VOL. 18 NO.

Electronic Design 24

FOR ENGINEERS AND ENGINEERING MANAGERS

NOV. 22, 1970

Telemetry frees the heart patient by allowing continuous remote monitoring of his electrocardiogram. But high electrical noise levels, FCC regulations, antenna design limitations and the need for patient comfort place severe constraints on the designer. For a look at the many problems of medical telemetry, see page 48.

A good bench DVM is fast and accurate...

A great bench DVM is fast, accurate, and easy to use!

HP's 3480 is a great bench DVM. Simple, foolproof controls and full, five-decade autoranging reduce operating effort and errors. Fast response time and low noise make millivolt adjustments easy. And high noise rejection makes the last digit fully useable.

Low injected noise will not disturb the circuit under test. And constant $>10^{10}\,\Omega$ input resistance on the lower three voltage ranges reduces loading errors.

The digital readout display is presented in standard format for easy reading, easy understanding; i.e., +143.17 mV—not backwards, or inside out. Other convenience features include a sampling-rate indicator and a manual trigger for quick one-shot samples.

Options and plug-ins are available to give you combinations of five DC ranges, five true-RMS AC ranges, and six ohms ranges. And you pay for only the capabilities you want. Prices begin at $1500 for five ranges of fully autoranging DC.

For further information, contact your local HP field engineer, or write to Hewlett-Packard, Palo Alto, California 94304. In Europe: 1217 Meyrin-Geneva, Switzerland.

HEWLETT hp PACKARD

DIGITAL VOLTMETERS

090/45

INFORMATION RETRIEVAL NUMBER 101

VOL. 18 NO. 24

Electronic Design

FOR ENGINEERS AND ENGINEERING MANAGERS

NOV. 22, 1970

NEWS

TECHNOLOGY

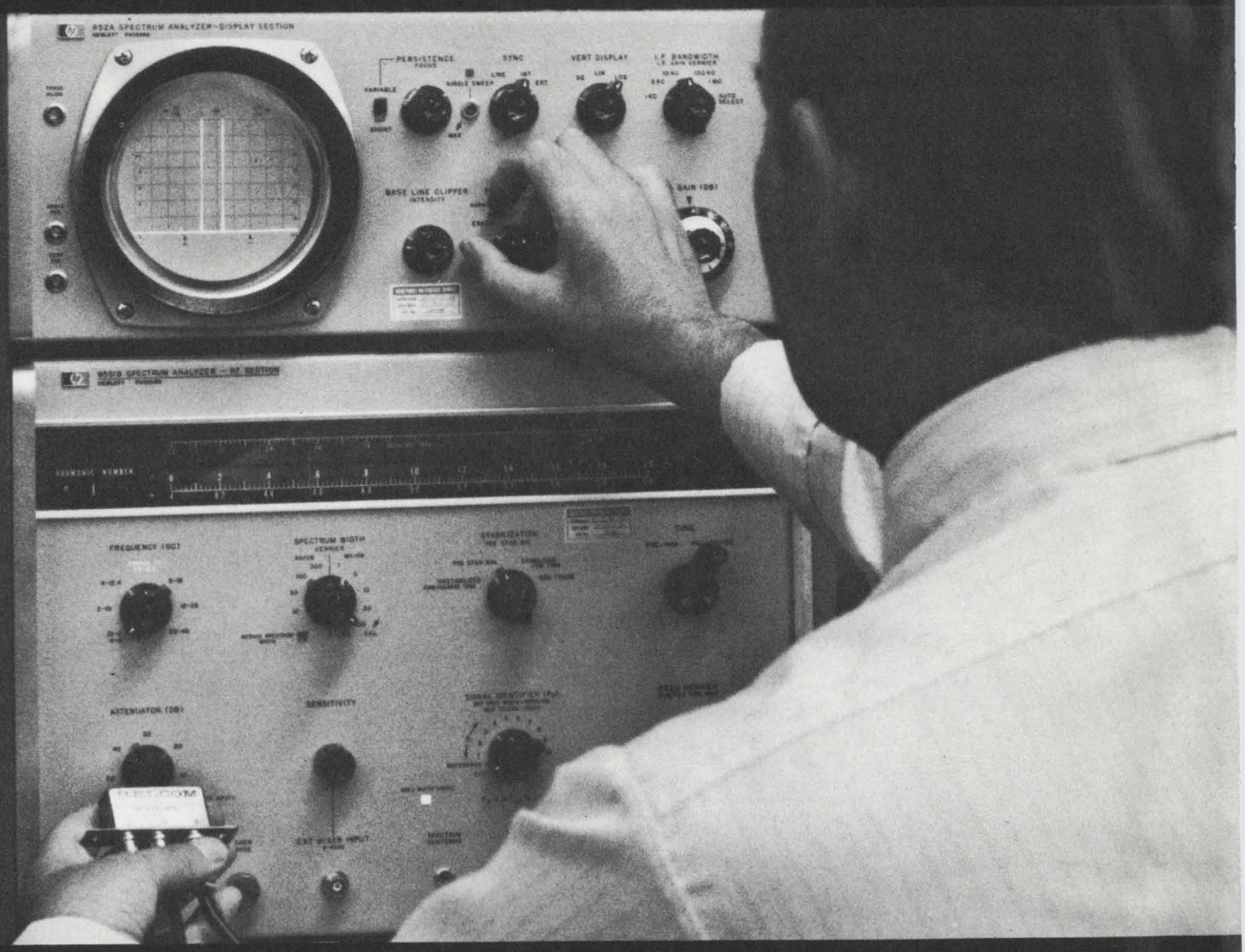
PRODUCTS

Departments

Cover: Designed by Art Director Clifford M. Gardiner and photographed by Henry Ries

ELECTRONIC DESIGN is published biweekly by Hayden Publishing Company, Inc., 850 Third Avenue, New York, N.Y. 10022. James S. Mulholland, Jr., President. Printed at Brown Printing Co., Inc., Waseca, Minn. Controlled circulation postage paid at Waseca, Minn., and New York, N.Y. 82,501 copies this issue.

EXPAND YOUR SPECTRUM ANALYZER CAPABILITY...



...AT ONLY 2.5% OF ITS COST!

Expand it with:

- Increased Sensitivity . . . 6 dB
- Reduction of Internal Spurs
- Flat Response down to 200 kHz (not 10.1 MHz)
- Flat Response up to 2 GHz (not 1.8 GHz)
- 15 db Less LO Signal at the Input Port
- 20 dB More Input Before Burn-out

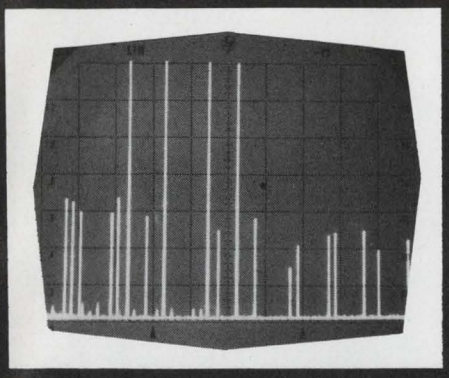
Now, all these things are economically possible with RELCOM's M1F double-balanced mixer . . . designed for use on analyzers with a 2 to 4 GHz LO and a 2 GHz IF. Just a small investment will give your instrument expanded capability to make more critical measurements.

For a better idea of what this mixer can do for your analyzer, compare the following spectrum analyzer photographs.

A major consideration in spectrum analysis is whether the response is real, or is internally generated. Spurious frequency components generated in the first mixer of the 8551B/851B are shown below. Where there are really only four −20 dBm input signals at 250, 350, 470, and 550 MHz, other spurious signals are present in the display.

The 8551B/851B is unspecified below 10 MHz. The numbered (in MHz) responses are −50 dBm calibrating signal inputs. Notice the low frequency response roll-off. The responses labeled "S" are internally generated spurious signals. The rise at the left of the picture shows the desensitization due to the LO feed-thru to the 2 GHz IF of the spectrum analyzer.

The dynamic range and sensitivity of the 8551B/851B is limited by the noise figure of the instrument. Shown below is a 600 MHz input signal at −20 dBm and a 500 MHz input signal at about −80 dBm. The settings on the analyzer are as follows: Horizontal scale 30 MHz/cm, vertical scale 10 dB/cm and IF bandwidth 10 kHz. Can you see the 500 MHz signal?



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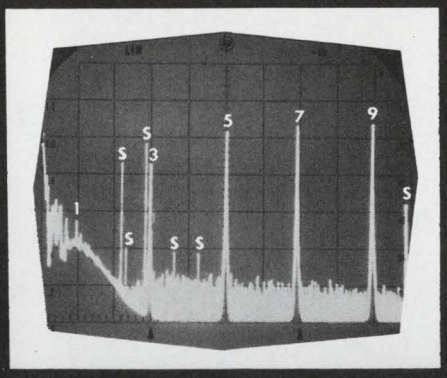

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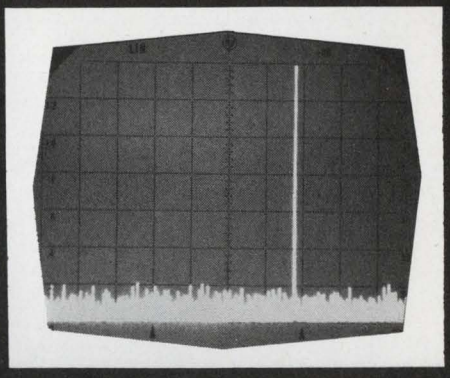

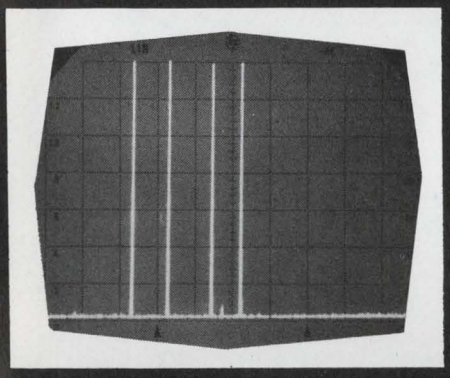

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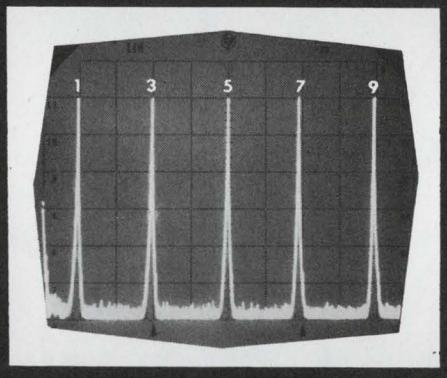

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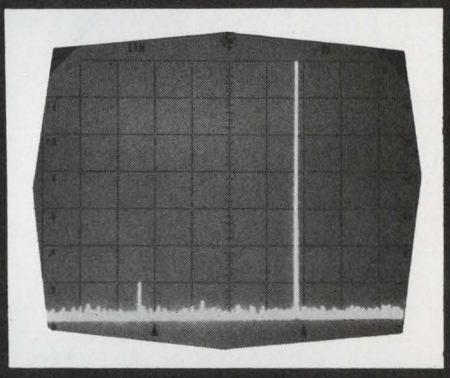

With the same input signals and spectrum analyzer settings as above, substitution of the Relcom Model M1F Double-Balanced Mixer for the first mixer (single-diode) in the spectrum analyzer eliminates the confusing intermodulation products. The vertical scale is 10 dB/cm.

Substitution of the Relcom Model M1F Double-Balanced Mixer for the first analyzer mixer under the same conditions as above provides: (1) a *flat* frequency response in the 200 kHz to 10 MHz range, (2) increased gain and less noise for more dynamic range, (3) a drastic reduction in internally generated spurious signals, and (4) a reduction in the desensitization due to the LO feed-thru.

Substitution of the Relcom Model M1F Double-Balanced Mixer for the first spectrum analyzer mixer reveals the presence of the low-level 500 MHz signal. Reduction of the spectrum analyzer IF gain provides the same reference amplitude for the 600 MHz input. The M1F provides about 6 dB improvement in the spectrum analyzer noise figure.

Same advantages apply in the 1.8 to 4.2 GHz range.

Buy a Model M1F now, and see its remarkable value for yourself. We'll include applications data with delivery. If you're not completely satisfied, just return the mixer within two weeks for a full refund. Act today! Delivery from stock. Price, $275 each.

RELCOM

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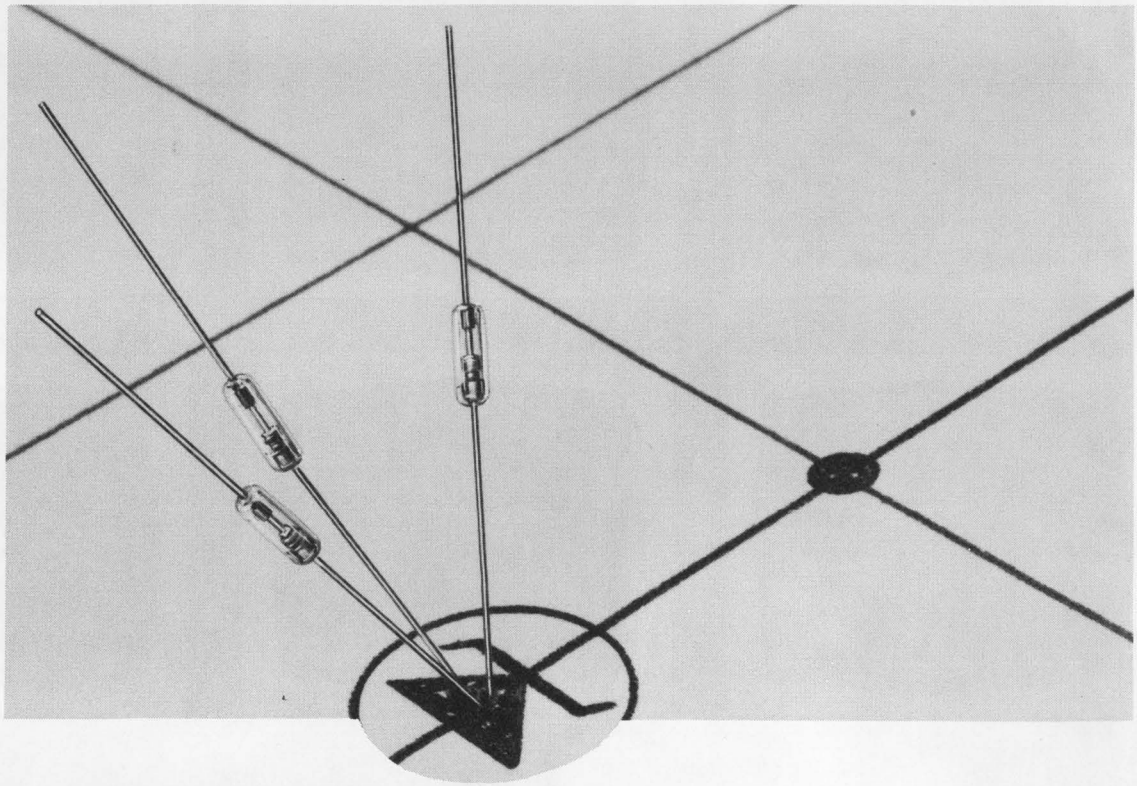
INFORMATION RETRIEVAL NUMBER 4

Run it hot, run it cold, run it wet, run it dry... ZERO-TC diodes always run it constant voltage...



Weather or not.

When all you can stand in your new circuit design is a few millivolts output voltage change over many degrees centigrade variation, a ZERO-TC*diode is the ideal equalizer.

Providing voltage-time stability limits as low as 5 ppm/1,000 hours of operation, ZERO-TC's provide environment-tight, hermetic glass seals, "no-failure" RamRod* construction and oxide-passivation for long-term, low-leakage stability and integrity of characteristics under most any external climate conditions.

We'll show you how to use them to best advantage, too.

Send for AN-437, an application note explaining all the design criteria and characteristics you'll need to know about how to lock in voltage stability and circuit equilibrium under most any ambient temperature/humidity environments. Write: Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, Arizona 85036.

You'll also receive a Selector Guide — for choosing the exact reference device you'll need from 141 standard ZERO-TC types — and the key to hundreds of specials, too.

So you can do just the right thing about the weather.

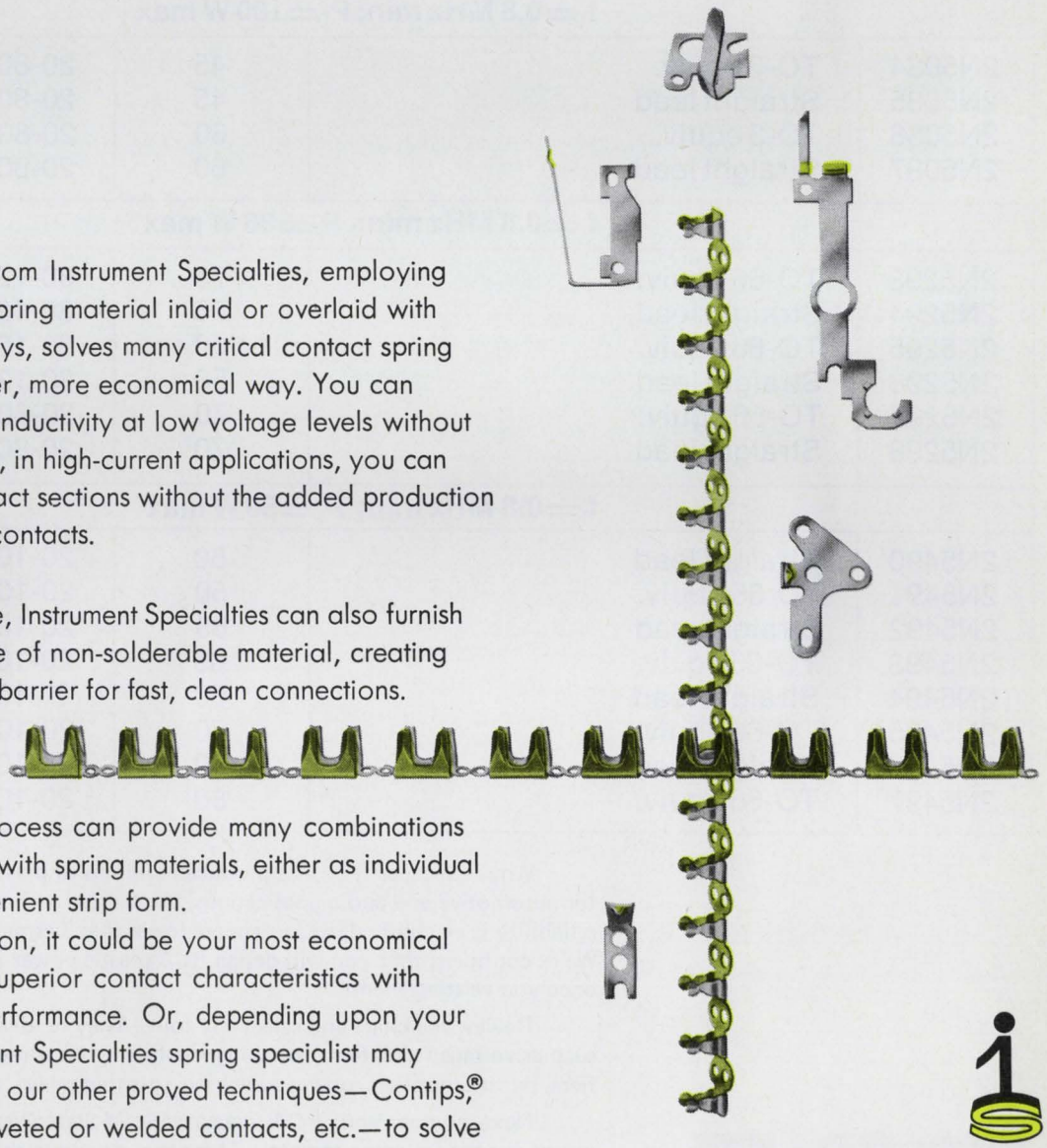
*Trademark Motorola Inc.

MOTOROLA ZENERS
—where the priceless ingredient is care!

INFORMATION RETRIEVAL NUMBER 5

Instrument Specialties new inlay-overlay technique

improves contact reliability, preserves spring characteristics.



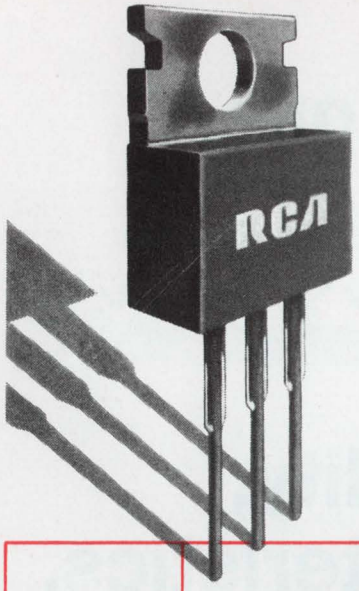
A new technique from Instrument Specialties, employing beryllium copper spring material inlaid or overlaid with precious metal alloys, solves many critical contact spring problems in a better, more economical way. You can improve surface conductivity at low voltage levels without electroplating. And, in high-current applications, you can obtain thicker contact sections without the added production cost of assembled contacts.

Using this technique, Instrument Specialties can also furnish springs with a stripe of non-solderable material, creating an effective solder barrier for fast, clean connections.

This cost-saving process can provide many combinations of precious metals with spring materials, either as individual springs or in convenient strip form.
In volume production, it could be your most economical way to combine superior contact characteristics with optimum spring performance. Or, depending upon your needs, an Instrument Specialties spring specialist may recommend one of our other proved techniques—Contips,® selective plating, riveted or welded contacts, etc.—to solve your problem. Write today for more information. There's no obligation. Address: Dept. ED-64.

INSTRUMENT SPECIALTIES CO., INC.
Little Falls, New Jersey 07424
Phone 201-256-3500

INFORMATION RETRIEVAL NUMBER 6



FOUR FOR FREE!

RCA offers you four plastic power transistors without charge.

RCA Type	Package	$V_{CER(sus)}$ V	h_{FE}	I_C A	V_{CE} V
f_T=0.8 MHz min; P_T=100 W max					
2N5034	TO-3 equiv.	45	20-80	4	4
2N5035	Straight lead	45	20-80	4	4
2N5036	TO-3 equiv.	60	20-80	5	4
2N5037	Straight lead	60	20-80	5	4
f_T=0.8 MHz min; P_T=36 W max					
2N5293	TO-66 equiv.	75	30-120	0.5	4
2N5294	Straight lead	75	30-120	0.5	4
2N5295	TO-66 equiv.	50	30-120	1	4
2N5296	Straight lead	50	30-120	1	4
2N5297	TO-66 equiv.	70	20-80	1.5	4
2N5298	Straight lead	70	20-80	1.5	4
f_T=0.8 MHz min; P_T=50 W max					
2N5490	Straight lead	50	20-100	2	4
2N5491	TO-66 equiv.	50	20-100	2	4
2N5492	Straight lead	65	20-100	2.5	4
2N5493	TO-66 equiv.	65	20-100	2.5	4
2N5494	Straight lead	50	20-100	3	4
2N5495	TO-66 equiv.	50	20-100	3	4
2N5496	Straight lead	80	20-100	3.5	4
2N5497	TO-66 equiv.	80	20-100	3.5	4

Why? Because RCA has produced millions of plastic power transistors for automotive and audio applications, production techniques are proven, reliability is established, and prices are lower than hermetic counterparts. We're confident that you will design RCA plastic power into your circuits – once you've tried them!

Review the chart and select any four. They're ideal for applications such as voltage regulators, switching regulators, linear regulators, pulse amplifiers, linear amplifiers, power switching, solenoid relays, and many others.

Next, contact your *RCA Industrial Solid-State Distributor;* he is your source for the four free samples. This offer is good in the U.S.A., and expires December 31, 1970.

RCA | Electronic Components | Harrison, N.J. 07029

RCA

INFORMATION RETRIEVAL NUMBER 8 ►

to get 56% more the same money:

ou need a sixth or seventh yours for only $75 each. A a output is just $50, regard- the number of digits. For ments between 50 and 500 the 1157-B Scaler – only e. For extra savings, GR has discounts for orders of 10 nits.

basic 1192 Counter has e-accepted by the FCC for uency monitoring and the version has been similarly for fm use (including vhf).

get a lot more range with- g out a single extra penny, call the GR District Office nearest you and ask for an 1192-B. If you prefer, write GR at 300 Baker Ave., Concord, Massachusetts 01742 or, in Europe, Postfach 124, CH 8034, Zurich, Switzerland.

General Radio

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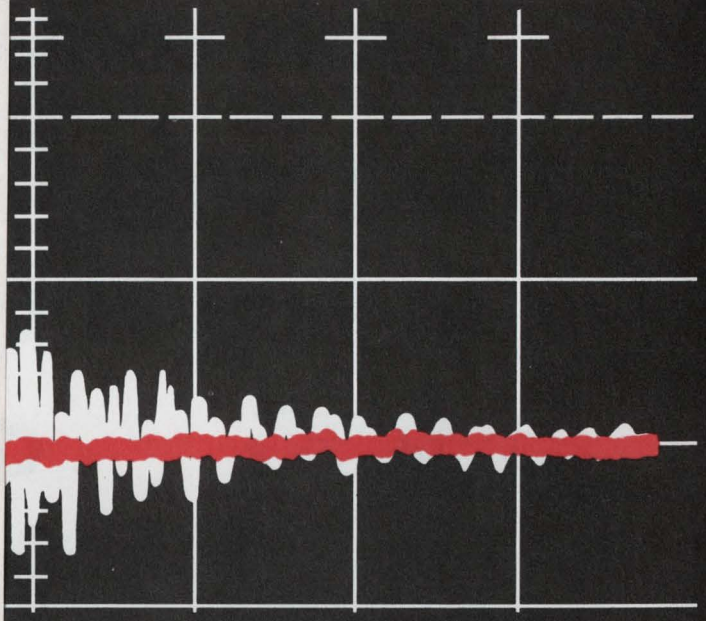
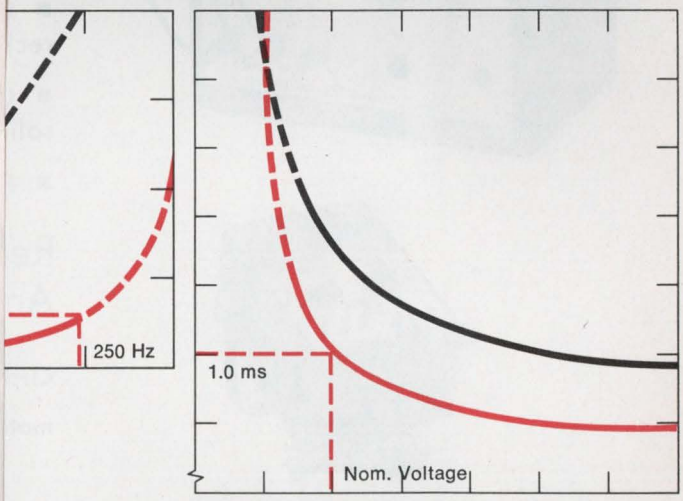
ROUGH
contact relays



e

th system, 4 ms after coil energization, HGJ contact zontal, 1 ms/div.; vertical, 50 μv/div. Red line: HGJ; standard relay.)

RELAYS
industry standards



y standard

faster response

At nominal voltage,
HGJ response time = 1 ms.

CLARE

C. P. CLARE & CO.
Chicago 60645 and worldwide.
A General Instrument company.

Its $395 price beats competition! But- that's only One reason to buy it! Look at the other reasons:

- Hickok's new Model 3300 3½ digit multimeter has 26 ranges of ac-dc voltage and current, and ohms.
- Ranges are 100.0 millivolts to 15.00 kilovolts, 1.000 milliamp to 1.999 amps, 100.0 ohms to 199.9 megohms.
- Measurement conveniences—automatic zeroing and polarity, constant input Z, LSI reliability.
- Operates 24 hours off internal battery pack (more than anyone else's). And the battery pack is standard.
- Recharges overnight (faster than others).
- Or, operates off the ac line, even during the recharge cycle.
- Goof-proof, even in less experienced hands—solid state circuitry is overload protected.
- Rugged case is impact-resistant and shockproof.

Really, should you pay more? And maybe get less?

Circle Reader Service Card # (9) for complete information. Or call your local Hickok man for a demonstration.

HICKOK

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LEAR SIEGLER, INC. / CIMRON DIVISION

What's so surprising about a new pulse generator with a rep rate of 1 HZ to 25 MHz, double pulse to 40 MHz, and rise time of 3 nanoseconds?

The price: $395.00

You can pay twice as much for what Cimron has designed into its new series of pulse generators. Or, you can spend the same money someplace else and get far less capability and performance. Even at its surprising price, the Model 3103 will handle just about any time domain testing requirement for the design and production of semiconductors and instruments.

First class features back up the 3103's great specs. There's simultaneous bipolar output, synchronous or asynchronous gating and a back-matched output amplifier that delivers a usable pulse even in the unterminated mode.

Whether your application calls for a simple repetitive clock source, controlled gating or external triggering, you get more for your money at Cimron. Select the 3103, or one of two companion models, for your specific requirement. The Model 3101 Logic Driver (just the thing for IC testing at $265) gives you a simultaneous complement output that eliminates the need for an external inverter. And for $325, the 3102 supplies a variable output to a full 10 volts into a 50 ohm load.

All our economical new pulse generators contain IC logic and are engineered with Cimron's "customer concern." So if you're ready to spend money on a general purpose timing pulse source, price Cimron. We wouldn't be surprised if you bought two of ours.

Write Cimron, Dept. E-112, 1152 Morena Boulevard, San Diego, Calif.

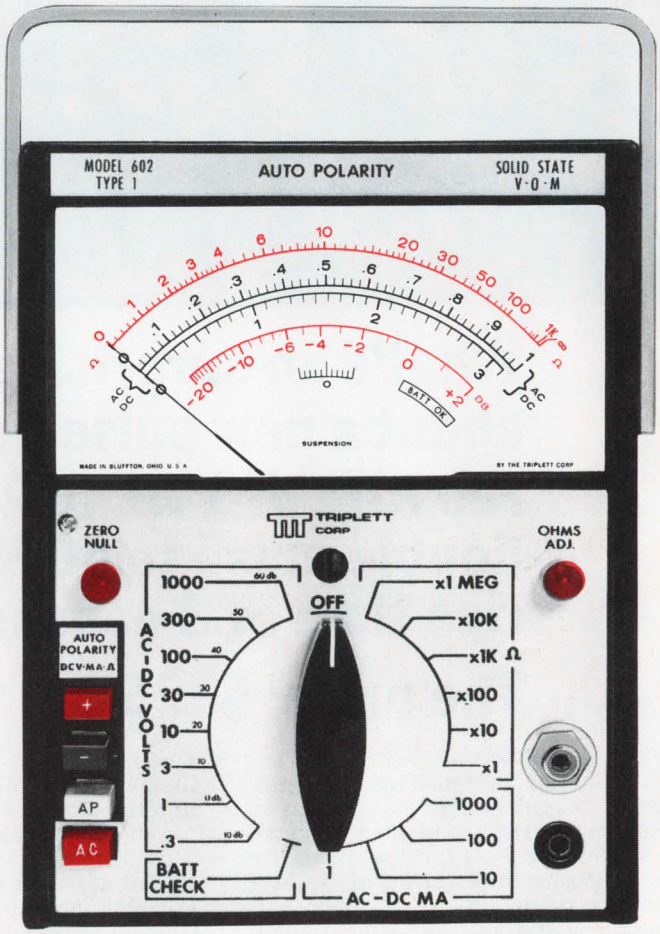
CIMRON

NEW AUTO-POLARITY FET V-O-M SPEEDS TESTING

You've probably imagined the convenience and time-saving you'd enjoy if you could just clip one of the V-O-M leads to ground or to the chassis, and have your meter always read upscale regardless of the polarity of any other terminal you touched.

No need to imagine it any more . . . you can see it and try it right now at your Triplett distributor. Called the Triplett Model 602, it's probably the most convenient V-O-M ever built. Its convenience goes well beyond the auto-polarity feature, though . . . to AC and DC measurements from 10 mV to 1000 V in 8 ranges at 11 megohms DC and 10 megohms AC input resistance . . . AC and DC from 0.02 to 1000 mA in 4 ranges . . . resistances from 0.2 ohms to 1000 megohms in 6 ranges. And with an accuracy of 3% on voltage measurements, and a rugged suspension-type meter movement, the Model 602 has what it takes to make your job easier.

This great new V-O-M is only **$100** suggested USA user net. For more information, or for a free, no-obligation demonstration, call your local Triplett distributor or your Triplett sales representative. Triplett Corporation, Bluffton, Ohio 45817.



1. Auto Polarity . . . convenient and time-saving; creates memory and suppressed scale.
2. High sensitivity (.3V AC and DC) at constant 11 megohms input resistance.
3. Simplified scale with only 2 arcs for 24 AC/DC ranges.

TRIPLETT

The World's most complete line of V-O-M's . . . choose the one that's just right for you.

INFORMATION RETRIEVAL NUMBER 11

Designer's Calendar

JANUARY 1971

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

For further information on meetings, use Information Retrieval Card.

Jan. 12-14
Symposium on Reliability (Washington, D. C.) Sponsors: IEEE et al. J. W. Thomas, Vitro Labs., 14000 Georgia Ave., Silver Spring, Md. 20910.

CIRCLE NO. 401

Jan. 25-26
Optics in Microelectronics Conference (Las Vegas, Nev.) Sponsor: Optical Society of America, Microelectronics Meeting, 2100 Pennsylvania Ave., N. W., Washington, D. C. 20037.

CIRCLE NO. 402

FEBRUARY 1971

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

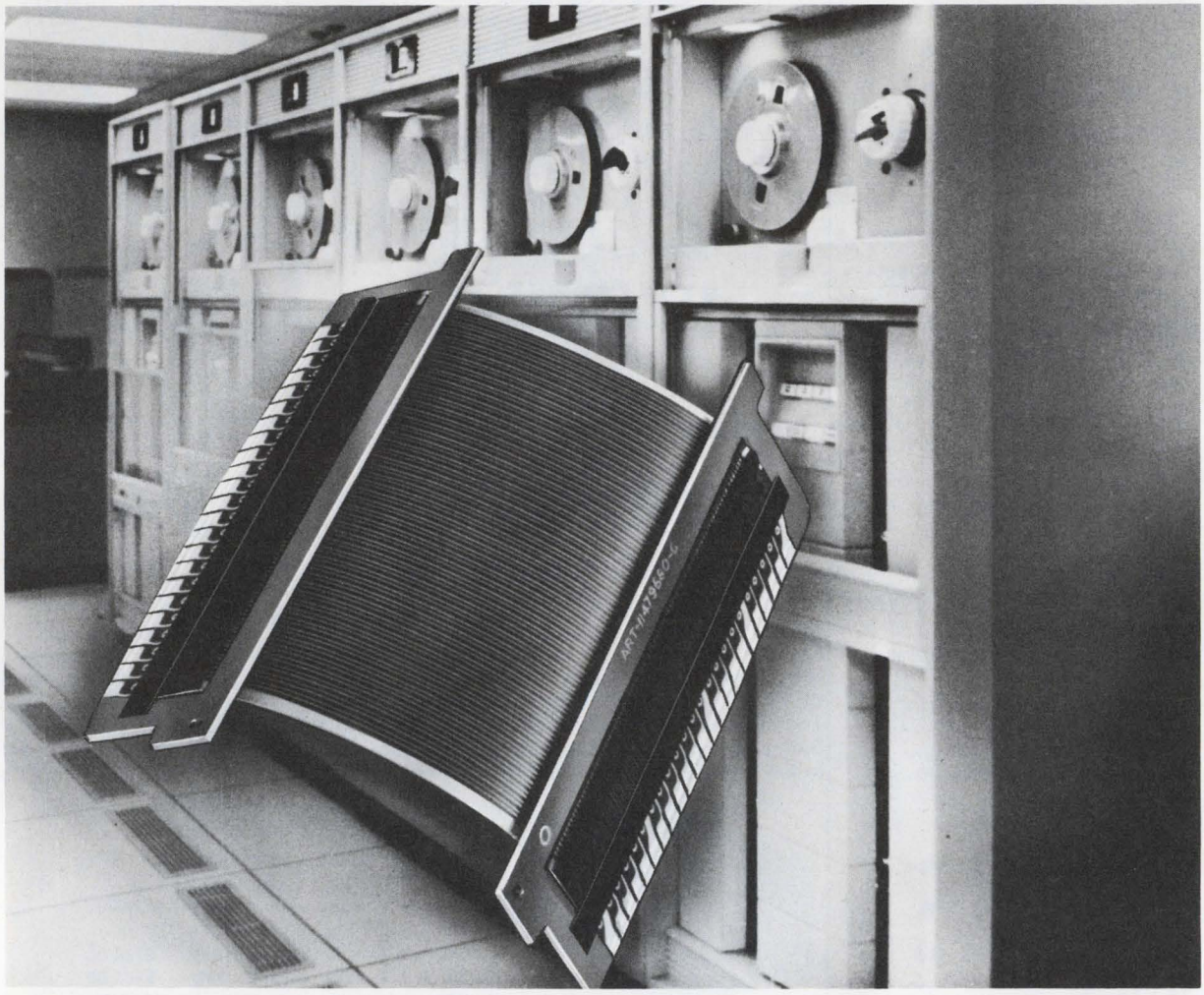
Feb. 9-11
Aerospace & Electronic Systems Winter Convention (WINCON), (Los Angeles). Sponsors: IEEE et al. William H. Herrman, Wincon '71, IEEE Los Angeles Council, 3600 Wilshire Blvd., Los Angeles, Calif. 90005.

CIRCLE NO. 403

Feb. 17-19
International Solid State Circuits Conference (Philadelphia, Pa.) Sponsors: IEEE et al. Lewis Winner, 152 W. 42nd St., New York, N. Y. 10036.

CIRCLE NO. 404

Want to do something about the high cost of interconnections?
...about runaway impedance values?
...about reliability?



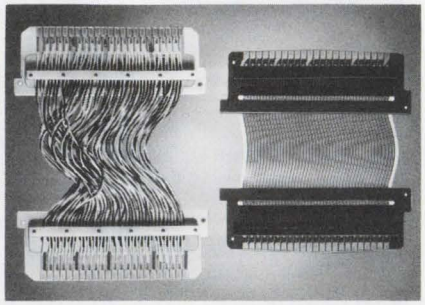
Call for Mektron® jumpers by Rogers!

Mektron jumpers are designed for point-to-point signal transmission following practically any path — in any kind of computer or peripheral equipment. Their economies begin with proprietary manufacturing techniques like continuous etching and mass termination . . . and extend all the way to simple, foolproof installation.

Impedance? In each and every jumper, we'll guarantee to control it to within ± 5% of the value you specify.

Reliability? There are scores of connections in every jumper. While the connections we've made now number in the millions, no failure has ever occurred! And wiring errors just can't happen.

If this is the kind of signal or current-carrying hardware YOU need, let us tackle your interconnection requirements today. Call Bob Sanders at (203) 774-9605.



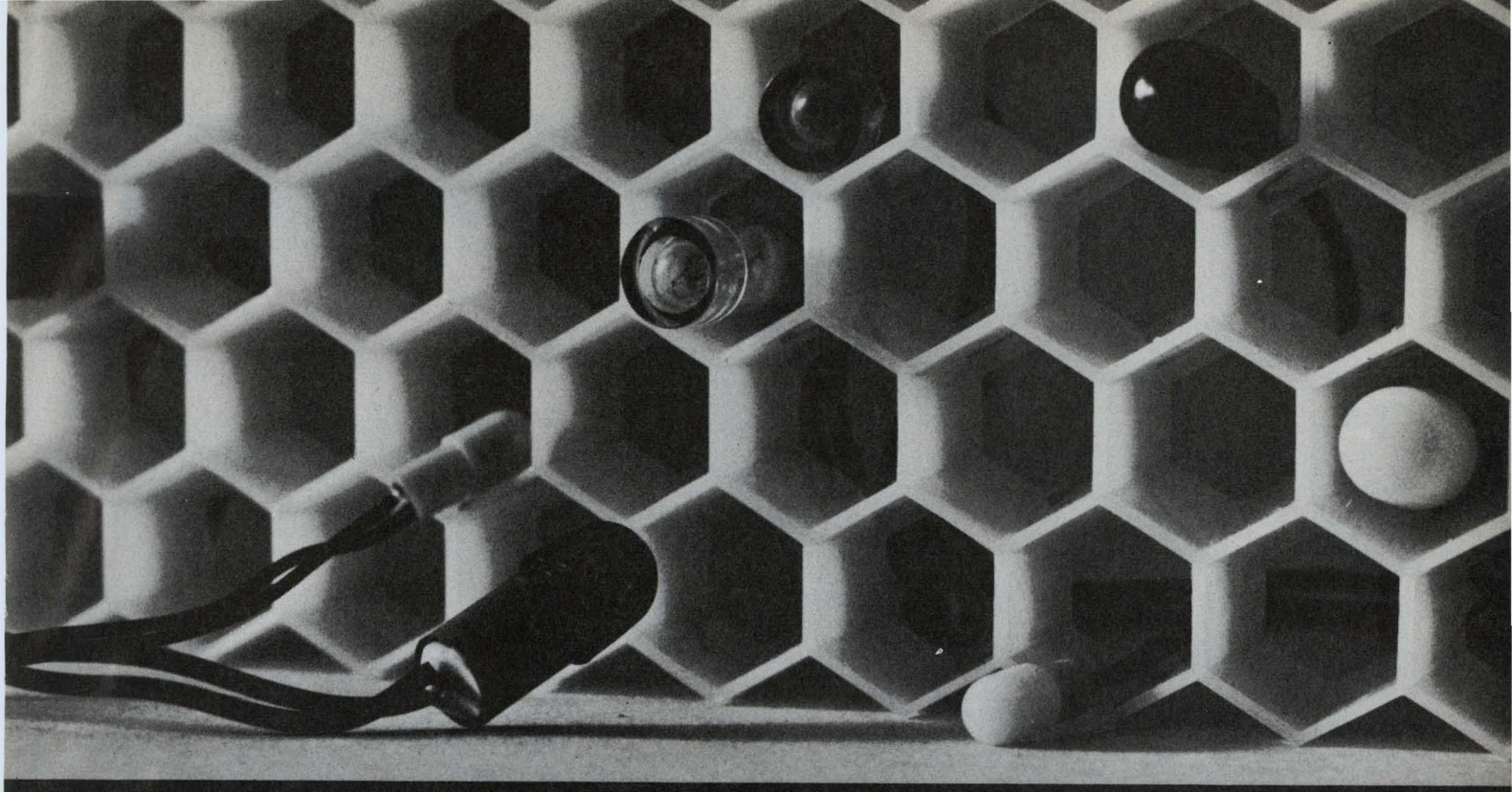
Conventional (wired) jumper

Compact Mektron jumper

Rogers Corporation / Rogers, Connecticut 06263

Mektron products are available from: Mektron Division, Rogers, Connecticut; Circuit Systems Division, Chandler, Arizona; Mektron N.V., Ghent, Belgium.

INFORMATION RETRIEVAL NUMBER 13



Just because you don't cost much doesn't mean you should wear out in a hurry. Our worker bugs are bred to overcome the problem of constant relamping which defeats the whole idea of using low cost units in the first place.

It's a matter of upbringing. We pay attention to detail in making the basic lamp.

Lamp assembly makes a difference, too. Such as the lamp and lead wires potted in place with high temperature polycarbonate for positive strain relief and resistance to temperature extremes. Or the flanged butyrate shell in clear, amber, red, green or white that assures simplified mounting with speed clips.

These Chicago Miniature lamps are available in the Migi-Lite (T-1) or Peanut-Lite (T-1¾) sizes for use in amplifiers, mobile equipment, computers, display panels, industrial controls . . . anywhere economy and extended life are important. Order the macrodome or cylindrical, neon or incandescent worker bugs.

They're equally diligent.

The worker bugs are only a sample of the many species listed in our CML-1 Lited Devices Catalog. For off-the-shelf delivery, contact your local authorized Chicago Miniature Electronic Distributor.

CHICAGO MINIATURE
LAMP WORKS
4433 N. Ravenswood Ave.,
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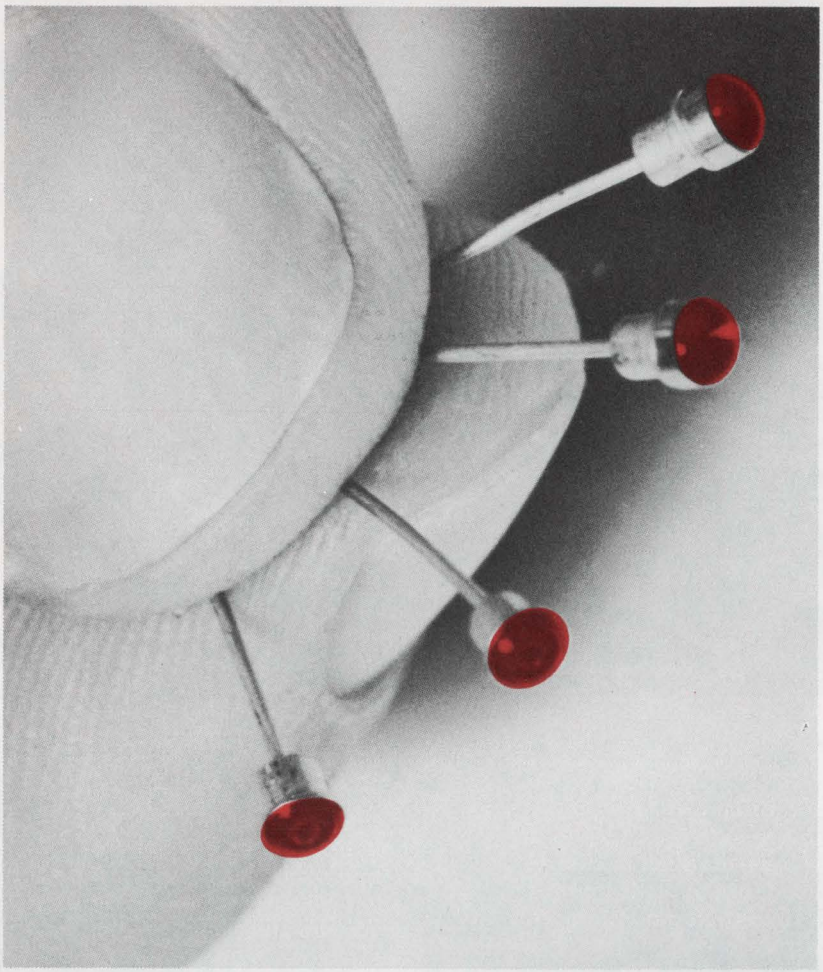
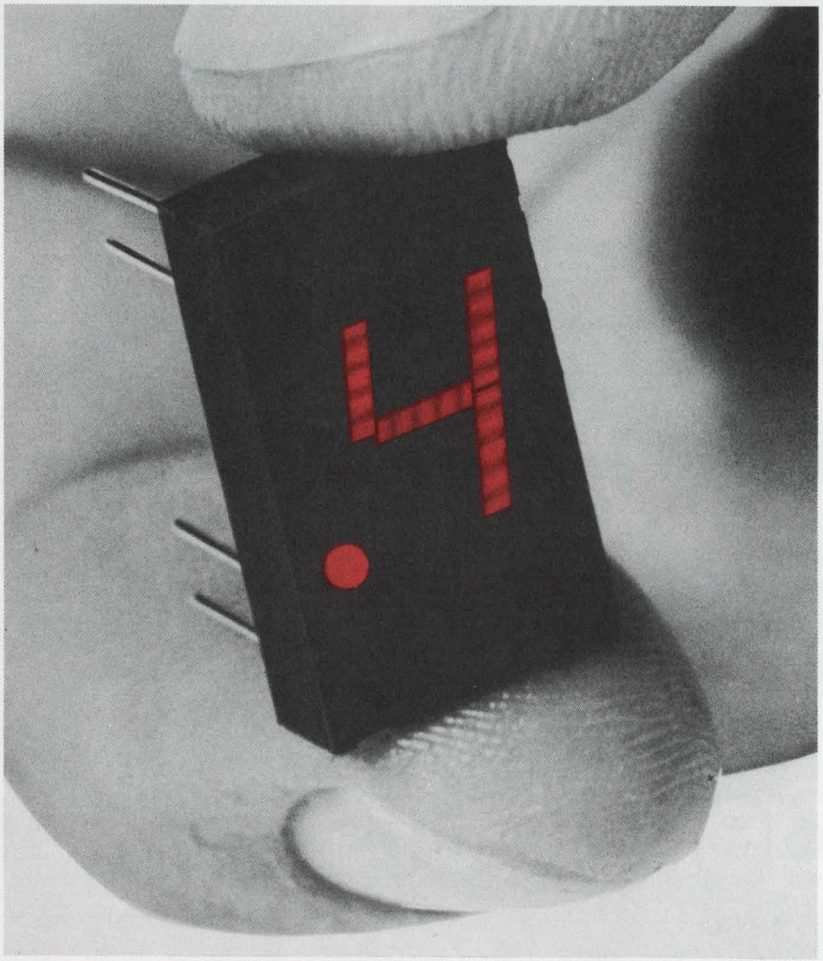
(312) 784-1020
a GENERAL INSTRUMENT company

THE LIGHTING BUGS

Our worker bugs put in longer hours.

INFORMATION RETRIEVAL NUMBER 14



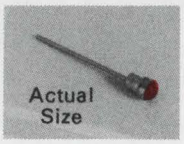


SOLID-LITE

SOLID STATE LAMPS AND NUMERIC INDICATORS

New Solid-Lite semiconductor display devices use gallium phosphide, the most efficient of all visible-light electroluminescent materials. You get bright light at lower current.

SOLID-LITE Solid State Lamps



Provide an area source of light—not just a pinpoint. These IC-compatible light-emitting diodes produce a luminous intensity of 2 millicandelas at 15 mA and 2.1 volts with easy wide-angle viewing. They offer:

- Low power consumption
- Excellent shock and vibration resistance
- High reliability—long life
- Low cost

SOLID-LITE Solid State Numeric Indicators

Actual Size

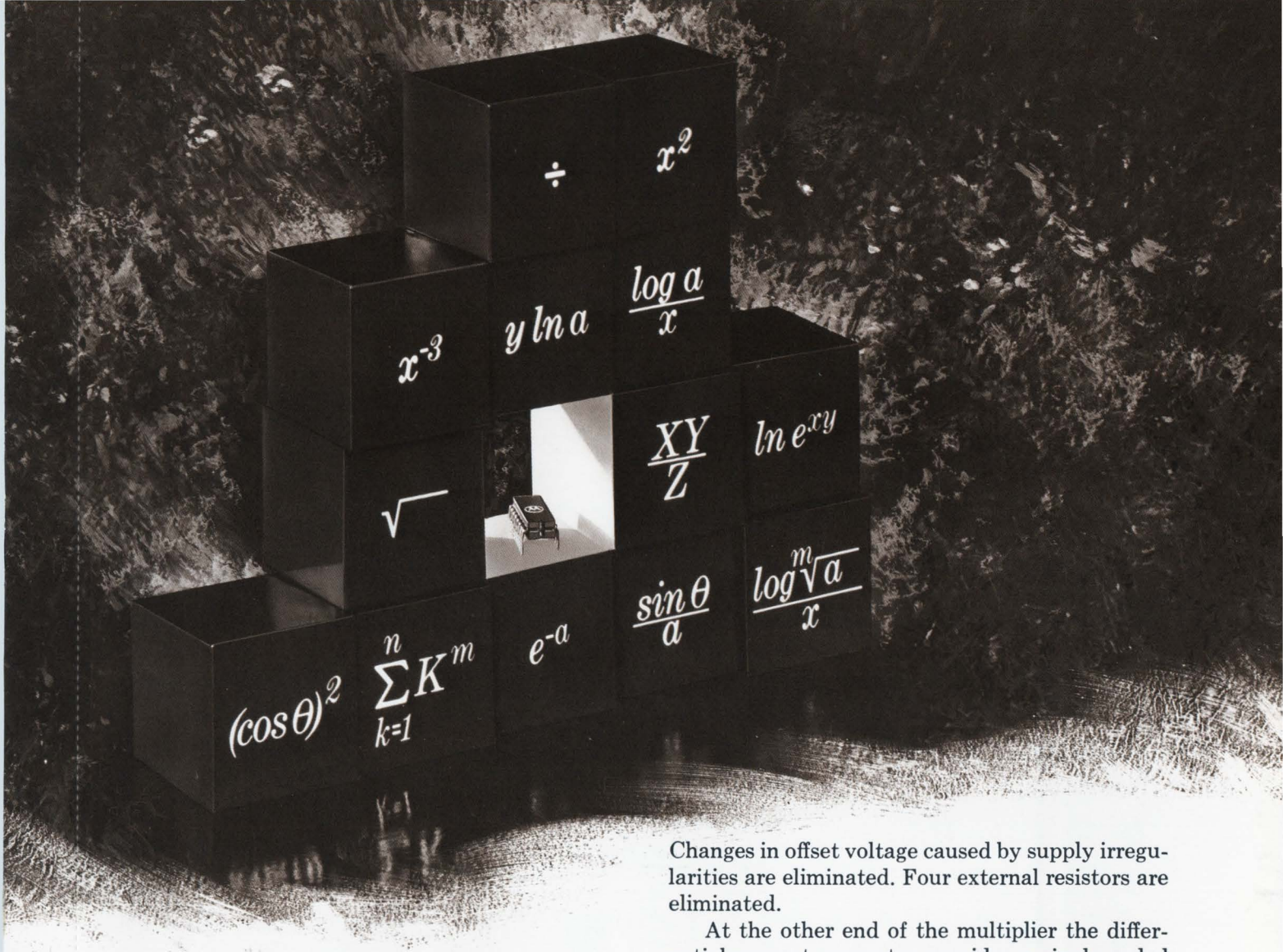
Low-cost, seven-segment numeric indicators in standard 14-pin dual in-line packages are compatible with TTL and DTL IC's. Large, bright numerals are pleasing to the eye. They offer:

- Low voltage operation at less than ¼ watt total power
- Large character size—.33″ x .21″
- Single-plane wide-angle viewing
- High reliability—long life
- Excellent shock and vibration resistance

For technical literature or applications assistance, write or call OPCOA, Inc., 330 Talmadge Road, Edison, New Jersey 08817; phone (201) 287-0355.

OPCOA INC.

INFORMATION RETRIEVAL NUMBER 15



Second generation IC "Multiplier Plus"

Plus What?... Plus built-in voltage regulator and current converter

Motorola's new MC1594/1494 introduces the second generation of monolithic IC four-quadrant multipliers based on the variable transconductance principle. The "multiplier plus" is easier to use than the familiar industry standard MC1595/1495, and it offers a new high level of performance.

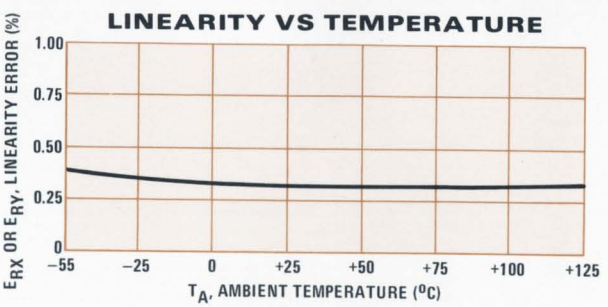
"Plus" features for cost reduction

The built-in current and voltage regulator eliminates the effects of power supply fluctuation and reduces the number of external components required. It regulates all current sources on the monolithic chip, effectively immunizing the multiplier to supply voltage fluctuations. It also provides two (+4.3 V) regulated voltages to bias the offset adjust potentiometers. Interaction among the pots during adjustment is eliminated. Changes in offset voltage caused by supply irregularities are eliminated. Four external resistors are eliminated.

At the other end of the multiplier the differential current converter provides a single-ended output current referenced to ground.

"Plus" features for Improved Performance

Linearity of 0.5% max (X or Y) for the MC1594 sets a new standard of excellence, and the MC1494 offers a fine 1.0% max error (X or Y). The "multiplier plus" is easier for the designer to use because it handles input and output voltages of ±10 V with ±15 V supplies. And power supply sensitivity is also significantly improved.

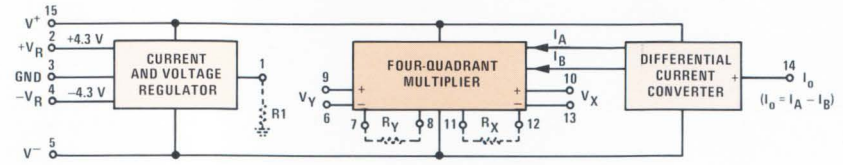


Please turn page for circuit information

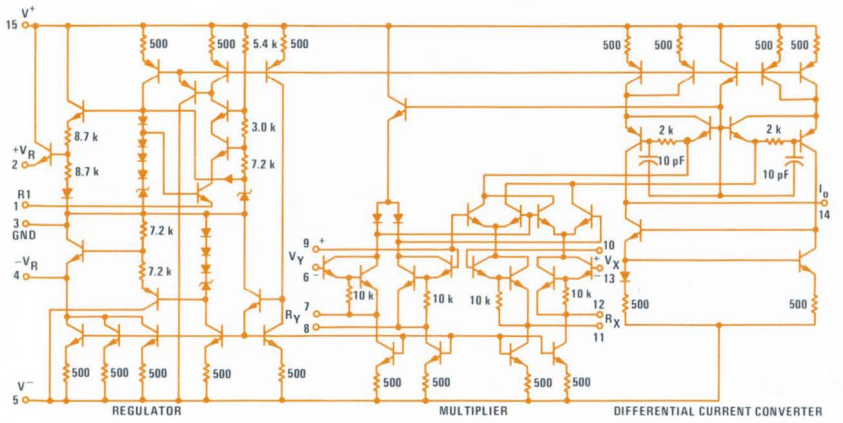
MOTOROLA LINEAR
— serving a greater range of analog designs!

Here Is The Second Generation Monolithic IC Multiplier Motorola's MC1594/1494 "Multiplier Plus"

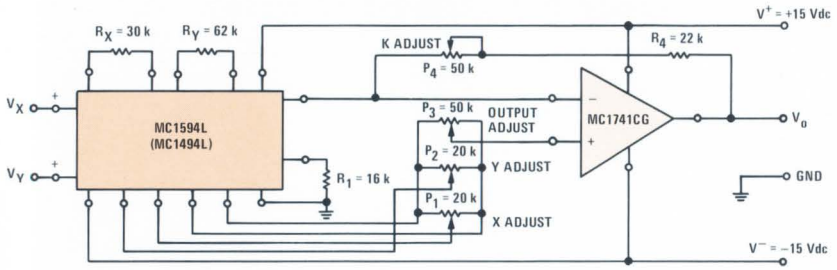
BLOCK DIAGRAM



COMPLETE CIRCUIT SCHEMATIC



TYPICAL MULTIPLIER CONNECTION



Check these performance features

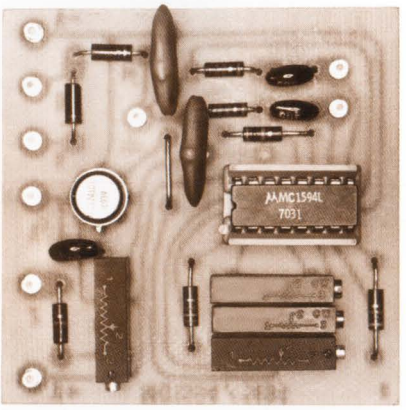
- Excellent linearity
  0.5% max (X or Y) — MC1594L
  1.0% max (X or Y) — MC1494L
- Wide input voltage range — ± 10 V
- ± 15 V supply operation
- Single ended output referenced to ground
- Improved offset adjust circuitry
- Adjustable scale factor
- Power supply sensitivity — 30 mV/V (typ)

Learn all about the "Multiplier Plus" right away

The MC1594L and MC1494L are available now from your nearest Motorola distributor at 100-up prices of $12.00 - MC1594 and $8.00 - MC-1494. Both devices are in the 16-pin ceramic dual in-line package. For a 14-page applications-specifications data sheet, circle the reader service number or write Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, Arizona 85036.

Circle No. 121

"Multiplier Plus"
Special Introductory Offer



Complete MC1594 or MC1494 Evaluation and Experiment Kit DC and AC applications — All you need to build it for Multiply • Square • Divide • Square Root • Balanced Modulator • Amplitude Modulator • Phase Detector • Frequency Doubler.

40% Off total 1-up price of all components and hardware!

MCK1594 Kit . . . This $38.45 value only $23.10

MCK1494 Kit . . . A $32.45 value at only $19.50 (substitute MC1494L multiplier)

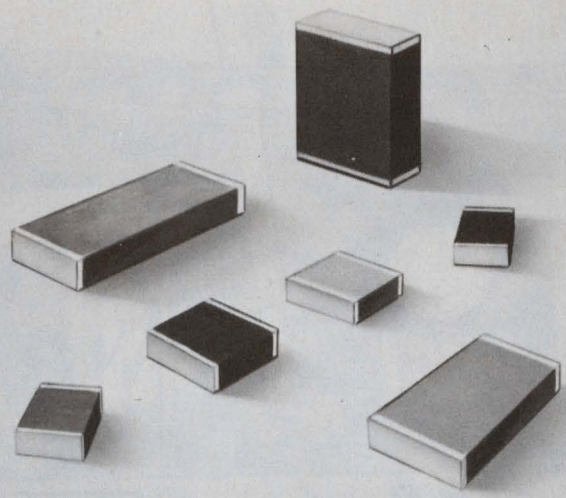
Parts list
MCK1594 and MCK1494

Quantity	Part Description
1	MC1594L or MC1494L
1	MC1741CG op amp
2	1N5241B Zener Diodes
2	510 ohm, ¼ W, 20% carbon resistors
1	16K, ¼ W, 5% film resistor
1	22K, ¼ W, 5% film resistor
1	30K, ¼ W, 5% film resistor
1	62K, ¼ W, 5% film resistor
2	20K, 15 turn cermet potentiometers
2	50K, 15 turn cermet potentiometers
2	0.1μF ceramic disc capacitors
3	10pF ceramic disc capacitors
1	16-pin dual in-line socket
1	PC board
10	terminals

Also contains complete "How To Do It" construction note and data sheet with applications information.

Specify by MCK1594 or MCK1494 — state quantity — enclose check (P.O. is OK for order over $20.00) — offer expires May 20, 1971 — limit, 5 (five) kits. Send order to Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, Arizona 85036.

MOTOROLA LINEAR
— serving a greater range of analog designs!



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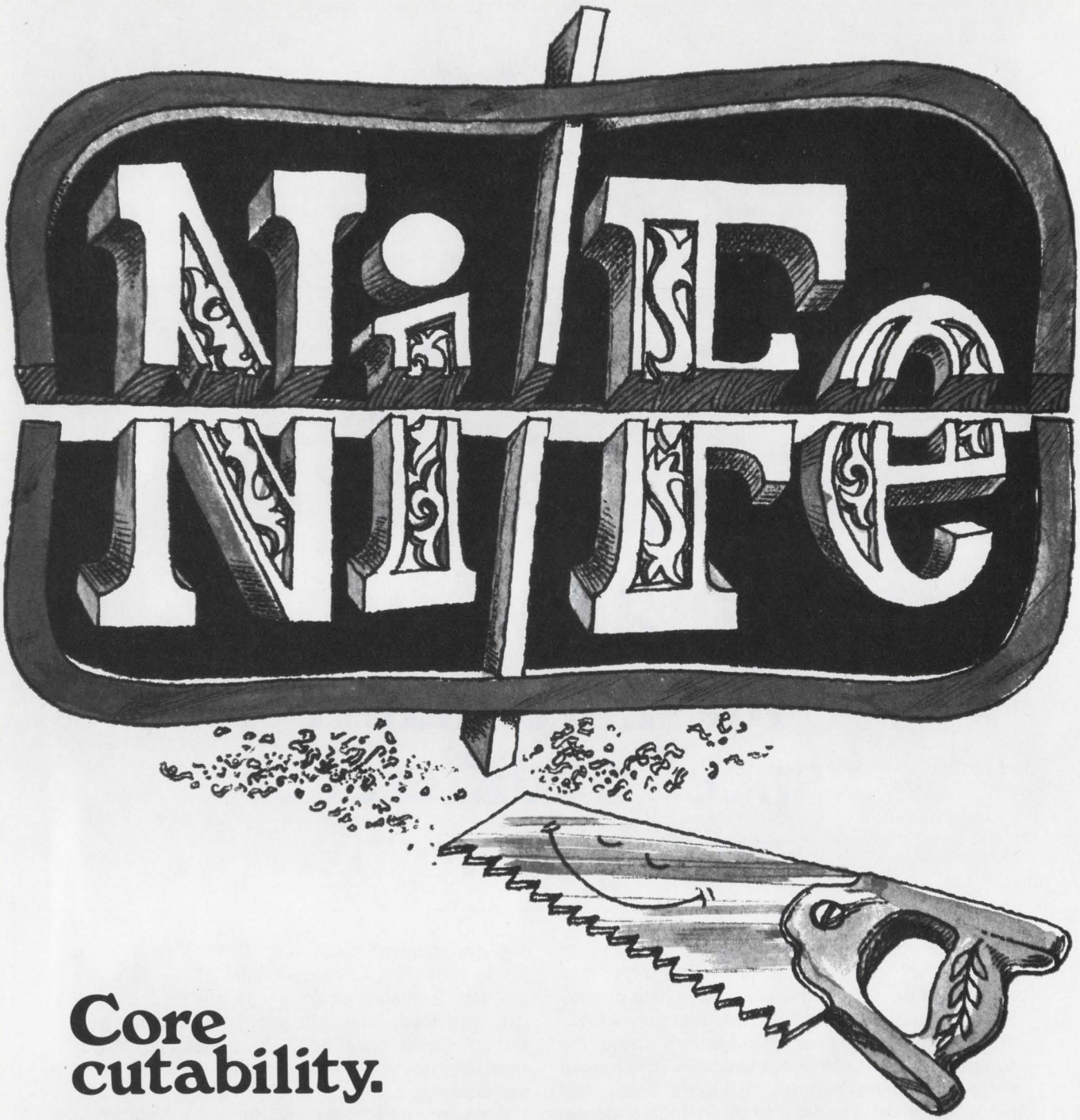

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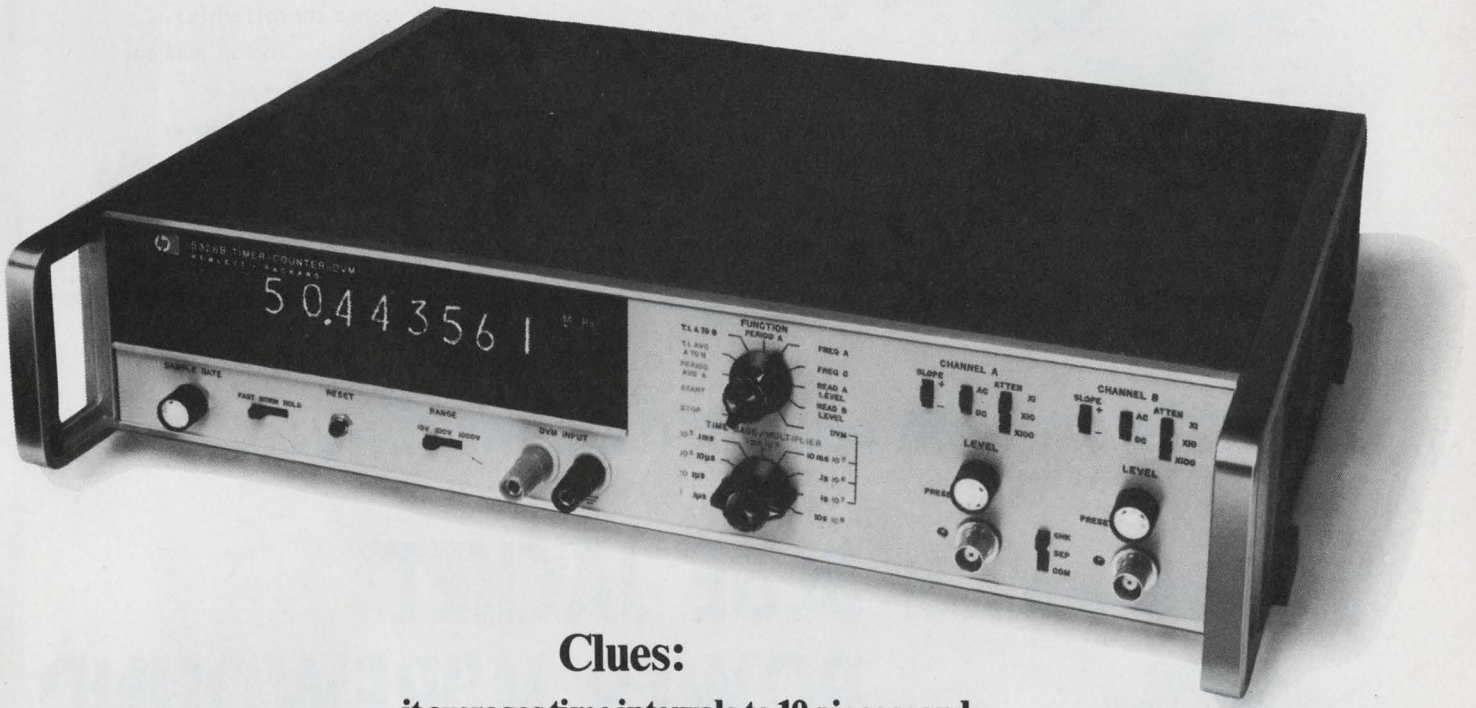
INFORMATION RETRIEVAL NUMBER 18

Guess the price of HP's new counter



Clues:

it averages time intervals to 10 picoseconds
it has a built-in 0.05% integrating DVM
it's dc to 50 MHz, CW or burst
its counter and DVM are easily programmable

Surprise: $1550. That modest amount buys a Hewlett-Packard timer/counter that does things universal counters never did before. For example, it averages time intervals as short as 0.15 nanoseconds. So you can resolve to 10 picoseconds on repetitive signals.

That modest sum also buys a counter with a built-in integrating digital voltmeter. So it's the only counter that can measure internal trigger level settings or other inputs with DVM precision. Now you can measure 10 to 90% rise times, half power points and other voltage-dependent time intervals. That means unprecedented simplicity, for example, in propagation delay measurements. The counter also features four integration times. As a DVM, it provides three voltage ranges, 60 dB noise rejection and 0.05% accuracy.

Even without these exclusive features, the 5326's are real bargains. They count to 50 MHz direct with seven-digit resolution (eight digits optional), measure period and multiple period average and scale input frequencies by any power of 10 up to 10^8. They measure ratio and they totalize.

With programming and BCD output options, the 5326's fit easily into systems applications. Counter and DVM are DTL programmable through a common connector.

You can get all of these benefits in the 5326B for $1550, or buy the same counter, less the DVM, in the 5326A for $1195. Any way you look at the 5326 A or B—either is a great counter value. Your local field engineer has all the facts about HP's new IC counter line. Give him a call or write to Hewlett-Packard, Palo Alto, California 94304; Europe: 1217 Meyrin-Geneva, Switzerland.

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ELECTRONIC COUNTERS

02003

INFORMATION RETRIEVAL NUMBER 19

News Scope

NOVEMBER 22, 1970

Medical electronics seeks prescription for standards

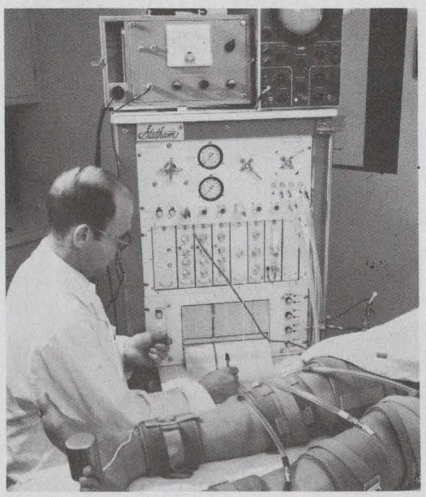
WASHINGTON, D. C.—With the demand for electronic medical devices rising, who will set the standards for products? Delegates to an Electronic Industries Association conference on health-care electronics wrestled with the issue inconclusively here this month.

After presentation of a paper and discussion by conferees, the following points were raised:

- Manufacturers often can't agree on standards.
- Standards are no good unless they can be monitored, and this is the role of the Government.
- If the Government steps in with "czar-like powers" to certify and enforce standards, both industry and users could be hurt.
- If users of electronic equipment—such as the American Hospitals Association—set up standards, people who know little about engineering would be specifying operational requirements.
- If organizations such as the Association for the Advancement of Medical Instrumentation, American National Standards Institute, the National Electrical Manufacturers Association and the EIA set standards, the members who financially support such organizations would be in the position of regulating themselves.

Meeting in the Washington Hilton Hotel, the conferees heard Dr. John Collins, president of the Association for the Advancement of Medical Instrumentation, present a paper strongly advocating a U. S. Government-funded standards group comprised of representatives from manufacturers, the medical profession, government and engineering fields.

But, Collins told ELECTRONIC DESIGN later, he would "like to see someone who is not the government set up standards." He said they should be formulated by "people who know how to make and operate the devices."



Medical electronics, such as that used to record arterial pulse (above) is part of a new market searching for standards.

The economic outlook for health-care electronics is good. Dr. Theodore Cooper, director of the National Heart and Lung Institute at the National Institutes of Health, said there were about 5000 types of medical devices on the market, produced by some 1300 manufacturers in the U. S.

He quoted Dept. of Commerce figures—"which may be underestimates," he said—showing that the total value of medical and dental instruments sold this year was $2-billion and projecting a rise to $2.8-billion by 1975.

Minicomputer joins heart disease fight

A low-cost minicomputer may soon relieve doctors of the tedious job of analyzing electrocardiograms. Instead of printing out the results of an EKG alongside the patient, an EKG cart sends a 3-channel, multiplexed, composite analog FM signal over common voice grade telephone lines to a central computer facility. There, a low-priced 35-pound, Varian 620/i minicomputer demodulates the signal, yielding three signals.

These are converted from analog to a digital representation. They are then formated on magnetic tape and stored for further analysis.

The tape is then taken to the central processor—an IBM 360/65—which examines the heart cycle intervals in terms of amplitude in millivolts and durations in seconds. The results are sent back to the user via teletypewriter or mail. The system was developed by the Boeing Co.'s Computer Services Div., Philadelphia, Pa.

New weather satellite to offer better coverage

A satellite intended to provide more weather coverage than ever before is slated to be launched next month by NASA from the Western Test Range, Lomboc, Calif. The new spacecraft is designated NOAA-1 after the recently formed National Oceanic and Atmospheric Administration, which will operate it.

The satellite's sensing system contains advanced vidicon cameras and scanning radiometers that gather data around the clock—visually by day and with infrared techniques at night. The information is being transmitted automatically with systems developed by the spacecraft's manufacturer, RCA Defense Electronics Products, Moorestown, N. J.

IBM's minicomputer worries competitors

The announcement of IBM's new sensor-based minicomputer—the System/7—has stirred ripples of uneasiness in the remainder of the minicomputer industry. The day after the announcement the stocks of leading competitors dropped noticeably.

The shudders among competitors come from System/7's minimum price—$352 per month rental of $16,060 to buy. This is low enough to cause some buyers to

News Scope CONTINUED

pass up the competition, even if the latter offers slightly lower prices.

System/7, a ready-to-operate system for gathering and processing analog or digital data, is aimed at the largest and most lucrative segment of the minicomputer market—the control of processes and manufacturing. Most mini manufacturers do not sell to this market directly but deal through OEMs. IBM is now a direct competitor of both the makers and marketers of minicomputers.

The front end of the IBM system contains input/output modules to condition the incoming information to match the needs of the central processing unit. In addition to the I/O and CPU, System/7 contains an operator's station to allow communication with the system. The CPU features a 400-ns cycle time, 16-bit words and a memory of 2000 words, expandable to 16,000. The CPU and memory are constructed of monolithic semiconductors.

Optional telecommunication controls are available to interface the S/7 with the S/360 or 370 or other IBM machines. System/7 cannot be used as a stand-alone computer.

Panel criticizes AT&T on data communications

Dissatisfaction with American Telephone and Telegraph's handling of the needs of digital communications users was aired at a recent conference held in New York City.

Panelists at the conference consisted of AT&T competitors in data communications hardware and possible future competitors as data communications common carriers.

The major charges against the Bell System were:

- transmission via telephone lines is slow and error rate high with respect to cost.
- with data communications growing at 50 percent annually, the Bell System is not expanding fast enough to meet user needs.
- telephone lines—designed for voice transmission—are basically incompatible with optimum digital transmission.
- the Bell System has purposely used the courts to slow down the construction of a competing data transmission system.

The conference was sponsored by *Computer Decisions* magazine.

Univac posts new entry in large-computer derby

With the largest plated-wire memory ever installed in a computer, Univac hopes to compete with IBM's System/370 and RCA's Models 2, 3, 6 and 7. The new Univac machine, which is scheduled to reach the market in November, 1971, is the Model 1110.

It has a capacity of 260,000 36-bit words with a 320-nsec read time and 520-nsec write time. It contains a disc subsystem—a departure from Univac's usual practice of using drums only.

The basic 1110 system is said to be capable of performing three million calculations a second, providing 300 to 500% more computer power than the Univac 1108, previously the company's most powerful computer.

Without peripherals the Model 1110 will rent for about $44,200 a month, with a purchase price of $2-million.

Univac's entry into this price range appears to confirm RCA's belief that this is currently the most lucrative segment of the computer market.

Infrared test system measures car exhaust

A small infrared test system to measure the emissions in automotive engine exhaust has been developed by Chrysler Corp.'s Space Operations in Huntsville, Ala.

To be used in manufacturing plants, automobile dealerships and by regulatory agencies, the system is "the first diagnotic tool that successfully measures all types of exhaust emissions together at the same time," the company says. Other devices sample gas emission components one at a time. The usual components of automotive exhaust are carbon monoxide, carbon dioxide and hydrocarbons.

A typical test starts with an exhaust sample drawn from the engine to the analyzer test cell. As the exhaust gas passes through the cell, energy from the infrared beam is absorbed by each emission component. Electrical detectors at the opposite end of the cell convert the energy into electrical signals, which are then scribed on a graph or chart.

About one-third the size of comparable nondispersive infrared test equipment, the vehicle exhaust analyzer is four feet long and three feet wide. The size reduction, the company says, is possible because the infrared dispersive energy beams use only one cell to sample exhaust, whereas other such devices need five.

Chrysler hopes to begin manufacturing the unit next month.

TI sees good prospects for standard hybrids

"After approximately three years of selling custom hybrids and six years of in-house use, Texas Instruments has decided that there is also a large market for standard components."

That's how Lloyd Norman, manager of hybrid circuits for TI in Dallas explains the company's recently announced entry into the standard hybrid circuit market.

According to Norman, there is a large market for linear devices that require higher current or voltage breakdown than monolithics can supply. Hybrids can meet these voltage and current requirements at lower cost and in less space than a combination of monolithics and discrete components, he says.

Another large market, Norman predicts, will be in computer interface circuits, especially in meeting high-speed requirements. He expects much of his initial business to be with the military.

The first products released by TI include a positive voltage regulator that provides 1 A over an output range from 2 to 37.5 V.

"I don't believe anyone has a similar device with this packaging density," Norman says.

Other standard hybrids released include three different quad drivers and a power Darlington.

THEY'RE MOLEX EDGE CONNECTORS. "Straight-on" or "right-angle" types for printed circuit boards. Terminals crimped to wires automatically. Reliable? And how! Connector terminals are bifurcated. Provide a really solid contact. Yet you can slip the connector on and off time after time without any damage to the printed circuits. And it's not a preload unit. Carries only contacts required. From six to twenty-four. Comes in white or six other colors. Terminals available in tin-plated brass with gold plating or selective gold plating. ■ A good example of how Molex helps create high-speed low-cost devices that simplify circuitry. If you want to save assembly time, steps and money, take a close look at these Molex edge connectors. For *free* samples write: Molex Incorporated, Downers Grove, Illinois 60515. Or you can make connections by calling (312) 969-4550.

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INFORMATION RETRIEVAL NUMBER 1

The mini-est computer is a house of cards

Stacked printed-circuit machine is smaller than a desk phone without sacrifice in performance

Milton J. Lowenstein
Computer Editor

By stacking printed-circuit cards —and with no other wiring—designers on the West Coast have come up with the smallest minicomputer yet built.

No bigger than the base of an ordinary desk telephone, the mini-mini does not sacrifice performance either. An 18-bit machine, it has a memory of 8192 words and a repertoire of 43 instructions. It can multiply in 33 μs and divide in 43 μs.

The tiny computer was designed by Bunker-Ramo Corp., Electronic Systems Div., Westlake, Calif., for military use—in guidance systems for missiles and torpedoes, among other applications. But plans are to offer it eventually on the civilian market, where it might be used in air and ground traffic control and for process control in industrial, chemical and machine plants, the company says. The new machine lends itself to distributed computing—the handling of data-processing tasks at the site of an operation or activity.

Pilot production for military applications is due to start in 1971, and the current price of the military version—designated BR-1018 —is $30,000. But Ralph S. LaMontagne, vice president of Bunker-Ramo, says:

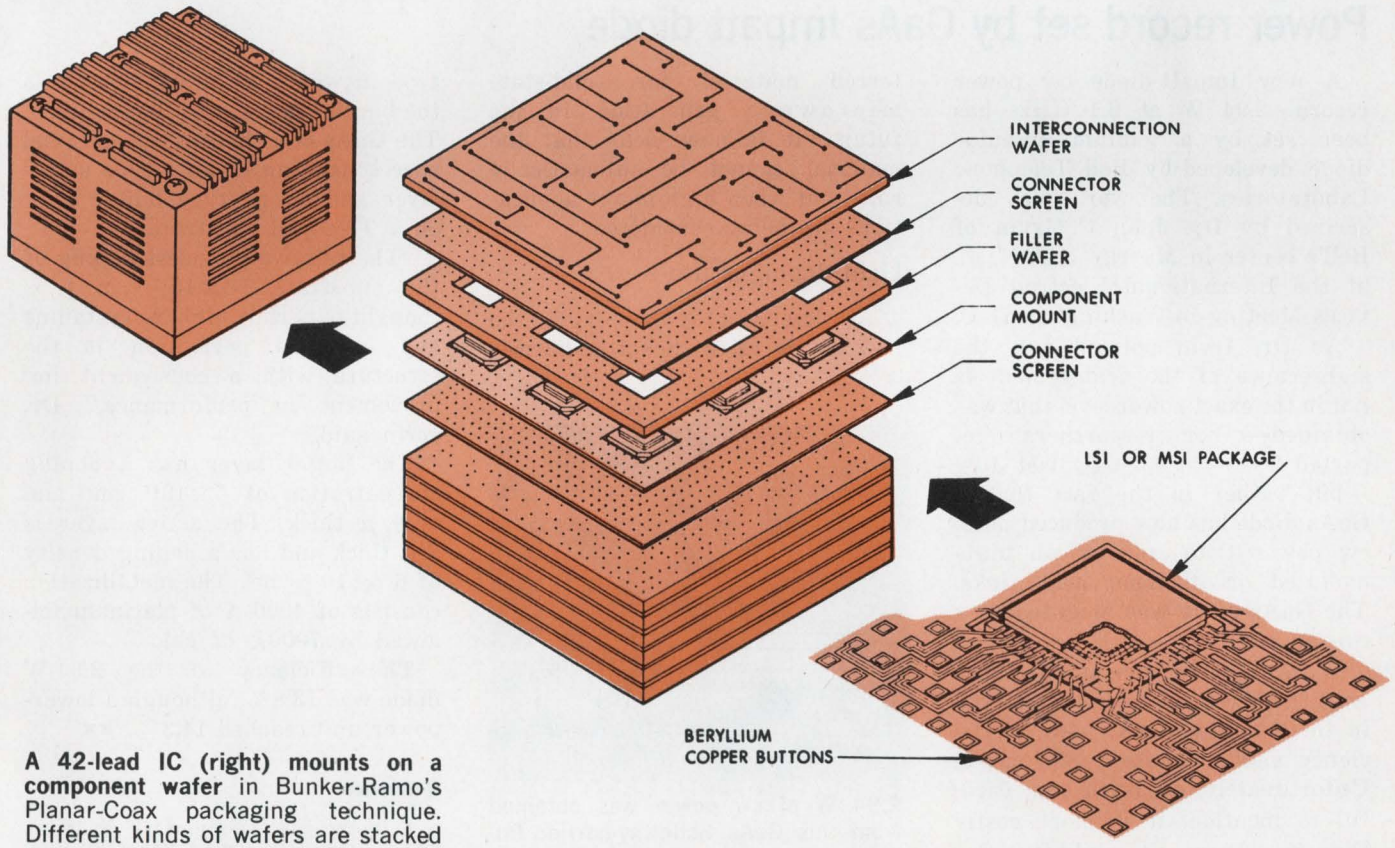
"The packaging technique used can make possible sharp reductions in cost through mass production. The price can be expected to fall as low as $5000 when full-scale production is reached."

Three basic types of two-sided wafers are used to assemble the computer components, central processing unit and input/output unit. The wafers—component, interconnection and connector-screen types —are stacked and then pressed together firmly to make electrical connections.

LSI or MSI semiconductors are mounted on the component wafers, and their leads are brought out to small beryllium-copper buttons (see diagram). The interconnection wafers carry the conductors up or down the stack and provide spacing. The connector-screen wafers then provide the wiring that runs across the stack.

A typical subassembly for one component wafer is a fraction of an inch thick; a stack of several subassemblies occupies very little volume. Wafers are typically 2 by 2 inches and can be used to package up to 200 MSI semiconductor devices per cubic inch.

All heat-generating components



A 42-lead IC (right) mounts on a component wafer in Bunker-Ramo's Planar-Coax packaging technique. Different kinds of wafers are stacked to create a rugged package with high component density (left).

(**mini-est,** *continued*)

are in intimate contact with the beryllium-copper, which is an excellent thermal conductor. Hot spots are thus eliminated, and temperature differentials throughout the assemblies do not exceed a few degrees, according to LaMontagne.

The use of the stacked connections also provides good electrical shielding, he says, thus minimizing the effects of cross talk, which can be a serious problem in such a compact structure. The elimination of most wiring, with its attendent problems of soldering and connectors, gives the system very high reliability, the Bunker-Ramo official reports.

The final assembly is made by stacking all of the cards and then clamping them together with screws. Once the screws are removed, any wafer can be replaced or repaired.

The central processing unit (CPU) and the input/output unit (I/O) are essentially identical in construction. They each make use of nine LSI chips on the component wafers. The CPU has six component wafers containing a total of 10,000 gates.

High density packaging compresses memory, CPU and I/O units into this rugged subminiature computer.

The computer uses a binary, single-address, stored-program, parallel organization. It occupies only 67 cubic inches including memory. The I/O section has analog and digital capabilities. The system clock frequency is 1 MHz.

Maximum memory size supplied in the unit is 8192 words although smaller memories down to 2048 words are available at lower cost. The memory is expandable in steps to 131,072 words.

Staked, or planar-coax, assembly has made the most significant size reduction in the BR-1018 computer, but it is not limited only to that unit. Any electronic assembly can be built using the technique. In particular, Bunker-Ramo has fabricated a programmable counter and a pseudo random code generator. Both occupy less than one cubic inch and weigh less than 2 ounces.

Size is not the only advantage of the method, however. In production, fabrication cost reduction of over five times are expected in comparison to more conventional techniques.

The first models of the BR-1018 make use of a plated-wire memory. Semiconductor memories will be used when they become available, LaMontagne says. ■■

Power record set by GaAs Impatt diode

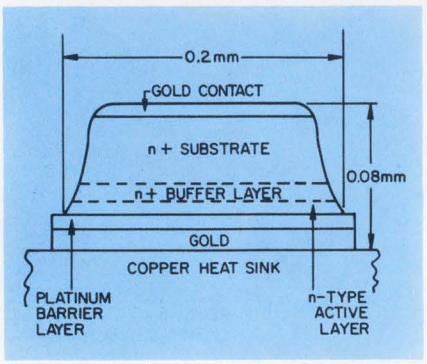
A new Impatt-diode cw power record—2.94 W at 6.1 GHz—has been set by a gallium arsenide diode developed by Bell Telephone Laboratories. The work was described by Dr. John C. Irvin of Bell's center in Murray Hill, N. J., at the International Electron Devices Meeting in Washington, D. C.

As Dr. Irvin pointed out, the significance of the achievement is not in the exact power level that was obtained—other researchers[1] reported 2.1 W at 9.2 GHz last July —but rather in the fact that a GaAs diode has now produced more cw power than even silicon units mounted on diamond heat sinks. The GaAs diode was mounted on a copper stud.

With this achievement, the GaAs Impatt diode now leads the Si type in three major areas: power, efficiency and low-noise performance. Unfortunately, as Irvin was careful to mention, it is more costly than the others. So, while it is not obvious that GaAs will be the preferred material for solid-state microwave generation in the future, it is now clear that the material cannot be automatically ruled out when high-power applications are being considered.

Light doping is used

As described by Dr. Irvin, the new diode is a Schottky-barrier type in which platinum is used as the barrier metal (see illustration). The GaAs is a three-layer epitaxial slice consisting of an n-type active layer and an n^+-type buffer layer on a Te-doped substrate.



2.94 W of cw power was obtained from this GaAs Schottky-barrier Impatt diode. It operated with an efficiency of 13.8% at 6.1 GHz.

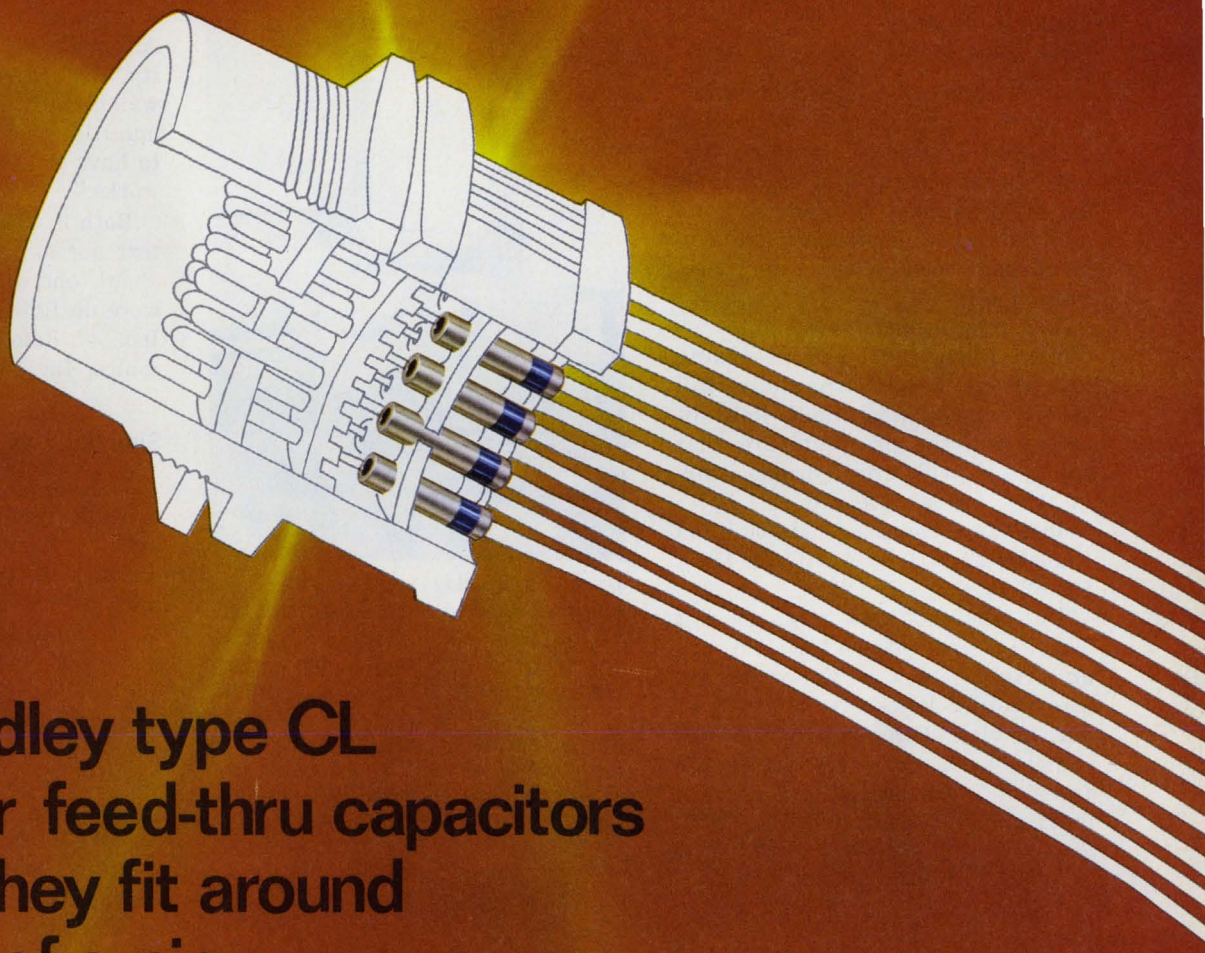
"The relatively modest doping of the substrate [8×10^{17} cm^{-3}] is thought to permit higher crystalline and chemical perfection in the structure with a consequent improvement in performance," Dr. Irvin said.

The buffer layer has a doping concentration of 5×10^{17} cm^{-3} and is 8 μ thick. The active layer is 7 μ thick and has a doping density of 6×10^{15} cm^{-3}. The metallization consists of 4000 Å of platinum followed by 7000Å of gold.

The efficiency of the 2.94-W diode was 13.8%, although a lower-power unit reached 14.3%. ■■

Reference

1. Yong Sik Lee and C. K. Kim, "Two-Watt CW GaAs Schottky-Barrier IMPATT Diodes," *Proc. IEEE*, July, 1970, pp 1153-1154.



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ALLEN-BRADLEY

NEW DIMENSION ELECTRONICS

Displays to help CATV stand on its own feet

2 new systems roll 'local origination' text across viewers' screens at a smooth one line per second

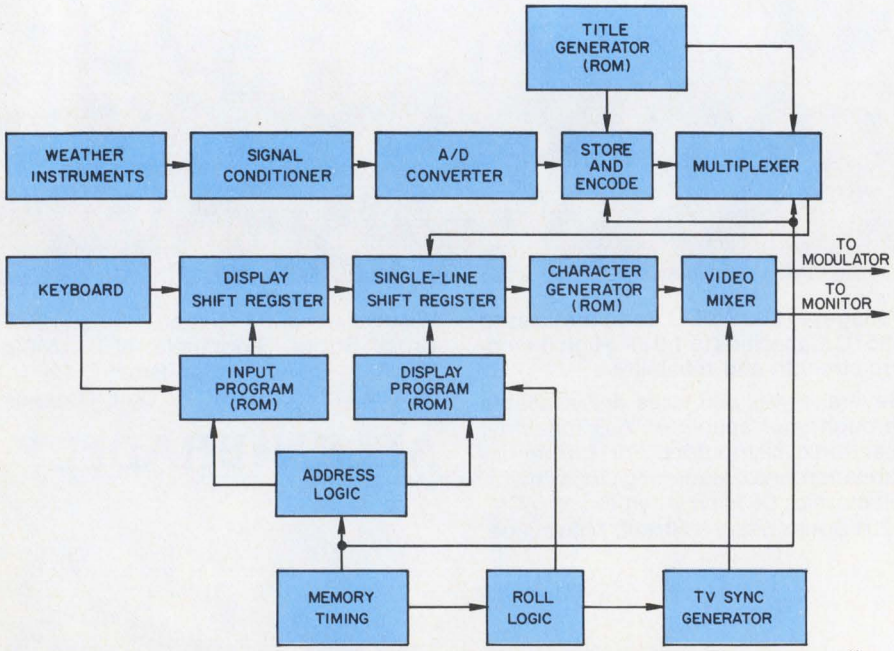
Elizabeth de Atley
West Coast Editor

Two competing electronic systems that provide rapidly rolling displays of key-board entered text have been designed to help cable TV stations meet the Federal Communications Commission requirement for "local origination" programs.

The requirement goes into effect in April, 1971, and, according to a recent Rand Corp. study, will affect some 400 stations immediately. And the prospects are that cable TV will grow dramatically in the 1970s (see "Cable TV: Slumbering Giant—A Multibillion Industry?" ED 8, April 12, 1970, pp. 62-72).

But what is "local origination"? The FCC order doesn't spell it out, and right now CATV owners are interpreting it loosely. Some show old movies. Others pan the TV camera back and forth across the faces of a barometer, a thermometer and an electric clock. Still others subscribe to a ticker-tape display from a national news service that taps out the news at teletype rate a character at a time. As one CATV program director puts it, "Such displays are tiresome to watch and won't sell CATV to communities that don't absolutely have to have it to receive the major networks."

Daconics display system allows the station editor to change copy for any of the channels without interrupting the program on the air (shown on the monitor at right). This permits almost instantaneous updating of news, sports scores, weather, or other information. The system includes a Hewlett-Packard computer (shown in the background).



This Data Technology system is set up for a weather display. The system displays two fixed lines of alphanumeric weather information plus six rolling lines of a 32-line stored text. It uses no computer.

Both of the new systems roll the text across the screen smoothly at about one line per second. They were designed by Data Technology, Inc., of Palo Alto, Calif., and Daconics, Inc., of nearby Sunnyvale.

Simplicity vs elaborateness

The simpler of the two systems is Data Technology's. It stores 32 lines of keyboard-entered text and displays it in rolling format six lines at a time—about six words to the line. It also includes a two-line stationary alphanumeric display of weather information that is updated every few seconds. The big advantage of the system is its price—$3500, compared with over $4000 for a typical weather display system with a camera that pans weather instruments and a clock.

The Daconics system, which was designed for the San Jose CATV Co., is much more elaborate—and also much more expensive. Under the control of a Hewlett-Packard computer, it displays 15 lines of text at a time—approximately five words a line—in rolling format. The operator types in text of any desired length, and it is stored on a drum. Then he divides the text into pages of 14 lines each and assigns a separate label to each set of three pages. A special format that the operator can call up on his monitor gives him step-by-step instructions for assigning labels.

A single-channel system, including keyboard, HP computer, drum, video generator, special hardware and operating software, leases for $1350 a month. Additional channels, with different text displayed on each channel, add $110 each to

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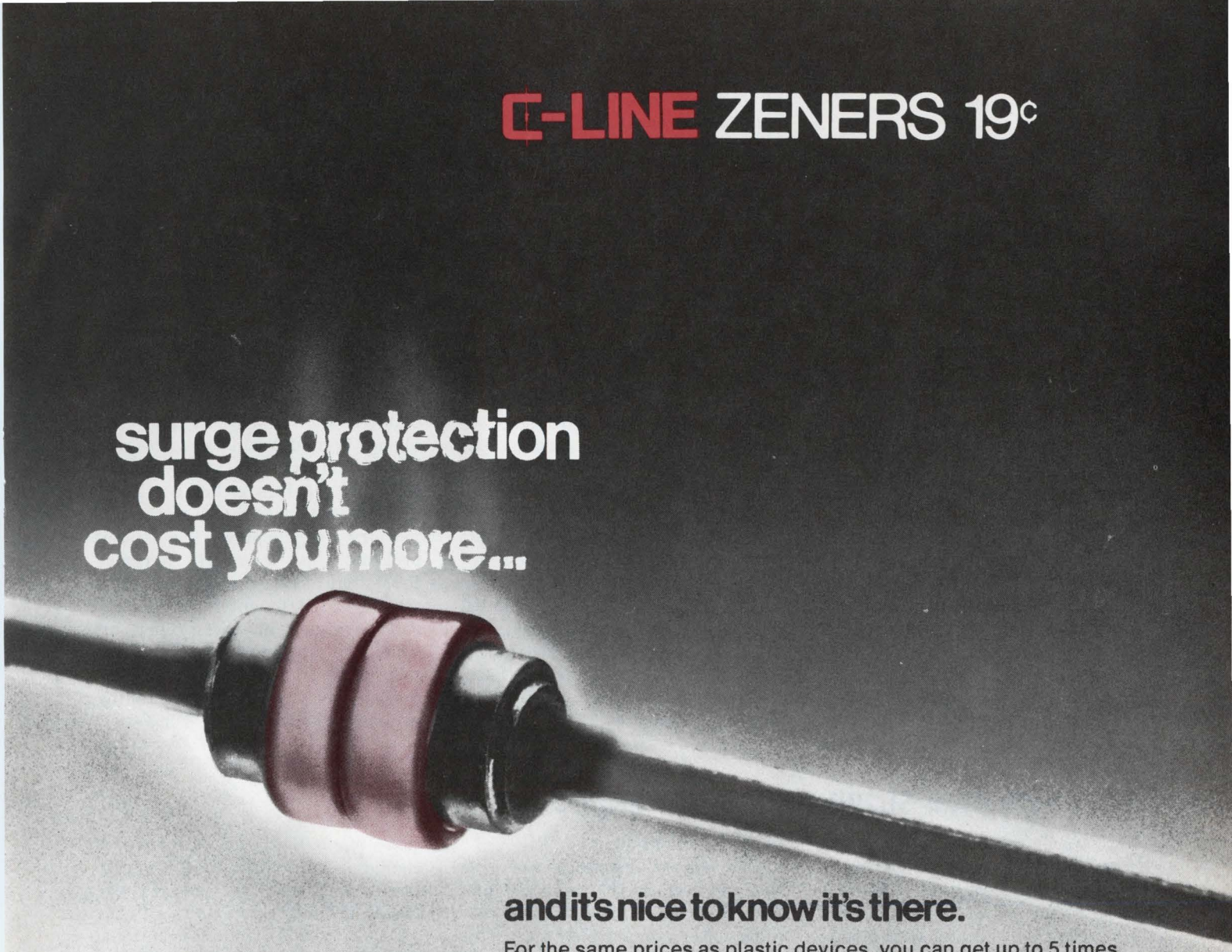

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(**CATV,** *continued*)

the leasing price.

Both Data Technology and Daconics visualize other applications for their systems besides CATV stations. Data Technology, for example, expects to interest hotels, airports and possibly supermarkets, as a means of displaying specialties, paging customers, etc. Daconics believes its system will be useful in hospitals for recording and displaying patient information.

How the systems work

The display circuitry for both the Data Technology system (see diagram) and the Daconics (see photo) is similar in concept. It includes two sets of recirculating shift registers and a read-only memory (ROM) character generator. One set of shift registers stores the entire display, while the other stores a single line, feeding it a character at a time into the character generator for display. In both systems, information from the keyboard is first stored in the display shift register. But in the Daconics system, each page of information is transferred by computer to a drum when the operator is satisfied that it is correct. Then when the operator sets the display into the rolling mode, the computer calls up the appropriate pages one after another into the recirculating shift registers for display.

The Data Technology system has no computer or drum, and operates only in the rolling mode. The information from the keyboard is stored in the larger of the two shift registers (the "text memory" in the diagram). The weather data is obtained from a roof-mounted instrument package. A signal conditioner converts the instrument outputs (temperature, wind velocity, etc.) into proportional analog voltages, which are then converted to digital signals by the A/D converter. In the "store and encode" modes, each signal is assigned an address in the display and converted to ASCII code. The title generator is a microprogrammed ROM that contains addressing and encoding for the weather titles—"temp," "wind velocity," etc.—and two instructions. One instruction is "read title directly"; the other is "read instrument measurement."

When the multiplexer receives a pulse from the memory timing circuit (a quartz crystal and frequency divider), it obtains the next instruction from the title generator and transfers either a title or an instrument reading into the line memory for display. The "input program" is a microprogramed ROM that allows information from the keyboard to enter the display shift register at the proper bit time. The display program is a microprogramed ROM that times the display to the normal scanning rate for TV. ■■

Most sensitive strain gauge developed

A linear-response, field-effect strain gauge, said to be the most sensitive yet developed, offers a gauge factor of 5800 and a signal-to-noise ratio of greater than 5 to 1. And it has applications besides its role as a strain gauge, says its developer, Sandia Laboratories in Albuquerque, N. M.

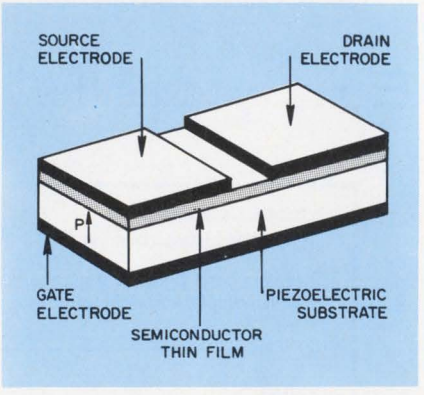
It can be used, Sandia says, as the active element of an accelerometer or seismometer, as well as a receiver transducer for low-intensity acoustic waves.

According to Dr. John C. Crawford, supervisor of Sandia's Solid-State Electronics Research Div., the device is made by evaporating a thin-film semiconductor on a substrate of polished lead zirconate-lead titanate ceramic.

Since the ceramic material is piezoelectric, applied stress causes charges to concentrate at its two surfaces. Through field-effect coupling, these charges alter the charge density of the semiconductor —vapor-deposited p-type tellurium —thereby increasing or decreasing its conductivity. A gate electrode is provided on the back surface of the ceramic substrate by using gold electrodes to form ohmic contacts to the tellurium film.

The current flowing between the two contacts on the tellurium film thus is changed by field-effect coupling to the ceramic substrate. This change is directly proportional to the deformation in the ceramic.

With the exception of the relatively expensive tunnel diode transducer, the new device is the most sensitive of its type available, Sandia says. The gauge factor, or gain, of 5800—achieved in laboratory experiments—means, for example, that a mechanical deformation of 0.01% can produce a change in current of 58%. Conventional semiconductor gauges are generally limited to a gauge factor of 100 to 200, and conventional metal foil gauges to a factor of 1 to 2. The device, therefore, provides an unusually high signal-to-noise ratio. Even at strain levels as low as 1.4 by 10^{-7} (indicating a change in length due to deformation of 0.000014%, the signal-to-noise ratio is greater than 5:1 when monitored on an ammeter. For greater accuracy a resistance bridge circuit might be used, Crawford says, "but only when operating in the lower strain areas, such as 10^{-7}."



New FET ceramic strain gauge is sensitive and has a good S/N.

The semiconductor film exhibits an electronic instability—a carrier trapping at the semiconductor-piezoelectric interface—that limits its present use to transient measurements with frequencies above one cycle per second.

Though the device is sensitive to temperature, this disadvantage can be countered by calibrating it electrically in place after it is bonded. The device is reported usable as a transducer up to at least 115°C (239°F). ■■

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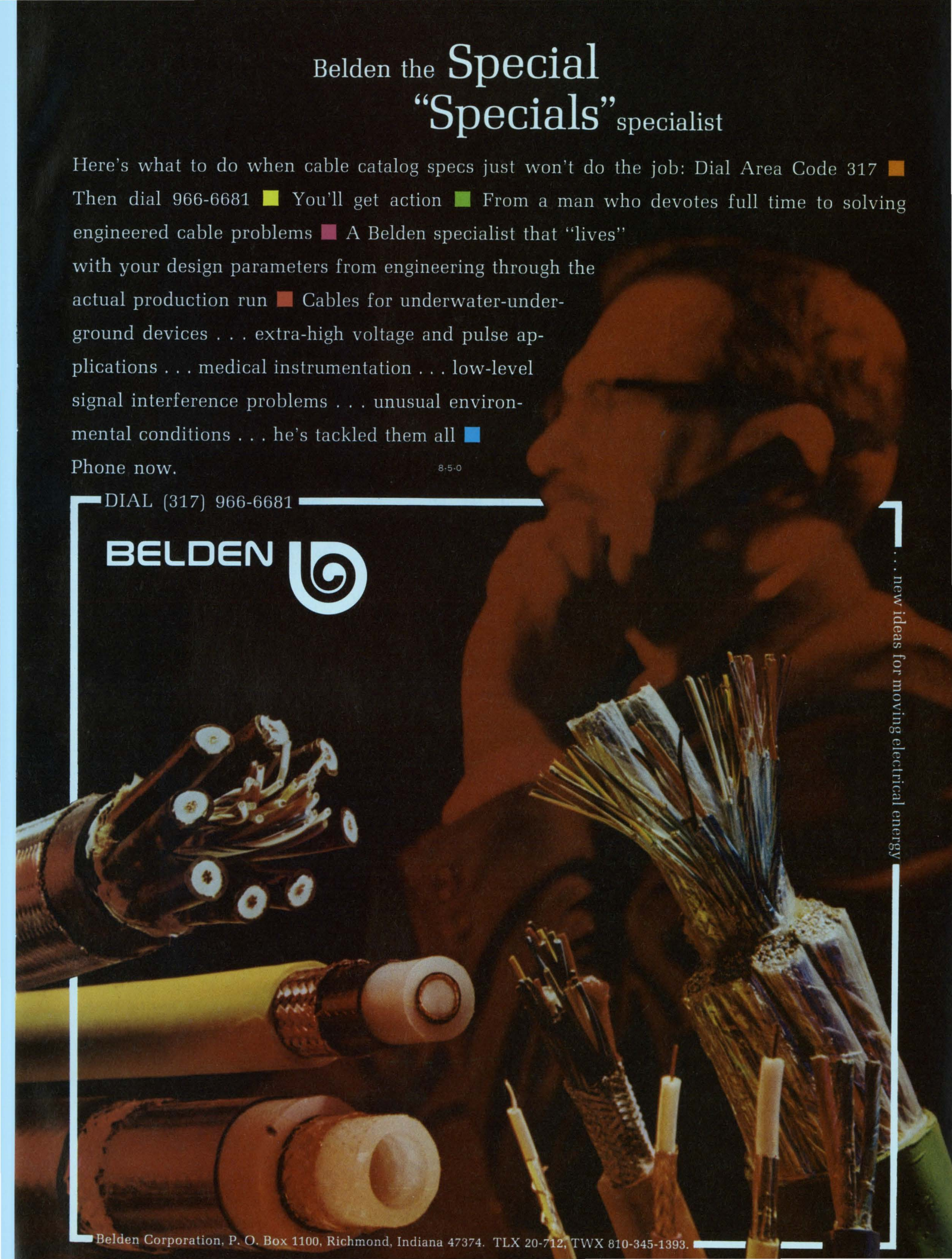

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Letters

Controversy rages over R&D cutbacks: Do we need more PhD engineers?

Reader challenges views of 'so-called educators'

Sir:

The tone of your editorial in the August 16 issue (ED 17) and the article by your news editor, John Kessler, in the same issue, puzzles me in view of the many highly trained engineers and scientists who are currently pounding the pavement looking for work. The job market for these people is lousy, and yet you state the opinion that our most important problem is that we do not produce enough highly trained scientists and engineers, including PhDs.

The samples of opinions expressed in Kessler's article come for the most part from so-called educators whose only concern seems to be to do their own things with slave labor in the form of graduate students and then throwing them into the job market without any concern for their future.

Once a graduate student receives his MS or PhD he still has, on the average, 35 or 40 years of his life to devote to his profession and hopefully to contribute to our progress. Yet, in accord with these so-called educators, the editorial emphasizes that for our progress we need young scientists and engineers who are flexible and able to accept change. This is ridiculous and unfair.

Has anyone established scientifically that only inexperienced youth in the 20-30 age category could contribute to our technological progress? The cult of youth, which seem to be practiced in our universities and in certain industries, is in any case self-defeating. Why would any intelligent young man choose to enter a profession that requires years of training but promises only a few years of tenure afterward?

I suggest that your editorial is not serving the profession and the development of science and technology. I hope you will rethink the issues involved with due emphasis on human values.

B. W. Lee, PhD
Vice-President
Noller Control Systems
Richmond, Calif.

Educators reply

Sir:

The gist of Mr. Lee's rather emotional complaint is that the "so-called educators" insist on training graduates in science and engineering without considering the latters' predicament in the present job market nor their personal future.

A change in professional careers is usually not a loss but an enrichment of the individual or society. It is easy to show that we need a great deal of cross-fertilization—that is, a pool of manpower with technological training whose members can address themselves intelligently to modern problems, whether purely technological or not.

The present depression in job markets can be traced to a particular fashion in the political and social climate of this country. Since fashion changes are greatly accelerated by modern means of communication, we may assume that turns, from and to technology, from and to environmental protection, etc., will continue to go through cycles. If we were to follow these cycles, we would surely always lag behind the moment of need because the time required between when young people become interested in problems and choose a career until they are proficient in their professions is today five to ten years. Thus, at the crest of one fashion, we would regularly train people for the next slump—as we have just done.

Barring the unforeseen . . . the American society will continue to be a technocratic one and will stand and fall by virtue of its technological prowess in competition with the other technological top nations . . . . In view of this, technological manpower, whether or not to be used exactly in the area of the original competence, is going to be vital for many years to come, and we have to plan accordingly.

Frederick R. Eirich
Dean of Research
Polytechnic Institute
Brooklyn, N. Y.

Sir:

Apparently this year is open season on educators. Perhaps we are open to Dr. Lee's criticism for having failed to foresee five or six years ago, when our present crop of students was admitted to graduate school, that cutbacks in federal R&D expenditures would drastically alter the employment picture for scientists and engineers by the time they had earned their degrees. Dr. Lee, perhaps, does not recall that at that time there were 20 job offers for every new PhD.

I can find nothing in your editorial that suggests only young men contribute to technological progress. It is a matter of record, however, that many of the most original and innovative pieces of new technology have resulted from the work of relatively young men. One need cite only the laser, the Gunn oscillator, the tunnel diode, and hundreds of other inventions, all of which came from men under 40. On the other hand, many of these inventions would not have found their way to commercial success if it had not been for the work of more experienced older engineers who knew how to transform a laboratory device into reality.

I believe our technological innovativeness comes from the interaction of men of varying ages, experience, and background, but that the continuous injection of young men into the system is essential to its over-all health.

Harvey Brooks
Dean of Engineering
and Applied Physics
Harvard University
Boston, Mass.

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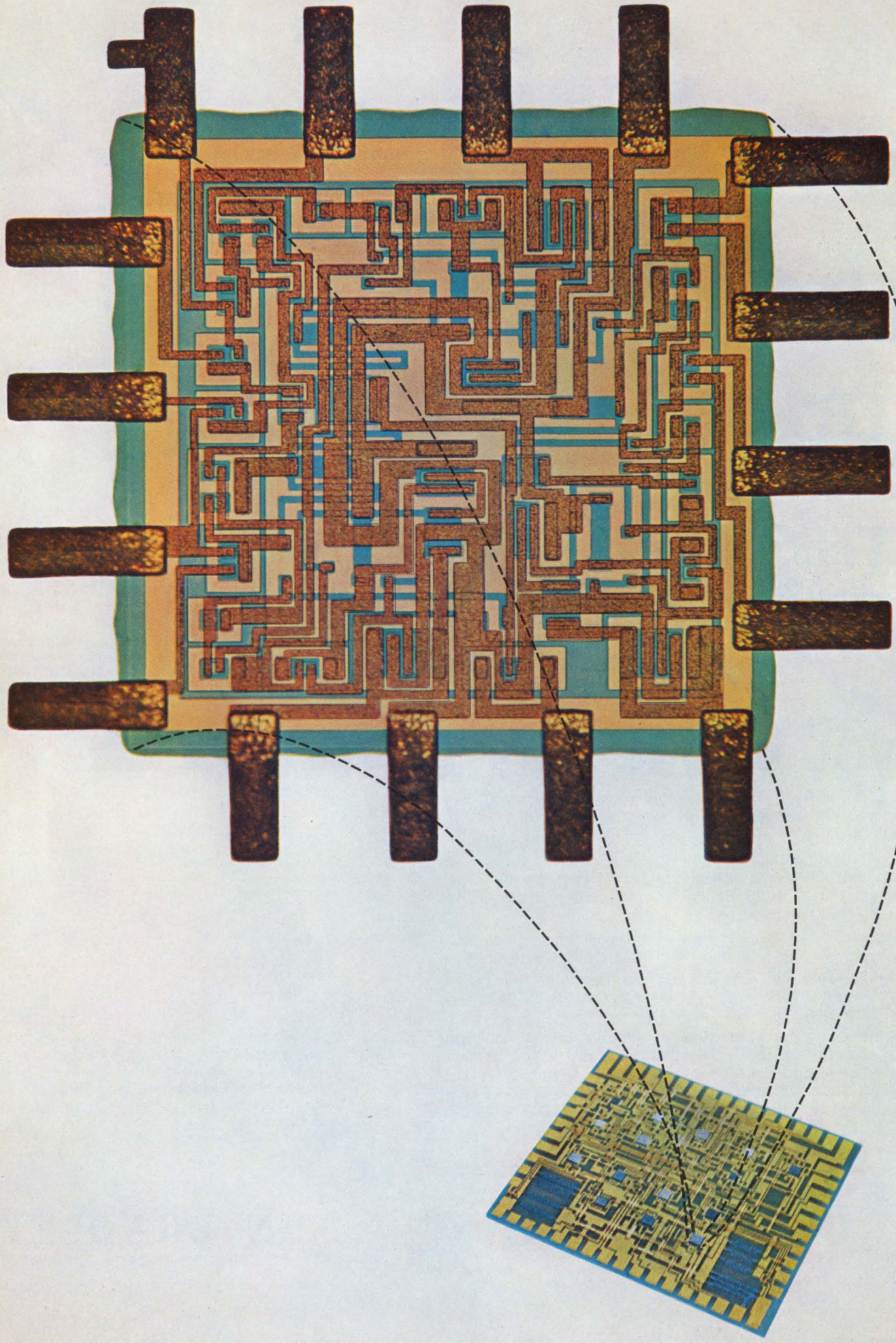

Circuits and synergy

To fill a variety of communications needs, Bell Labs and Western Electric have worked together to develop a special kind of integrated circuit. Based on two compatible and complementary technologies—silicon and tantalum—this "hybrid integrated circuit" is hundreds of times smaller and more reliable than circuits using discrete solid-state components.

The silicon portions of the circuit contain active components such as diodes and transistors; some low-precision resistors and the necessary interconnections are also formed on the tiny silicon chips. Hundreds of these chips are fabricated on one silicon slice. Tiny gold conductors—"beam leads"—are formed on each chip at the same time. Then the chips are separated and the beam leads bonded to tantalum thin-film circuits. Typically no more than one or two square inches, tantalum circuits contain precision resistors, capacitors, and interconnections etched into the metal film, previously deposited on glass or ceramic substrates.

Hybrid integrated circuits open new opportunities for circuit designers in many areas of communications systems engineering—telephone equipment, transmission, switching.

In this hybrid integration technology, design and manufacturing are intimately related. Designer and maker must work closely together. The Bell System fosters this concerted action—this synergy—with Bell Labs, for research and development, and Western Electric for manufacturing and supply. At several plants Bell Labs and Western Electric engineers work together in Process Capability Laboratories, speeding new designs into manufacture.

Here are a few examples of their teamwork.

The tantalum portion of a hybrid circuit starts as a 2000-Angstrom layer of tantalum, deposited on glass or ceramic. This process, invented at Bell Labs, was first carried out in a vacuum under bell jars. Western Electric designed and built "open ended" machines. Now, deposition takes place as the glass or ceramic chips move through the machine on a chain.

For highest precision, newly formed tantalum thin-film resistors require adjustment. This is done by removing, electrochemically, just the right amount of tantalum to raise the resistance to the required value. Bell Labs devised the process; Western Electric computerized and automated it.

Silicon circuits are sensitive to impurities such as sodium ions in the air. So, they used to be sealed into expensive evacuated cans. But now, a gold and silicon-nitride shield gives the required protection at low cost. Originated by Bell Labs, it was put to work by Western Electric.

Making connections to integrated circuits once called for individual attachment of fine gold wires. Then Bell Labs came up with "beam leads": gold conductors plated into place on silicon circuits. In addition to being conductors, the leads also give mechanical support. Western Electric developed methods for bonding them to circuits.

Beam leads are fabricated as part of the silicon circuit but their free ends must be attached to other circuitry. Bell Labs and Western Electric have developed thermocompression bonding techniques for this job. With the proper combination of time, temperature, and pressure all leads on the silicon circuit are bonded simultaneously to a thin-film circuit.

In the future, we hope to get more circuitry into less space and to find new functions for the technology. The circuit shown here, for instance, is one of some 200 logic "building blocks" for use in private branch exchanges, data sets, and other customer telephone equipment. It could not have been built with "discrete-component" technology. And we will not stop with silicon and tantalum. For other jobs, other materials may be better. Bell Labs and Western Electric are working together to find and apply them.

Technology Abroad

The first of six medium-range air-traffic-control radar antennas for the West German Government has been installed at Bremen by AEG-Telefunken, Ulm. The 4.2-ton antenna is 47.5 by 30 feet and has an antenna gain of 38 dB at 23 cm. Transmitting power will be about 4 MW. The six-station system, designed to cope with growing air traffic over European routes, can acquire targets with an echo area of 15 square meters at 60,000 feet altitude and a distance of 150 nautical miles.

An experimental high-voltage, solid-state rectifier is to be tested soon at the Lydd, England, terminal of a dc power link operated jointly across the English Channel by France and Britain. The rectifier—developed by English Electric of Stafford with the assistance of Britain's Ministry of Technology—includes three thyristor stacks clad with ceramic for outdoor mounting. Design capacity is for 150-kV, 1250-A bridge rating with the use of 4 kV thyristors. At Lydd, the assembly, down-rated to 100 kV, will replace one arm of a 100-kV mercury arc bridge.

A four-pound, portable electrocardiogram recorder, based on the familiar cassette tape recorder, has been developed by Philips NV of the Netherlands for use by patients. The device can be used anywhere—a useful feature, since symptoms a doctor may want to monitor may occur when the patient is far from the doctor's office. The recorder consists of an electrode set and an amplifier that plugs into a standard cassette recorder. The patient attaches the electrodes to prescribed areas of his chest and connects them to the machine. The electrocardiogram record can be fed later into conventional laboratory equipment for analysis.

A three-million-volt electron microscope, developed by Hitachi, Ltd., in collaboration with Osaka University in Japan, is 36 feet tall, weighs 67 tons and can magnify up to 100,000 times. Its high power enables the researcher to examine thick samples. The system includes a TV camera that is highly sensitive to electronics. It can thus detect low-energy electron beams in cases where samples might be damaged by irradiation at higher levels. Another feature permits suspension of specimens, including living cells, in a suitable environment as they are viewed through the electron-transparent walls of a pressure chamber.

The world's first fully automated natural gas pipeline—a 700-mile project in Iran—is to be served by an extensive telecommunications system operating at 7 GHz. The system will provide automatic control of eight compressor stations and will relay information by telemetry as either teleprinter code or voice communication. It will monitor control positions along the pipeline, giving operating personnel a continuing picture of various conditions, including pressure and flow. Initial design of the microwave system and assistance on optimum microwave site locations was carried out by International Aeradio, Ltd., of Southall, England.

The study of radio galaxies will be conducted at a new radiotelescope at Ootacamund, in southern India. The reflective surface of the telescope is a 530-by-30-meter array of 1100 stainless steel wires mounted parallel to the earth and supported by 24 equidistant steel towers. Radio waves reflected from the wire grid are focused on an array of 968 dipoles mounted along the telescope's focal line. The reflector can be rotated through a 140-degree angle. Now operating in the 324-to-329-MHz band, future additions will allow 100-MHz reception. The program is being sponsored by the Indian Government.

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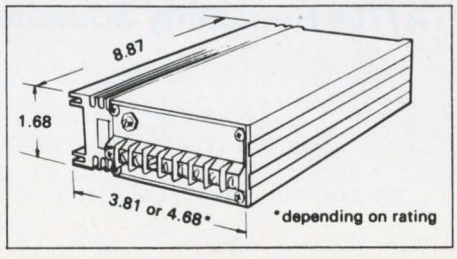

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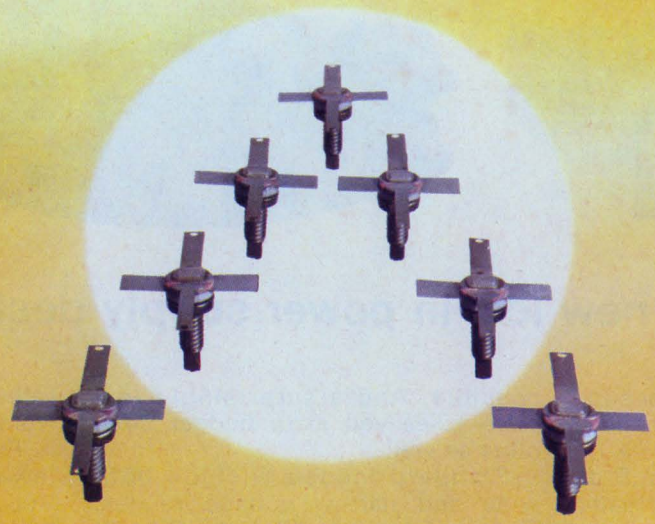

TA7706 Reliability Squadron

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INFORMATION RETRIEVAL NUMBER 28

Washington Report

DON BYRNE, WASHINGTON BUREAU

Airlines want bigger say in R&D done by FAA

The nation's airlines, which will be paying higher taxes as a result of the passage of the Airport and Airways Development Act in Congress, have told the Federal Aviation Administration that they want better results from federal money spent on R&D. Through the Air Transport Association (ATA), the airlines told the FAA that they believe its R&D efforts have in the past been irrelevant and "largely a series of failures." In a position paper, the airlines stated that FAA's R&D efforts, when viewed from an engineering point of view, have often been stifled by a lack of vision and a lack of willingness to innovate and "even to clearly spell out needs." Referring to air traffic control needs, the ATA said, "Each R&D effort must also be considered in terms of its specific cost, the results to be expected in quantitative terms and the timetable on which the improvement can be expected to be implemented."

Navy will ask permission for long ship leases

The Navy will ask Congress in January for permission to sign 10-year leases for 10 multipurpose ships. The new ships would take the place of the planned 30 Fast Deployment Logistics (FDL) ships that earlier this year were rejected by Congress. By leasing the ships, the Navy will avoid the cost of building, while the long leases will make the deal attractive to private ship builders. At present, the Navy is not allowed to sign a lease over five years. The ships are estimated to cost about $25-million each, 10% to 15% of which will be spent for electronic equipment.

NASA sees possible microwave-band expansion

NASA says that early results of its millimeter-wave experiment aboard the Applications Technology Satellite-5 (ATS-5) indicate that the overcrowded microwave band may be opened up to frequencies above 10,000 megahertz. Millimeter-wave frequencies, NASA says, offer better gain-to-antenna characteristics, extremely wide bandwidths and allowance for a size and weight reduction in components. The space agency also reported that expected interference with the millimeter-wave portion of the frequency spectrum by snow and rain has not materialized; tests so far have shown that only a very heavy rain will affect communications. NASA is now trying to find out how far apart ground receiver stations must be placed so that one large storm doesn't entirely block communications.

SST and imports move to front burner

As Congress reconvenes this week in a lame-duck session, the supersonic transport and import duties are expected to be in the first order of business. SST supporters say they expect to be able to get the $297-million measure through the Senate—it has already cleared the House.

They feel that they will pick up supporters who, before election, were wary of the issue. Environmental safeguards are also expected to be added to the SST provision, thus drawing additional liberal support.

The question of protective import duties will come before the House early, but the fate of the bill is at best cloudy. The feeling is that so many amendments will be hung on it in the House or Senate that it will either be totally unacceptable, or, if passed, will be vetoed by the President. Compromises that may clear the way for passage are being sought.

DOD personnel cuts to be higher than expected

The Dept. of Defense estimated that 35,000 jobs would be cut in the coming year due to budget tightening, but Civil Service Commission sources now say that as many as 100,000 DOD civilian employees may get the ax. The CSC is urging that the firings be accomplished as soon as possible to fit the coming budget. Layoffs are expected to begin around the first of the year.

Western Union seeks deal with Comsat

Western Union, an entrant in the domestic communications satellite competition, has said it would like the Communications Satellite Corp. to handle the space segment of its proposed system. Comsat has already joined with AT&T in a filing with the Federal Communications Commission for a domestic satellite system.

Meanwhile FCC Chairman Dean Burch has warned firms in the domestic-satellite field that they face serious problems—the key ones being limited orbital slots, costs and local distribution. It must be decided for example, Burch said, whether the role of CATV should be expanded, whether telephone company facilities should be utilized or whether new facilities should be constructed. Of tremendous importance to companies planning general-use networks, he pointed out, is whether the broadcast networks will decide to buy service from these carriers or put up their own networks.

Capital Capsules:

Congressional sources say that the Navy will mothball at least four carriers in the coming year to cut operational costs. Types of carrier are not indicated. . . . **The House of Representatives has awarded contracts amounting to $450,000 to eight firms to study its automatic data-processing requirements.** . . . **Western Union** has told the FCC that its existing New York-Washington microwave link will be saturated within two years and **asks permission to add a 20-million-bit-per-second digital transmission capability.** The proposed link would be opened by 1972 and would eventually serve New York, Philadelphia, Baltimore, Pittsburgh, Cincinnati, Cleveland, Columbus, Detroit and Indianapolis. . . . **AT&T and Comsat have two weeks to file with the FCC details on land interconnection arrangements** for their proposed domestic satellite system. FCC asked for the additional data by December 1, stating that a "system proposal is not complete without some provisions for a terrestrial interconnection."

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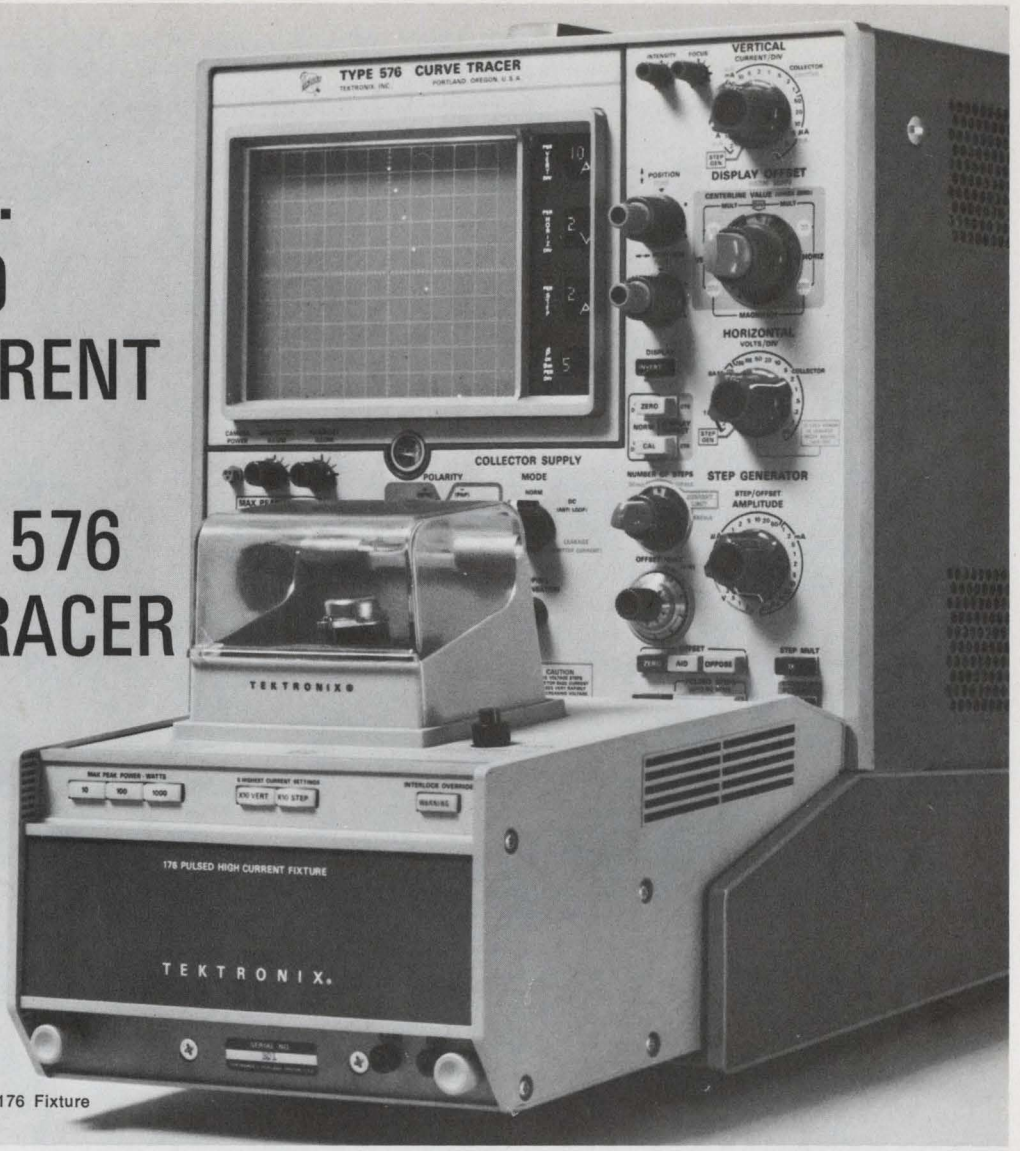
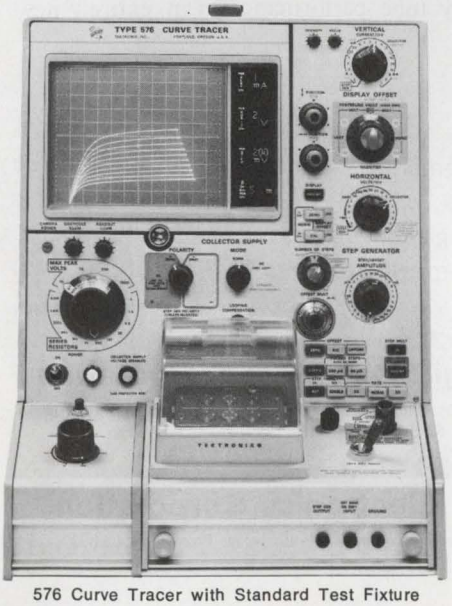


576 Curve Tracer with 176 Fixture



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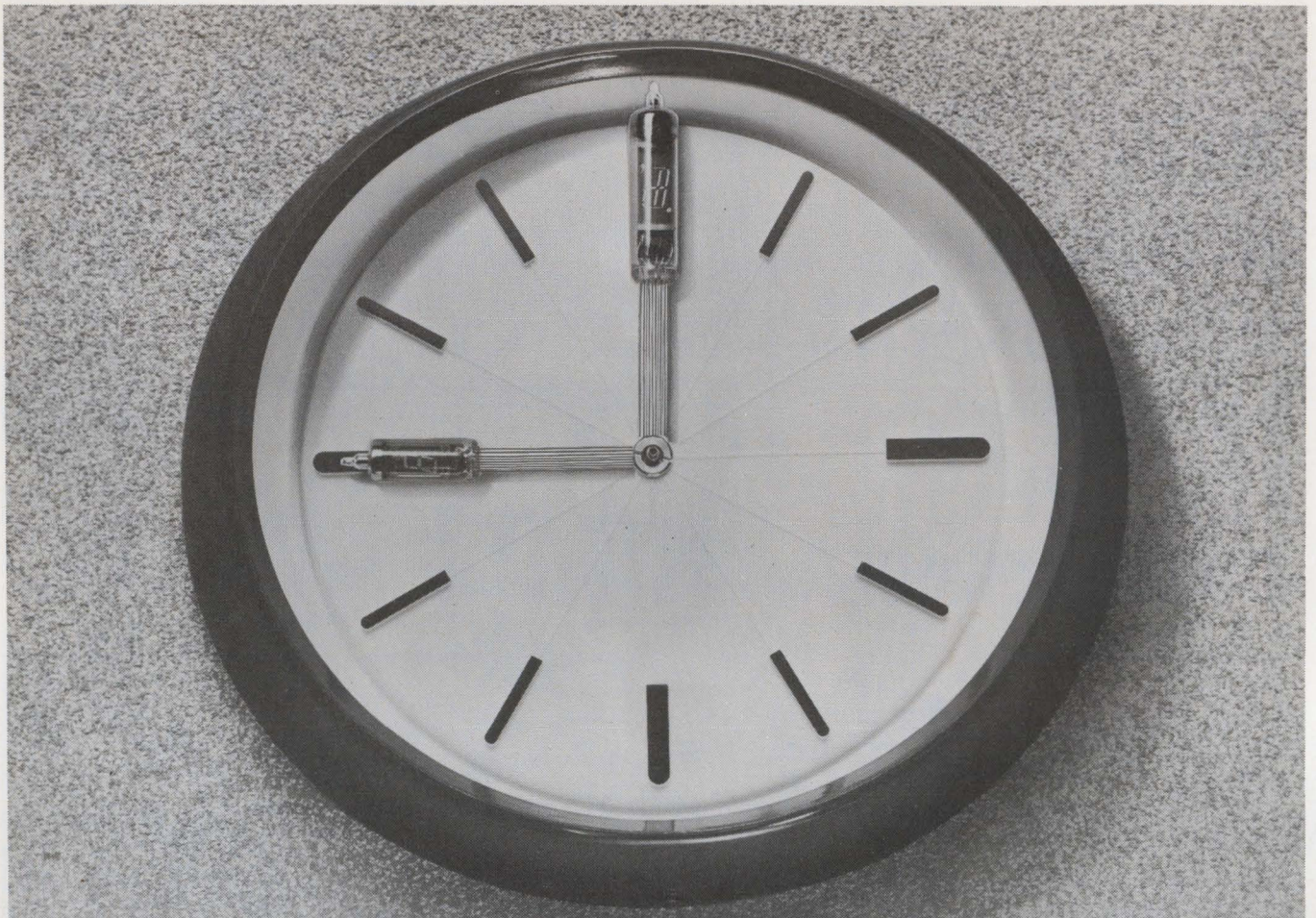

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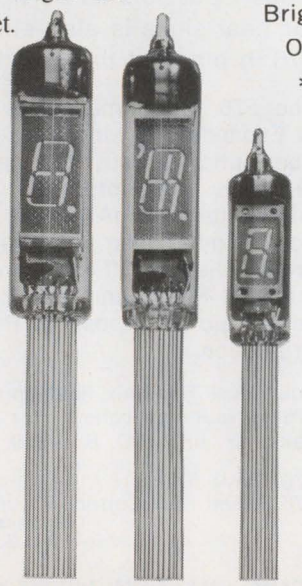

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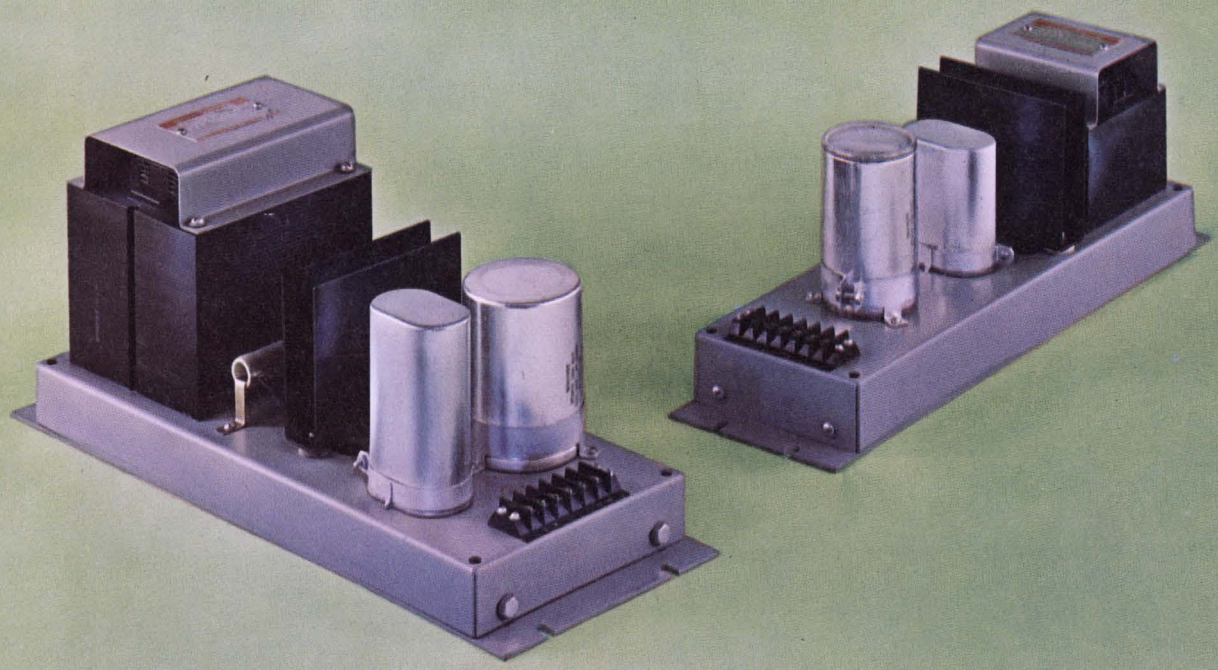

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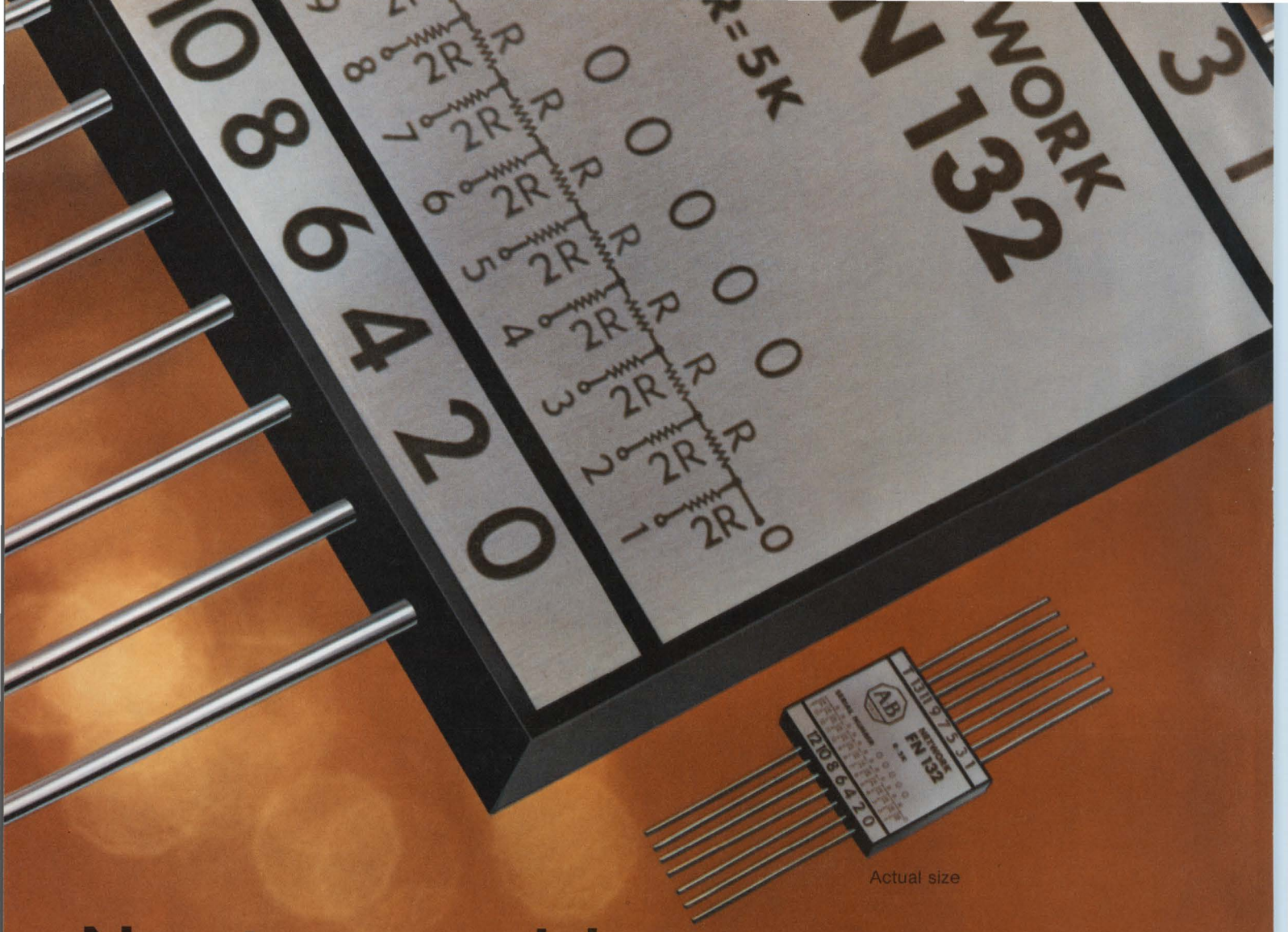

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EDITORIAL

Introducing civionics — a term you'll be hearing more about

Pick up a magazine or newspaper, listen to a radio or television broadcast, and you will hear the language of the 70s: "Thermal pollution . . . anticrime legislation . . . postal reform . . . urban transportation . . . aircraft collision avoidance" and more. What is the common message that these words convey? Change.

Change in our society. Change in the electronics industry. Change in the education and skills demanded of the design engineer.

These changes, spurred by new national priorities, are even now creating new opportunities for the electronics industry. The ultimate size of these markets is hard to gauge, but there's little doubt that in time they will reshape the electronics industry.

Recognizing the importance of these shifts and their significance to the designer, ELECTRONIC DESIGN plans to carry a series of special reports next year, ranging from urban mass-transportation and anticrime electronics to pollution monitoring and control. These reports will be strictly hardware and design-oriented, not merely "blue sky" surveys. They will inform readers of hardware needs, as well as circuit and system problems and proposed solutions.

What is the most meaningful term we can apply to this changing technology? ELECTRONIC DESIGN suggests *civionics*—civilization electronics. By civionics we mean the application of electronics for the public good, as opposed to electronics that benefits the individual or a private business. For example, a highway traffic-control system would be considered civionics, since it is designed to allay auto congestion for the public. On the other hand, a solid-state car ignition system would be considered consumer electronics since it benefits individuals.

Highway traffic control already has a healthy headstart on some of the other civionics areas in creating a new market for the electronics industry. More than 40 cities in the U. S. have installed or are planning to install electronic traffic-control systems during the next two or three years. Improvements now under development or in the planning stage include vehicle-identification systems, car-passing devices and antiskid systems.

The electronics industry is on the threshold of breaking its dependence on aerospace and defense contracts. So, too, must the designer as he looks toward new opportunities in civionics in the years ahead.

RALPH DOBRINER

The patient comes first in telemetry.

Hospital system design must consider transmitter size and weight, noise and FCC rules.

Biomedical telemetry will have a great impact on hospital care. By keeping an ambulatory patient under continuous observation, it can instantly warn the hospital staff of a medical crisis. And it can allow a patient, who otherwise might be forced to remain bedridden, almost complete freedom of movement. Finally, telemetry can save money, by giving older hospitals the capability of continuous patient monitoring without the need for expensive rewiring.

At the moment, there are not many biomedical telemetry systems in operation. The only reason is that not enough of the necessary equipment is available. To make biomedical telemetry a reality, engineers must become aware of the needs of both hospitals and patients, and must be especially aware of the parameters that govern the design of such systems.

Although many forms of communication have been proposed for hospital telemetry—magnetic, coherent and noncoherent light and ultrasonics—only electromagnetic radiation now has the efficiency and ease of transmission suitable to meet

Edited by **Milton J. Lowenstein**

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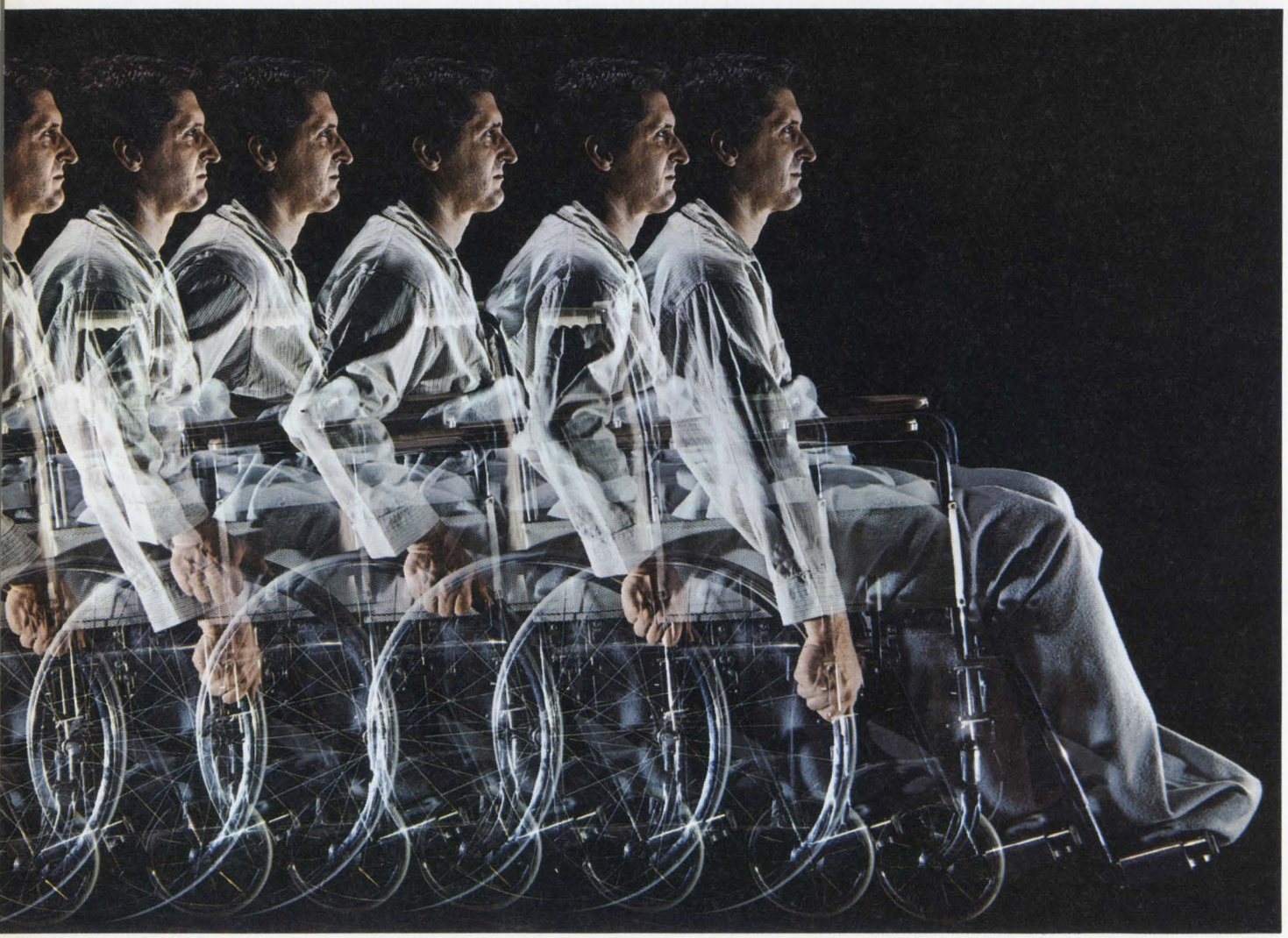


all the requirements.

Once this obvious choice has been made, it is necessary to decide how information is to be carried. Power levels and the kind of modulation will have significant effects on system design. Therefore, basic specifications must be enumerated.

The most obvious parameters to be considered are the size of the transmitter, the design of the patient sensors and the interconnections between these devices. Since sensors for pulse and respiration rates, blood pressure, EKG, EEG and body temperature have their own design parameters, it can be assumed that these devices are available and can be directly wired to the transmitter.

To avoid burdening the patient and to ensure his cooperation in using the device, the transmitter must be as small and light as possible. An ideal size would be 1 by 1 by 1/4 inch with a weight of 1 ounce. Market surveys indicate that it could be as large as a pack of king-size cigarettes and weigh up to a pound and still be tolerable, but the lower limits are a more suitable design objective. If the transmitter is too large and heavy, certain patients—old people and children—will not be able to use it. Table 1 lists the basic transmitter specifications consistent with patient comfort, hospital environment and FCC regulations.

The transmitter must be shockproof and stable and able to withstand the normal hospital environment. Adjustments should not be necessary —tuning by means of packaged crystals, for instance, is almost mandatory. Table 1 lists several of the physical and operating parameters that define the transmitter.

Modular design of the transmitter is desirable, too. An attractive possibility is separately packaged power amplifiers and oscillators, for matching plug-in preamplifiers and modulators for different sensors.

What kind of modulation?

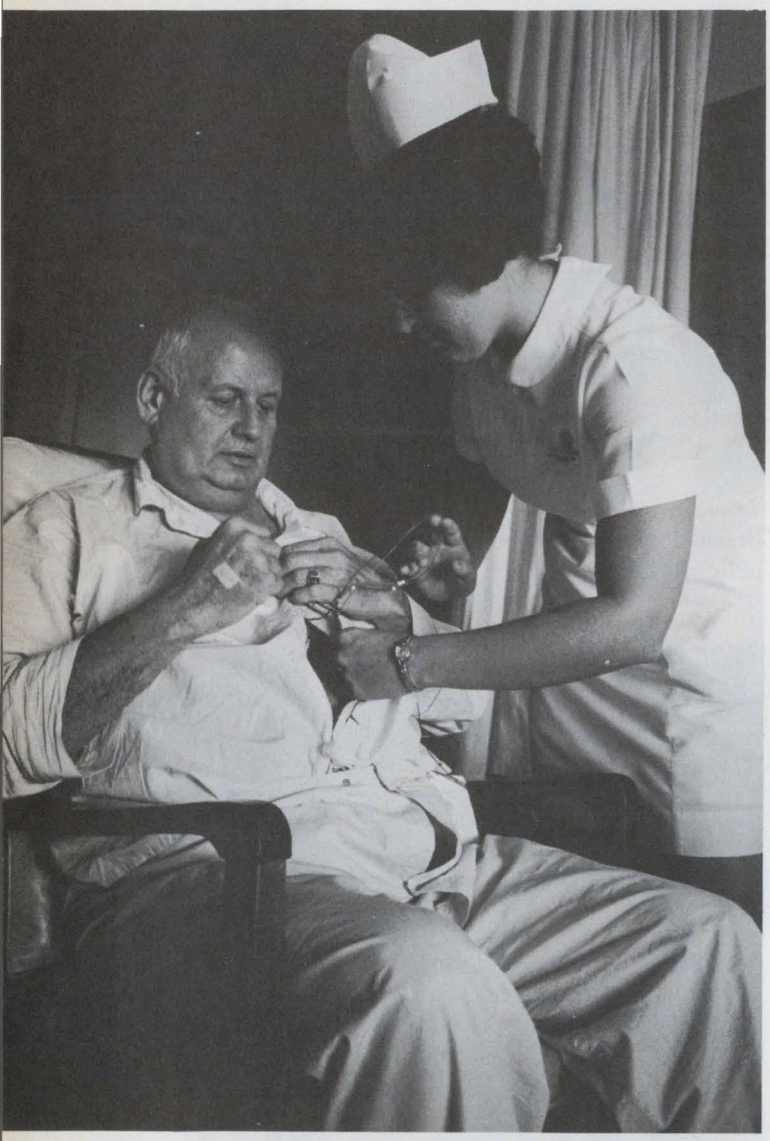
Regulations of the FCC bear heavily on the choice of communication system. Part 15 of the *FCC Rules and Regulations* is especially significant to the design of biomedical telemetering. Some pertinent excerpts from this section are:

> Operation in the band 88-108 MHz is limited to low power communication devices employed as telemetering devices or as wireless microphones. This band shall not be used for two-way communication.
>
> Users of these devices shall take adequate precautions to insure that harmful interference is not caused to the reception of transmissions from any FM or television broadcast station or any other class of station licensed by the Commission. In the event that such interference does occur, operation of the telemetering device or wireless microphone shall be promptly suspended and shall not be resumed until the interference

Table 1. Transmitter parameters

Size	1 by 1 by ¼ inches
Weight	1 ounce
Temperature range	0 to 40°C
Frequency stability	0.01%
Radiated power	50 μV/m at 50 feet
Frequency range	88 to 108 MHz
Number of channels	1, with plug-in module capability for others
Bandwidth	0.05 to 150 Hz
Modulation	FM, or PCM
Operating range	70 m
Signal/noise	$>$ 40:1
Antenna	whip
Installation time	$<$ 5 min.
Adjustments	none
Calibration	1 mV pushbutton for EKG
Power	One 1.35 V mercury battery (hearing aid type, 60 day life)
Effect on patient	None

Hospital corridors offer no telemetering problems when they are straight. However, bends can shield the receiver from the transmitter.



1. **An electrocardiogram telemetering transmitter** is attached to patient Clifford W. Longell of Berkeley Heights, N. J. prior to placing him in a wheel chair. Although there are 12 points on the body that must be monitored for a complete EKG, present transmitters and receivers are limited to only one.

has been eliminated. Users of these devices must accept any interference which may be caused by the operation of any licensed station operating in accordance with the terms of its license.

The field strength of emissions radiated within the specified 200-kHz band shall not exceed 50 μV/m at a distance of 50 feet or more from the device.

The field strength of emissions radiated on any frequency outside the specified 200-kHz band shall not exceed 40 μV/m at a distance of 10 feet or more from the device.

Other paragraphs of the FCC regulations limit telemetering services to frequencies below 70 MHz, except for the 88-108 MHz band. Because low-frequency antennas become too large, the higher frequency band is the only one suitable for medical telemetry. A possible point of conflict is a requirement for periodic announcement of call letters. This is clearly impossible in the kind of transmitter we are considering. Careful study of legal ramifications must be made by the designer before he commits himself to a final design.

On a technical level, decisions are based on more solid information. Five basic types of modulation can be considered: amplitude modulation (AM); frequency modulation (narrow or broadband FM); pulse-amplitude modulation (PAM); pulse-position modulation (PPM); and pulse-code modulation (PCM)—sometimes called pulse-width modulation (PWM). For lowest equipment cost, AM is the best. However, when the performance requirements involved in the system, such as reliability and electrically noisy hospital environments (primarily radiated noise from other equipment), are considered wideband FM or PCM is the best choice.

Since noise is one of the major problems in a hospital environment, good signal-to-noise ratio is vital. A comparison of signal-to-noise ratios (S/N) is useful. Note that the subscript c in the following equations denotes the unmodulated carrier with the minimum bandwidth required to transmit information.

$$(S/N)_{AM} = S_c/N_c$$

$$(S/N)_{FM} = 3\beta^2 (S_c/N_c)$$

For a modulation index, $\beta >> 1$, which is the case in wideband FM, S/N is significantly better than AM. The FM equation also shows that S/N for wideband FM is better than narrowband FM. A wider bandwidth system, of course, requires more stages of gain.

Performing the same comparison for PAM and PPM, we have $(S/N)_{PAM} = S_c/N_c$

and $(S/N)_{PPM} = 1/2\ (t_o/\tau_r)\ S_c/N_c$,
where t_o is the maximum frequency deviation and τ_r is the rise time of the pulse.

It can be seen from these equations that PPM is a better choice than PAM and that

$(S/N)_{AM} = (S/N)_{PAM}$.

Increasing the modulation index (t_o) in PPM, or decreasing the pulse rise time, increases the S/N. It is more difficult to characterize S/N for PCM, but it improves exponentially, once past the threshold level, rather than linearly as in the case of FM or PPM.

To choose the best system in terms of both performance and cost criteria, a complete analysis of all the variables, including actual radiated noise levels in hospitals, must be made. Then competing systems—AM, FM, PCM—can be blocked out and compared on a cost-effective basis.

Determine output levels

Assuming that the FM band will be used, the FCC maximum for radiated output must be less than 50 μV/m at 50 feet. If a half-wave dipole is used as the transmitter antenna, the following relation between power and field intensity apply:

$E = (49.2\ P^{1/2})/R$

where E is field intensity in volts, P is transmitted power in watts, and R is distance in meters.

In this case E is 50 μV, R is 50 feet or 17 m, and

$P = (ER)^2/49.2 = (50 \times 10^{-6} \times 17)^2/49.2$
$= 147 \times 10^{-10}$ W.

Maximum power output, therefore, from the transmitter is 0.0147 μW.

This power output, although feasible with a miniaturized transmitter, is very close to hospital noise levels. The FCC regulations that determine this low power were not written with the special problems of hospitals in mind.

One way to overcome this inherent difficulty is to have the regulations changed. Another is to view the FCC limitation as referring to average output power. A pulse-modulated signal, rather than FM, can then concentrate energy at much higher power levels over a short duty cycle.

The earlier discussion of S/N and this power restriction suggest strongly the advantage of PCM in producing a strong, clear signal. Existing hospital telemetering systems rely on FM; future systems, it seems, should be built using PCM.

The possibility of power transmitted by the

2. **This biomedical transmitter, in use in Overlook Hospital, Summit, N. J., is larger than ideal size.** Additional design is necessary to make it small enough for young children or for transmission of several channels of medical data.

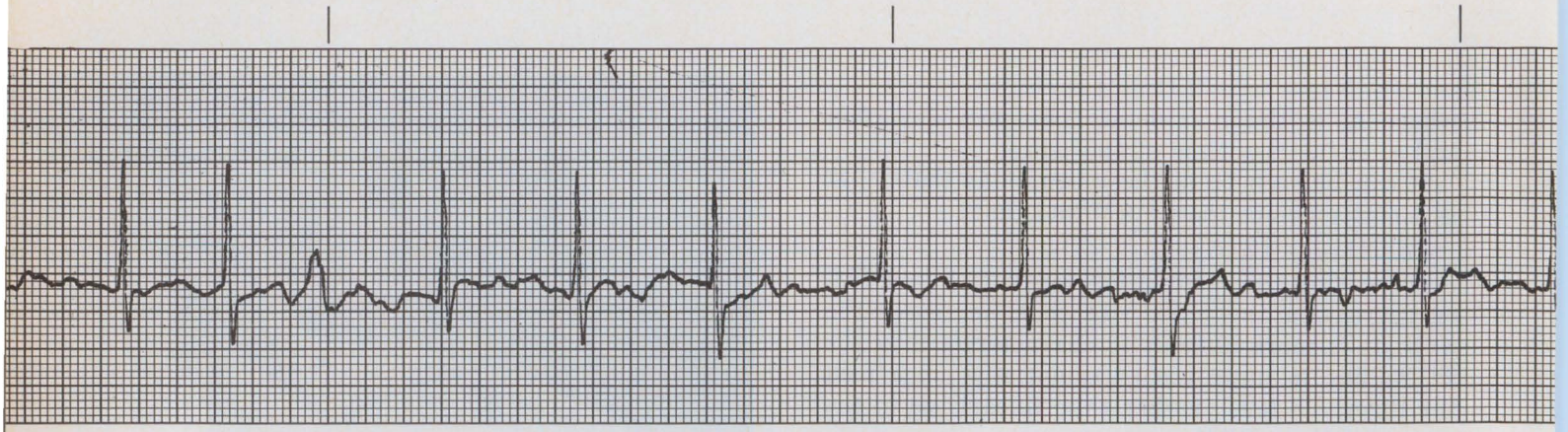


Table 2. Receiver parameters

Frequency range	88 to 108 MHz
Bandwidth	0.05 to 150 Hz
Modulation	FM or PCM
Frequency stability	0.01%, crystal controlled
Temperature range	0 to 65°C
Number of signals/channel	1 with possible addition of 3 more
Signal/noise	> 40:1
Baseline drift at display device	< 1 mm/min; ±2 cm/day
Antenna	external
Adjustments	none
Calibration	none
Power	115/230 V, 50/60 Hz

telemetry transmitter causing interference with other vital medical equipment must be explored, particularly in the case of a cardiac pacemaker used by a heart patient. But so far, the results of studies on pacemakers has indicated that there is no severe interference. And by shielding the leads of the transmitter and positioning it so that the patient's body is between it and the pacemaker, any interfering signal will be highly attenuated.

Receiver design is important

Because of the severe limitations on the transmitter, a carefully designed receiver is necessary. Low noise characteristics are a must. Since several patients may be monitored simultaneously, there must be frequency channel allocations to keep them separate. Front-end modules can be used to match each transmitter, or several separate channels can be incorporated into a single receiver.

Size and weight are not critical parameters for the receiver, but stability and reliability are. Table 2 lists receiver specifications based on previously determined transmitter parameters. The transmitter is the limiting element in the design. Much more design freedom is possible with the receiver. However, there should be no need for adjustments or calibration—hospital personnel are not skilled in this area.

Receiving antennas should be placed at strategic locations to eliminate dead areas and to make the system operate satisfactorily with low transmitter power. One possibility is to make use of electrical wiring as a receiving antenna, provided this wiring is not shielded and contains no intervening transformers.

System complexity depends on the hospital and the kind of installation. Small and large hospitals have different needs. Installation in an existing hospital or designing into a new hospital will effect the specifications and performance. Radio noise levels are different in city and country. Obviously, each system must be carefully assembled for best results.

Another area that should be given careful consideration is that of proper human engineering. The elimination of adjustments and calibrations has been mentioned. Color coding and indexing of connectors are other areas where good design can prevent accidents. The hospital environment is one in which the staff is under pressure. The engineer must make his equipment simple and easy to use. ■■

Test your retention

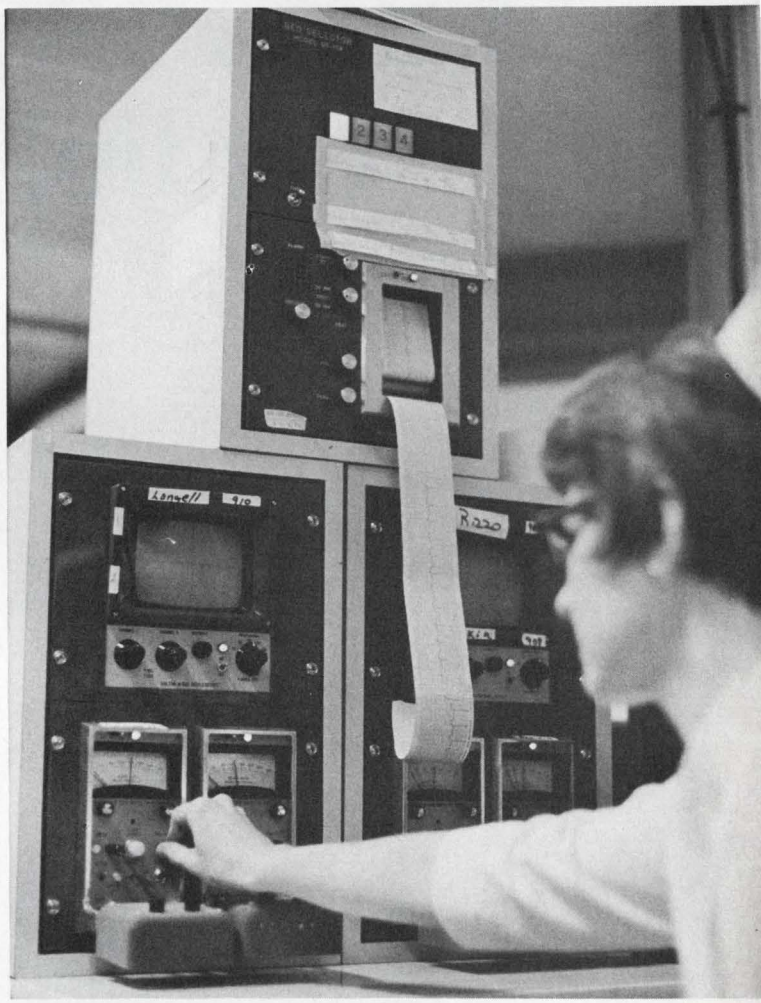
Here are questions based on the main points of this article. Their purpose is to help you make sure you have not overlooked any important ideas. You'll find the answers in the article.

1. What are the major benefits of telemetry to the patient? to the hospital staff?

2. Why are transmission power limitations imposed on hospital telemetry by the FCC?

3. What kind of modulation has the best signal-to-noise ratio for hospital telemetry?

4. Why should hospital telemetry equipment be designed with no adjustments?



3. **This display is located near the telemetry receiver in Overlook Hospital.** Oscilloscope and alarm units are mounted below a hard-copy oscillograph which produces a permanent record, like that shown at the top of the page. The use of the scopes and oscillograph is desirable; the alarm units are mandatory.

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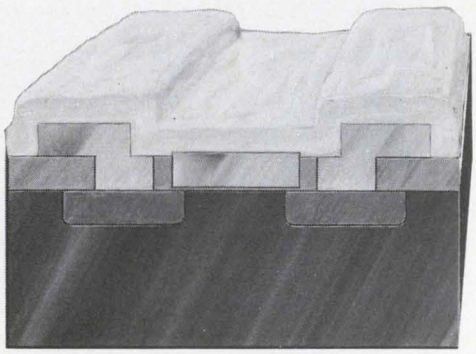

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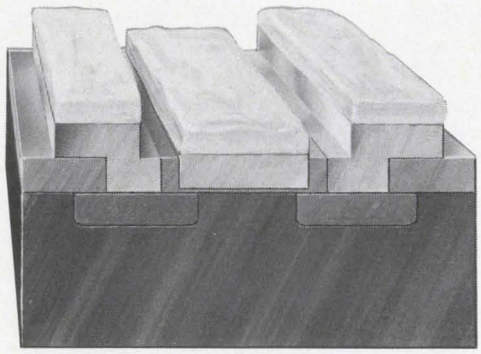

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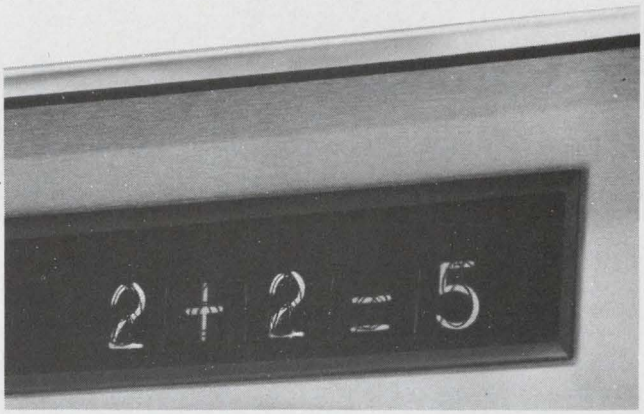

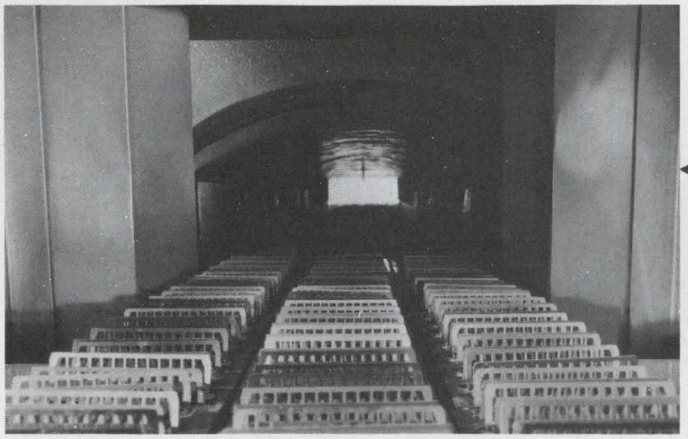

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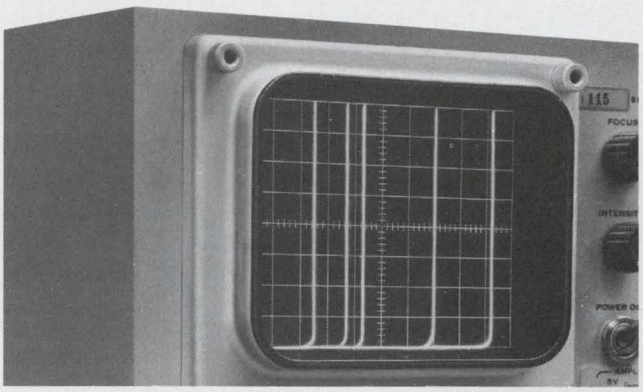

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INFORMATION RETRIEVAL NUMBER 35

Three-level logic eliminates inverters.

The use of all NAND logic can reduce gate count by inherent generation of complemented variables.

Standard synthesis of logic circuits uses the 2-level AND-OR logic that results from Karnaugh maps or the Quine-McCluskey chart. The conventional results of this approach produce a design in which delay is minimized. But it is possible to make use of 3-level NAND logic[1,2] only and to reduce total gate count.

This is possible because the NAND design requires no complemented variables as inputs, and, consequently, no inversion gates. If complemented variables are needed, they can be produced within the designed logic structure.

A second advantage is that only one kind of logic gate need be kept in stock. This is most useful to engineers who have infrequent demands for logic circuits. The only disadvantage of the method is the increase in propagation time through the logic network as a result of the additional stage.

Careful design reduces gate count

If minimum gate count is the design objective, the logic network should reflect alternate design techniques. There is no criterion by which the minimum gate count is assured, so the designer must investigate many possibilities.

Two-level AND-OR logic is related to all NAND logic by the following expression, based on DeMorgan's theorem:

$$ABC + DEF + GHI = [(ABC)'(DEF)'(GHI)']' . \quad (1)$$

The left-hand side of Eq. 1 is expressed in terms of two levels of AND-OR logic, while the right-hand side is three-level NAND only. The following identities, which can be derived from fundamentals, also prove especially useful in reducing gate count:

$$[XY(Z)']' = [XY(XZ)']' = [XY(XZ)']' = [XY(XYZ)']', \quad (2)$$

and

$$[(W)'(XY)']'[(X)'(XY)']' = [(WX)'(XY)']'. \quad (3)$$

The most direct way of describing the use of three-level NAND logic is to work through some examples.

Example 1:

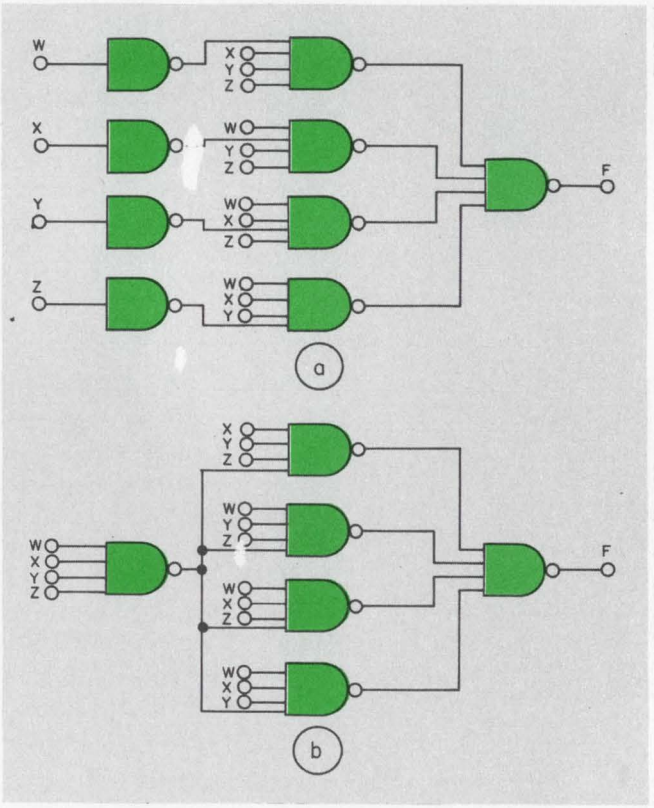
Let $F = W'XYZ + WX'YZ + WXY'Z + WXYZ'$ be the desired expression and W, X, Y and Z be the inputs. Substituting into Eq. 1, the expression becomes

$$F = [(W'XYZ)'(WX'YZ)'(WXY'Z)'(WXYZ')']' .$$

The logic structure for this equation is shown in Fig. 1a. It uses nine NAND gates.

If F is further modified by the identities of Eq. 2,

$$F = [(WXYZ)'(XYZ)\ (WXYZ)'(WYZ)\ (WXYZ)'(WXZ)\ (WXYZ)'(WXY)]'.$$



1. **All-NAND logic can be used to perform any logic function.** Straightforward application of NAND gating (a) makes use of nine gates. With manipulation, the count is reduced to six by eliminating inverters (b).

Edmond I. Vinarub, Electronic Systems Engineer, Reflectone, Inc., 2051 W. Main St., Stamford, Conn. 06904

The implementation of this logic (Fig. 1b) requires only six NAND gates. The original two-level logic used four AND gates, one OR gate and four inverters, for a total of nine gates.

Example 2:

Let $G = X'Y'Z + W'Y'Z$.

If only uncomplemented variables are available, the implementation of this equation requires two AND gates, an OR gate and three inverters, or a total of six gates. The direct conversion into NAND logic results in

$G = [(X'Y'Z)'(W'Y'Z)']'$.

Figure 2a is the corresponding logic diagram. The circuit uses six NAND gates, which is no improvement. However, if the identity of Eq. 3 is used, the equation can be rewritten as

$G = [(WX)'Y'Z]''$,

and this may be implemented as in Fig. 2b, using only four NAND gates.

Example 3:

The first two examples made use of either Eq. 2 or Eq. 3 for simplification. This final example makes use of both relationships.

Let $H = WXY' + WXZ' + XYZ'$. The conventional solution uses six gates. Converting to NAND also uses six gates (Fig. 3)

$H = [(WXY')'(WXZ')'(XYZ')']'$.

Applying first Eq. 2 and then Eq. 3, the modified function is

$H = [(WX(YZ)')'(XY(YZ)')']'$.

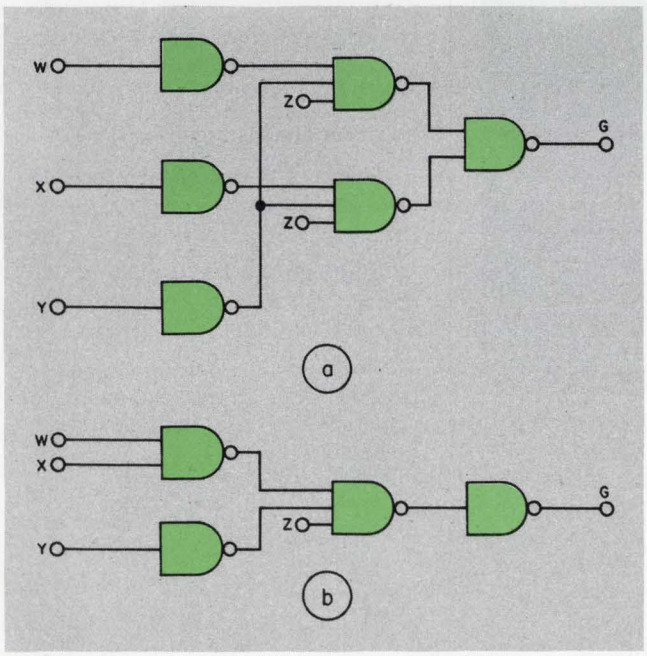
This yields the structure of Fig. 3b, which uses only four NAND gates.

The use of three-level NAND logic is one more tool for logic designers. It is an additional option when gate count or parts supply is critical. ■■

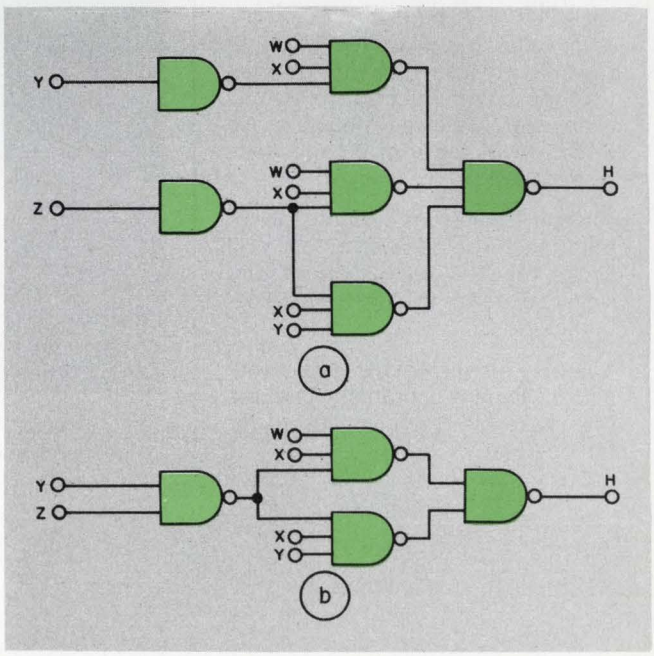
References

1. Starr, Gilbert, "Be Logical—Consider Unfamiliar Gating," *Electronic Design*, Sept. 13, 1970, pp. 90-91.

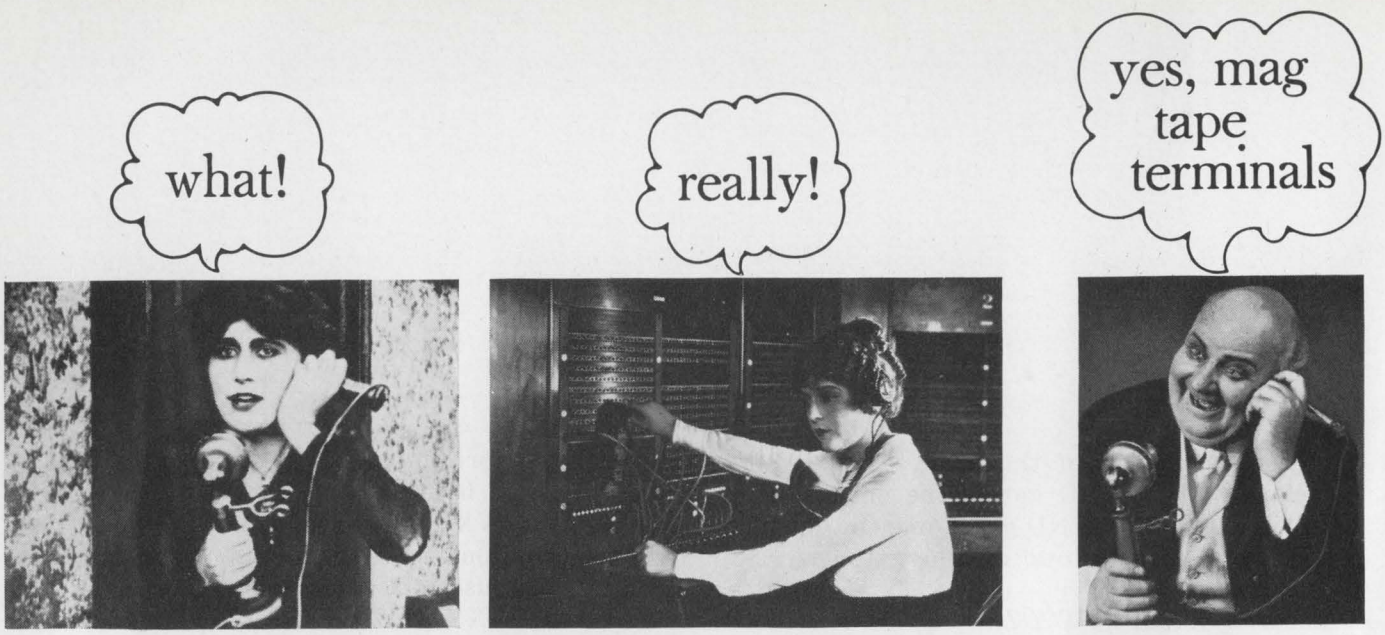
2. Ellis, D. A., "A Synthesis of Combinational Logic with NAND or NOR Elements," *IEEE Transactions on Electronic Computers*, October, 1965, pp. 701-705.

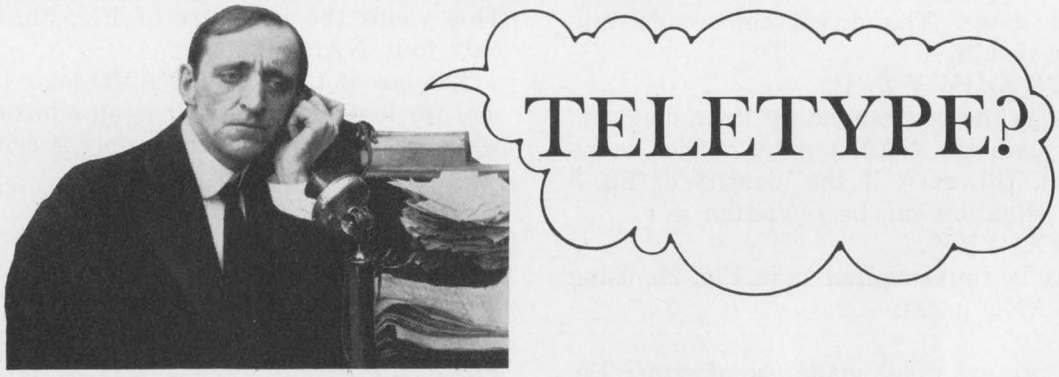


2. **An original network with six gates** (a) can be reduced to four by using all-NAND logic (b). Note that the final gate in "b" is a NAND gate with only one input, or simply an inverter.



3. **Two simplifying equations are used to reduce the gate count** in this final example. The number of gates is reduced even with an extra level by producing complemented variables within the logic structure.



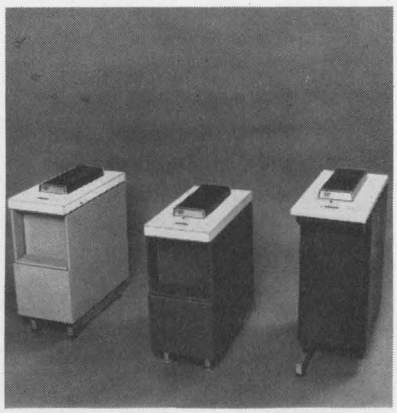


It's true.

After helping a jillion feet of paper tape wind and unwind its way through communications systems everywhere, Teletype announces the addition of magnetic tape data terminals.

There are some basic advantages in both mediums. But as you are well aware, the medium that's right for a system depends a lot on the application criteria.

The new magnetic tape data terminals have many operational features that make life less complicated for the operator.



New, modular line of Teletype® 4210 magnetic tape data terminals.

For example, take a look at the tape cartridge, which was specifically designed for reliability required for data transmission.

Its vital statistics are: 3″ x 3″ x 1″.

It contains 100 feet of ½″ precision magnetic tape.

It will hold 150,000 characters of data, recorded at a density of 125 characters per inch. The equivalent of a 1000 foot roll of paper tape.

This means that your data is easier to store, easier to handle, easier to work with than ever before. And it's reusable.

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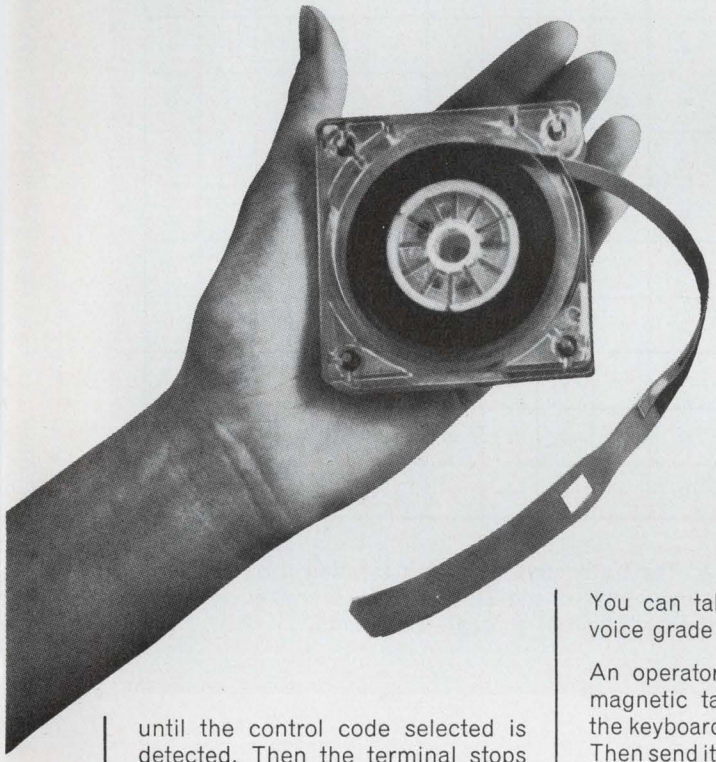
The units have a "fast access" switch which will move tape forward or reverse at a speed of 33 inches per second. A digit counter provides a reference point to help locate various areas of the tape.

Four ASCII control code characters can be recorded in the data format to aid character search operations. When the terminal's "search" button is pressed, tape moves at the rate of 400 characters per second until the control code selected is detected. Then the terminal stops the tape automatically.

A "single step" switch is also provided which enables you to move the tape forward or backward one character at a time. In editing or correcting tape, you can send a single character using this feature.



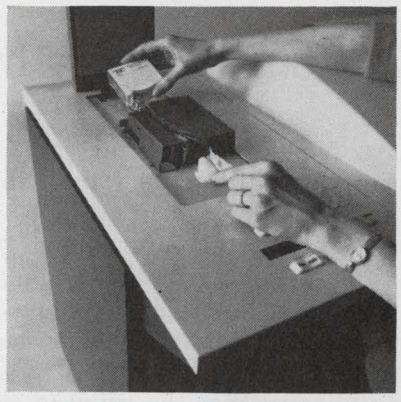
Also magnetic tape adds high speed on-line capability to low speed data terminals.

You can zip data along the line at up to 2400 words per minute. For example: Take a standard speed Teletype keyboard send-receive set, and a typical typist. Add a new magnetic tape unit to this combination and the on-line time savings can pay for the magnetic tape terminal in short order.

You can take better advantage of voice grade line speed capabilities.

An operator can prepare data for magnetic tape transmission using the keyboard terminal in local mode. Then send it on-line via the magnetic tape terminal up to 2400 words per minute.

These new modular magnetic tape data terminals offered by Teletype are perfectly compatible with model 33, model 35, model 37 and Inktronic® keyboard send-receive equipment.



Straight-through threading makes tape loading and unloading exceptionally easy.

They can send or receive at high or low speed. Or can be used independently as stand-alone terminals on-line.

If you would like to know more about this new line of Teletype magnetic tape data terminals, please write Teletype Corporation, Dept. 89-15, 5555 Touhy Avenue, Skokie, Illinois 60076.

Teletype 4210 magnetic tape data terminal with 37 keyboard send-receive set.

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INFORMATION RETRIEVAL NUMBER 36

Vary op-amp gain by 2048:1 in steps of 2:1

An inexpensive circuit can lower the gain of an operational amplifier by a factor of two each time the binary outputs of a 4-bit binary counter increase. A total gain change of 2^{11} or 2048 is possible using a circuit with only five spst miniature, dual-in-line relays and one quad-NAND gate (Fig. 1). The truth table for the circuit is shown in Fig. 2, in which a ZERO at a relay coil terminal indicates that the relay is energized.

Initially, relays 1, 2 and 3 are not energized (open) and relays 4 and 5 are energized (closed). The gain of the op amp is 1 MΩ/499Ω ≈ 2000.

On the first three counts relays 1, 2 and 3 turn on during the count that their respective inputs are ZERO, and the gain is progressively lowered by factors of two. On the fourth count relay 4 opens. Since relays 1, 2 and 3 are also open, the gain is 1 MΩ/7.99 k ≈ 125. During the fifth, sixth and seventh count, relays 1, 2, and 3 again close. On the eighth count relay 5 opens and relay 4 closes. Since relays 1, 2, and 3 are again open, the gain is 1 MΩ/127.499 k ≈ 7.84.

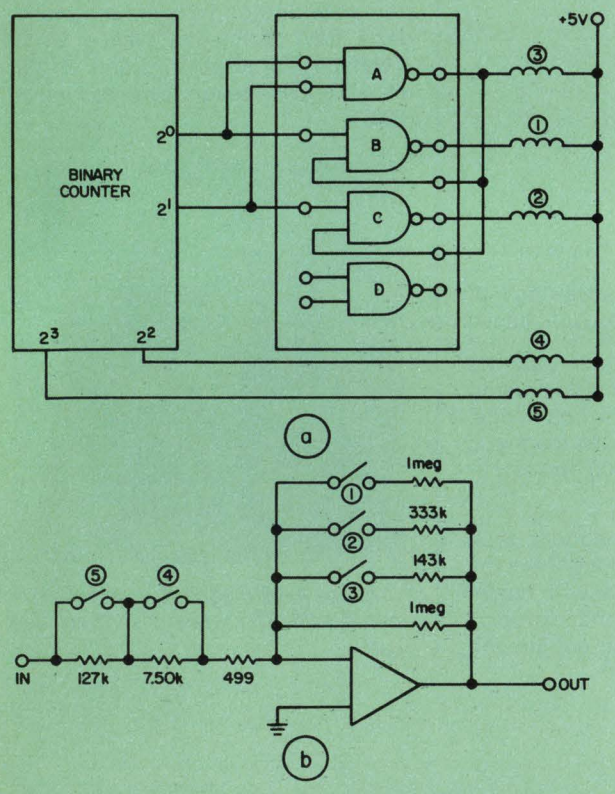
On the ninth, tenth and eleventh counts, relays 1, 2 and 3 again turn on. On the eleventh count the gain is 125k/127.499k ≈ 0.98, for a total reduction in gain of 2048.

Norman Tobey, Senior Electrical Engineer, Itek Corp., Optical Systems Div., 10 Maguire Rd., Lexington, Mass. 02173.

VOTE FOR 311

COUNT	COUNTER				RELAY				
	2^3	2^2	2^1	2^0	1	2	3	4	5
0	0	0	0	0	1	1	1	0	0
1	0	0	0	1	0	1	1	0	0
2	0	0	1	0	1	0	1	0	0
3	0	0	1	1	1	1	0	0	0
4	0	1	0	0	1	1	1	1	0
5	0	1	0	1	0	1	1	1	0
6	0	1	1	0	1	0	1	1	0
7	0	1	1	1	1	1	0	1	0
8	1	0	0	0	1	1	1	0	1
9	1	0	0	1	0	1	1	0	1
10	1	0	1	0	1	0	1	0	1
11	1	0	1	1	1	1	0	0	1

2. **The truth table of relay operation** uses ONE for a de-energized and ZERO for an energized relay as the circuit steps through 12 counts.



1. **A gain variation of 2048:1** is accomplished by the circuit. The logic (a) uses only three gates of the quad NAND. The relay coils (a) operate contacts (b) to change gain.

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■ Accuracy: (Code)	D1	D2	D3	D1	D2	D3
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−20 to 85°C	±0.05%	±0.1%	±0.2%	±0.05%	±0.1%	±0.2%
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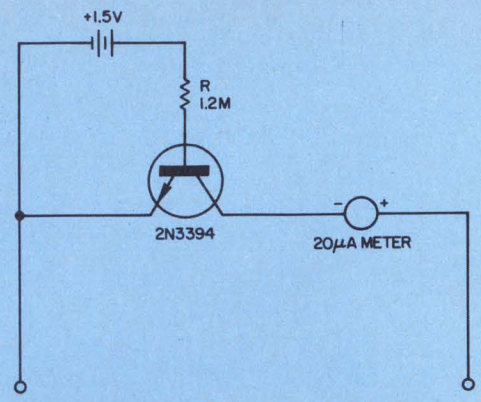
INFORMATION RETRIEVAL NUMBER 37

Transistor protects sensitive meter movements

Diode protection, often used for meter-movement overload protection, is useless for microammeters in which the meter voltage drop is below that required for conduction. But the circuit shown will limit the current through any meter to a predetermined value.

The transistor is connected so that the meter current flows through the collector circuit. The maximum base current is established by the battery and the resistor. The resistor is chosen so that the maximum collector current is between 1.5 and 2 times the full-scale meter current, a value the meter can stand. The resistor shown is the nominal value for a 20-μA meter and must be changed for other movements. Also, because of the wide variation in beta for inexpensive transistors, the maximum meter current should be checked.



The current limiting action of the transistor provides a better method for meter-movement protection than the use of a diode. This circuit can be used with any meter by changing the resistor.

Paul C. Krueger, Electronic Consultant, 20 Wabash Ave., Wharton, N. J. 07885

VOTE FOR 312

Generate normally distributed random numbers with BASIC

Normally distributed random numbers are often required for statistical problems such as sampling. BASIC language contains the instruction RND (−1), which generates uniformly—as opposed to normally—distributed random numbers, r_i, in the interval 0 to 1.

```
10 READ K,S,M
20 DATA 24,10,50
30 FOR I=1 TO 50
40 LET T=0
50 FOR J=1 TO K
60 LET R=RND(-1)
70 LET T=T+R
80 NEXT J
90 LET N=S*SQR(12/K)*(T-K/2)+M
100 PRINT N
110 NEXT I
120 END
```

Uniformly distributed random numbers are converted to normal distribution by this BASIC program. Any mean or standard deviation can be specified.

Using the central limit theorem, the following formula, which yields normally distributed random numbers from a set of uniformly distributed numbers, can be derived:

$$x = \sigma \left(\frac{12}{k}\right)^{1/2} \left(\sum_{i=1}^{k} r_i - \frac{k}{2}\right) + \mu,$$

where

σ = standard deviation,

μ = mean,

and

k = some quantity of uniformly distributed random numbers.[1] This equation appears in line 90 of the program shown.

The value of k is selected large for accuracy or small for computational efficiency.

The program listing is shown in the figure. In line 10, S is σ, M is μ.

Reference

1. Naylor, Balintfy, Burdick, and Chu. *Computer Simulation Techniques*, John Wiley & Sons, New York, 1966.

Marvin Perlman, Senior Systems Engineer, Singer-General Precision Inc., Link Division, Silver Spring, Md.

VOTE FOR 313

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				25°C	100°C				
		Volts	Volts	μA	μA	pf	n sec	Amps	Amps
1N5185	20	50	1.1	5	100	600	250	3	80
1N5186	20	100	1.1	5	100	400	250	3	80
1N5187	20	200	1.1	5	100	320	250	3	80
1N5188	20	400	1.1	5	100	240	300	3	80
1N5189	20	500	1.1	5	100	200	350	3	80
1N5190	20	600	1.1	5	100	160	400	3	80
1N5185A	20	50	1.1	2	80	400	250	4	80
1N5186A	20	100	1.1	2	80	300	250	4	80
1N5187A	20	200	1.1	2	80	250	250	4	80
1N5188A	20	400	1.1	2	80	200	250	4	80
1N5189A	20	500	1.1	2	80	160	250	4	80
1N5190A	20	600	1.1	2	80	120	300	4	80

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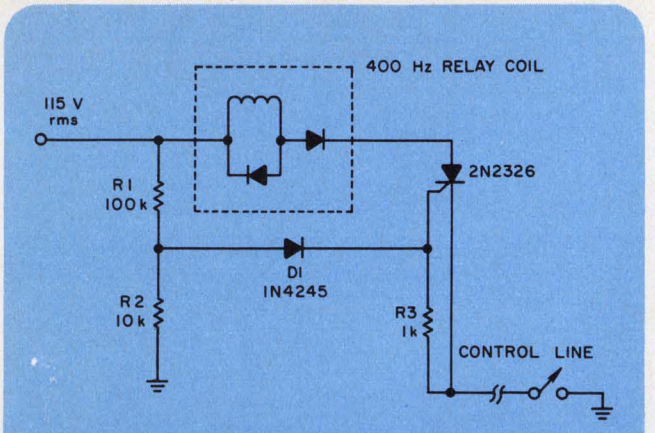
INFORMATION RETRIEVAL NUMBER 38

Operate remote relays with low control-line voltage

The voltage level on equipment control lines in many new aircraft must be kept low. This makes it difficult to operate relays without resorting to a low-voltage control-line supply—something that is usually not available. Other published[1] solutions to this problem use transformers, which take up valuable space, or zener diodes, which dissipate power either in standby or when the relay is energized. The following method is inexpensive, compact and dissipates little power.

When the remote switch is closed, the SCR conducts every half cycle as required by the 400-Hz relay coil. With the switch open, D_1 prevents gate current flow through R_2. R_1 and R_2 establish a maximum control-line voltage of 15 V peak at the highest aircraft supply (122 V rms).



Compact relay control consumes little power and meets modern aircraft design requirements. The control-line voltage never exceeds 15-V peak.

Reference

1. ARINC Spec. No. 413

Peter Lefferson, Electronic Communications Inc., 1501 72nd St. N., St. Petersburg, Fla. 33733.

VOTE FOR 314

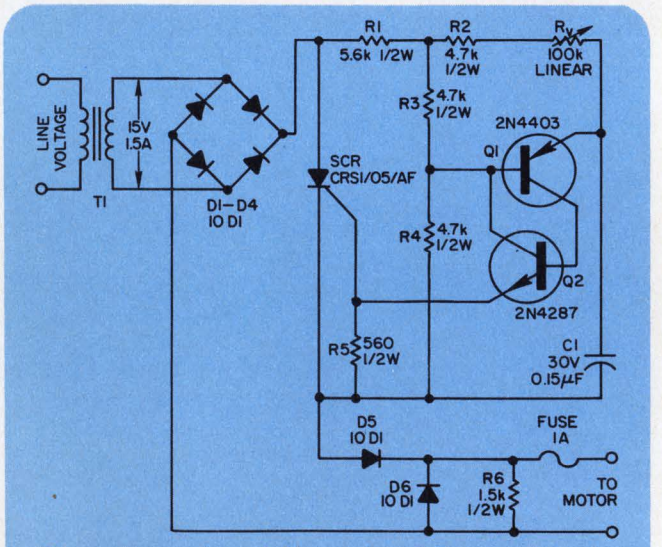
Solid-state circuit gives wide-range motor speed control

The speed of 12-V permanent-magnet motors may be smoothly controlled over a wide range by means of the circuit shown. The two transistors are connected so that when the emitter Q_1 is positive with respect to its base, the impedance between the emitters of Q_1 and Q_2 is very low. When the emitter of Q_1 is negative with respect to its base, the impedance is very high.

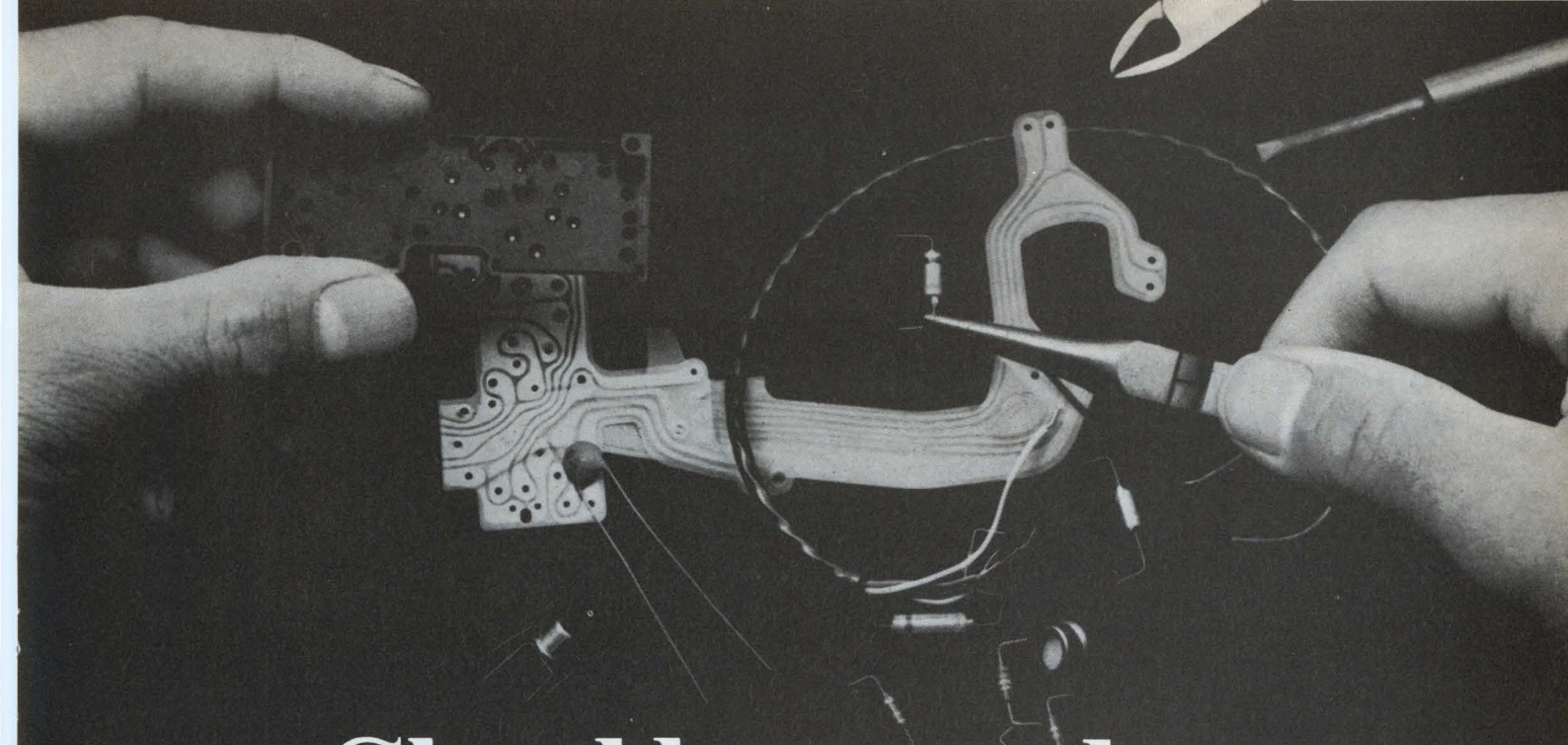
The base of Q_1 is fed from a fullwave rectified voltage. The voltage on the emitter of Q_1 starts from zero every half cycle, but its waveform is modified by the exponential charging current of C_1. The zero crossover point of the waveform can thus be varied by the adjustment of R_v. When the crossover point is reached, C_1 is discharged through R_5, turning the SCR on. This provides a dc pulse to the motor, and the voltage across the transistors drops to zero. The action repeats every half cycle. D_5 and D_6 protect the circuit from the motor back-emf. R_6 limits the open-circuit voltage.

J. Johnstone, Consultant Electronic Engineer, P. O. Box 4, Macclesfield, Cheshire, England.

VOTE FOR 315



The setting of variable resistor R_v controls the speed of a 12-V permanent-magnet motor. Stepless control with wide range of operation is a feature of the circuit, which makes use of readily available semiconductor components.



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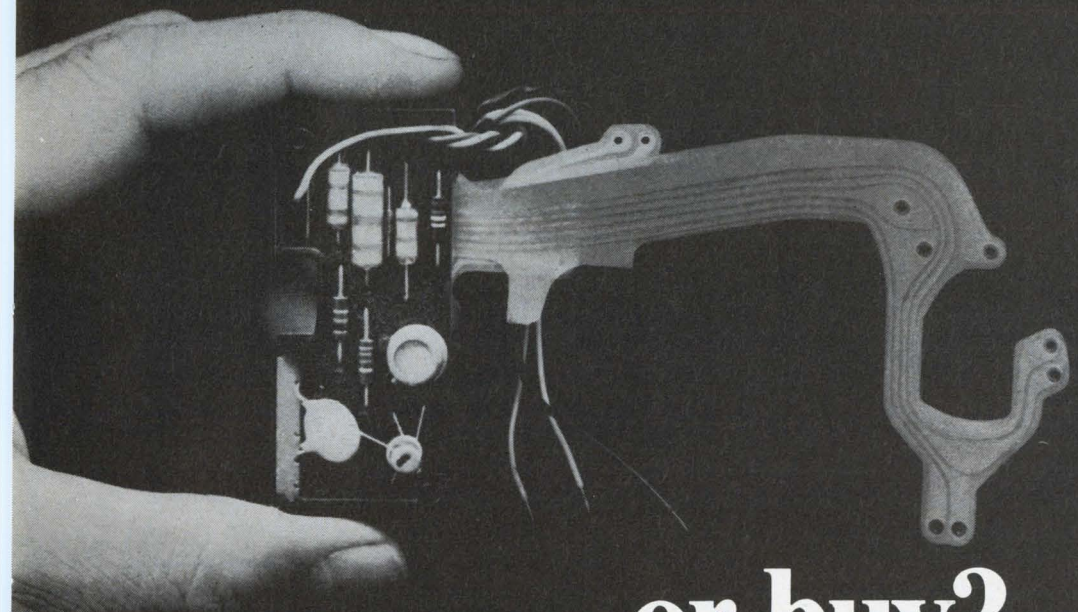

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Build two monostable multis with a single IC

Two independent monostable multivibrators on a single monolithic chip can be obtained by using a quad two-input NAND gate connected as shown. These monostable circuits are capable of output pulse widths that can be varied from less than 1 μs up to several seconds. If simultaneous triggering is desired, just connect terminals 5 and 13 together and apply the trigger pulse to that connection.

The output pulse width is controlled by the time required for the coupling capacitor (C_1 or C_2) to charge to a voltage that initiates turn-on of the gate input transistor. For the MC846P the input transistor starts to turn on when the input voltage is on the order of 1.6 V. Since $V_{ce(sat)}$ is approximately 0.3 V, the capacitor must charge to approximately 1.3 V. The total effective resistance in the charging circuit is 3.75 kΩ in parallel with the coupling resistor R_1 (or R_2). The charge time, t, can be determined from the equation

$$1.3 = \frac{V_{cc}\, R_1}{3.75 + R_1}\ (1 - e^{t/RC})$$

where $R = \dfrac{3.75k \times R_1}{3.75k + R_1}$ and

$C = C_1$.

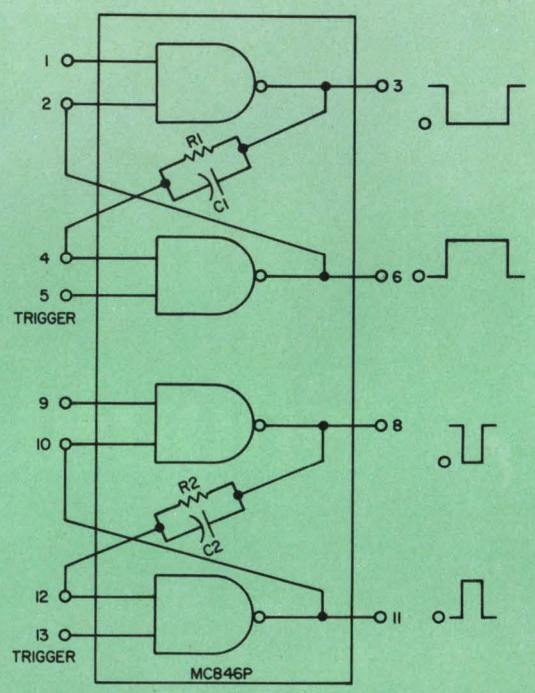
The coupling resistor R_1 should be restricted to the following range of values:

$$\left[\frac{4.875 \times 10^3}{V_{cc} - 1.3}\right] < R_1 < \left[\frac{1}{10\ fC}\right]$$

where f = trigger frequency.

The lower limit on R_1 is the value that produces an infinite-width output pulse. In other words, the circuit behaves as a Set/Reset bistable multivibrator. The upper limit on R_1 is necessary since R_1 provides the only discharge path for the coupling capacitor (due to the fact that the input diode internal to the IC is reverse-biased).

Since the capacitor must be completely discharged before any subsequent trigger pulse is applied, R_1 should be sufficiently small to permit this. The upper limit allows a minimum of 10 RC time constants between trigger pulses. Larger values of R_1 would cause the coupling capacitor to have an initial non-zero charge at the beginning of the next trigger pulse, and as a result the output pulse width would be shorter than that predicted.



Two independently triggered, variable pulse-width monostable multivibrators can be built with this single quad two-input NAND gate. Connecting pins 5 and 13 together provides simultaneous triggering.

C. F. Reeves, Electronics Engineer, Code 2300, U. S. Navy Electronics Laboratory, 271 Catalina Blvd., San Diego, Calif. 92152.

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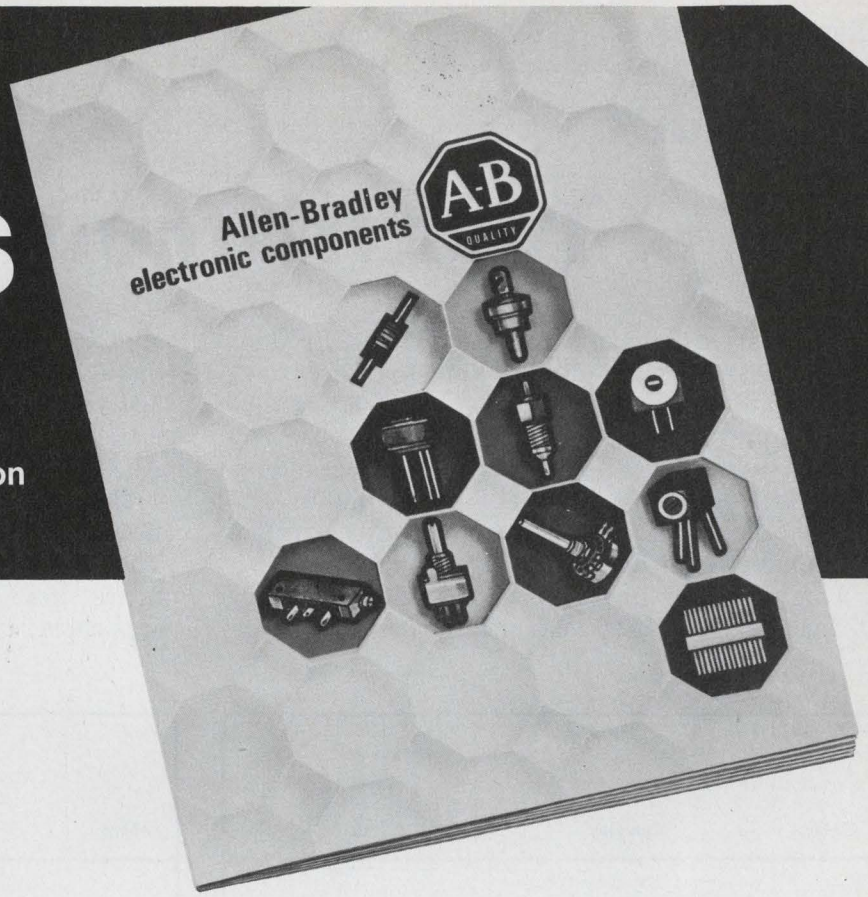

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INFORMATION RETRIEVAL NUMBER 40

Product Source Directory

Test Instruments

The test instruments covered in this Product Source Directory are divided into four groups—digital voltmeters, frequency counters, oscilloscopes and spectrum analyzers.

Each table lists the instruments in ascending order of a major parameter, like maximum voltage or frequency. Units are subsequently arranged alphabetically according to manufacturer.

This directory updates last year's compilation. It includes only the instruments introduced or significantly modified since Nov. 22, 1969. For more information on how to obtain a copy of last year's directory, see page 83. A vital addendum to our word generator directory (ED 17, Aug. 16, 1970) is also in this issue.

Manufacturers are identified by the abbreviations shown in the Master Cross Index below. The following abbreviations are used in the tables: ina—information not available; n/a—not applicable; typ—typical.

Abbrev.	Company	DVMs	Frequency Counters	Oscilloscopes	Spectrum Analyzers	Info. Ret. No.
AMC	Automated Measurements Corp. sub. of E-H Research Labs, Inc. 638 University Ave. Box 1225 Los Gatos, Calif. 95030 (408) 354-6491			X		424
Anadex	Anadex Instruments Inc. 7833 Haskell Ave. Van Nuys, Calif. 91406 (213) 873-6620		X			425
Atec	Atec Inc. Box 19426 Houston, Texas 77024 (713) 468-7971		X			426
B&F	B&F Instruments, Inc. Cornwells Heights, Pa. 19020 (215) 639-7100			X		427
B&K	B&K Instruments, Inc. 5111 W. 164th St. Cleveland, Ohio 44124 (216) 267-4800				X	428
BAC	BAC Electronics 7300 Crescent Blvd. Pensauken, N.J. 08110 (609) 662-3031			X		429
Beckman	Beckman Instruments, Inc. Electronic Instruments Div. 2200 Wright Ave. Richmond, Calif. 94804 (415) 526-7730		X			430
Boonton	Boonton Electronics Corp. Route 287 at Smith Rd. Parsippany, N.J. 07054 (201) 887-5110	X				431
CMC	CMC (Computer Measurements Co.) Div. of Pacific Industries 12970 Bradley Ave. San Fernando, Calif. 91342 (213) 367-2161		X			432

Abbrev.	Company	DVMs	Frequency Counters	Oscilloscopes	Spectrum Analyzers	Info. Ret. No.
Calico	California Instruments Corp. 5150 Convoy St. San Diego, Calif. 92111 (714) 279-8620	X		X		433
Cimron	Cimron Div. Lear Siegler Inc. 1152 Morena Blvd. San Diego, Calif. 92110 (714) 276-3200	X				434
Dana	Dana Laboratories, Inc. 2401 Campus Dr. Irvine, Calif. 92664 (714) 833-1234	X	X			435
Dumont	Dumont Oscilloscope Labs., Inc. 40 Fairfield Pl. W. Caldwell, N.J. 07006 (201) 228-3665			X		436
Dynascience	Dynascience Div. Whittaker Corp. 583 Monterey Pass Rd. Monterey Park, Calif. 91754 (213) 341-0800	X				437
E-N	Electro-Numerics Corp. 2961 Corvin Dr. Santa Clara, Calif. 95051 (408) 738-1840	X				438
Eldorado	Eldorado Electrodata Corp. 601 Chalomar Rd. Concord, Calif. 94520 (415) 686-4200	X	X			439
FSC	Federal Scientific Corp. 615 W. 131st St. New York, N.Y. 10027 (212) 286-4400				X	440
Fluke	John Fluke Manufacturing Co. Box 7428 Seattle, Wash. 98133 (206) 774-2211	X				441
GR	General Radio Co. 22 Baker Ave. W. Concord, Mass. 01781 (617) 369-4400		X		X	442

Abbrev.	Company	DVMs	Frequency Counters	Oscilloscopes	Spectrum Analyzers	Info. Ret. No.
H-P	Hewlett Packard Co. 1501 Page Mill Rd. Palo Alto, Calif. 94304 (415) 326-7000	X	X	X	X	Contact local sales office
Heath	Heath Co. Benton Harbor, Mich. 49022 (616) 983-3961			X		**443**
Iwatsu	Iwatsu Electric Co., Ltd. E-H Research Labs. 515 11th St. Box 1289 Oakland, Calif. 94604 (415) 834-3030			X		**444**
J-Omega	J-Omega Co. 2271 Mora Dr. Mountain View, Calif. 94040 (415) 961-2000	X				**445**
Keithley	Keithley Instruments Corp. 28775 Aurora Rd. Cleveland, Ohio 44139 (216) 248-0400	X				**446**
Kikusui	Kikusui Electronics Corp. Marubeni-Iida (America), Inc. 200 Park Ave. New York, N.Y. 10017 (212) 973-7152			X		**447**
Leader	Leader Instruments Corp. 37-27 27th St. Long Island City, N.Y. 11101 (212) 729-7411			X		**448**
Micro	Micro Instrument Co. 12901 Crenshaw Blvd. Hawthorne, Calif. 90250 (213) 772-1275	X				**449**
Millivac	Millivac Instruments, Inc. 1100 Altamont Ave. Box 997 Schnectady, N.Y. 12301 (518) 355-8300	X				**450**
Monsanto	Monsanto Electronic Instruments 620 Passaic Ave. W. Caldwell, N.J. 07006 (201) 235-6010	X	X			**451**
NLS	Non-Linear Systems Inc. Box N Del Mar, Calif. 92014 (714) 755-1134	X				**452**
N. Ross	Nelson-Ross Electronics, Inc. 5 Delaware Dr. Lake Success, N.Y. 11040 (516) 328-1100				X	**453**
Novatronics	Novatronics Inc. Spectran Div. Box 878 Pompano Beach, Fla. 33061 (305) 942-5200				X	**454**
Numeric	Numeric Laboratories 329 S. Greenwood Ave. Palatine, Ill. 60067 (321) 359-5985	X				**455**
Philips	Philips Electronic Instruments Div. of PEPI, Inc. 750 S. Fulton Ave. Mt. Vernon, N.Y. 10550 (914) 664-4500			X		**456**
Precision	Precision Standards Corp. 1701 Reynolds (Irvine Industrial Complex) Santa Ana, Calif. 92705 (714) 546-0431	X				**457**
Quan-Tech	Quan-Tech Laboratories 45 S. Jefferson Rd. Whippany, N.J. 07981 (201) 887-5508				X	**458**
R&S	Rohde & Schwarz 111 Lexington Ave. Passaic, N.J. 07055 (201) 773-8010		X		X	**459**
RCA	RCA Electronic Components & Devices Harrison, N.J. 07029 (201) 485-3900			X		**460**
Siemens	Siemens Corp. 186 Wood Ave. S. Iselin, N.J. 08830 (201) 494-1000				X	**461**
Simpson	Simpson Electric Co. 5220 W. Kinzie St. Chicago, Ill. 60644 (312) 379-1121	X	X			**462**
Singer	Singer Co. Ballantine Operation Box 97 Boonton, N.J. 07005 (201) 334-1432	X				**463**
Singer	Singer Co. Instrument Div. 915 Pembroke St. Bridgeport, Conn. 06608 (203) 366-3201				X	**464**
Spectral	Spectral Dynamics Corp. Box 671 San Diego, Calif. 92112 (714) 278-2501				X	**465**
Systron	Systron-Donner Corp. 888 Galindo St. Concord, Calif. 94520 (415) 682-6161	X	X		X	**466**
TSC	Time Systems Corp. 265 Whisman Rd. Mt. View, Calif. 94040 (415) 961-9321		X			**467**
Tektronix	Tektronix Inc. Box 500 Beaverton, Oregon 97005 (503) 644-0161	X	X	X	X	**468**
Telonic	Telonic Industries, Inc. Box 277 Laguna Beach, Calif. 92652 (714) 494-9401			X		**469**
Triplett	Triplett Electrical Instr. Co. 286 Harmon Rd. Bluffton, Ohio 45817 (419) 358-5015	X				**470**
United	United Systems Corp. 918 Woodley Rd. Dayton, Ohio 45903 (513) 254-6251	X				**471**
Vu-Data	Vu-Data Corp. 7595 Convoy Ct. San Diego, Calif. 92111 (714) 279-6572			X		**472**
Xetex	Xetex Marconi Instruments 111 Cedar Lane Englewood, N.J. 07631 (201) 567-0607			X		**473**

Select the right oscilloscope

There are probably more good oscilloscopes available on today's market than ever before. Picking the one that solves your measurement problem can be simplified if some in-depth thought is given to its use.

Is it to be used as a general-purpose lab scope on a production line or on a short-term project such as a proposal? Is it to be used in an air-conditioned environment, the Sahara desert, the South Pole, or maybe atop Pikes Peak? Will it continuously test microvolt circuits, or must it record only a one-time occurrence? Perhaps you need a scope with a bandwidth of several hundred megaHertz for designing state-of-the-art computers.

Will the new oscilloscope be used only five hours a day or twenty-four hours a day? Is it to be carried on-board a commercial jet or will it always sit comfortably on a bench or scope cart? Will you be looking at the scope from 10 feet away?

By mentally answering these questions, you will be much closer to obtaining a scope that will solve your problems, without emptying your company's pocketbook needlessly.

Lab scopes must do tomorrow's job today

General-purpose laboratory oscilloscopes are used in the fundamental design of almost every electronic product and circuit. Picking a lab scope to do only today's job is unwise since the engineer or technician who gets it tomorrow will probably be short-changed. For laboratory use, it is best to select a mainframe that will accept a variety of plug-in amplifiers for both the vertical and horizontal deflection axes.

There are several good reasons for this. First, the instrument's flexibility is vastly increased since the user can make special types of measurements without having to invest in a whole new oscilloscope. Secondly, manufacturers of plug-in scopes generally keep close pace with the designer's requirements, so that new plug-ins parallel state-of-the-art needs as they occur.

Today's lab scopes are not the big brutes of yesterday, which took up half the designer's bench. Power requirements for a good lab scope are now around 150 W and are achieved with solid-state devices, smaller power supplies, and convection cooling. This is probably not much of an issue in buying a single scope, but think of the wasted power—and money—used by 200 to 500-W scopes in big design labs.

A good mainframe should not limit the versatility of the available plug-ins. Even if you are doing millisecond work today, you will be dollars ahead tomorrow if you purchase a mainframe capable of at least 100-MHz performance in its vertical axis.

The heart of the entire oscilloscope is the display, since it is here that waveforms are evaluated. Be sure you can see what you are evaluating—today's lab scopes typically have 8 by 10-cm displays, and some are even larger.

If yours is a generally used lab scope, be sure the CRT has an internally scribed graticule where the phosphor and graticule are deposited in the same plane. This eliminates parallax errors and insures easier and more accurate interpretation of waveform characteristics.

Most lab-scope CRT graticules are divided into 10 divisions horizontally and eight divisions vertically. These are further subdivided into 0.2-division markings on the major axes.

If display size is important to you, remember that a division is not always equal to 1 cm; manufacturers have standardized somewhat on the number of divisions rather than the size. Divisions come in many sizes—some are 0.6 cm to the division while others are 0.8, 0.95, 1, 1.27 or 1.34.

A few manufacturers put horizontal rows of dots 10% below the top of the uppermost division and 10% above the bottommost division. These dots are spaced 0.2 divisions apart and offer another finely divided scale for waveform evaluation. More important, though, they allow accurate measurement of the 10% and 90% points

Robert Bell, Product Manager, Hewlett-Packard Co., 1900 Garden of The Gods Rd., Colorado Springs, Colo. 80907.

(rise time) on pulses, when the signal base is located along the bottom graticule line and the peak along the top graticule line.

Most scope manufacturers use the same P-31 phosphor since it is the brightest, most burn-resistant, and is pleasing to the eye. Its persistence is very short (approximately 40 μs) so no confusing traces caused by display afterglow are viewed. Other important characteristics of the display are brightness, spot size and fidelity. Generally these are not specified, but a side-by-side instrument comparison will quickly tell the whole story.

Before you reach that final decision, spend some time with the technicians who must calibrate and repair the oscilloscope, and see what they think. If they cannot keep your wonderful choice operating, then you are out of business.

One final word on lab scopes. If you are the small consumer—and most users are—ask about some of the extras you can buy for a minimal investment. Some of these are shown as operations on the data sheet, but not always. They include rear-panel outputs, higher sensitivities and outputs for cascading channels. Ignoring small trimmings may limit your most profitable tool—your design team.

Portable scopes must be rugged

With most test equipment going solid-state today, it is somewhat difficult to distinguish between the lab and the portable oscilloscope. For our purposes, a portable scope will be considered one used for a specific field service requirement, such as on-site computer servicing. Generally speaking, portable oscilloscopes should be capable of line, 28-V, 400-Hz and battery operation for true on-site operation.

A desirable feature of battery operation is self-contained rechargeable batteries. Self-contained, rather than strapped-on batteries, keep the scope portable and easy to handle. The batteries should be capable of several hundred recharges and at least several hours of continuous operation per charge. Battery-check indicators are very helpful.

Portable models put the true test to environmental specifications, since they are more likely to operate in extremes than laboratory instruments. An oscilloscope used under field conditions must be ruggedly constructed.

The frills and calibrated gadgets on lab scopes are seldom needed on a portable model, since the waveforms being examined are already known. The portable scope is usually used to observe the qualitative nature of a waveform rather than its quantitative characteristics. The CRT traces of the portable scope must be especially bright, since the ambient light level ranges from that of a computer room to bright sunlight.

Oscilloscope performance comes first

The adage, "It's performance that counts," is certainly true with respect to oscilloscopes. A scope that has all the frills and gadgets but cannot make the required measurement is a wasted investment.

Traditionally, oscilloscope performance is measured by frequency response or bandwidth. Most creditable scope manufacturers define bandwidth as the upper frequency limit at which the displayed signal amplitude drops 3 dB below the amplitude of a lower reference frequency (the display size is 71% of the reference).

The reference frequency should be at least 20 times less than the listed upper frequency limit. Also, the bandwidth should be measured when the scope is driven by a low-impedance source—nominally 25 to 50 ohms. If you have reason to question a manufacturer's bandwidth specifications, ask him what the measurement conditions are or insist on a demonstration.

You should also beware of oscilloscopes that have non-Gaussian-responding amplifiers. Gaussian amplifiers roll off at 6 dB/octave. Other types of amplifiers may have excessive peaking (to increase the upper frequency limit) and may severely alter the fidelity of the displayed signal.

The range of vertical deflection factors determines the maximum and minimum signal amplitudes you are able to view. Some vertical ampilfier designs obtain low deflection factors by merely reducing the specified bandwidth—a fact not always noted on the data sheet. Full-system bandwidth at low deflection factors is another figure of merit to consider, and may determine if a scope will fit your application.

In recent years, the trend in oscilloscope design has been toward smaller frames and larger displays. This has been achieved mainly by using solid-state devices and field-expanding cathode-ray tubes. Solid-state circuitry has in almost all

Special scopes have a niche, too

As the name implies, special oscilloscopes are usually employed for single-use applications. They may start from standard models but become highly directed toward a single application. They are more expensive than the standard unit, since the manufacturer must spend additional time on modifications. Special requirements can vary, from a different paint job all the way to new controls or a different mechanical chassis. Almost any requirement can be met if you are willing to pay for it.

Take a close look at oscilloscope data sheets.

Time Base Characteristics		Vertical Amplifier Characteristics	CRT Display Characteristics	General Features
Sweep speed	Calibrated delay	Bandwidth	Screen size	Weight (pounds)
Sweep time magnifier	External-trigger delayed sweep	Deflection factor	Accelerating potential	Weight with batteries
Mixed sweep mode	Variable trigger hold-off	Cascaded deflection factor	Graticule illumination	Operating time, with batteries
Main gate out	High-frequency trigger hold-off	Input impedance	Single-shot writing speed	Power (watts)
Delayed gate out	Single-sweep operation	Composite trigger (alternate)	Dc-coupled Z-axis input	Fan
Main sweep out	Automatic-sweep operation	Selectable triggering	Beam finder	X-Y operation
Delayed sweep out	Trigger coupling	Differential-channel operation	Internal graticule	Price Price with batteries
Delayed trigger out	Line synchronization			Type of probes included
				Plug-ins available
				Line filter
				Options available

respects replaced vacuum-tube designs and has proved to be more reliable, particularly under severe environmental conditions like humidity, temperature, and shock.

A vacuum-tube design is probably a poor investment today. Even though the purchase price may be less, the costs of maintenance and calibration are considerably greater than that of a solid-state design. Also, the drift, noise and frequency response obtainable are usually poorer. It might be worthwhile to consider that most technical trade schools have all but eliminated courses in vacuum-tube trouble shooting.

Another performance specification is a measure of the scope amplifier's ability to reject 60-Hz and other common-mode signals. This number, expressed in decibels or as a voltage ratio, is called the common-mode rejection ratio (CMRR). Most good oscilloscopes incorporate differential amplifiers to achieve a high CMRR. The common-mode signals developed across each side of a differential amplifier literally cancel each other.

An interesting characteristic of oscilloscopes is that poor circuit design always shows up in some way on the display. Few test instruments so dramatically show their problems in this way. The table is a listing of oscilloscope features to help you make a worthwhile comparison between competitive choices by looking at important specifications.

Should you buy, rent or lease that scope?

After you decide which oscilloscope you want, you must then consider whether to rent or to buy. If the anticipated use is for only a few months, your best bet is to rent the scope. There are many good rental companies that will have the scope you want on hand. Some will even go out and buy what you want if guaranteed only a few months' rental.

Most rental companies shy away from special oscilloscopes, simply because they try to turn over rentals as quickly as possible, and special units have little selling appeal. Rental companies typically recover the price of an oscilloscope within one year. Therefore, if you want to buy but cannot afford to now, you may want to lease.

Leasing generally costs a little more than renting, but offers the option of purchasing at a later date. If the purchase option is exercised, only a portion of the money paid for leasing applies to the purchase.

One last word of advice—always renew your evaluation at each new buying opportunity, because new product innovations may make last year's decisions obsolete. ■■

digital frequency sweep with synthesizer accuracy

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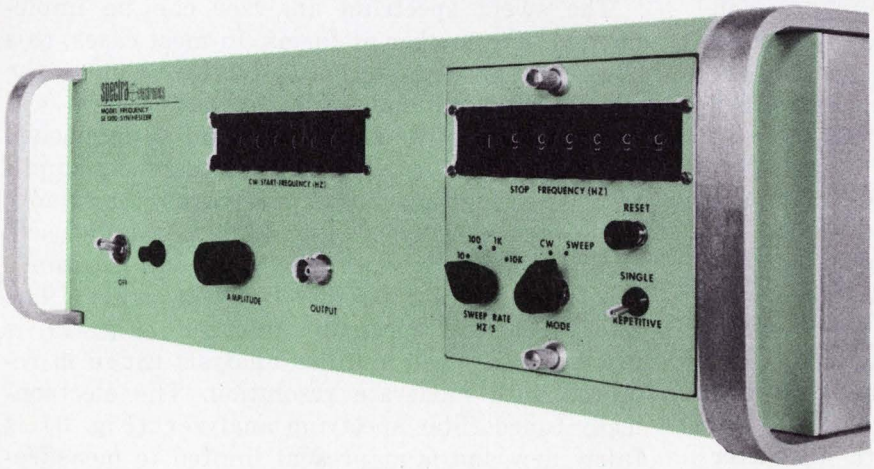
SPECIFICATIONS

Frequency Range	1 Hz–1.999999 MHz
Frequency Increments	1 Hz
Stability	1 pp 10^7/day
Selection	Digital
Switching Speed	400 μsec
Spurious Signals	−90 dB
Harmonic Signals	−35 dB
Output Level	1 to 2 Volts

Sweep increments are selectable from 1 Hz to full band; Sweep start-stop accuracy is basic synthesizer accuracy; Sweep characteristics are linear, frequency versus time; and selectable sweep rates are 10 Hz/sec, 100 Hz/sec, 1 KHz/sec, 10 KHz/sec.

Price: $3595.00



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INFORMATION RETRIEVAL NUMBER 41

Spectrum analyzers—let's look at the field

Today's spectrum analyzers make possible fast precise frequency-domain measurements because of improved instrument designs. Some of these new units now employ sophisticated digital sampling techniques or can directly compute Fourier transforms at very high speeds. There are several types of analyzers from which to choose, and the buyer can even elect to perform his measurements in real time.

Review practical spectrum analysis

The Fourier transform of a sine wave that lasts from minus infinity to plus infinity is a deltic function. Since no practical instrument is capable of observing an infinitely long function, it must measure a time-limited segment of the signal.

The Fourier transform of a truncated sine wave lasting for τ seconds is of the form $(\sin x)/x$ with an approximate 3-dB bandwidth of $1/\tau$ seconds. The signal to be measured may be time-limited by the observation time of the spectrum analyzer itself, or the signal may last for only a short duration as a pulsed sine wave.

Any spectrum analyzer that is capable of analyzing a signal within its frequency coverage in τ seconds with a resolution of $1/\tau$ is considered a real-time spectrum analyzer. An instrument like this is capable of displaying changes in either frequency or amplitude that occur within a period of τ seconds.

As an example, consider a spectrum analyzer that can perform over a band from 0 to 500 Hz with a resolution of 1 Hz. When supplied with a one-second sample of the signal, the instrument can display all the frequencies that exist within the analysis range with a resolution of 1 Hz. If the signal changes at a rate faster than one second, then the instrument must be capable of displaying a full analysis range with a shorter time interval. However, the resolution will not be as fine since it is the reciprocal of the shorter time interval.

Harold Klipper, Vice President, Federal Scientific Corp., 615 W. 131 St., New York, N. Y. 10027.

Swept analyzers are used most

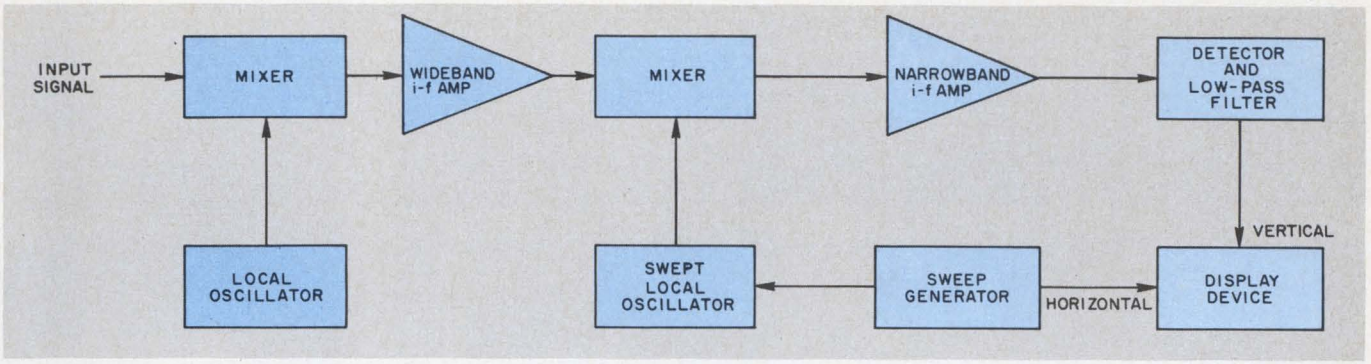
The most commonly used spectrum analyzer is the swept-frequency type. It employs a single narrowband filter whose center frequency is varied over the frequency-analysis range, while the filter bandwidth is held constant. As the filter is swept across the analysis range, its output is the magnitude of each frequency component of the input signal.

If we consider the example just given, the swept analyzer would move a 1-Hz filter from 0 to 500 Hz in order to perform the spectrum analysis. Since the effective time constant of a 1-Hz-wide filter is one second, the filter must remain at each frequency location for one second.

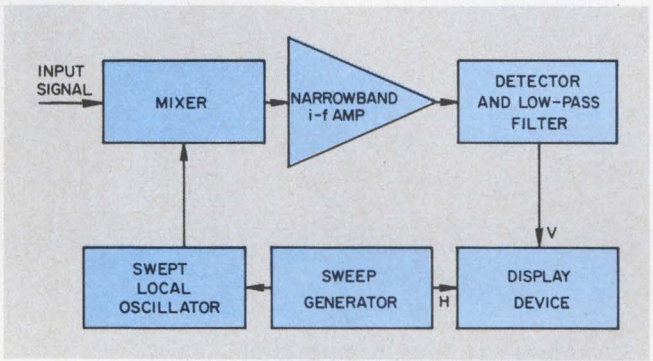
Thus, to perform an analysis from 0 to 500 Hz, approximately 500 seconds would be required. This may be entirely satisfactory if the signal lasts for 500 seconds and does not change during this time interval. However, if the signal is changing at a rate of one second, then real-time analysis is required.

The swept spectrum analyzer can be implemented in a number of forms. In most cases, this type of analyzer uses heterodyning to move the signal past a stationary filter by sweeping a local oscillator. Usually, the narrowband filter needed is implemented by using a narrowband i-f amplifier. When high resolution is required, the swept/i-f spectrum analyzer (Fig. 1) is normally used. In this system, however, the wideband i-f amplifier normally limits the analysis range. The swept-front-end spectrum analyzer (Fig. 2) is usually used when a wider analysis range is required with moderate resolution. The electronically tuned filter spectrum analyzer (Fig. 3) is fairly new and is at present limited to measurements not requiring fine resolution.

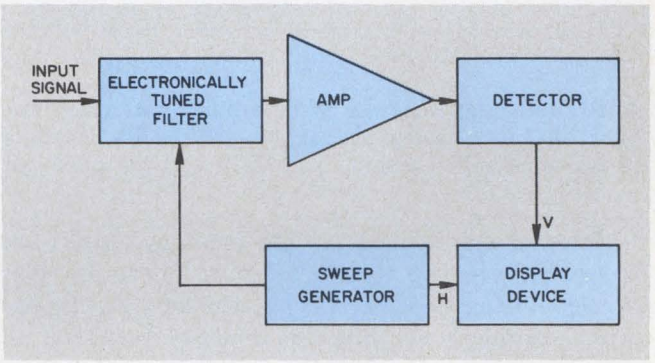
As mentioned previously, the rate at which the filter may be moved across the band is limited by the time constant of the filter. Because of the long processing time required by the swept spec-



1. **The swept/i-f spectrum analyzer is the most useful** swept-type analyzer for making high-resolution measurements. Like other swept analyzers, it moves the input signal past a stationary narrowband filter by sweeping a local oscillator. Its wideband i-f amplifier, however, normally limits the analysis range.



2. **The swept-front-end spectrum analyzer** provides a reasonably wide frequency analysis range while giving moderate-resolution performance.



3. **Electronically tuned filter spectrum analyzers** are swept-type instruments, but are fairly new and limited to measurements not requiring fine resolution.

trum analyzer, it is not suitable to analyze spectra for short-duration signals.

Real-time instruments speed analysis

One of the first and simplest real-time spectrum analyzers uses multiple filters (Fig. 4) arranged so that the bandpass of each filter overlaps the adjacent filter, providing complete coverage of the analysis range. The output of each filter channel is proportional to the amplitude of the frequency component within the bandpass of the filter that is present at the input signal. The time constant of each filter is the reciprocal of its bandwidth.

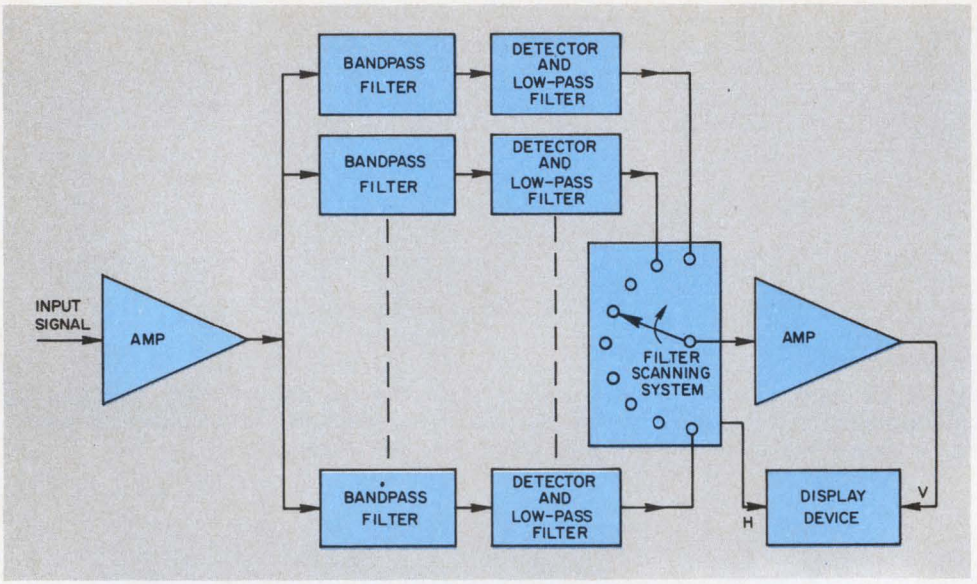
Since each filter channel contains its own detector and low-pass filter, the output of the entire filter bank may be scanned as fast as necessary. It is possible, therefore, to scan the entire filter bank in the time constant of one filter, thus operating in real time.

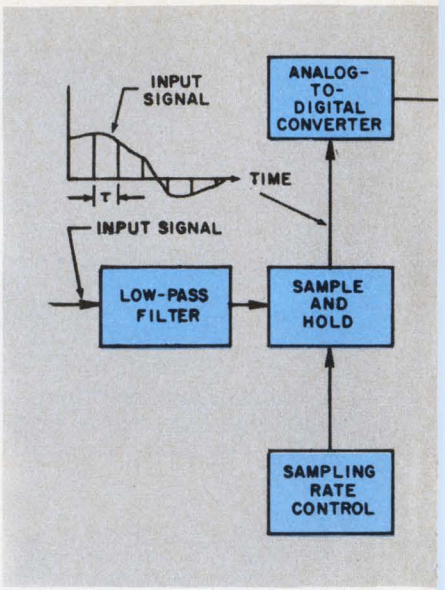
There are two basic types of filter banks: one with constant bandwidth, and other with constant Q or constant percentage-bandwidth (one-third or one-octave bandwidth, etc.). In the constant-bandwidth filter bank, the bandwidth of each filter is the same, but the center frequency of each filter is separated by approximately one bandwidth from the previous filter. In the constant Q filter bank, filter bandwidth and spacing increase with center frequency, thus requiring fewer filters for coverage of a given analysis range.

Multiple-filter spectrum analyzers employing constant-bandwidth filter banks normally contain a few hundred individual filter channels. In order to obtain narrow bandwidth, these filters are generally centered at some frequency higher than that of the input signal. In order for the electronically switched filter scanning systems to operate properly, all filter channels must have the same amplitude response and a constant center frequency. The constant-Q filter banks generally operate at lower frequencies than the constant-bandwidth filters and consist of less than 100 channels.

Signal's time base can be compressed

The time-compression real-time spectrum analyzer (Fig. 5) compresses the time base of the input signal, thus expanding its spectrum and permitting it to be analyzed at very fast rates. The input signal is sampled with an analog-to-digital converter, and the digitized samples are passed, in parallel binary form, into a recirculating digital memory.





4. **Multiple-filter real-time spectrum analyzers cover the analysis range** with adjacent filter channels having overlapping passbands. There are two basic types of filter banks—one with constant bandwidth and the other with constant Q.

Samples emerging from the memory output are fed back into the memory input. These samples are sequenced (with respect to the newly obtained input samples) so that the memory contains all samples in their order of arrival.

Thus, the time interval between successive digitized samples that emerge from the memory is extremely short compared to the interval between samples of the analog input signal. This speedup contracts the signal's time base.

The digital memory output is fed to a digital-to-analog converter. The output of this converter is an accelerated version of the original input signal. This waveform, after being passed through a low-pass filter to eliminate the sampling frequency, is applied to the equivalent of a swept spectrum analyzer.

For this application, the swept spectrum analyzer must cover a band that is S (the speedup factor) times the analysis range desired and has a filter bandwidth S times greater than the resolution required. The speedup factor is equal to the ratio of the length of the input sample to the length of the time-compressed sample (or the time between input samples to the time between samples after compression).

Consider the previous example of analyzing a band from 0 to 500 Hz with a 1-Hz resolution. Using swept techniques, the duration of the input signal should be one second. If this signal is compressed to 2 ms, the speedup factor is 500.

The input analysis range, which went from 0 to 500 Hz, would go from 0 to 250 kHz at the output, and the analysis filter required would go from 1 to 500 Hz. Since a filter with a bandwidth of 500 Hz has a time constant of 2 ms, it can be made to scan the range from 0 to 250 kHz in exactly one second, thus completing the analysis of the input signal.

Advantages of time compression

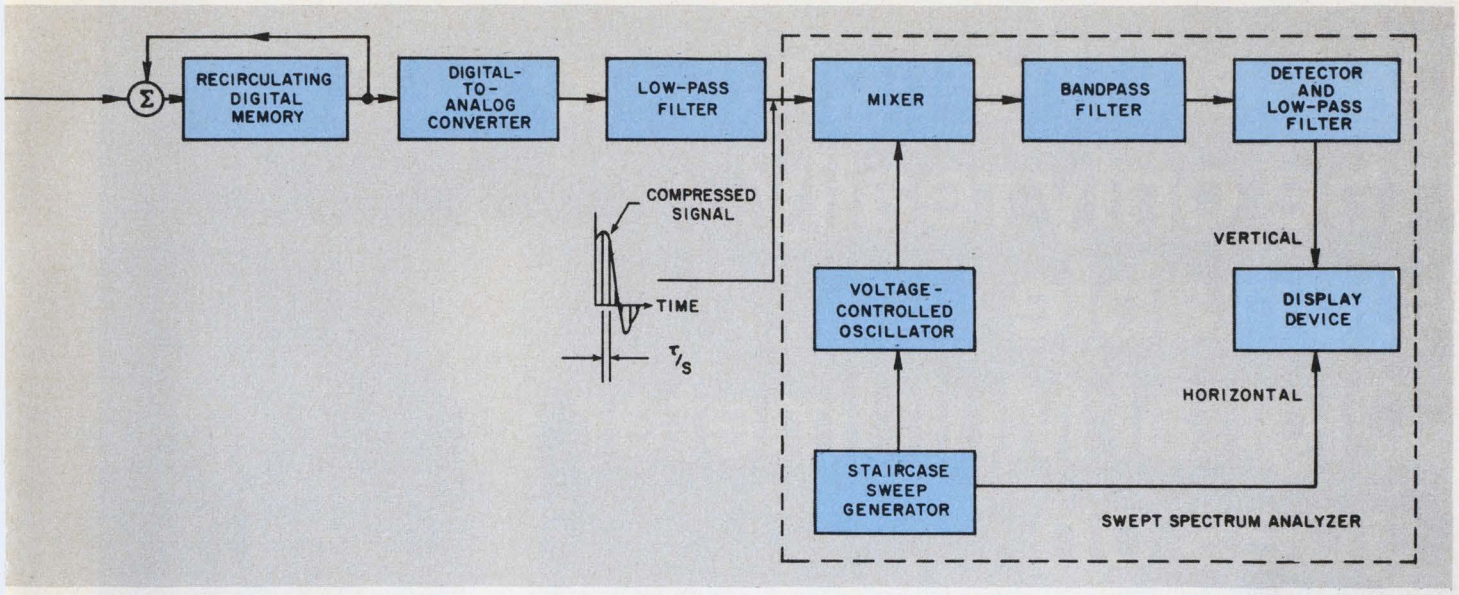
The time-compression spectrum analyzer allows the effective analysis range and bandwidth to be changed by simply varying the input sampling rate. In our example, if the input sampling rate is decreased by a factor of 10, then it will take 10 seconds to accumulate the same number of samples previously accumulated in one second. Since the output is still compressed to 2 ms, the speedup factor will be 5000 instead of the previous 500. The band of 0 to 250 kHz would then be equivalent to 0 to 50 Hz, and the 500-Hz filter bandwidth would yield a 0.1-Hz resoltuion.

The time-compression spectrum analyzer with its digital memory offers a major advantage. If at any time new data is prevented from entering the memory, the compressed input signal will continue to circulate in the digital memory. Thus, a transient or a short duration of the input signal is captured and may be continuously displayed and analyzed. In this respect, the time-compression analyzer with a digital memory behaves very much like a tape loop.

Besides the digital time-compression technique, there are a number of analog implementations for real-time analyzers, including the use of tape loops and magnetic drums. These, in general, are not widely and commercially available.

Other types of analyzers available

Another kind of spectrum analyzer is called the Coherent Memory Filter. It is a coherent



5. **Time-compression real-time spectrum analyzers squeeze a signal's time base,** thereby expanding its spectrum and permitting very fast analysis rates. The instrument shown above uses digital sampling and a recirculating digital memory to capture even signal transients for continuous display and analysis.

delay-line integrator that performs spectrum analysis by means of an ultrasonic delay line and a heterodyning circuit in a closely regulated unity-gain feedback loop. The physical phenomenon by which the spectrum analysis is performed can best be described as wave interference. This technique has not been applied to general laboratory spectrum analyzers but to system applications.

More recently, a number of signal-processing instruments are based on FFT (Fast Fourier Transform) techniques. These analyzers generally use a digital computer to obtain the Fourier transform of an input signal in real time up to a limited frequency, depending on their speed.

FFT spectrum analyzers can also find other characteristics of the input signal like the power spectral density, cross spectrum, cross power spectrum, transfer function, autocorrelation function, and the crosscorrelation function. As a rule, they are not used as general-purpose laboratory instruments, but rather as signal-processing equipment where more than the Fourier transform is required.

A glossary of terms

Analysis range, dispersion, or frequency coverage generally describe the frequency band over which spectrum analysis may be performed in a specified time period or in one scan or sweep. The resolution or selectivity of a spectrum analyzer is its ability to display two equal-amplitude signals separated by one resolution element. It should be noted that the complete filter shape of the analyzer is important because it influences noise bandwidth.

Sweep rate, sometimes called scan time or display period, is the time required to perform a spectrum analysis. All sweep rates available on a given instrument may not be usable for all analysis ranges and resolutions. For example, the selected resolution will determine the maximum rate for swept-type analyzers. For multiple-filter analyzers or time-compression analyzers, all display rates are usable with all analysis ranges. However, for real time operation, a sweep rate that is equal to the reciprocal of the selected resolution is required.

Sensitivity has been defined for a number of different measurements, including the minimum discernible signal, the minimum rms signal for full-scale deflection, or the condition that occurs when the signal plus noise is equal to twice the noise. The dynamic range is normally defined as the ratio of the signal for full-scale readout to the signal for minimum discernible readout.

Frequency linearity or frequency accuracy is a measure of the reliability of the display device (either supplied with the instrument or generated by the instrument's sweep output) to determine the frequency of a given response to a certain accuracy. Amplitude linearity (amplitude accuracy) is the error of the relative response of two output amplitudes with respect to the input amplitudes. ■■

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Bickel, Henry J., "Spectrum Analysis with Delay-Line Filters," Federal Scientific Corp., IRE WESCON Convention Record (Part 8), 1959.

Crooks, R. Kent and Falkenbach, George J., "Summary Report on a Survey of Low-Frequency Real-Time Spectrum Analyzers and Techniques," Battelle Memorial Insitute, Columbus, Ohio, Report No. BAT-197-30-2, April 30, 1966.

"Instructional Manual for Ubiquitous Spectrum Analyzer Model UA-6A," Federal Scientific Corp., 1969.

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FLUKE®

INFORMATION RETRIEVAL NUMBER 42

Digital Voltmeters, dc

146

Manufacturer	Model	Voltage Ranges			Number of Digits	Average (%)	Speed (readings per sec)	Basic Price ($)	Notes
		No.	Min (mV)	Max (V)					
Keithley	615	4	100	100	3-½	0.2	24	1195	s
Calico	8420	4	1000	1000	4-½	0.01	3	695	b,y
Dana	5330/600, 5370/600	5	0.001	1000	5	0.005	2	1275	b,j
Dana	5330/700, 5370/700	5	0.001	1000	5	0.005	2	1375	b,j
Dana	5333/600	5	0.001	1000	5	0.005	2	1425	b,i
Dana	5333/603	5	0.001	1000	5	0.005	2	1625	b,f
Dana	5333/700	5	0.001	1000	5	0.005	2	1525	b,i
Dana	5333/703	5	0.001	1000	5	0.005	2	1725	b,f
Dana	5400	5	100	1000	4	0.01	500	1495	b,h,i
Dana	5403	5	100	1000	4	0.01	500	1695	b,h,i
Dana	5800	6	10	1000	5	0.003	10	3150	b,i
Dynascience	414	6	10	1000	4	0.01	10	795	b
H-P	3480A/B	5	100	1000	4-½	0.01-0.02	1000	900	i,q
Keithley	160	7	0.001	1000	3-½	0.1	2	545	b
Keithley	163	7	0.001	1000	3-½	0.1	2	495	
Millivac	MV-754A	7	0.1	1000	3-½	0.1	5	1100	b
Monsanto	200A	4	1000	1000	4-½	0.01	4	795	e,f,p,v
NLS	LX-2	4	0.1	1000	4	0.008	2	795	b,e
NLS	LX-3	4	0.1	1000	3	0.05	2	495	b,e
NLS	MX-2	5	0.01	1000	4	0.008	10	1645	b
NLS	MX-3	6	0.01	1000	3	0.05	1	595	b
Numeric	350	4	2000	1000	3	1	60	179	b
Numeric	351	4	2000	1000	3	1	60	195	b
Singer	3600	4	1000	1000	4-½	0.01	5	645	
Systron	7005	5	1	1000	5-½	0.003	5	1295	
Tektronix	7D14	4	2000	1000	3-½	0.1	5	495	b,w
United	266	4	1000.0	1000.0	4-½	0.02	2	500	p,v
United	268	5	100.00	1000.0	4-½	0.02	2	600	p,v
Cimron	6453A	5	100	1199.9	4	0.01	4	995	d,e,f,g
E-N	1000A	6	20.00	1200	3-½	0.1	20	295	n,p
E-N	1400	5	199.99	1200.0	4-½	0.01	20	495	b,p
Fluke	8110A	4	0.1	1200	4-½	0.01	4	850	b
Precision	DM42	5	100	1200	4-½	0.02	5	690	b
Triplett	8000	5	100	1200	3-½	0.1	6	575	b
Triplett	8000A	5	100	1200	3-½	0.1	6	630	b,x
Dana	3800	5	200	2000	3	0.1	4	350	b
Dana	3860	5	200	2000	3	0.1	4	425	b
J-Omega	415A-16	6	320	16,000	4	0.1	1	860	

Digital Voltmeters, ac

147

Manufacturer	Model	Frequency		Voltage Ranges				Number of Digits	Speed (readings per sec)	Basic Price ($)	Notes
		Min (Hz)	Max (kHz)	No.	Min (mV)	Max (V)	Acc. (%)				
NLS	LX-2	50	10	4	0.1	1000	0.04	4	2	795	b,e
NLS	LX-3	50	10	4	0.1	1000	0.05	3	2	495	b,e
NLS	MX-2	50	10	4	0.1	1000	0.05	4	2	1645	b
Numeric	351	50	10	4	2000	1000	1.5	3	60	195	b
Eldorado	1800	40	20	5	1	1000	0.1	3-½	5	275	n
Eldorado	1820A	40	20	4	1	1000	0.01	4-½	10	695	
NLS	MX-3	50	20	3	10	300	2	3	1	595	b
Precision	DM42	20	20	4	1000	1200	0.2	4-½	1	690	b
Simpson	2700-02	40	20	4	999.9	1000	0.1	4	5	730	b
Triplett	8000	40	20	5	100	1200	0.2	3-½	6	575	b
Triplett	8000A	40	20	5	100	1200	0.2	3-½	6	630	b,x
Keithley	160	45	45	7	100	250	1	3-½	2	595	c
Keithley	163	45	45	7	100	250	1	3-½	2	550	c
Calico	8420	50	100	4	1000	1000	0.1	4-½	3	695	b,y
Cimron	6453A	50	100	4	1	1199.9	0.1	4	4	1370	c,d,e,f,g
Dana	5330/600, 5370/600	50	100	4	1000	1000	0.1	5	2	1695	b,j
Dana	5333/603	50	100	4	1000	1000	0.1	5	2	2050	b,f
Dana	series 5400	50	100	4	1000	1000	0.04	4	500	2290	b,h,i,z
E-N	1200	40	100	4	1200.0	12,000	0.25	4-½	20	595	b,n,p
Dana	5330/700, 5370/700	30	250	4	1000	1000	0.1	5	2	1900	b,j
Dana	5333/600	30	250	4	1000	1000	0.1	5	2	1425	b,i
Dana	5333/700	30	250	11	1000	1000	0.1	5	2	1525	b,i
Dana	5333/703	30	250	4	1000	1000	0.1	5	2	2250	b,f
Dana	5800	10	300	4	0.01	1000	0.05	5	10	3950	b,k
Micro	5206	dc	500	5	10	100	1	4	10	1950	t
H-P	3480A/B	1	10,000	5	100	1000	0.1-2	4-½	1	1700	a,q,r
Singer	3573	10	11,000	6	10	1000	0.2	4-½	5	1995	a
Micro	5204A	dc	20,000	4	1000	1000	1	4	10	1550	u
Boonton	92AD	10,000	1.2 GHz	8	1	3	2	3-½	4	1200	f
Millivac	MV-722A	10,000	1.2 GHz	8	1	10	3-10	3	5	1150	m

a. True-rms-responding unit
b. Digital multimeter
c. Ac/dc voltmeter
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e. Features autoranging
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g. Includes printer output
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k. Dc or ac-coupled rms conversion
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n. Battery operation standard
p. BCD output
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u. Includes built-in printer
v. Features solid-state readout
w. Plug-in for all series 7000 oscilloscopes
x. Features memory storage capability
y. Includes 10-MHz frequency counter
z. Includes Computing RMS™ converter plug-in

Frequency Counters

Manufacturer	Model	Frequency Min (Hz)	Frequency Max (MHz)	Stability (ppm)	Number of Digits	Input Sensitivity (mV, Min-Max)	Gate Time (s, Min-Max)	Display Time (s, Min-Max)	Basic Price ($)	Notes
TSC	270	1	1	10	5	100 typ	0.1-1	0.1 typ	750	u
R&S	FEG 2	dc	2	1	4-6	100 typ	5 ms-6 s	5 ms-6 s	1295	
TSC	400-1	dc	2	2	6	100 typ	10 μs-10 s	0.1 typ	850	b,e
Atec	1151A	10	3	d	5	20 typ	0.1-10	0.9 fixed	375	
Systron	6654	dc	10	2	6	100 typ	1 μs-10 s	0.2 typ	1175	b,s
Anadex	CF-602	3	15	1	4-6	10 mV-300 V	0.1 ms-100 s	0.1-8	1245	b,c
Anadex	DC-600	3	15	ina	4-7	10 mV-300 V	ina	a	375	
Eldorado	1635	dc	15	1	5	100 mV-100 V	1 ms-1 s	1 ms-1 s	650	
Monsanto	103B	5	20	0.1% typ	4-6	50 typ	0.1 or 1	0.1-5	420	r
Monsanto	107A	0.1	20	0.02	5	100 typ	p	0.2-2	1250	m
Atec	2200A	2	32	1	5-6	15-32 MHz	0.01-10	0.2-5	495	b,e
Eldorado	325B	dc	32	1	5	100 mV-100 V	0.1-10	0.1-10	475	b,j
Simpson	2726	5	32	10	6	100 mV-200 V	10 ms-10 s	5 typ	575	b,e
Monsanto	100B	5	40	2	5	50 typ	1 μs-10 s	0.1-5	575	
GR	1192-B	dc	50	2	5-7	10 mV-400 V	10 ms-10 s	1-10	625	b
H-P	5326A	dc	50	0.3	7-8	100 mV-250 V	0.1 μs-10 s	100 μs typ	1195	b,f
H-P	5326B	dc	50	0.3	7-8	100 mV-250 V	0.1 μs-10 s	100 μs typ	1550	b,f,k
H-P	5326C	dc	50	0.3	7-8	100 mV-250 V	0.1 μs-10 s	100 μs typ	950	b
Monsanto	101B	5	50	2	5-7	50 typ	1 μs-10 s	0.1-5	695	j
Beckman	1248	dc	136	0.003	8	100 mV-500 V	1 μs-10 s	0.1-10	2500	b,f,h
Beckman	6401A	dc	136	0.003	8	100 mV-500 V	1 μs-10 s	0.1-10	1875	b,f
Dana	8010	dc	150	0.005	8-9	50-100	1 μs-100 s	1 μs-100 s	1495	i
Dana	8015	dc	150	0.005	8-9	50-100	1 μs-100 s	1 μs-100 s	1995	i
Monsanto	110B	dc	150	0.07	8	10 typ	1 μs-100 s	2-5	1285	q
Monsanto	114A	5	150	0.02	9 max	100 typ	10 μs-1 s	0.2-5	995	
Monsanto	1500B	dc	150	0.001	8	100 typ	1 ms-10 s	0.2-5	2400	
CMC	904	dc	200	0.0007	8	10 ms-100 s	1 μs-100 s	100 ms-10 s	1975	
Atec	4058	10	500	0.4	7	100 mV-5 V	0.08-10	0.2-5	1475	b
Dana	8020	dc	500	0.005	8-9	1-100	1 μs-100 s	1 μs-100 s	2195	i
Dana	8030	dc	500	0.005	8-9	1-100	1 μs-100 s	1 μs-100 s	2495	i
Dana	8035	dc	500	0.005	8-9	1-100	1 μs-100 s	1 μs-100 s	2995	i
Tektronix	7D14	dc	500	0.5	8	100 mV-10 V	1 ms-10 s	0.1-5	1400	b,t
Monsanto	120A	dc	512	0.07	9 max	10 typ	1 μs-100 s	3 ms-5 s	1775	m,n
Beckman	6421	10	525	0.003	8	50 mV-10 V	1 μs-10 s	0.1-10	1575	g
Dana	8060	dc	3000	0.005	8-9	−10 dBm typ	1 μs-100 s	1 μs-100 s	2795	i
Dana	8075	dc	3000	0.005	8-9	−10 dBm typ	1 μs-100 s	1 μs-100 s	3595	i
Systron	6053	dc	3000	0.003	9	10 typ	1 ms-10 s	0.2 typ	2295	b,h

Frequency-Counter Extenders

Manufacturer	Model	Counter Used With (Model)	Frequency Min (MHz)	Frequency Max (MHz)	Input Sensitivity (mV)	Basic Price ($)	Notes
CMC	933	901, 904	0.5 Hz	250	v	325	
R&S	BN47376	FET 2	10	800	10	1250	
CMC	935	901, 904	150	3000	50	1085	

a. Display time is customer selected (optional)
b. Display can be held
c. Offers multi-channel inputs
d. Uses line time base for 0.1% accuracy
e. Universal counter
f. Full counter-timer
g. Offers battery-operation option
h. Programmable
i. Offers systems interface
j. BCD output
k. Includes digital voltmeter
m. Features solid-state readout
n. Offers autoranging
p. Gate time selected automatically
q. Display is continuously adjustable
r. Crystal clock is optional
s. Features variable preset time base
t. Plug-in for all series 7000 oscilloscopes
u. Computing counter
v. Increases counter sensitivity by a factor of 30

Word Generator Addendum

Manufacturer	Model	Clock Rate Min Hz	Clock Rate Max MHz	Word Length (Bits)	Number of Channels	Bit Width (ns)	Bit Rise & Fall Time (ns)	Output Voltage (V)	Output Impedance (Ω)	Notes	Price ($)
Tau-Tron	DFE-4	1	35	16	48	15 ns-10 ms	5	10	50		req
Tau-Tron	DG-7	1	35	16	1	15 ns-10 ms	5	10	50	(a)	990
Tau-Tron	DFE-8	1	75	16	16	8 ns-10 ms	1.8	5	50	(b)	req
Tau-Tron	DG-700A	1	75	16	1	8 ns-10 ms	1 8	5	50	(a)	2395
Tau-Tron	DG-1200A	1	120	16	1	4 ns-10 ms	1.5	2.5	50	(a)	3385
Tau-Tron	WG-111	1	125	8	8	4 ns-10 ms	1	1	50		req
Tau-Tron	DG-525	1	330	8	1	3	0.9	1	50		req
Tau-Tron	System 1000/1100	250 MHz	330	32,767	1	3	0.9	1	50	(c)	req

(a) Dual-function instrument designed to be used as word generator and/or pulse generator.
(b) Can be used as pseudo-random signal generator for word lengths up to 1,000,000 bits.
(c) Pseudo-random signal generator only. Includes built-in error detection and automatic synchronization.

More information on the word generators in the above table can be obtained from Tau-Tron Inc., 685 Lawrence St., Lowell, Mass. 01852, phone: (617) 458-6871; or by circling **474** on the Information Retrieval card.

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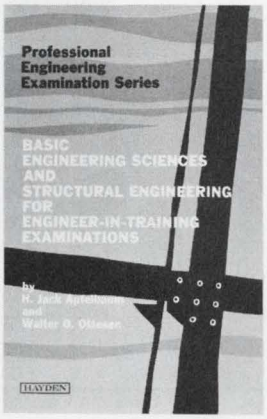
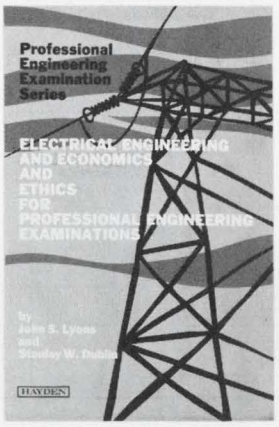


H. JACK APFELBAUM, P.E., Department of Mechanical Engineering, Lowell Technological Institute; and WALTER O. OTTESEN, P.E., Patent Counsel

Comprehensive and well balanced in its coverage of the concepts and techniques fundamental to all areas of engineering practice, this volume presents nearly two-hundred problems carefully chosen from recent examinations given by the individual states. Typical of the material the reader is likely to encounter in Engineer-in-Training Examinations, these are conveniently arranged by subject, and cover three broad areas: background material in mathematics, physics, and chemistry; the basic engineering sciences: statics, dynamics, fluid mechanics, thermodynamics, electricity, and engineering economy; and seven chapters detailing topics in structural engineering. Introductory sections precede each subject area and its fully worked-out problems, providing background in the specific concepts, principles, and terminology. More than three-hundred detailed illustrations insure a complete grasp of problem-solving techniques. *#5712, 408 pages, illustrated, $13.95*

ELECTRICAL ENGINEERING AND ECONOMICS AND ETHICS FOR PROFESSIONAL ENGINEERING EXAMINATIONS



JOHN S. LYONS, P.E.; and STANLEY W. DUBLIN, Institute of Environmental Medicine, New York University Medical Center

Presenting a wide range of problems in electrical engineering, this book concentrates on the subjects and topics that form the basis for an ever-changing technology. The portion of the book devoted to economics and legal and ethical considerations is equally complete, providing in-depth understanding that will prove valuable in future engineering assignments.

Almost one-hundred problems in electrical engineering range from basic circuitry to the uncategorizable "bonus" problems frequently encountered in examinations. More than one-hundred-seventy illustrations illustrate the text. The section on economics features an unusual approach to such topics as interest, costs, valuation, and the like — the summarized use of formulas in solving nearly fifty typical problems. *#5715, 320 pages, illustrated, $12.95.*

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Oscilloscopes, general purpose 150

Manufacturer	Model	Frequency		Sensitivity		Sweep Speed		Basic Price ($)	Notes
		Min (Hz)	Max (MHz)	Max (mV/cm)	Min (V/cm)	Max (μs/cm)	Min (s/cm)		
Kikusui	5121	dc	0.01	>5	20	h	h	580	e
Kikusui	5122	dc	0.01	>5	20	h	h	798	a,e
Telonic	101	dc	0.04	50	10	ina	ina	395	e
Telonic	121	dc	0.04	0.5	10	ina	ina	425	e
Kikusui	573	dc	0.2	>1	20	i	i	410	e
Kikusui	572	dc	0.6	>20	20	100 kHz	1 Hz	589	e
Tektronix	5031	dc	1	0.01	10	1	5	2500	d,k,m
Kikusui	536A	dc	1.5	>20	20	100 Hz	10 Hz	167	
Kikusui	556A	dc	1.5	>20	20	100 Hz	10 Hz	239	
Iwatsu	SS-5020	dc	2	20	50	0.2	1.25	250	
Iwatsu	SS-5050	dc	5	10	25	0.1	1.25	550	a
Kikusui	557	dc	5	>20	20	100 kHz	10 Hz	249	
RCA	WO-505A	dc	5	15 mV/in.	ina	1 MHz	10 Hz	299	(5)
H-P	1215A/B	dc	7	5	20	1	5	950	d
H-P	1217A/B	dc	7	5	20	1	5	1175	d,f
Leader	LBO-301	dc	7	10	5	1 μs/div	50 ms/div	335	j
BAC	555	dc	10	20	10	1000	1	346	
Calico	7000	dc	10	100 mV/in.	10 V/in.	100 kHz	10 Hz	2995	(6) (7)
Calico	7005	dc	10	100 mV/in.	10 V/in.	100 kHz	10 Hz	4495	(6) (8)
Kikusui	553	dc	10	10	20	1	1	538	a
Kikusui	555G	dc	10	20	10	1	1	349	
Leader	LBO-501	dc	10	20	10	1	0.2	340	j
Vu-Data	MS200A	10	10	70 mV/div	7 V/div	0.1 μs/div	0.01 s/div	2995	n,p
Vu-Data	MS300A	10	10	70 mV/div	7 V/div	0.1 μs/div	0.01 s/div	10,304	q
Heath	EU-70A	dc	15	50	20	0.04	0.1	565	a,e
Iwatsu	SS-4200M	dc	15	5 mV/div	25 V/div	10 ns/div	1.25 s/div	1360	a,g
Xetex	OS1000	dc	15	5	50	0.04	5	635	a
B&F	SM111	dc	18	2	50	0.2	2.5	995	g
Dumont	1051	dc	50	10	20	0.1	1	1995	a,b,c,d
Dumont	1052	dc	50	10	20	0.1	1	2045	a,b,c,d
Dumont	1053	dc	50	10	20	0.1	1	1845	a,b,c,d
Iwatsu	SS-4500	dc	50	5	10	10 ns/div	0.5 s/div	1875	a,g
Iwatsu	SS-200	dc	200	5	12.5	1 ns/div	1.25 s/div	3590	a

Oscilloscopes, sampling 151

Manufacturer	Model	Frequency (dc to GHz)	Sensitivity		Sweep Speed		Rise Time (ps)	Basic Price ($)	Notes
			Max (mV/cm)	Min (mV/cm)	Max (ns/cm)	Min (μs/cm)			
AMC	1100	1	2 mV/div	100 mV/div	2 ps/div	100 μs/div	350	5895	r
Philips	PM 3400	2	1	200	1	20	200	2890	s

Oscilloscopes, main frame 152

Manufacturer	Model	Frequency		Sensitivity		Sweep Speed		Basic Price ($)	Notes
		Min (Hz)	Max (MHz)	Max (mV/cm)	Min (V/cm)	Max (ns/cm)	Min (s/cm)		
Telonic	201	dc	0.02	0.05	100	10^6	1	2700	v
Telonic	202	dc	0.02	0.05	10	10^6	1	2450	
Tektronix	7503	dc	90	t	t	t	t	1775	m
Tektronix	7514	dc	90	t	t	t	t	3200	k,m
H-P	182A	dc	100	t	t	t	t	1100	
H-P	183C/D	dc	>600	t	t	t	t	2500-2600	d,u

Oscilloscope Plug-Ins, vertical amplifier 153

Manufacturer	Model	Number of Traces	Frequency		Sensitivity		Main Frames for Plug-In	Basic Price ($)	Notes
			Min (Hz)	Max (MHz)	Max (mV/cm)	Min (V/cm)			
H-P	1806A	2	dc	0.5	0.1	20	180A/AR, 181A/AR, 182A, 183A/B	675	x
Tektronix	3A10	1	dc	1	0.01	10	series 560	750	(1)
H-P	1801A option 001	1 or 2	dc	50	0.5	20	180A/AR, 181A/AR, 182A, 183A/B, 183C/D	845	y
Tektronix	7A15	1	dc	75	5	5	all series 7000	250	
H-P	1831B	1	<20 k	>500	ina	5.75	183A/B, 183C/D	425	w
H-P	1831A	1	<20 k	>600	ina	5.75	183A/B, 183C/D	375	
Tektronix	3S7	1	n/a	n/a	5	0.5	series 561 and 564	425	(2)

Oscilloscope Plug-Ins, horizontal amplifier 154

Manufacturer	Model	Type	Delay Time Min (μs)	Delay Time Max (s)	Delay Time Acc. (%)	Sweep Speed Max (μs/cm)	Sweep Speed Min (s/cm)	Sweep Speed Acc. (%)	Main Frames for Plug-In	Basic Price ($)	Notes
H-P	1841A	time base or delay	0.05	1	1	0.01	0.1	3	183A/B, 183C/D	1150	z
Tektronix	7B52	time base	0.05	50	2	0.05	5	2	all series 7000	900	(4)
Tektronix	3T7	(3)	n/a	n/a	n/a	100 ps	1 μs	3	series 561 and 564	575	

a. Dual-trace scope
b. Dual modulated triggering system
c. Low-level constant-amplitude triggering at full bandwidth
d. Rack-mounted model available
e. X-Y capability
f. Dual-channel scope
g. Portable scope
h. Alignment oscillator
i. No sweep
j. Triggered and automatic sweep
k. Offers split-screen storage
m. Features automatic scale-factor readout
n. Seven discrete displays for multi-point system monitoring
p. Slave-display and biomedical monitors available
q. Sixteen-channel military scope
r. Four-channel four-trace capability
s. Variable sampling rate
t. See plug-in tables for specifications
u. High-writing-speed scope
v. Tri-color display
w. Includes built-in delay line
x. Dual differential inputs
y. Times-five multiplier provides dual-trace operation
z. Sweep speeds of 1 ns available

(1) Uses differential/transducer amplifier
(2) TDR sampler for use with 3T7 TDR sweep gives 140-ps TDR system
(3) TDR sweep for use with 3S7 TDR sampler gives 140-ps TDR system
(4) Dual unit with delayed and mixed sweeps
(5) Non-triggered scope with preset sweep positions for TV frequencies
(6) Features seven dual channels
(7) Includes times-ten sweep magnifier
(8) Features automatic sweep from 10 Hz to 10 kHz

Spectrum Analyzers, plug-in 155

Manufacturer	Model	Frequency Min (Hz)	Frequency Max (MHz)	Frequency Acc. (%)	Sensitivity Max (mV/cm)	Sensitivity Min (V/cm)	Sweep Width Min-Max (kHz)	Sweep Rate Min-Max (Hz)	Basic Price ($)	Notes
N. Ross	PSA-200	500 kHz	100	q	−100 dBm	ina	10 Hz/cm min	0.02-10	800	r
N. Ross	PSA-230	500 kHz	100	q	−100 dBm	ina	10 Hz/cm min	0.02-10	900	s
N. Ross	PSA-512	10 MHz	6500	5	−92 dBm	ina	0-1 GHz	1-60	2200	r,t

Spectrum Analyzers 156

Manufacturer	Model	Frequency Min (Hz)	Frequency Max (MHz)	Frequency Acc. (%)	Sensitivity Max (mV/cm)	Sensitivity Min (V/cm)	Sweep Width Min-Max (kHz)	Sweep Rate Min-Max (Hz)	Basic Price ($)	Notes
Quan-Tech	304-TDL	1	0.005	0.01	30 μV total	300 V total	0.05-5	5 s-5000 s	4200	w
FSC	PSD-10	dc	0.02	0.5	0.4	20	0.02-20	50 ms-50 s	13,300	a,d,e
FSC	PSD-14	dc	0.02	0.25	0.4	20 V total	0.02-20	100 ms-100 s	17,800	a,d,e
FSC	SP-6	dc	0.02	f	0.4	20 V total	0.02-20	ina	30,000	g,h
FSC	UA-10	dc	0.02	0.5	0.4	20	0.02-20	50 μs-50 s	9800	a,d,e
FSC	UA-14	dc	0.02	0.25	0.4	20 V total	0.02-20	100 ms-100 s	13,900	a,d,e
GR	1922	dc	0.02	1	100 mV total	ina	ina	ina	32,000	a,b
R&S	FAT 1	5	0.02	ina	300	30	0.005-20	4 s-200 s	5999	
R&S	FAT 3	5	0.02	ina	30	3	0.005-20	4 s-200 s	8150	j
Spectral	301B	0.03	0.02	0.2	100 mV total	10 V total	n/a	n/a	14,900	a,b,n,u
Singer	SA-2	20	0.035	1	3	30	0.025-25	ina	3350	m
Novatronics	500-5MSS	10	0.06	ina	ina	ina	ina	0-100	49,820	p
R&S	FAT 2	10	0.06	ina	300	30	0.01-60	4 s-200 s	6200	
B&K	2113	2	0.2	0.5 dB	10 μV/cm	300	one-third octave	ina	3405	a,b
B&K	3347	2	0.2	0.5 dB	ina	ina	20 fixed	ina	14,250	a,b,c
Singer	SA-3	100	0.7	1	0.003	30	1-400	1-60	3450	m
N. Ross	TA1013	100	1.3	1	30 μV/cm	ina	0.5-1250	1-10	4200	
Quan-Tech	350	10 kHz	10	1 kHz	10 μV total	10 V total	4-40	x	2495	
Siemens	K1023	10 kHz	25	0.15 dB	0.05 dB/cm	5 dB/cm	50 Hz typ	25 kHz typ	18,000	
Singer	SA-4	1000	27.5	5	0.003	3	0.5-5000	1-60	4550	m
Singer	SA-51B	10	40	1	0.5	3	0.15-14	0.1-30	6060	m
Systron	720	10	56	1	0.03 μV/cm	3 mV/cm	0.01-50	3 ms/cm-10 s/cm	4500	d
H-P	8552B/8553B/141T	1000	110	1 MHz	−140 dBm	+10 dBm	0.2-100,000	1 ms-100 s	6750	i
R&S	EZF	6000	170	k	0.5	3.5	6-136,000	21 ms-175 ms	11,300	
Tektronix	1401	1 MHz	500	5 MHz	−100 dBm	ina	100-500,000	1-100	1900	d,u,v
Singer	SA-70A	500 kHz	1300	1	−120 dBm	+20 dBm	3 kHz-1.3 GHz	1-330	5730	m
Singer	SPA-30005	10 MHz	40,000	1	−105 dBm	+30 dBm	10 kHz-3 GHz	1-330	11,395	
Systron	761	10 MHz	40,000	1	−60 dBm	ina	100 kHz-500 MHz	3 ms/cm-10 s/cm	5950	d

a. Real-time analyzer
b. Primarily intended for acoustical analysis
c. Frequency performance depends on input transducer
d. Portable
e. Computer compatible
f. One resolution element
g. Includes computer
h. Features data scaling, pattern recognition and equalization
i. Features absolute amplitude calibration
j. Includes built-in sweeper
k. Accuracy depends on frequency marker used
m. Storage display available
n. Sweep performance depends on frequency selected
p. Includes fiber-optic recorder
q. Accuracy depends on external local oscillator
r. Plugs into Tektronix letter series oscilloscopes
s. Plugs into Hewlett-Packard series 140/141 oscilloscopes
t. Features phase-lock local oscillator
u. Does not include built-in display. X and Y outputs compatible with most oscilloscopes
v. Battery operated
w. Features logarithmic scale
x. Has manually operated sweep

New Products

Multiplying d/a converters slash prices down to $125

Hybrid Systems Corp., 95 Terrace Hall Ave., Burlington, Mass. Phone: (617) 272-1522. P&A: $125, $150, $175; stock to 4 weeks.

Utilizing four-quadrant multiplication, a series of three new low-cost multiplying d/a converters with 10, 11 and 12-bit capabilities feature price breakthroughs with costs of only $125, $150 and $175, respectively, in single units.

The models 315-10, -11 and -12 multiplying converters with 10, 11 and 12 bits respectively, accept dc or ac reference signals and produce an output that is the mathematical product of this reference and the applied digital input.

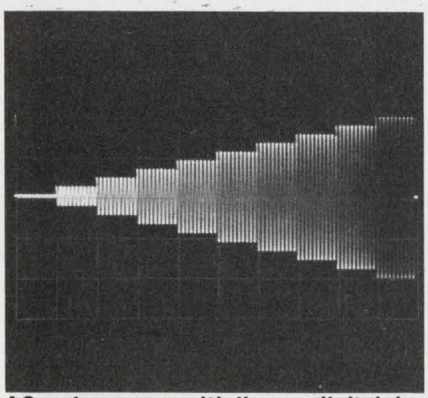
They can accept positive and negative analog signals and positive and negative digital numbers. Outputs include the effect of the input and reference polarities.

The new converters can be used as conventional d/a converters in addition to their multiplying capabilities. Except for resolution, the three models are mechanically and electrically identical.

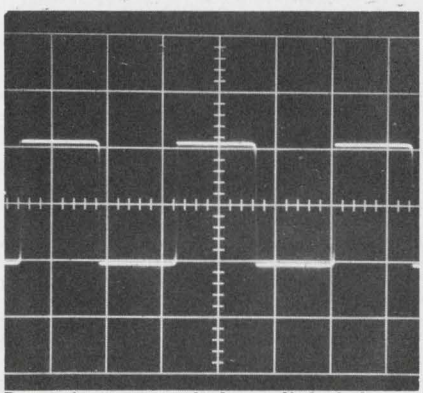
Typical electrical specifications include an output voltage range from —10 to +10 V, a 400-kHz bandwidth, a slew rate of 6 V/μs and output impedance of less than 1 Ω. Input impedance is 10 kΩ and the analog-reference voltage range is also —10 to +10 V. Operation is from ±15-V power supplies.

Mechanical specifications include completely self-contained modules measuring 2.8 by 3.1 by 0.4 in. Each is suitable for printed-circuit board mounting on 0.5-in. centers.

CIRCLE NO. 250



AC reference multiplies a digital input which counts up at 100 Hz.



Dc reference switches digital input from ZERO to ONE state repeatedly.

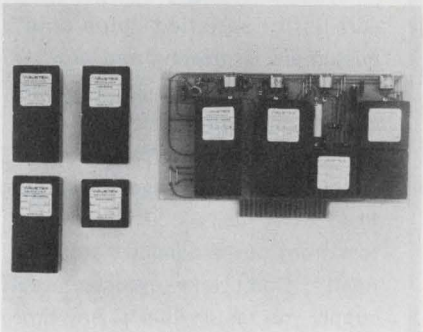
Modular power supplies are 75% efficient

Power/Mate Corp., 514 S. River St., Hackensack, N. J. Phone: (201) 343-6294.

The HE series of power-supply modules features efficiencies of better than 75% at current and voltage ratings up to 200 A and up to 50 V dc. Forty-six models are offered in four package sizes. Built-in overvoltage and self-restoring current limiting are provided. Output current is limited on external loads. Remote sensing and programming are additional features.

CIRCLE NO. 251

Functional modules generate waveforms

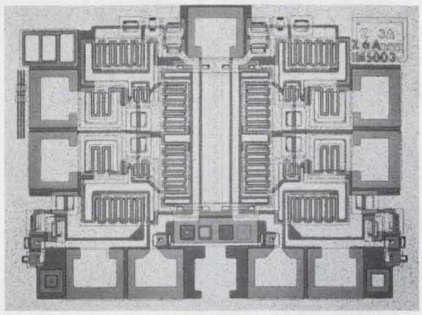


Wavetek, P. O. Box 651, San Diego, Calif. Phone: (714) 279-2200. P&A: $54 to $465; stock.

A unique series of modules with triggered and tone-burst capabilities can generate sine, square, triangle, pulse and ramp waveforms from dc to 100 kHz. The 120 series generators function as voltage-to-frequency converters, voltage-controlled oscillators, cw oscillators, timing signals, sweep generators, or tone-burst sources. They include four separate elements.

CIRCLE NO. 252

Monolithic clock driver dual sinks 1 ampere



Intersil, Inc., 10900 N. Tantau Ave., Cupertino, Calif. Phone: (408) 257-5450. P&A: $10.70; stock.

Containing four independent outputs, each capable of sinking and sourcing up to 500 mA of current on the same MOS monolithic chip, the new IM5003 integrated-circuit clock driver can function as a dual NAND gate with a current-sinking capability of 1 A per output, when two or more outputs are paralleled with each other.

It also features a supply voltage capability as high as 30 V, with a resultant output-voltage swing of 2 V less than the supply differential voltage.

Any TTL quad driver can be used to drive the new monolithic IC clock driver to give four complete clock-driven circuits with TTL inputs in only two integrated-circuit packages.

The IM5003 clock driver can also be driven directly if the most negative MOS voltage is at ground level. It can also be driven through a capacitor when level-shifting applications are required.

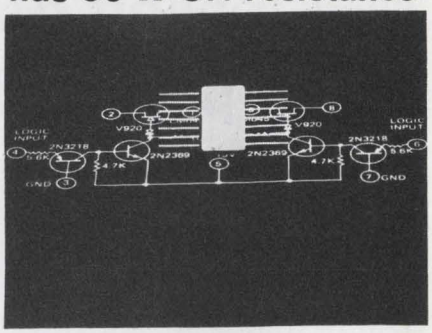
With its 1-A current-sinking capability, the new IM5003 clock driver becomes ideal for applications requiring clock drivers that can handle large currents.

A dual version of the IM5003 clock driver, known as the IM5013, will soon become available. It will contain two pairs of driver circuits that are internally wired in parallel with each other.

The new clock driver is currently available in two packaging configurations: either in a standard 14-pin dual-in-line case or in a TO-8 case. It is priced at $10.70 for 100-piece quantities and is available from stock.

CIRCLE NO. 253

Flatpack analog switch has 50-Ω ON resistance

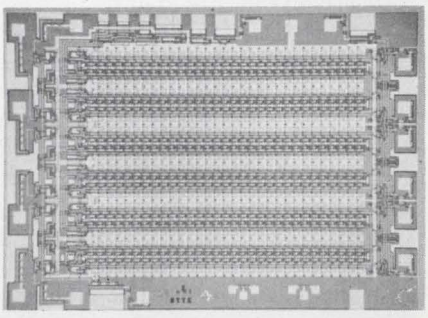


Crystalonics, A Teledyne Co., 147 Sherman St., Cambridge, Mass. Phone: (617) 491-1670. P&A: $40; stock.

The flatpack CAG13C dual FET analog gate is a spst break-before-make switch with maximum ON resistance of 50 Ω. It consists of two separate switch circuits capable of switching up to ±9-V signals and being controlled directly from most logic circuits. In addition to its zero-offset voltage, it turns off faster than it turns on for multiplexing without crosstalk.

CIRCLE NO. 254

MOS/LSI static register has six 32-bit content

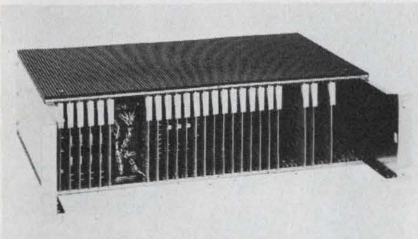


Texas Instruments, Inc., 13500 N. Central Expwy, Dallas, Texas. Phone: (214) 238-2011. P&A: $11.20; stock.

The TMS3112 is a MOS/LSI static shift register organized as six registers by 32 bits. Standard power-supply requirements for the new register are +5 and −12 V. Direct interface is possible with TTL and DTL circuits without input or output resistors. Only a single clock with a TTL swing is required, which can be easily obtained from a normal TTL gate.

CIRCLE NO. 255

Flexible processor starts from $2450



Ferroxcube Corp., 5455 S. Valentia Way, Englewood, Colo. Phone: (303) 771-2000. P&A: $2450 (basic FDC-302 unit); 60 days.

Designed for the OEM user who needs a low-cost and high-speed flexible processor, the new FDC-300 programmable digital controller features building-block system expandability starting with a low basic price of $2450 (100-unit quantities or more).

The new system is composed of a frame with memory on plug-in cards. Additional plug-in cards containing logic circuitry turns the system into a processor. Furthermore, the user has the advantage of optionally purchasing whatever I/O hardware he needs, such as Teletype or punch cards, all of which are on plug-in cards.

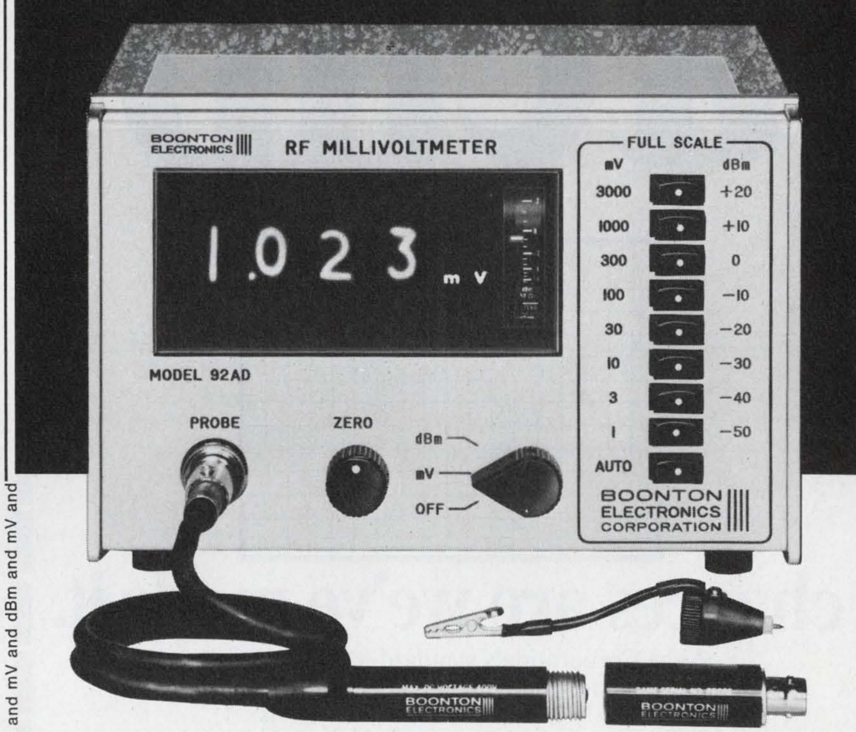
The FDC-302 is the basic controller unit housed in a 5-1/4-in. rack-mountable chassis, which includes a core memory configuration of 4096 words by 18 bits with a full cycle time of 2.5 μs. It is made up of 9 plug-in cards.

The system's memory is field ex--pandable up to 32,768 words which are directly addressable. It can logically operate upon full 18-bit words of 6 octal 3-bit bytes.

The controller organization uses minimal hardware in a logical configuration that also provides processing capabilities through 11 basic software techniques. This approach provides a controller system with sufficient processing speed at a low cost for most OEM processing applications.

The FDC-300 system is DTL/TTL-interface compatible and contains program-interrupt control. It includes a plug-in control panel that contains sense switches and data indicators. Direct memory access is optionally available with a transfer rate of 400 kHz.

CIRCLE NO. 256



DATA PROCESSING

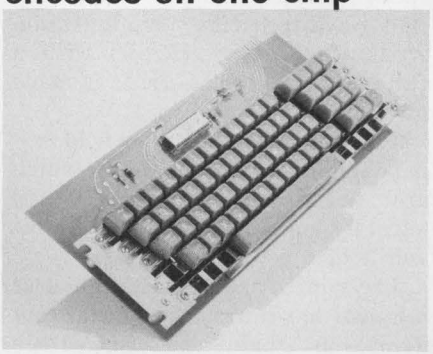
Miniature calculator weighs only 38 oz

SCM Corp., 299 Park Ave., New York, N. Y. Phone: (212) 752-2700. Price: $495.

A new lightweight portable calculator features dimensions of only 10 by 5 by 2 in. in a 38-oz package. It contains a built-in memory and an eight-numeral readout for displaying divisions, multiplications, additions, subtractions and accumulated products or quotients. It can also retain a constant multiplier or divisor for applications requiring repetitive calculations.

CIRCLE NO. 257

MOS/LSI keyboard encodes on one chip

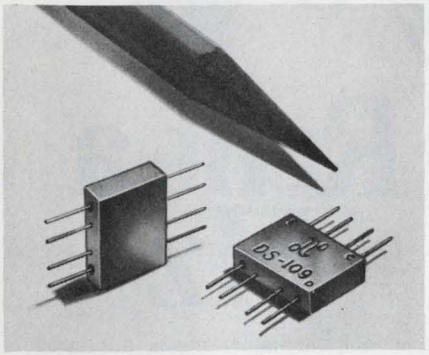


Clare-Pendar Co., P. O. Box 785, Post Falls, Idaho. Phone: (208) 773-4541. Availability: stock.

Up to 9 bits and 4 levels of encoding are accomplished on one chip in a new 88-key LSI/MOS keyboard. It uses a scanning technique that searches for a switch closure. Upon detecting a closure, valid encoded data appears at the bit outputs and a strobe appears to signal valid data. Features include 200-mW power drain, two-key rollover and TTL/DTL/MOS compatibility.

CIRCLE NO. 258

Broadband rf devices use tiny flatpacks

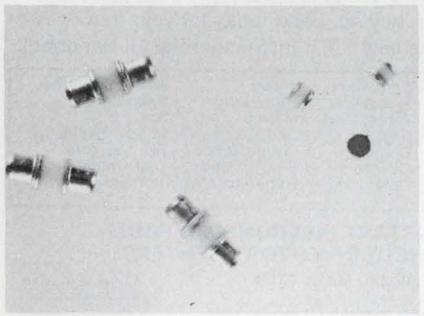


Anzac Electronics Div. of Adams-Russell Co., Inc., 39 Green St., Waltham, Mass. Phone: (617) 899-1900.

A new series of rf signal-processing components features subminiature flatpack configurations of only 0.125 by 0.375 by 0.5-in. The devices include a double balanced mixer (MD-113), a two-way isolated power divider (DS-109) and a hybrid magic-tee (HH-104), all covering the range of 10 MHz to 1 GHz.

CIRCLE NO. 259

Schottky mixer diodes lower noise to 6 dB



Aertech Industries, 825 Stewart Dr., Sunnyvale, Calif. Phone: (408) 732-0880. P&A: $12 to $36.50 (single units) $26 to $80.50 (matched pairs); stock to 3 wks.

Two new series of silicon Schottky-barrier mixer diodes feature noise figures as low as 6 dB. The A2S106 series provides 6 dB maximum noise figure at 9.375 GHz, while the A2S122 series provides 6.5 dB maximum noise figure at 16 GHz. Other units are available in flat-pill, prong-pill, chip and carrier configurations.

CIRCLE NO. 260

Beam-lead arrays use 1000 sensors

Texas Instruments, Inc., 13500 N. Central Expressway, Dallas, Tex. Phone: (214) 238-2011. Availability: 3 to 5 wks.

Custom-designed beam-lead sensor arrays are now available with anywhere from 50 to 1000 beam-lead phototransistors on a PC board. They are available for either X-Y or linear addressing. Phototransistor beam-tip-to-beam-tip size is 0.055 in. permitting array construction with center-to-center spacing of 0.06 in. Placement accuracy for individual sensors is ±0.002 in. Light and dark currents are 0.75 mA at 20 mW/cm^2 and 0.1 μA, respectively.

CIRCLE NO. 261

Red GaAsP LEDs emit 5000 foot-lamberts

Monsanto Electronic Special Products., 10131 Bubb Rd., Cupertino, Calif. Phone: (408) 257-2140. P&A: $13.50; stock.

A new series of high-power red LEDs make possible typical light output levels of 5000 foot-lamberts at 2 V and 1 A. The MV 4 series has light output wavelength of 6700Å which is controlled to ±200 Å, well above the sensitivity range of most photographic films. The series can allow peak currents to 25 A for 1-μs durations at rates to 300 pulses/second. The MV 4 series are diffused planar GaAsP diodes.

CIRCLE NO. 262

Wideband attenuator holds down phase shift

Koch Industries, 401 S. Dale St., Anaheim, Calif. Phone: (714) 527-1864. P&A: $175; 30 days.

Operating over the frequency range of 3 to 65 MHz, the model 1001 wide-band voltage-controlled attenuator provides very low phase shifts of ±4, ±1.5 and ±0.7 degrees for 30-dB attenuation at 50, 20 and 5 MHz, respectively. Its maximum attenuation is 50 dB.

CIRCLE NO. 263

He-Ne laser line drops price to $275

RCA Electronic Components, 415 S. 5th St., Harrison, N. J. Phone: (201) 485-3900. P&A: from $275; stock.

A new line of cw He-Ne lasers features price reductions with a typical 1-mW He-Ne laser costing $275. The line consists of the LD-2118 and LD2131V1 plasma tubes, the J15404 laser head and the J15405 laser power exciter. The LD 2118 is a 1-mW tube that provides 633 nm of coherent red light. The LD2131V1 plasma tube provides a 1-mW double-ended or a 2-mW single-ended model at 632.8 nm. The J15404 He-Ne laser head has a 1-mW cw output.

CIRCLE NO. 264

175-MHz transistors sock out 90 W peak

Motorola Semiconductor Products, Inc., P.O. Box 20912, Phoenix, Ariz. Phone: (602) 273-6900. Price. $43.50.

Two new npn silicon rf power transistors operating from 100 to 175 MHz provide 90-W peak power outputs. Types MM1552 and MM-1553 utilize balanced-emitter construction. The MM1552 is rated at 90 W for 18 W of input power at 150 MHz. The MM1553 has the same output at 150 MHz for a 13.5-W maximum input.

CIRCLE NO. 265

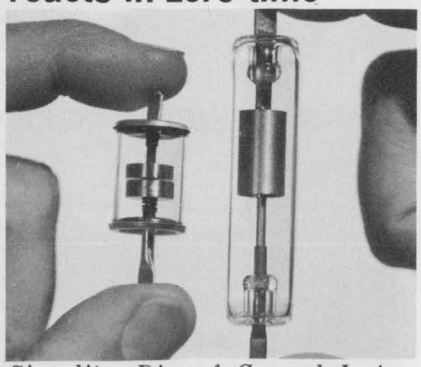
Small planar triode packs 100 W at 2.3 GHz

Siemens Corp., Components Div., 186 Wood Ave., Iselin, N. J. Phone: (201) 949-1000.

A new conduction-cooled miniature planar triode of metal-ceramic design delivers as much as 100 W of cw output power at frequencies as high as 2.3 GHz. The triode, type YD1380/81 has a maximum plate dissipation of 250 W and will provide the 100-W cw power output with 1300 V on its plate when used in Class-B grounded-grid operation.

CIRCLE NO. 266

5-kV/μs surge arrestor reacts in zero time

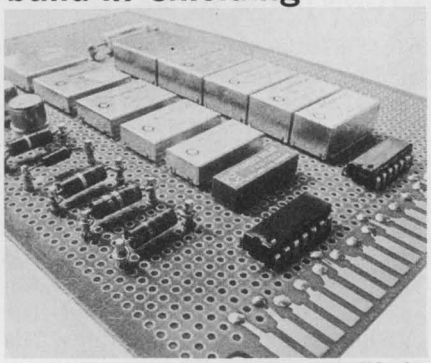


Signalite, Div. of General Instrument Corp., Neptune, N. J. Phone: (201) 775-2490.

Uni-Imp is a gas-filled surge arrestor with a unity impulse ratio that will absorb all transient pulse wavefronts up to 5 kV/μs in zero reaction time. Two models are available: model UBD which is available in 22 ratings from 550 V to 3 kV and model UGT which is available in 18 ratings from 3.1 to 15 kV. Impedance is infinite to the trip voltage and capacitance is 15 pF.

CIRCLE NO. 267

Low-profile reed relays build-in shielding

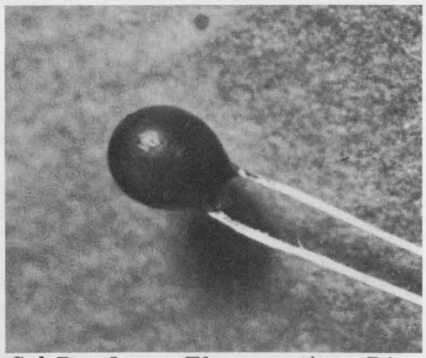


C. P. Clare & Co., 3101 Pratt Blvd., Chicago, Ill. Phone: (312) AM2-7700.

With 0.225 to 0.35-in.-high profiles and 0.375-in. mounting centers, the PRB series of multi-pole reed relays provides standard internal electromagnetic and optional electrostatic shielding. They have contacts rated to switch 500 mA at 10 V and 10 VA and can carry as much as 2 A of current. Maximum contact resistance is 200 mΩ. In-line pins used are arranged in spacings of 0.1 by 0.7 in.

CIRCLE NO. 269

Stable thermistors are 1/8-in. in dia

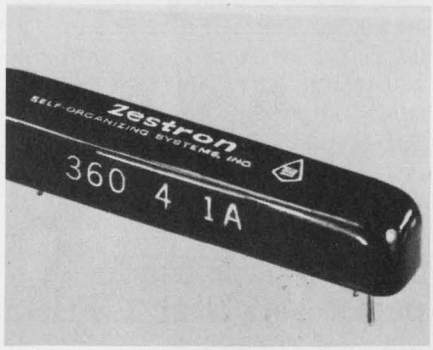


Cal-R, Inc., Thermonetics Div., 1601 Olympic Blvd., Santa Monica, Calif. Phone: (213) 451-9761.

New small stable epoxy-coated disc thermistors shaped as teardrops measure only 1/8-in. in diameter or less. Their long-term stability results from epoxy coatings which provide insulation of up to 500 V dc. Thermistors with insulated leads are available to customer specifications in resistance values from 100 to 20,000 Ω, at tolerances from 0.5 to 20%.

CIRCLE NO. 268

Low-cost reed relays offer $1.84 price tags



Self-Organizing Systems, Inc., P.O. Box 9918, Dallas, Tex. Phone: (214) 276-9487. P&A: $1.84, $2.44; stock.

The new Zestron series 360 line of reed relays with encapsulated magnetically shielded housings are priced at only $1.84 for spst and $2.44 for dpdt models (100 quantities). Available in 12 and 4.5-V coils, the series uses rhodium contacts rated at 0.5 A and 50 V dc and 120 V ac at 10 VA with 0.2-Ω maximum contact resistance.

CIRCLE NO. 270

0.5-in.-dia trimmer dissipates 1 watt

Bourns, Inc., Trimpot Products Div., 1200 Columbia Ave., Riverside, Calif. Phone: (714) 684-1700. Price: $1.15.

A 1-W power rating in a 1/2-in. dia case (125°C) is what distinguishes the new model 3369 cermet single-turn potentiometer. This cermet element with a ±150-ppm/°C temperature coefficient offers stability over an operating temperature range of −65 to +175°C. Model 3369 comes in two terminal styles: with printed-circuit pins or with solder lugs. Specifications include a standard resistance range of 100 Ω to 5 MΩ and standard tolerance of 10%.

CIRCLE NO. 271

Open-frame reed relays plug into 0.15-in. grids

Precision Products, 11161 W. Pico Blvd., Los Angeles, Calif. P&A: from $1.75; stock to 2 wks.

Designed to plug-in on 0.15-in. grids is a new line of open-frame reed relays. Over 150 of these reed relays can be mounted on a single 4-by-6-in. PC board. They are available in 6, 12 and 24-V dc ratings. They include a switching speed of 0.5 ms nominal, a dc power rating of 7 W at 0.25 A, a sensitivity as low as 240 mW.

CIRCLE NO. 272

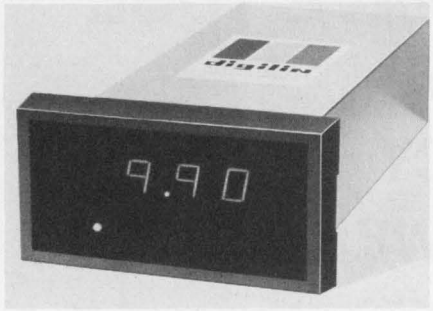
10-μF 50-V capacitor is 0.5 by 1.87 in.

Wesco Electrical Co., Inc., 27 Olive St., Greenfield, Mass. Phone: (413) 774-4358. Availability: 4 to 5 wks.

Type 32MPC metallized polycarbonate capacitors are available in voltage ratings from 50 to 200 V dc with a 50-V 10-μF unit measuring only 0.4 in. in dia by 1.187 in. long. Temperature range is −55 to +85°C. Retrace or stability is less than 0.3% and capacitance change is less than ±0.25% from +25 to +85°C. Capacitance range is 0.012 through 10 μF and standard tolerance is ±10%. Tolerance to ±1% is also available.

CIRCLE NO. 273

Tiny 3-1/2-digit DPM has GaAs LED readouts

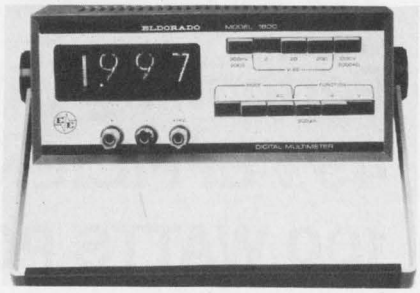


Digilin, Inc., 1007 Air Way, Glendale, Calif. Phone: (213) 240-1200.

Containing a 3-1/2-digit display, type 3330 digital panel meter shrinks its size with a ruby-red GaAs LED readout. It measures just 1.15-in. high by 2.04-in. wide by 5-in. deep and is accurate to 0.1% full scale ±1 digit. It automatically zero-adjusts itself, has external programming, is front-panel relampable and offers optional BCD output. Input impedance is 100 MΩ.

CIRCLE NO. 274

3-1/2-digit multimeter retails for just $275



Eldorado Electrodata Corp., 601 Chalomar Rd., Concord, Calif. Phone: (415) 686-4200. P&A: $275; stock.

The model 1800 is a 3-1/2-digit 0.1% digital multimeter retailing for the low price of $275. It measures 0.2 to 1000 V ac and dc in 5 ranges each, 200 Ω to 2 MΩ in 5 ranges, and currents of 200 μA ac and dc with 200-nA resolution. Input impedance is 10 MΩ and measurement is by the dual-slope integration method. Battery operation is optionally available.

CIRCLE NO. 275

Versatile curve tracer comes in a $79.95 kit

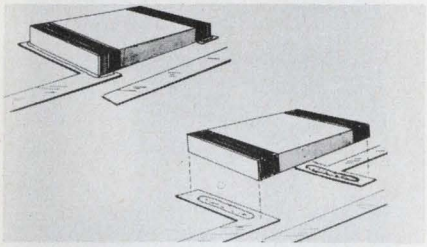
EICO Electronic Instruments, 283 Malta St., Brooklyn, N. Y. Phone: (212) 949-1100. P&A: $79.95 (kit), $119.95 (wired); stock.

Diodes and signal and power transistors can easily be tested by the model 443 curve tracer which is available in kit form for only $79.95. Its output is displayed on an oscilloscope. Diode tests include forward and reverse currents and voltages with variable 0-to-1400-V PIV tests. Transistor tests include h_{FE}, h_{OE}, I_{CEO}, V_{CE} and BV_{CEO}.

CIRCLE NO. 276

FOR DAMON INSERT CIRCLE 123 ►

One-part silver epoxy bonds hybrid strips

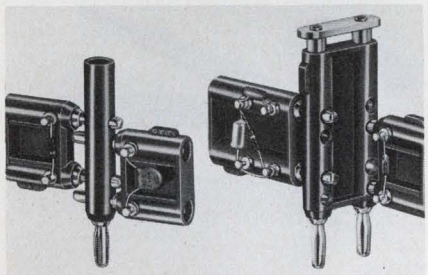


Epoxy Technology, Inc., 65 Grove St., Watertown, Mass. Phone: (617) 926-0136. Price: $15/trial kit.

A new single-component electrically-conductive silver epoxy bonds chips in hybrid circuits. Epo-Tek H31 is a soft, smooth, slightly thixotropic, flowable paste of 100%-solids composition. Its volume resistivity is 0.0001 to 0.0005 ohm-cm and it cures in 15 minutes at 150°C or in 45 minutes at 120°C. It may be used at 200°C continuously or 350°C for short durations.

CIRCLE NO. 277

Series-parallel plugs build voltage networks



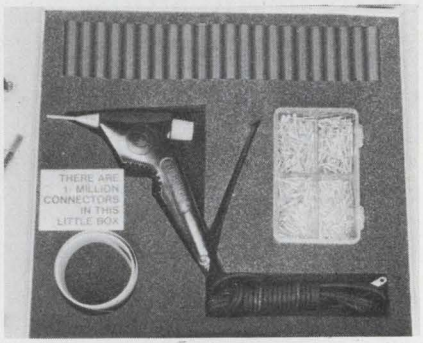
Pomona Electronics Co., Inc., 1500 E. 9th St., Pomona, Calif. Phone: (714) 623-3463. P&A: $1.50, $3.25; stock.

A new group of series-parallel isolation plugs can be used to build voltage dividers, attenuators, and other networks. The group consists of two versions: model 3501 single plug and model 3502 dual plug. Both items provide top banana jacks and upper pairs of cross holes isolated from lower cross hole pairs and banana plugs.

CIRCLE NO. 278

Nov. 8 issue has your renewal card, inside front cover. Mail it today.

Low-cost potting kit makes instant connector

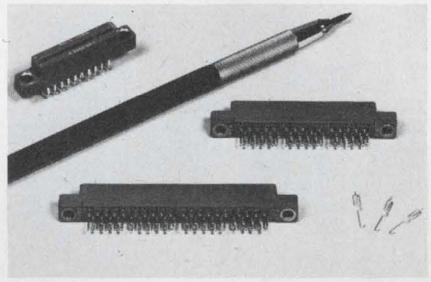


Wiring Analyzers, Inc., 9015 Wilshire Blvd., Beverly Hills, Calif. Phone: (213) 657-0122. P&A: $72; stock.

Using a heat gun, polyethylene cartridges and connector contacts, a mate can be made to any existing connector configuration in a matter of minutes for as low as 50¢. The polyethylene also serves as an agent for potting and waterproofing. Kits containing a heat gun, polyethylene cartridges and connectors are available.

CIRCLE NO. 279

Tiny PC connector houses 80 pins



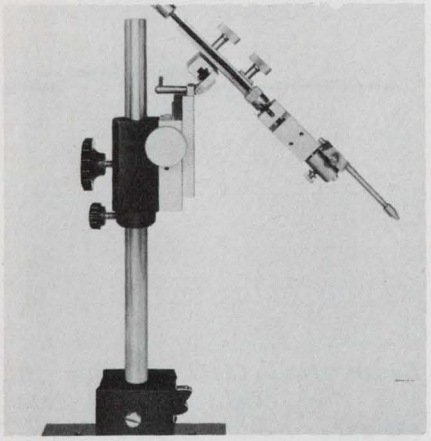
Fabritek, Inc., National Connector Div., 9210 Science Center Dr., Minneapolis, Minn. Phone: (612) 533-5361.

A new tiny high-density PC-board connector for 1/16 and 1/32-in. boards, with contacts spaced on 0.05-in. centers, offers a choice of 20, 40, 60, or 80 terminations. Gold-plated solder tails on the connector back are staggered for easy access and are available hooked or straight. The connector can be polarized as required.

CIRCLE NO. 280

Have you sent us your subscription renewal card? See Nov. 8 issue.

Micromanipulator unit eliminates vibration



Brinkman Instruments, Inc., Cantiague Rd., Westbury, N. Y. Phone: (516) 334-7500. Price: from $195.

A new versatile shock-absorbing micromanipulator called the RP-F uses a unique flexible drive shaft to reduce component vibration to virtually zero. A slight touch is all that is needed for trouble-free micro-movements at magnifications up to 500 times. This is accomplished by having the fine motion actuated by a flexible shaft so that vibrations are completely eliminated.

CIRCLE NO. 281

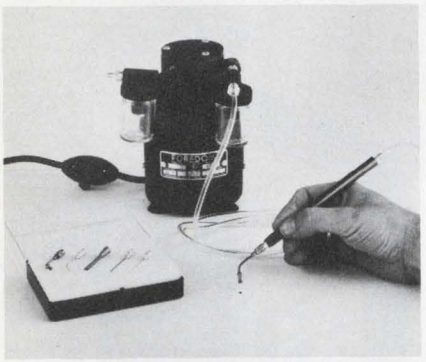
Ratchet tool handles accept many blades

Xcelite, Inc., Thorne & Bank St., Orchard Park, N. Y. Phone: (716) 662-4461. Availability: stock.

The regular model 99-1R and the Tee-type model 99-4R plastic handles incorporating a reversible ratchet mechanism accommodate more than 60 individually available nutdriver, screwdriver and special-purpose snap-in blades to speed and simplify assembly and service work. A patented spring chuck holds the blades firmly. The ratchet mechanism is fully enclosed to keep out dirt and grit.

CIRCLE NO. 282

Three-section system eases parts handling

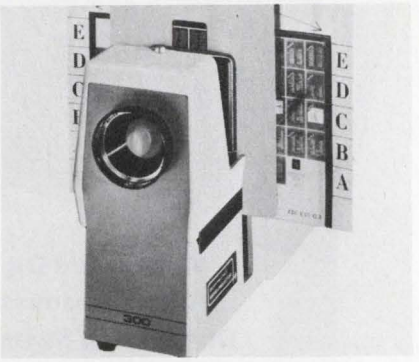


Foredom Electric Co., Stony Hill, Bethel, Conn. Phone: (203) 748-3521.

A versatile miniature parts-handling system in kit form consists of a heavy-duty oil-less electric vacuum pump, a vacuum probe handpiece and a selection of five probes for handling a wide variety of small parts. The system is especially designed for separating, sorting, grading, positioning and assembly operations. Five probes are offered with the kit.

CIRCLE NO. 283

Microfiche projector displays up to 4 feet

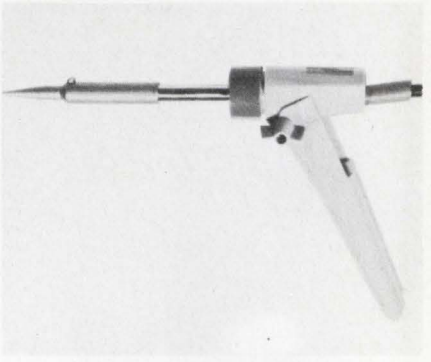


Taylor-Merchant Corp., 25 W. 45 St., New York, N. Y. Phone: (212) 757-7700. Price: $69.50.

The 300 XF COSATI microfiche projector weighing only 3 lbs and measuring 8 by 6-1/4 by 3 in. will project the full size of a standard 8-1/2-by-11-in. page a distance of 48 in. The fan-cooled unit contains a three-element condenser system that affords a bright and sharp image even in ambient and incandescent office light. It has its own built-in screen.

CIRCLE NO. 284

Compact soldering iron supplies 40 or 50 W

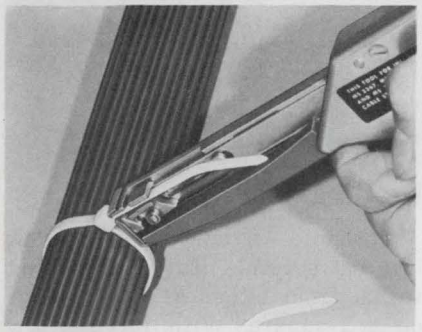


Edsyn, Inc., 15954 Arminta St., Van Nuys, Calif. Phone: (213) 989-2324. Availability: stock.

The Ersa Varius is a rugged, easy-to-handle industrial soldering iron available in 40 or 50 W sizes. It is suited for continuous heavy-duty line soldering operations and is designed to lessen operator fatigue with its light weight of less than 8 oz. It has an adjustable pistol grip and a long-life tip which requires no filing or shaping during its life.

CIRCLE NO. 285

Evaluation Samples



Cable ties

A new line of one-piece, all-nylon Pan-Ty cable ties offers all the advantages of 90-degree tie insertion into a self-locking head, as well as a curved-tip and low-profile design. Six cable ties are available for bundle sizes up to 4 in. in dia. These are available in miniature, intermediate, standard and heavy cross-section sizes. They meet all applicable military specifications and are offered in natural nylon and ten other colors. New Pan-Ty cable ties can be installed by hand or with tension-controlled production harnessing tools. They contain no metal barbs and require no twisting. Serrations at the top of the lead end of the cable tie provide a finger-grip tip which assists in pulling cable ties tight. Free samples are available. Panduit Corp.

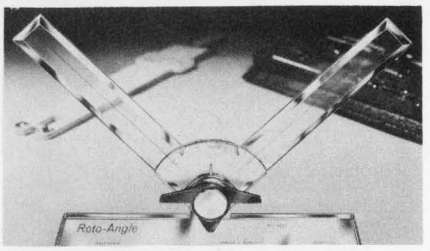
CIRCLE NO. 286

Foil chips

A complete range of baked epoxy-coated foil chips is available in many colors, textures and shapes. They are composed of minute uniformly cut particles of highly polished aluminum foil, with or without light-fast color pigments baked into an epoxy coating. They are compatible with polyester and epoxy resins, acrylic lacquers, vinyl or plastisol. Individual pigment particle size ranges from 0.004 by 0.002 by 0.00045 in. to 0.125-in. square by 0.002-in. thick in rectangular, square, hexagonal and star shapes. Additional sizes and shapes can be made to order. A chip sample folder is available. Meadowbrook Inventions, Inc.

CIRCLE NO. 287

Design Aids



Drafting tool

The Roto-Angle Drafter is a new low-cost portable drafting tool that works from either a parallel edge or a T-square. With its use, the construction of angles from 0 to 180 degrees is greatly simplified. It is ideal for the economy-minded student, engineer, designer, architect or draftsman. It is made of tough unbreakable Lexan plastic and comes complete with a vinyl carrying case and a detailed instruction booklet for a price of less than $10. Alvin & Co.

CIRCLE NO. 288

Drafting template

A new drafting template is available for applications involving fault-tree analysis. The new fault-tree template, No. 555, contains the generally accepted symbols used to graphically display anticipated trouble areas, in chart form, for systems safety analysis. All the template's symbols are precision-milled for professional quality. The template's cost is only $2.25. Rapidesign, Inc., sub. of Berol Corp.

CIRCLE NO. 289

Circular slide rule

From West Germany comes a modern and high-precision circular slide rule for multiplication, division, percentages, interest, fractions, currency conversion and technical calculations. The Multor circular slide rule can be used by engineers, technicians, students and merchants. The absolute accuracy of its graduations provided in three colors on solid metal discs, together with its easy operation, make the Multor an ideal calculating device. It has a 3-1/2-in. dia and is available with a case for only $5.95. Lykins Imports.

CIRCLE NO. 290

Application Notes

Crystal filters

Entitled "Selecting, Specifying and Optimizing Modern Crystal Filters," a new crystal filter manual contains information a circuit designer needs to select, specify and optimize his crystal filter design. Its contents include such material as filter theory, nomenclature, symbology and specifications. It also discusses tradeoffs and parametric optimization. In addition, standard filter families are listed. Bulova Watch Co., Inc.

CIRCLE NO. 291

Servomechanisms

A new handbook contains a wealth of theoretical and practical information on testing and evaluating servomechanisms. It includes sections on servomechanism principles, test objectives and methods, common difficulties and data interpretation. The booklet's 56 pages are well illustrated. Ling Electronics, Div. of LTV Ling Altec, Inc.

CIRCLE NO. 292

Radiation detectors

A new basic guide discusses solid-state radiation detectors. It provides direction to applications of high-resolution x-ray and particle detectors. Discussed in the guide are various properties of lithium-drifted, diffused-junction and surface-barrier detectors of silicon and germanium. The publication's six pages give attention to problems associated with x-ray spectroscopy, charged-particle counters, dE/dX detectors, timing and coincident experiments and ionization chambers. Nuclear Semiconductor, Inc.

CIRCLE NO. 293

New Literature

A/d/a catalog

A 16-page short-form catalog summarizes a complete line of analog/digital/analog conversion, signal-conditioning and digital-display products. Analogic.

CIRCLE NO. 294

High-current supplies

The newly revised catalog AC-70 covers a complete line of high-current dc power supplies. Christie Electric Corp.

CIRCLE NO. 295

Relays

A 27-page technical manual describes new high-speed standard mercury-wetted relays for PC boards which provide bounce-free, hard-contact switching up to 250 Hz with significant reduction in contact noise. C. P. Clare & Co.

CIRCLE NO. 296

Instrument cases

A sixteen-page brochure details a line of hardwood cases for test equipment, spare parts and measuring devices. Schry-Way Cases.

CIRCLE NO. 297

Tools

A line of assembly tools is displayed in a 56-page catalog geared for electronic production. Electronic Tool Co.

CIRCLE NO. 298

Timers

A 16-page brochure about timers and time delay relays includes selection charts, specifications, outline drawings and wiring diagrams. Timeco, Inc.

CIRCLE NO. 299

Control handbook

A 408-page handbook includes an introduction to solid-state logic and chapters on DEC's K series industrial control logic, A series analog modules, PDP-14 programmable controller, and the K series logic and computer laboratory for use as training and design aids. Digital Equipment Corp.

CIRCLE NO. 335

Rfi/emi filters

A line of miniature rfi/emi filters is described in a 12-page catalog. Included are design data, descriptions and illustrations of five separate series. Lundy Electronics & Systems, Inc.

CIRCLE NO. 336

Optical materials

An extensive technical brochure on optical fused quartz and fused silica provides complete information on uses and physical characteristics of eight specific qualities. Described are general applications and advantages of the optical materials, as well as technical information of optical transmission, radiation resistance and fluorescence data. Amersil, Inc.

CIRCLE NO. 337

Timing motors

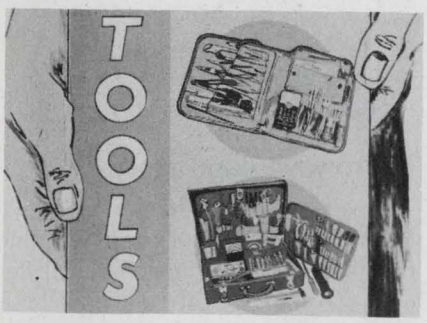
Industrial timing motors for 50 and 60-Hz applications are spotlighted in a bulletin. A. W. Haydon Co.

CIRCLE NO. 338

Digital instruments

Solid-state digital indicators, servo-digital instruments, manual multi-point indicators and digital data systems are shown in a catalog. Howell Instruments, Inc.

CIRCLE NO. 339



Electronic tools

A new catalog contains 72 pages of tools for electronic assembly and precision mechanics. Over 1700 individual items are described. A separate solder section lists tin-lead solders with four pages devoted to tips on tool selection. Jensen Tools and Alloys.

CIRCLE NO. 340

Beryllia substrates

Properties of stock beryllia substrates are listed in a new brochure. Listed are such properties as water absorption, specific gravity, color, temperature, hardness, thermal expansion linear coefficient and shear modulus. American Lava Corp. sub. of 3M Co.

CIRCLE NO. 341

Dc-to-dc supplies

Over 700 standard dc-to-dc power supplies are shown in a 20-page catalog. Models range in power levels from less than 1 W to 15 W and in sizes from 1/2 cubic in. to 15 cubic in. MIL Electronics, Inc.

CIRCLE NO. 342

Microwave modules

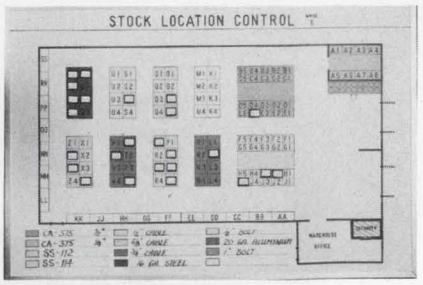
A 16-page brochure presents capabilities and applications of various microwave circuit modules. General Electric Co.

CIRCLE NO. 343

Capacitors

Recently developed data on the performance of precision trimmer capacitors at uhf and microwave frequencies is outlined on a data sheet. Voltronics Corp.

CIRCLE NO. 344



Control boards

A complete line of visual control boards is fully described in a 28-page catalog. Featured are white write-on magnetic boards with satin non-glare finishes. Methods Research Corp.

CIRCLE NO. 345

Pushbuttons

A new catalog describes several series of molded push buttons for use with switches and keyboards. These include illuminated, single or double-light-cavity, single or multiple-station, engraved or double-shot molded-character types. Maxi-Switch Co.

CIRCLE NO. 346

Connectors

An expanded series of pin and socket connectors for rack-and-panel cable applications is fully described in a 32-page catalog. AMP, Inc.

CIRCLE NO. 347

Linear-IC test modules

Seven low-cost linear-IC test modules are described in a brochure. The modules are designed for interconnection with laboratory instruments to form test circuits. I. C. Metrics, Inc.

CIRCLE NO. 348

Rf instrumentation

A new short-form catalog describes a complete line of rf instrumentation products. Microdot, Inc.

CIRCLE NO. 349

Don't miss an issue of Electronic Design; return your renewal card today. See Nov. 8 issue.

Microwave capacitors

Featured in a product brochure are eight new microwave variable capacitors of a unique internal design. Graphically detailed are operating life, temperature coefficient, dynamic noise and rotational life characteristics. Johanson Manufacturing Corp.

CIRCLE NO. 350

Telemetering modules

A 52-page catalog describes a line of FM-FM telemetering modules which include voltage-controlled oscillators, dc amplifiers and signal isolators, frequency-to-dc converters, discriminators and transducers. Solid State Scientific Corp.

CIRCLE NO. 351

Optical components

Described in a four-page brochure are optoelectronic and solid-state display components. Electrical characteristics and package outline drawings with dimensions are given for numeric and alphanumeric displays, including the newest monolithic displays. Hewlett-Packard.

CIRCLE NO. 352

Capacitors

Thousands of dc filter, pulse, rf, low-inductance, fast-discharge and instrumentation capacitors along with their performance charts and tables are featured in a 20-page catalog. Condenser Products Corp.

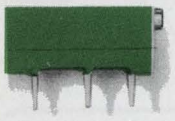
CIRCLE NO. 353

Beryllia adhesives

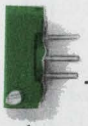
A technical bulletin describes three new beryllia-filled epoxy adhesives for bonding ICs and for preparing electrically insulating and heat-sinking barrier coats. National Beryllia Corp.

CIRCLE NO. 354

lots more about pots.

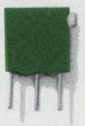


When you need a trimming potentiometer to meet *any* configuration, you can depend on WESTON to supply the right unit. Volume production of ¾-inch rectangular pots, the 530-533 Series enables Weston to supply these models at the lowest prices in the industry. We'll supply them in wirewound with a temperature coefficient of ±70 ppm/°C maximum, or CERMET with a T.C. of ±100 ppm/°C, maximum. Prices are as low as $1.09 each in quantities of 500 units, with substantial reductions in larger quantities. Delivery is from stock.



Then, too, it's hard to beat our ½-inch 701 Series Squaretrim® potentiometer available with either commercial or military specs. Prices are as low as $1.85 each in quantities of 500 units.

When you want a small, single-turn, wirewound Squaretrim® potentiometer, order the 501-505 Series. Prices are as low as $1.95 each in quantities of 500 units.



Buy them all from WESTON.

For samples or complete details on any or all of these units, call 717-876-1500, or write Weston Components Division, Archbald, Pa. 18403, *a Schlumberger company.*

WESTON®

INFORMATION RETRIEVAL NUMBER 74

Bulletin board

of product news and developments

A new video playback system known as Video Disc., utilizing thin plastic discs that play at 1500 revolutions/minute, has been jointly developed by London Records, subsidiary of British Decca of England, Teldec, and AEG-Telefunken of Western Germany. The new system uses 12-in. recorded discs containing five or twelve minutes of moving picture/sound information. These are reproduced through a color or monochrome television set to which a video disc player is attached via the TV set's antenna terminals. The system is expected to be available for marketing in about 18 months. Tentative prices are $150 for a manual player and from $250 to $300 for an automatic player.

CIRCLE NO. 355

Signetics Corp., Sunnyvale, Calif., is adding 50% more circuits to its **Utilogic II line of dual-in-line silicone packages** during the months of October and November, 1970. The new products include 3 MSI elements (two counters and one shift register), several AND gates, power drivers, a dual type-D flip flop and other devices.

CIRCLE NO. 356

Lockheed Electronics Data Products Div. has developed an **18-mil core for data-storage memories,** known as the 18MTO5, that requires a drive current of only 420 mA yet features switching speeds as fast as 270 ns. According to Lockheed, this low drive current compares favorably with typical drive-current requirements for 18-mil cores of 750 to 800 mA for the same switching speeds. Lockheed says that future cores with 14-mil sizes and with the same low drive currents will become available.

CIRCLE NO. 357

Nov. 8 issue has your renewal card, inside front cover. Mail it today.

Advertisers' Index

Design Data from Manufacturers

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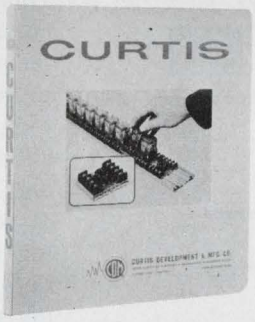
(Advertisement)

NEW RELAY SOCKET ASSEMBLIES CATALOG

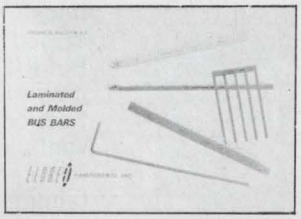


The new Curtis line of printed circuit snap-in track-mounted relay socket assemblies is completely illustrated in this new 2-color, 6 page catalog. Variations include RS8 octal relay sockets, as well as RS11 and RS15 with eleven and fifteen pin relay sockets. Complete dimensional drawings and list prices are included. All units snap in or pop out vertically from prepunched vinyl track and feature Curtis barrier terminal blocks. CSA approved. Send today for your free copy.

CIRCLE NO. 171

Curtis Development & Mfg. Co.
3236 North 33rd Street
Milwaukee, Wisconsin 53216

Bus Bars For Noise Reduction



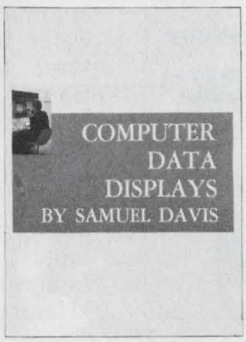
A 16 page Technical Bulletin is now available, describing a new concept in power or signal distribution. Basic mechanical and electrical design principles, along with descriptive pictures and diagrams, are included in this bulletin. These compact buses can replace bulky cable harnesses and repetitive wiring for computer or modular application. This method of construction satisfies the demanding requirements of low inductance and resistance of high speed, solid state systems, while controlling electrical noises.

CIRCLE NO. 172

Send For Free Sample

Eldre Components, Inc.
1239 University Avenue
Rochester, New York 14607

Devices, subsystems & design methods in computer data display



A 416-page guide to computer data displays, including the latest devices, subsystems, & techniques found in cathode ray tube displays. Brings you vital know-how on the latest techniques in character & line generation — provides hardware-oriented descriptions to thoroughly acquaint you with details for a wide variety of alphanumeric & graphic display systems. Detailed explanations, such as for deflection, Z-axis, & display processing subsystems, help you improvise on current techniques & create your own designs. Pub. Dec. 1969, 416 pp., 233 illus., 6" x 9", $15.95. Circle the reader-service number below for a 15-day examination copy.

Prentice-Hall, Inc.
Englewood Cliffs, N. J. 07632

CIRCLE NO. 173

Electronic Design

ELECTRONIC DESIGN's function is:

- To aid progress in the electronics manufacturing industry by promoting good design.
- To give the electronic design engineer concepts and ideas that make his job easier and more productive.
- To provide a central source of timely electronics information.
- To promote two-way communication between manufacturer and engineer.

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Editor
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Design Data from

Quality Fasteners For All Designs

This 8-page catalog provides design data on the complete group of DZUS 1/4-turn self-locking fasteners for standard, high speed and panel applications, as well as universal high strength multiple thread fasteners for high tensile and shear stresses. Dzus stud assemblies, wire forms and receptacles offer an exceptional, wide variety of combinations from stock to fit specific fastening requirements. Diagrams and tables give full details for rapid, unlimited design selection. Condensed or complete Catalog available on request.

CIRCLE NO. 174

Dzus Fastener Co., Inc.
425 Union Boulevard
West Islip, L. I., N. Y. 11795

PEMHEX Self-clinching, Self-locking Nuts

PEMHEX® fasteners are self-clinching to ensure permanent mounting in metal sheets 0.040" and thicker, and they mount with a squeeze into predrilled holes. A blue nylon element in each PEMHEX fastener provides thread-locking capabilities meeting or exceeding MIL-N-25027C* specifications, and its hexagonal configuration prevents loosening or rotating in service. A PEMHEX nut can be used 15 times or more while maintaining prevailing torque. Here's a fastener that is reliable, economical and permanently mountable on thin metal. It's patented using PEM® self-clinching design.
*Independent laboratory test reports available.

CIRCLE NO. 175

Penn Engineering & Manufacturing Corp.
Doylestown, Pa. 18901

Mini-Computer Mated with Real-Time Analyzer for Automatic Testing

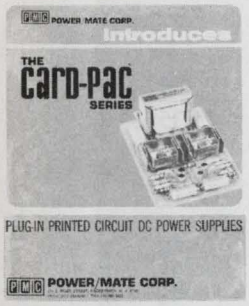
Complete Spectrum Processing System SP-6-1 automatically scales, equalizes, processes underwater acoustic data and noise/vibration signatures for production testing. Monitors on-line signals (nuclear reactor noise, heart sounds, machine tool vibration), recognizes aberrations, gives alarm. Setup conditions are entered via teletype unit as requested by computer. System prints out **all** spectral data or only frequency amplitude above preset levels. Data also pre-recordable on tape, played back often faster than real time. Analysis over frequency bands as wide as 40 kHz are possible. Many options. CIRCLE NO. 176

Federal Scientific Corporation
a subsidiary of Elgin National Industries, Inc.
615 West 131st Street, New York, N. Y. 10027.

Manufacturers

Advertisements of booklets, brochures, catalogs and data sheets. To order use Reader-ServiceCard (Advertisement)

NEW PLUG-IN PRINTED CIRCUIT POWER SUPPLIES



Power/Mate Corp. has introduced a new complete line of 129 models of Printed Circuit DC regulated power supplies-now described in this 4 page catalog. These 129 CARD-PAC models collectively cover from 3.6 to 48 vdc and currents up to 2 amps. The CARD-PACS feature adjustable DC outputs, low cost, high performance and Power/Mate's full five year warranty. The catalog covers complete specifications, model numbers, sizes and prices. Write, call or twx for your free copy.

CIRCLE NO. 177

Power/Mate Corporation
514 South River Street
Hackensack, New Jersey 07601
(201) 343-6294

Plastic Parts

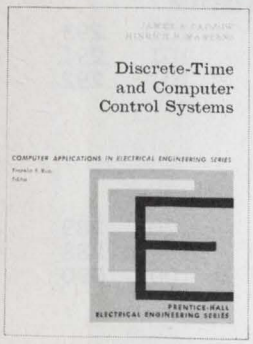
CUSTOM production to your specs from patented, low-cost tooling. Any size, any quantity in Nylon, Delrin, other thermoplastics. Let us quote. We have 20 years experience.

STANDARD gears, racks, bearings, sprockets, pulleys, washers, insulators, many other components available quickly from stock tools. Over 2,500 items described in our 48-page catalogue. Write today for a free copy.

CIRCLE NO. 178

Nylomatic
28 Nolan Ave.. Morrisville, Pa. 19067

A guide to computerized analysis & design



Use this new 448-page guide in putting the speed & accuracy of the computer to work in solving your analysis & design problems. Shows how to use z-transform in analyzing & synthesizing discrete time systems. Information on the analytical design of discrete systems helps you solve modern discrete-control problems such as minimum time & energy problems. Includes many analog, digital & hybrid computer techniques for systems simulation. Worked out sample problems & computer programs further help you in both solving analysis problems & implementing design objectives. Pub. Aug. 1970, 448 pp., 224 illus., 6" x 9", $15.95. Circle the reader-service number below for a 15-day examination copy.

CIRCLE NO. 179

Prentice-Hall, Inc.
Englewood-Cliffs, N. J. 07632

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Product Index

Information Retrieval Service. New Products, Evaluation Samples (ES), Design Aids (DA), Application Notes (AN), and New Literature (NL) in this issue are listed here with page and Information Retrieval numbers. Reader requests will be promptly processed by computer and mailed to the manufacturer within three days.

New Literature

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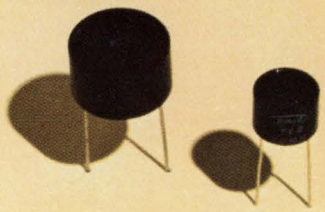
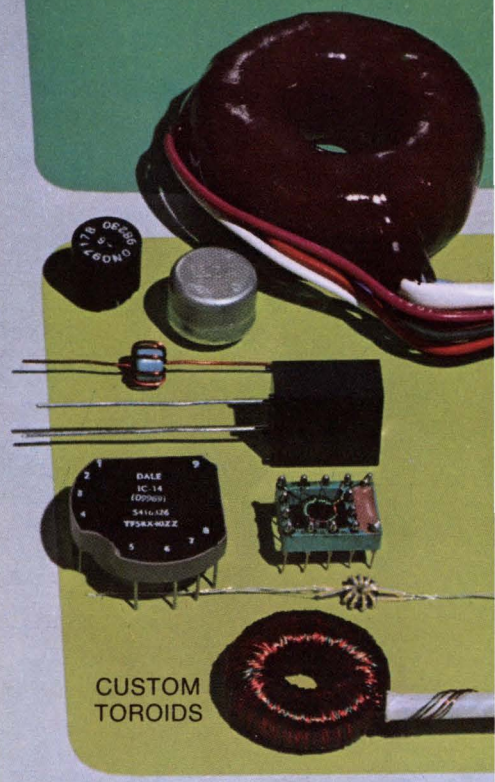
DALE®

COIL COUNTRY

CUSTOM BOBBIN COILS





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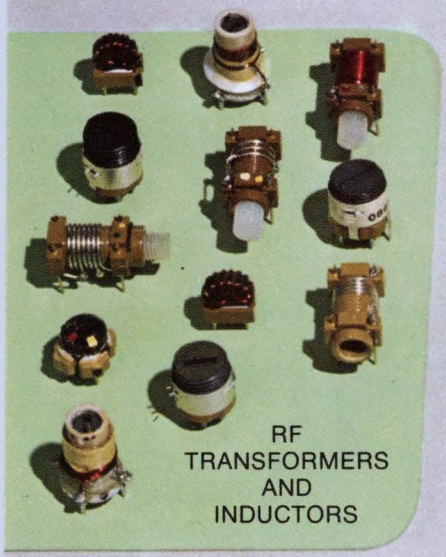
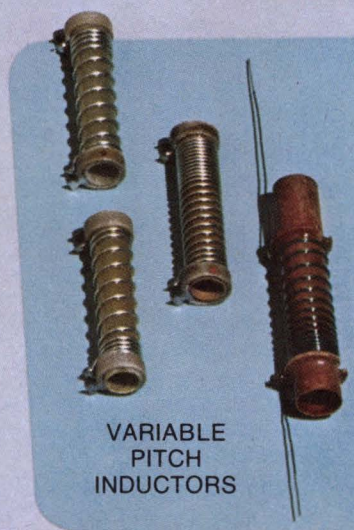


RF TRANSFORMERS AND INDUCTORS

New High Q Toroids

Now PC-mount toroids designed to meet MIL-T-27C are part of Dale's growing standard inductor line. Two epoxy encapsulated styles: TE-2 (.437d x .270h) and TE-3 (.685d x .385h) conform to Type TF5SX20ZZ. Inductance range: .05 mh to 400 mh; Frequency: Audio to 5 mHz. *And there are more styles coming* to meet your applications for wave filters, frequency discriminators, DC power supplies and loading coils. Give Dale a shot at your next toroid requirement. Standard or special, you'll find there's plenty of time and money to be saved in Coil Country.



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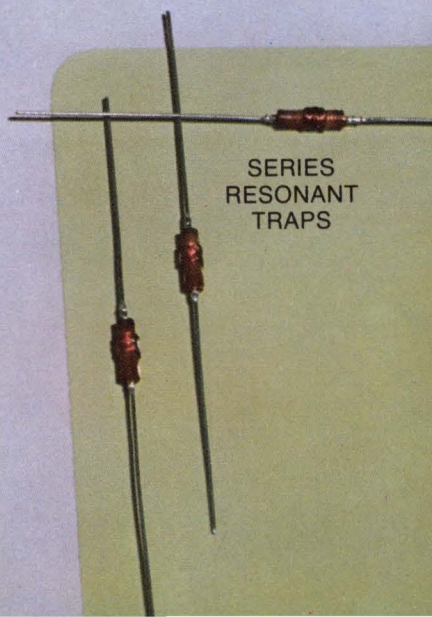

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Box 180, Yankton, South Dakota 57078
In Canada: Dale Electronics Canada, Ltd.
A subsidiary of The Lionel Corporation

INFORMATION RETRIEVAL NUMBER 102

COMPARE!
In cost-effectiveness, RCA 1" Vidicons outperform 1" lead-oxide types!

CAMERA USERS' AND DESIGNERS' GUIDE

Cost-Effective Factors	RCA		Registered Tmk XQ1070 Series	
Tube Type	8507A	7735	16XQ	16XQ-IG
Resolution (MTF at 400 lines)	60%	45%	30%	30%
Sensitivity at 0.1 fc	100 nA	100 nA	100 nA	100 nA
Automatic Sensitivity Control	Yes	Yes	No	No
Gamma Matched to Picture Tube Characteristics	Yes	Yes	No	No
Cost*	$190	$110	$1730	$ 810

*Optional Distributor Resale Price

Add to this the typical life of 10,000 hours for a Vidicon at a cost of about 2¢ per hour. In educational and industrial CCTV, RCA Vidicons offer a combination of performance, reliability and low cost that lead-oxide types just can't meet. Take a look at the chart. Compare. Make your own decision.
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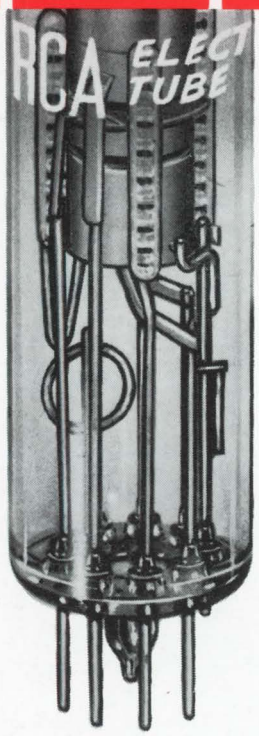

RCA