetic and algebraic calculations in computer base number systems. The calculators are also capable of performing most operations of a conventional slide rule in the decimal base and converting them to the computer base. Technical leaflet S-3 describes the two instruments. Science Spectrum, Inc., 1216 State St., Santa Barbara, Calif. 93101.

Circle 340 on Inquiry Card

LITERATURE

Drafting aids

A 68-page illustrated design manual contains tips on the proper use and application of pressure-sensitive electronic component drafting aids. Catalog 104 covers component mounting



methods, preparation of printed wiring master art work, basic connector configurations and flat pack and dual in-line component mounting configurations. Bishop Graphics, Inc., 7300 Radford Ave., North Hollywood, Calif. 91605.

Circle 341 on Inquiry Card

Permanent magnet motor

A 23-frame (2¼ in. dia.) reversible motor is the subject of a 4-page bulletin. Specifications and ratings are listed for 18 standard part numbers. Other useful data, including design formulas, graphs, and dimensional drawings, are given. Indiana General Corp., Electro-Mechanical Div., Walnut St., Oglesby, Ill. 61348.

Circle 342 on Inquiry Card

Automatic measurement systems

Engineering bulletin AEB-100, titled "Precise Measurement of Spike Leakage in Gas Switching Tubes," covers TR function and spike leakage effects. MPHD operating principles are included as is descriptive data for a microwave pulse height detector's performance, attenuator settings for measuring leakage, and TR tube evaluations. Available on company letterhead from Varian, Salem Rd., Beverly, Mass. 01915.

Tantalum capacitors

Specification GR500/F describes high-reliability F-series solid tantalum capacitors and their applications. The hermetically-sealed, rectangular devices are for aerospace, military, and industrial circuit applications. Union Carbide Corp., Electronics Div., Box 5928, Greenville, S.C. 29606.

Circle 343 on Inquiry Card

Transformer guide

Catalog GEC-1090B provides selection data for a line of dry-type transformers. Application information and ordering guidelines for general purpose, buck-boost and distribution transformers are included in the 28-pager along with descriptions for machine tool transformers, integral distribution centers, ac voltage stabilizers and portable oil testers. General Electric Co., Distribution Svs., Bldg. 705, Corporation Park, Scotia, N.Y. 12302.

Circle 344 on Inquiry Card

Electromagnetic shield designing

A 48-page manual provides information for those involved in the design, specification and/or purchase of drawn and fabricated shields. Electrical and mechanical design considerations are included as is a dimensional listing of drawn and fabricated shapes. The guide also covers terms used in electromagnetic shielding. Magnetic Metals Co., Hayes Ave. at 21st St., Camden, N.J. 08101.

Circle 345 on Inquiry Card

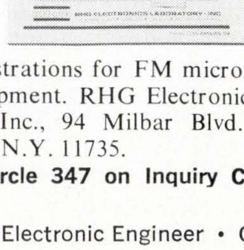
Laser applications

Applications of laser technology, such as etching, resistor trimming, hole drilling, and welding, are the subject of a 16-page brochure. Included are more than 50 pictures that illustrate the various applications. Laser Nucleonics, Inc., 123 Moody St., Waltham, Mass. 02154.

Circle 346 on Inquiry Card

Microwave transmitters

A line of microwave transmitters, receivers and components is the subject of a 12-page short form catalog, designated 70A. Specifications for the microwave devices are provided as are descriptions

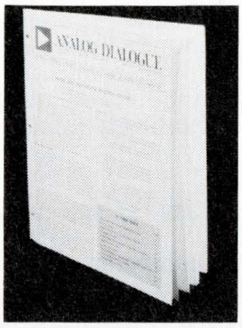


and illustrations for FM microwave relay equipment. RHG Electronics Laboratory, Inc., 94 Milbar Blvd., Farmingdale, N.Y. 11735.

Circle 347 on Inquiry Card

Minimizing op amp noise

Fundamentals of op amp noise and circuit principles for minimizing noise error are discussed in a 12-page article. Topics covered include noise characteristics of representative amplifier types including bipolar input, FET input, chopper stability and varactor bridge types.



Included in the literature is a bibliography listing sources for various aspects of circuit noise, including general theory, conventional treatment and methods of minimizing noise effects. Analog Devices, Inc., 221 Fifth St., Cambridge, Mass. 02142.

Circle 348 on Inquiry Card

IC read only memory

A 26-page catalog covers a P-channel IC static 1024 bit ROM. An operational description is contained in the brochure as are application data, and mechanical and electrical characteristics. Logic, timing and bipolar system block diagrams are provided. Union Carbide, Semiconductor Dept., Box 23017, San Diego, Calif. 92123.

Circle 349 on Inquiry Card

Modem manual

A high speed data modem, designated AE-96, is the subject of a 10-page brochure. A general description of the device is included in the discussion along with its theory of operation and salient features. An operational schematic which illustrates the modem's functioning is provided. Codex Corp., 150 Coolidge Ave., Watertown, Mass. 02172.

Circle 350 on Inquiry Card

Encoders guide

Encoder technology and its applications are discussed in a 12-page booklet. Included in the guide is a section on the conversion of encoders into useable data, as in A/D conversion systems. A list of encoding definitions is also provided. Collectron Corp., 304 E. 45th St., N.Y., N.Y. 10017.

Circle 351 on Inquiry Card

Precision instrument switches

A 24-page catalog describes a line of precision instrument switches for use in computers, telemetering systems and automatic check-out equipment. Tips for selecting switches, terminal boards and multiple deck units are provided as are mechanical and electrical specs for the switches. Aerovox Corp., New Bedford, Mass. 02741.

Circle 352 on Inquiry Card

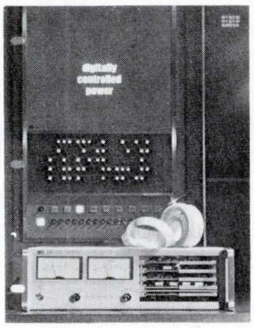
Measuring pulses precisely

Examples of digital data acquisition systems for use in scientific and industrial applications are discussed in a 15-page booklet. Tips for selecting the right system for a specific application are provided in both written and block diagram form. System options are included. Vidar, 77 Ortega Ave., Mountain View, Calif. 94040.

Circle 353 on Inquiry Card

Power sources

"Digitally Controlled Power" is the title of a 22-page brochure that deals with the characteristics and applications of digitally-controlled power sources. These sources are basically D-to-A converters followed by power amplifiers, but they can be used as



power supplies or waveform generators in computer-controlled and other automatic systems. They are designed for easy interfacing with digital controllers. Inquiries Mgr., Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. 94304.

Circle 354 on Inquiry Card

Hybrid computing systems

Hybrid computing systems which can be built around EAI's 640 digital computer are the subject of an 18-page brochure. The publication covers hybrid computer applications and user case histories, and describes the variety of integrated systems now available. Electronic Associates, Inc., West Long Branch, N.J. 07764.

Circle 355 on Inquiry Card

LITERATURE

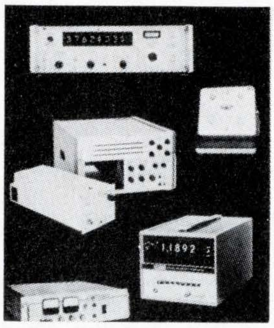
Microwave test equipment

Various standard waveguide and coaxial instruments and components which comprise a precision test equipment product line are covered in an up-dated catalog. Complete information on waveguide and coaxial devices, as noise sources, attenuators, directional couplers and phase shifters, is included as are engineering reports on noise measurement and standard waveguide data. Waveline, Inc., Box 718, W. Caldwell, N. J. 07006.

Circle 356 on Inquiry Card

Renting electronic equipment

A 48-page catalog covers a line of electronic instruments available for short term rental. The equipment includes oscilloscopes, counters, recorders, signal generators, digital voltmeters



and power supplies along with general purpose test equipment and small computers and accessories. Rentronix, 11501 Huff Court, Kensington, Md. 20795.

Circle 357 on Inquiry Card

Timing instruments

A file folder contains descriptions of high resolution instruments for scintillation and germanium timing experiments. Data pertaining to constant fraction timing and instrumentation for timing experiments is printed directly on the folder. A selection guide to the manufacturer's timing instruments, including block diagrams for a variety of experiments is contained in the folder as are spec sheets for popular instruments. Ortec, 219-C Midland Rd., Oak Ridge, Tenn. 37830.

Circle 358 on Inquiry Card

Mini connectors

Catalog CN-5 devotes itself to a line of miniature connectors. The devices described use a one-piece molded dielectric retention system rather than metal retention clips, therefore the number of contacts is increased in a given shell size. Included in the catalog are electrical and mechanical specs in addition to performance characteristics and available accessories. Illustrations, and instructions on the assembly of the connectors are also provided. Cinch Electronics Group, 1501 Morse Ave., Elk Grove Village, Ill. 60007.

Circle 359 on Inquiry Card

Electronic components

A 100-page catalog covering electromechanical components features a transducer selection guide. The guide, which has been designed to assist the engineer in his selection of transducers, accelerometers and load cells, describes popular types, functions and applications for each. Sections on counters, flow meters, precision pots, test equipment and timers are included as are photographs and diagrams. American Relays, Electronics Div., 39 Lispenard St., New York, N.Y. 10013.

Circle 360 on Inquiry Card

Laser accessories

A comprehensive 20-page catalog covers laser accessories and components. Included in the rundown are reflex beam expanders, laser focus assemblies, corner-cube retroreflectors, laser finder goggles and laser line filters. A section on pocket cells, a practical component for laser systems, discusses the theory and applications of the cells and includes specification tables and performance curve charts. Baird-Atomic, Inc., 125 Middlesex Turnpike, Bedford, Mass. 01730.

Circle 361 on Inquiry Card

Hybrid microcircuits

This 12-page brochure discusses the make or buy philosophy in hybrid microcircuits and the necessary required skills of electrical circuit design, materials and processing, mechanical design and packaging, manufacturing and quality control. It also describes the facilities and capabilities of a specialist in custom hybrid microcircuits with emphasis on micropower. Lansdale Microelectronics, Inc., Colmar, Pa. 18915.

Circle 362 on Inquiry Card

CLASSIFIED ADVERTISING

Light and color measurements

A 168-page volume is intended for the engineer or technologist interested in the measurement of light and color, specifically related to small light sources. The catalog provides a clear treatment of concepts of light and color that electronic engineers involved in optoelectronics need, yet are unable to find clearly defined in textbooks on the subject. It would take a good deal of browsing through several references to find the material covered in this comprehensive source. Available for $7.50 from General Electric Inquiry Bureau, Dept. L-C, Nela Park, Cleveland, Ohio 44112.

Life test/burn-in systems

Life test/burn-in systems are the subject of Catalog 61. Those covered include power aging, thermal fatigue, free air and controlled ovens for ICs. Descriptions for the models are provided, as are illustrations, specs and available components. Wakefield Engineering, Inc., Wakefield, Mass. 01880.

Circle 363 on Inquiry Card

Analog instruments

A 1969/1970 version of Philbrick/Nexus' product catalog features op amps, non-linear function modules, power supplies, regulators and accessories. The 100-pager contains up-to-date specs on available instruments, as well as selection guidelines. Products are indexed both by function (with applications) and by model number. Philbrick/Nexus Research, 3 Allied Dr., Dedham, Mass. 02026.

Circle 364 on Inquiry Card

Power components catalog

A line of power components, systems, and instruments are outlined in a comprehensive 64-page brochure. Included in the guide are dimensional drawings for each group as well as performance data and operating characteristics. A selection guide of the manufacturer's power instruments for lab, test equipment, systems, and OEM applications is provided. Lambda Electronics Corp., 515 Broad Hollow Rd., Melville, N.Y. 11746.

Circle 365 on Inquiry Card

Silicon semiconductor devices

A 1969 product catalog contains data for silicon semiconductor devices including analog switching instruments, varactor diodes, military devices, photo sensitive instruments, hybrid circuits and power FETs. The various products are coded by device, numerical, application and military indices. Provided too is a category locating guide as well as product data sheets. Available on company letterhead from Crystalonics, 147 Sherman St., Cambridge, Mass. 02140.

CAD techniques

Some of the advantages in using computer-aided design techniques in CATV equipment design are discussed in a 6-page technical bulletin. Titled "CATV Repeater Amp Design Utilizing Digital Computer," the paper contains design examples and includes schematics. Anaconda Electronics Co., Sales Dept., 1430 S. Anaheim Blvd., Anaheim, Calif. 92803.

Circle 366 on Inquiry Card

LITERATURE

Ferrite microwave devices, including 4-port isolators, circulators, co-isoguide devices, ferrite switches, drive electronics and mini isolators and circulators (32-pages). Advanced Microwave Labs, 611 Vaqueros Ave., Sunnyvale, Calif. 94086.
Circle 367 on Inquiry Card

Ultrasonic cleaning systems utilizing magnatrak generators with magnapak transducers—bulletin DB 80-350 (4-pages). Westinghouse Electric Corp., Box 868, Pittsburgh, Pa. 15230.
Circle 368 on Inquiry Card

Fluidic industrial control modules, available with brass fillings or with recessed O rings—data sheet FAD-935. Corning Glass Works, Corning, N.Y.
Circle 369 on Inquiry Card

Digital voltmeter with dc accuracy of 0.0025% and 10 μV resolution has full systems capability—data sheet 959 (8-pages). Dana Laboratories, Inc., 2401 Campus Dr., Irvine, Calif. 92664.
Circle 370 on Inquiry Card

Videotape equipment, including recorders, closed circuit TV cameras, monitors, lenses and accessories—brochure V69-5. Ampex Corp, 2201 Estes Ave., Elk Grove Village, Ill.
Circle 371 on Inquiry Card

Data communication products for use in data processing terminals and data communications equipment (4-pages). Cermetek, Inc., 660 National Ave., Mountain View, Calif 94040.
Circle 372 on Inquiry Card

Data manipulation lingo (Omnitab), developed to elminate time spent on manual computations (2-pages). International Telecomputer Network Corp., 7315 Wisconsin Ave., Bethesda, Md. 20014.
Circle 373 on Inquiry Card

Micro-mini digital display readouts, including micro decoder/driver modules and incandescent lamps with display brightness values up to 5000 feet—catalog 1969-2 (16-pages). Pinlites, Inc., 1275 Bloomfield Ave., Fairfield, N. J. 07007.
Circle 374 on Inquiry Card

Advertisers—October 1969

This Index is published for a convenience.
No liabilty is assumed for errors or omissions.

Index to Product Information

Listed below are all products and new literature that appear in this issue, along with the page number they appear on and their Reader Service Numbers (RSN). For more information, see the appropriate page and circle the corresponding number on the reader service card.