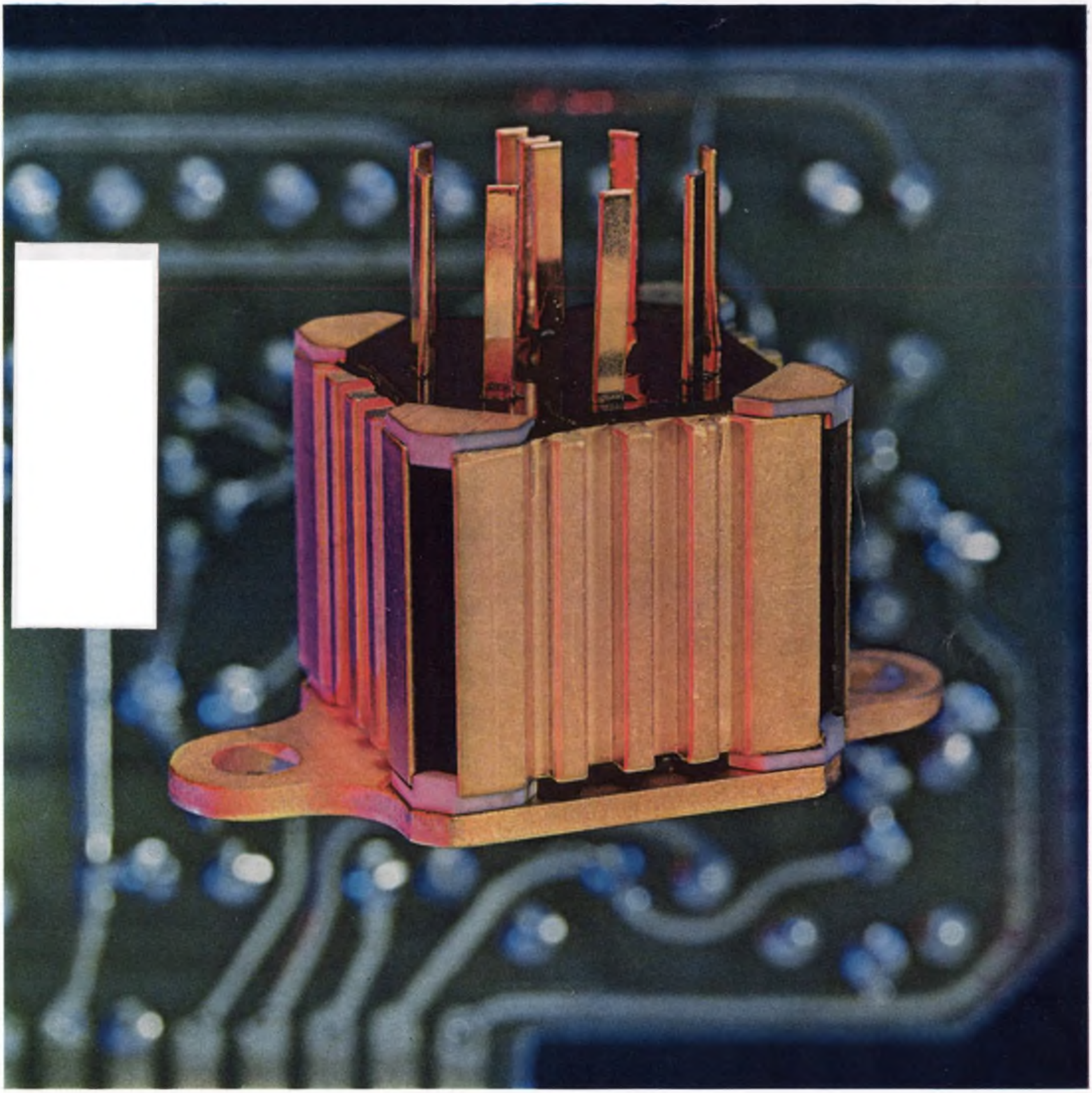
Electronic Design

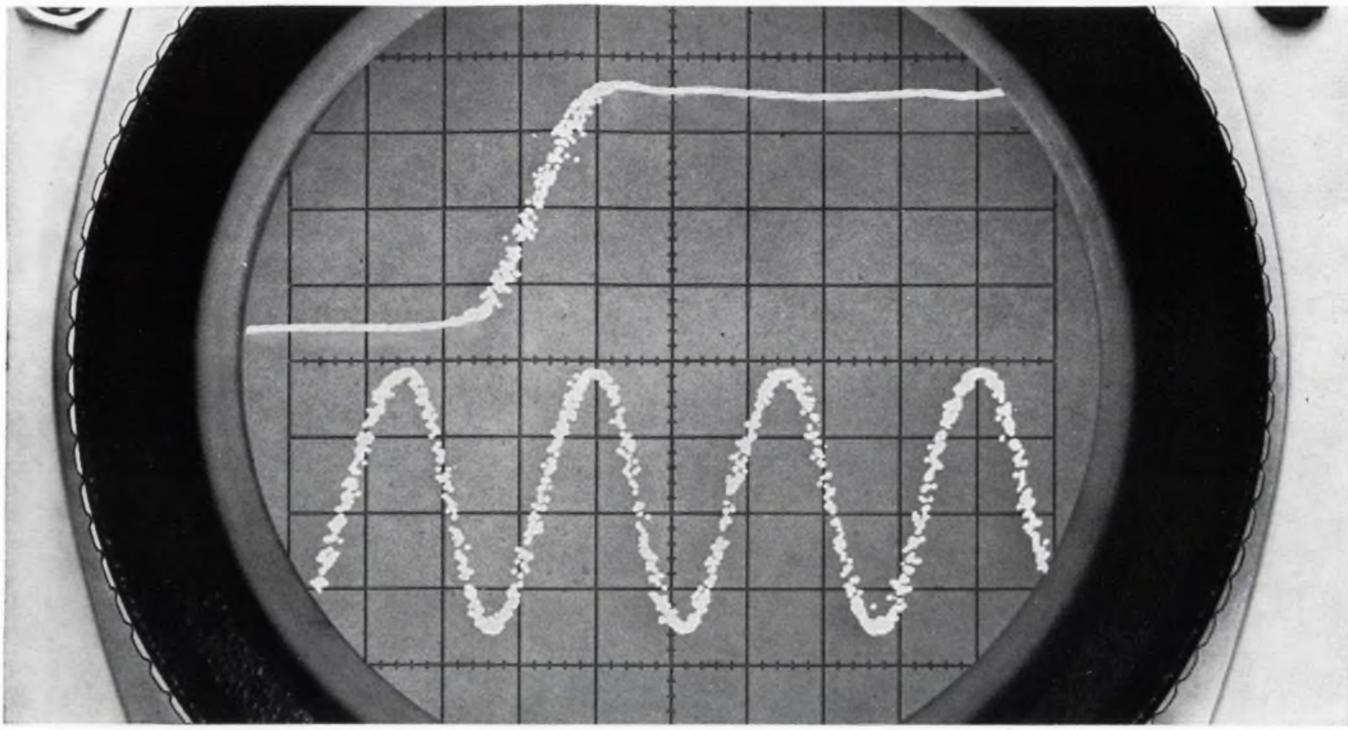
VOL. 15 NO. 14

FOR ENGINEERS AND ENGINEERING MANAGERS.

JULY 5, 1967

Power circuits in a tiny cube supply 30 to 100 watts. All five members of the family—inverters, converters and regulators—are in this unique new half-cubic-inch package. The electrically isolated 'terminator-dissipators' serve as mechanical housing, terminations and heat dissipators. For a look at some cubic art, see page 130.





Put this new design window in your lab

SEE WAVEFORMS TO 12.4 GHz & BEYOND

For the first time, you can directly see 12.4 GHz phenomena, 28 psec rise time pulses, delayed sweep displays, and 40 psec TDR. And, for an encore, this new sampling scope system gives you less than 20 psec jitter for sharp displays, automatic triggering for fast easy trace set-up, and remote samplers which monitor fed-through signals with minimum loading. Time difference between channels is less than 5 psec for accurate phase measurements. You can build your system around the field-proven 140A mainframe (or the stop-action 141A with variable persistence and storage) using these all solid-state plug-ins:

NEW DUAL-CHANNEL 1411A VERTICAL AMPLIFIER functions with any of three dual-channel remote samplers, with sensitivities to 1 mv/cm: (1) Model 1430A with 28 psec rise time for optimum pulse response; (2) Model 1431A, DC to 12.4 GHz with an extremely flat bandwidth and low VSWR (1.4:1 to 8 GHz, 2:1 at 12.4 GHz); and (3) Model 1432A with 4 GHz bandwidth, 90 psec rise time. Additional versatility is provided by front panel recorder outputs, and A vs. B mode for accurate phase measurements. Price of the 1411A Vertical Amplifier: $700. Samplers: $3000 for 1430A and 1431A; $1000 for 1432A.

NEW 1425A TIME BASE & DELAY GENERATOR, first with delayed sweep sampling, gives sharp, jitter-free magnification of complex signals or long pulse trains. It provides maximum sweep speeds of 10 psec/cm, triggering to 1 GHz and delay times as long as 5 ms. Straightforward control nomenclature and layout make it easy to use. So does automatic triggering, push-button return to X1 magnification and an intensified dot which locates the expansion point for you when setting up a magnified trace. $1600.

Also available: Model 1410A Vertical Amplifier with 1 mv/cm at 1 GHz ($1600), 1104A/1106A Countdown for triggering to 18 GHz ($750), and 1105A/1106A 20 psec Pulse Generator ($750). Mainframe prices: 140A, $595; 141A, $1395. With the versatile hp 140 Scope System, you get *better performance in any direction:* 20 MHz wideband • TDR • high-sensitivity with no drift • variable persistence and storage – *and sampling.*

Get complete specs on the new hp sampling oscilloscopes. Write or call Hewlett-Packard, Palo Alto, California, 94304. Phone (415) 326-7000. In Europe: 54 Route des Acacias, Geneva.

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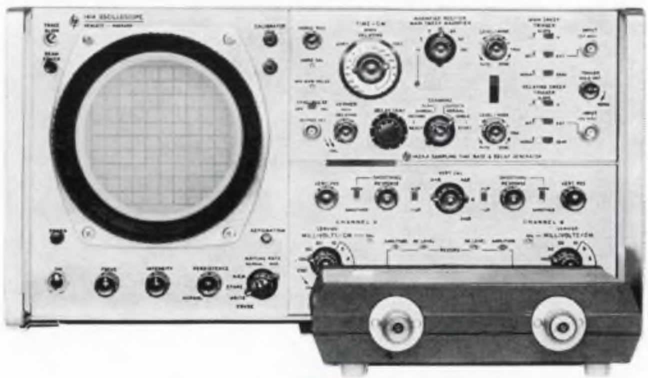

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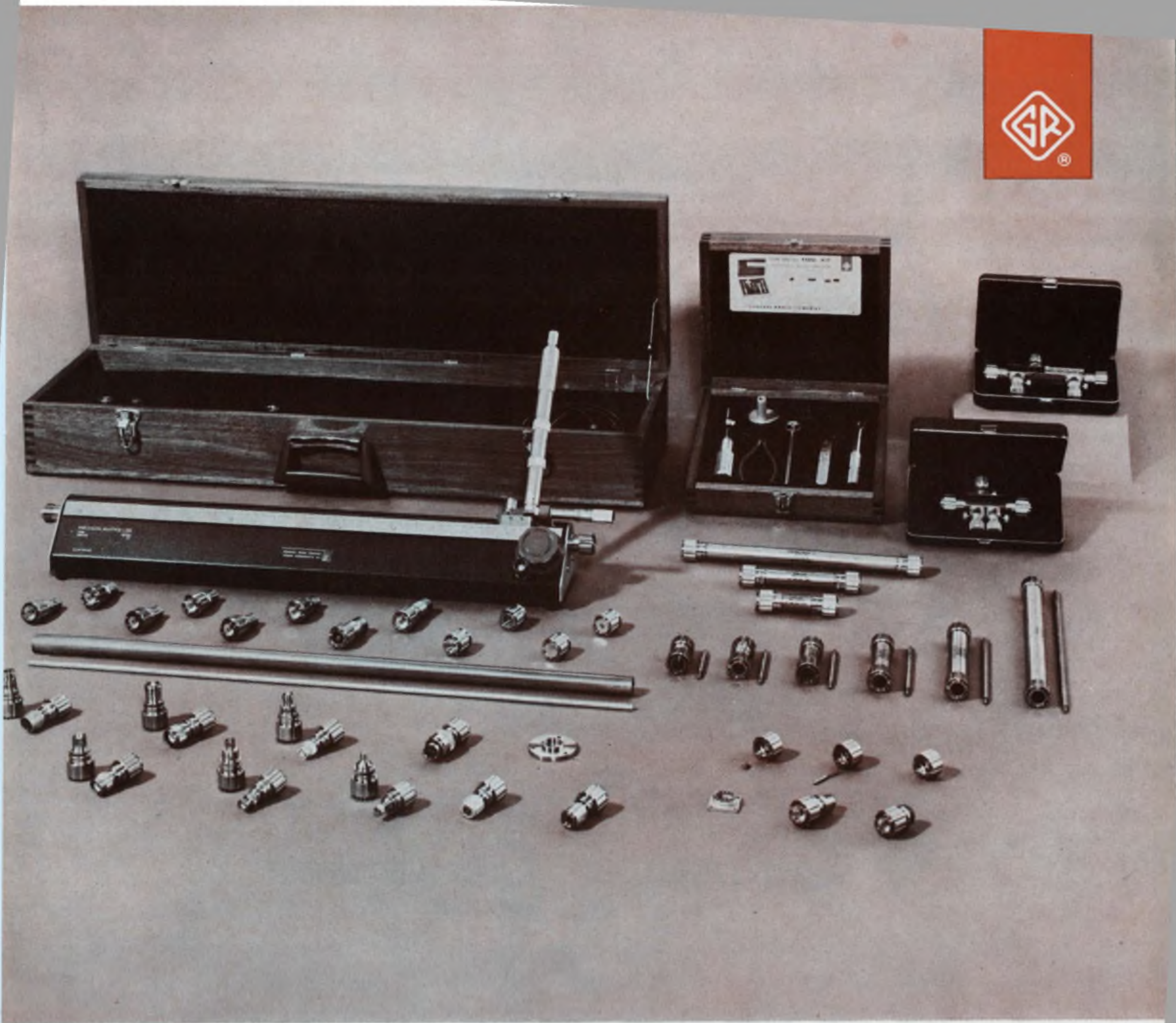
An extra measure of performance

ON READER-SERVICE CARD CIRCLE 232



Electronic Design 14

VOL. 15 NO.

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JULY 5, 1967

NEWS

TECHNOLOGY

PRODUCTS

Departments

ELECTRONIC DESIGN is published biweekly by Hayden Publishing Company, Inc., 850 Third Avenue, New York, N. Y. 10022. James S. Mulholland, Jr., President. Printed at Poole Bros., Inc., Chicago, Ill. Controlled-circulation postage paid at Chicago, Ill., and New York, N. Y. Application to mail at controlled postage rates pending in St. Louis, Mo.

62,558 copies this issue.

Growth of good basic design makes hp oscillators

YOUR BEST CHOICE FOR A WIDE VARIETY

Hewlett-Packard Oscillators are the progressive growth of the first successful Wien-bridge oscillator design introduced to the measurement industry by Hewlett-Packard in 1939. Now you can select from a variety of fifteen hp instruments using improved components and the well-known Hewlett-Packard RC oscillator design to give you the best price-to-performance ratio on the market! Choose from frequency ranges of 1 Hz to 10 MHz.

General Purpose Oscillators.—The *hp Model 200CD* is a direct descendant of the first Wien-bridge design. With its low price, high power, balanced output and low distortion, the 200CD is an ideal instrument for school, communications and military use.

You get a fully-transistorized and battery-powered signal source with easily-portable *hp Model 204B*. Amplitude and frequency control circuits give excellent stability over a range of 5 Hz to 560 kHz. You also get a completely floating output, isolated from chassis and ground. The 204B is ideal for field use.

Test Oscillators.—The *hp Model 651B* Test Oscillator is an advanced design, wide-band, solid state test oscillator! This line-operated instrument gives you a wide frequency range of 10 Hz to 10 MHz with highly stable amplitude and frequency. There are separate 50Ω and 600Ω calibrated outputs. A 75Ω output is optional.

Battery-powered *hp Model 208A* Test Oscillator is a compact, lightweight, easily-carried laboratory or field source of 5 Hz to 560 kHz signals.

Pushbutton Digital Oscillator.—For your production line or wherever you have repetitive testing, the hp Model 241A Oscillator gives positive pushbutton frequency selection from 10 Hz to 1 MHz. You get repeatable test sigals with three-digit frequency resolution. Set 4500 discrete frequencies!

A Pick hp Model 200CD Oscillator For A Low-Cost, General Purpose Instrument

— When you need a low distortion signal independent of load—you'll get excellent results with hp Model 200CD Oscillator! Use it for generating subsonic to radio frequencies; testing servo and vibration systems; supplying medical and geophysical equipment; for checking audio circuits and systems.

The output of the 200CD is 600Ω balanced, with a balanced accuracy of 0.1 to 1%, depending on frequency. Accurate frequency settings over a range of 5 Hz to 600 kHz are possible with the 85 dial divisions, effective scale length of 78 inches, and a vernier drive for precise adjustment. Frequency response is ±1 dB over the entire range.

Distortion rating of sinewave output is less than 0.2% below 200 kHz. The modified hp Model H20-200CD provides a low distortion of 0.06% in the 60 Hz to 50 kHz range.

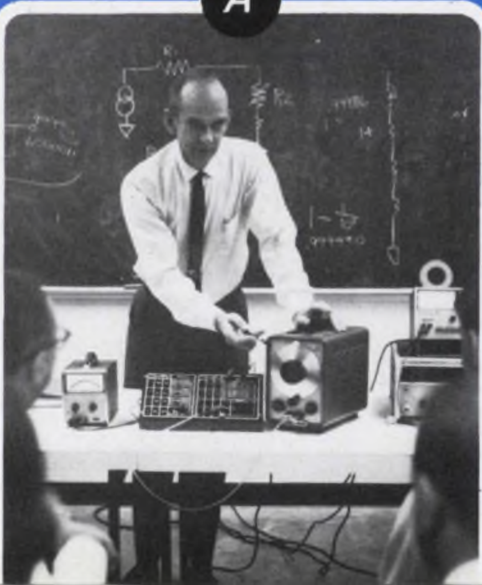
For excellence in design in a general purpose oscillator, pick hp Model 200CD. Price is only $225.00

B Pick hp Model 204B Oscillator for Portable, Highly-Stable Signal Source

Solid-state, battery-powered hp Model 204B Oscillator is an excellent choice for a source of stable, accurate signals in the field. You have an unusually low

B

A



C

OF LOW COST, SUPERIOR SIGNAL SOURCES

drift on warm-up; instantly available signals over a frequency range of 5 Hz to 560 kHz!

Stability is typically better than 5 parts in 10^4—even at 560 kHz! Rapidly changing loads do not affect stability. Output is fully floating, flat within ±3% at all settings of the dial and range switch.

Price of the hp Model 204B: Equipped with mercury batteries, $315.00; with ac power supply in place of batteries (Option: 01), $350.00; with rechargeable batteries and recharging circuit self-contained for ac or dc operation (Option: 02), $390.00.

C Pick hp Model 651B Test Oscillator for Accurate 10 MHz Frequency Range

— Outstanding flatness, stability and accuracy from 10 Hz to 10 MHz are yours with the hp Model 651B Test Oscillator. You get a typical ±0.1% amplitude stability and ±0.02% frequency stability, and a 1% accurate 90 dB output attenuator.

The 651B has two outputs: 200 mW into 50Ω, and 16 mW into 600Ω. Output attenuator has a 90 dB range in 10 dB steps, with a 20 dB coarse and fine amplitude controls for increased resolution in setting output voltage. Attenuator accuracy is ±0.1 dB from −60 dBm to +20 dBm, ±0.2 dB on −70 dBm range. Output monitor is calibrated to read volts or dBm into a matched load. Price: hp Model 651B, $590.00.

652A: The hp Model 652A is identical to 651A, with the additional ability to monitor output amplitudes within 0.25% over the entire frequency range of the instrument using the X20 expanded scale. Uppermost scale of the 652A reads in percent for quick reading of frequency response measurements. Price: hp Model 652A, $725.00.

652A Expanded Scale Monitor

208A: Add a meter for accurate setting of output voltage and an attenuator to the 204B, and you have the hp Model 208A Test Oscillator. Model 208A is calibrated in volts, covering 0.01 mV to 1 V full scale with a 2.5 multiplier to extend range to 2.5 V. Model 208A (Option: 01) is calibrated in dBm for 0 to 110 dB in 1-dB steps. Output is constant within ±3% at all attenuator settings over 5 Hz to 560 kHz range. Price: hp Model 208A, $525.00; hp Model 208A (Option: 01), $535.00.

D Pick hp Model 241A Oscillator for Pushbutton Repeatability

— Repeatability possible with the hp Model 241A digital oscillator makes it ideal for production line use—or in the laboratory where repetitive testing is a requirement. Set any frequency between 10 Hz and 999 kHz to three significant figures—simply by pushing buttons! This solid state instrument is designed with special hp precision resistors to provide typical frequency repeatability of 0.01%. Frequency accuracy is within ±1% selected value on any range.

Infinite frequency resolution is provided by a vernier control, which also extends the upper frequency to 1 MHz. Output is flat within ±2% over the entire range at any attenuator setting.

Use the 241A as a digital frequency source for filters and frequency sensitive circuits. Response test at audio and communication frequencies, or use it as a repeatable source in production testing. Price: hp Model 241A, $490.00.

For full details on the wide variety of hp oscillators shown here and in our catalog, call your nearest hp field engineer. Or, write to Hewlett-Packard, Palo Alto, California 94304, Tel. (415) 326-7000; Europe: 54 Route des Acacias, Geneva.

	200CD	204B	208A	651B	241A
Frequency	5 Hz to 600 kHz	5 Hz to 560 kHz	5 Hz to 560 kHz	10 Hz to 10 MHz	10 Hz to 1 MHz
Frequency Response (Rated load)	±1 dB	±3%	±3%	±2% to ±4%	±2%
Accuracy	±2%	±3%	±3%	±2%, ±3%	±1%
Output	10 V, 160 mW/600Ω, balanced	2.5 V, 10 mW/600Ω, floating	10 mW, nominal 2.5 Vrms (+10 dBm/600Ω), floating	3.16 V, 200 mW into 50Ω 16 mW into 600Ω, floating	2.5 V, +10 to −30 dBm/600Ω floating
Distortion	0.2% to 0.5% (200CD) 0.06% to 0.5% (H20-200CD)	<1%	<1%	<1% to 2% MHz, 2% at 10 MHz	<1%
Price	200CD, $225.00 H20-200CD, $250.00	204B, $315.00	208A, $525.00	651B, $590.00 652A, $725.00	241A, $490.00

ON READER-SERVICE CARD CIRCLE 4

097/10R

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Use Algebra?

$$V_{INST} = V_{DC}\left(1-e^{-\frac{Rt}{L}}\right)$$

$$\omega = \frac{1}{\sqrt{LC}}$$

$$R_E = \frac{R_1 R_2}{R_1+R_2},$$

Use FORTRAN.

```
VINST=VDC*(1-EXP(-R*T/L))
OMEGA=1/SQRT(L*C)
RE=R1*R2/(R1+R2)
```

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For example, the algebraic step response equation above is practically written in FORTRAN already. To solve the problem you state: VINST=VDC*(1−EXP(−R*T/L)). Then just enter the data. The computer does the rest. Leaving you with more time for engineering. Engineering the way you've always wanted it to be. With more freedom of design and more confidence in meeting deadlines.

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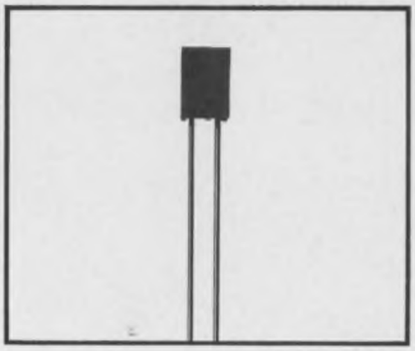
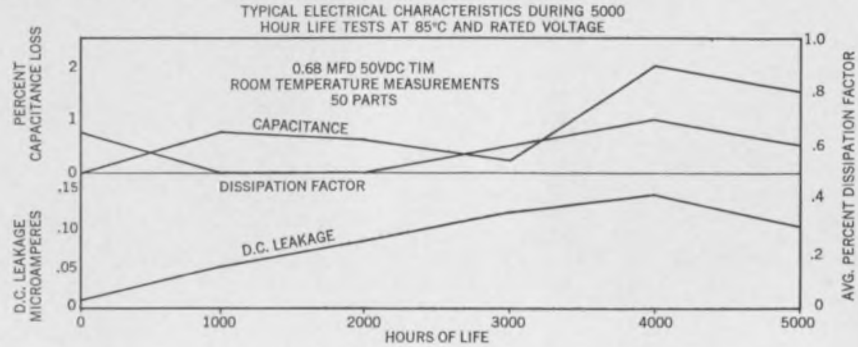
DESIGNER'S

P. R. MALLORY & CO. INC., INDIANAPOLIS, INDIANA 46206

Rectangular case molded tantalum capacitor takes minimum space on circuit boards





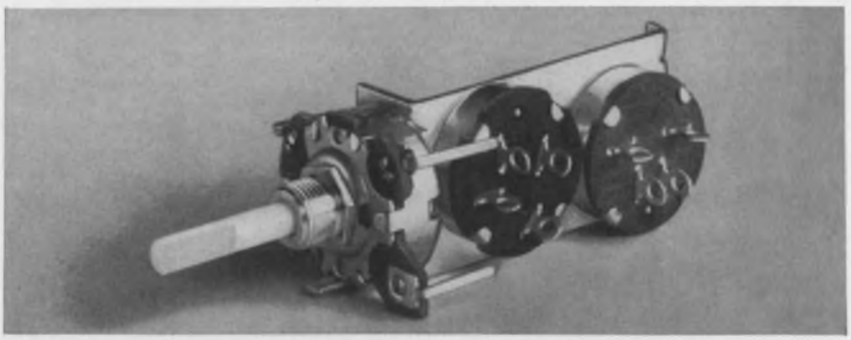
The new TIM miniature solid tantalum capacitor comes in a fully molded epoxy case in rectangular configuration which affords maximum efficiency of space utilization on printed circuit boards. The single standard case size measures .345″ by .288″ by .105″ thick. Stand-off ribs are molded into the base to permit ease in soldering in printed circuits. Parallel leads are spaced .125″ apart, fitting the newer printed circuit designs. The small, uniformly sized case is well suited for automatic insertion.

This new capacitor meets exceptionally high standards of performance and reliability. Tests of 5000 hours, both for high temperature life and humid life, demonstrate the TIM's excellent stability of capacitance, DC leakage and dissipation factor . . . all of which stayed well within specification limits.

Standard ratings extend from 12 mfd, 3 WVDC to .68 mfd, 50 WVDC. Standard capacity tolerances are ±20% and ±10%. The TIM is now in high volume production at attractive price.

CIRCLE 105 ON READER SERVICE CARD

Special control and switch for "instant-on" color TV



This "instant-on" control and switch for color TV demonstrates Mallory's ability to engineer and produce special assemblies to meet the requirements for specific applications in a variety of electrical and electronic products.

The assembly has two side-mounted DPST switches. In the "off" position, reduced voltage is applied to heaters, and pilot light and B+ voltages are cut off. In the "on" position, normal voltages are applied to all circuits. Switch action is push-pull.

Both switches are the Mallory type OAC, with proved long life and reliability. Switch ratings can be any desired combination of 2, 3, 5, or 6 amperes, 125 volts AC. This configuration can be supplied attached to any Mallory single or dual carbon control. We welcome inquiries for special assemblies, on your company letterhead.

Extreme high and low values available in Mallory controls

Need a 100-megohm carbon control? Or a 50-ohm? You can get them from Mallory. And practically any value in between. All of them have the unique hard-surface Mallory element that consistently gives 100,000 cycles of rotational life. A broad range of standard and special designs can be supplied promptly.

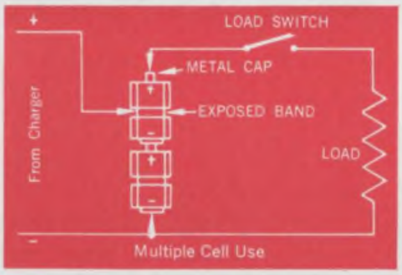
CIRCLE 106 ON READER SERVICE CARD

FILE MALLORY

The Rechargeable Batteries You Can Afford

New Duracell® rechargeable alkaline batteries. These are the batteries that will make a new generation of battery-operated devices possible. Because this battery now exists, portable TV sets, radios, phonographs, tape recorders and transceivers can be designed to function at lower operating costs.

The low initial cost of the rechargeable alkaline batteries is one reason why they promise so much for new designs. Another reason is their unique exposed band contact. It lets you design battery-operated equipment with built-in rechargers that automatically prevent charging when a primary cell is in the circuit. (See schematic.) This means that, when necessary, any primary battery can provide the power.



But that's not all. Duracell alkaline rechargeable batteries are lighter than most rechargeables. They come fully charged. They're available in 3 standard sizes, "D", "C" and "AA". And one glance at the discharge-cycles graph will tell you how little they cost to operate.

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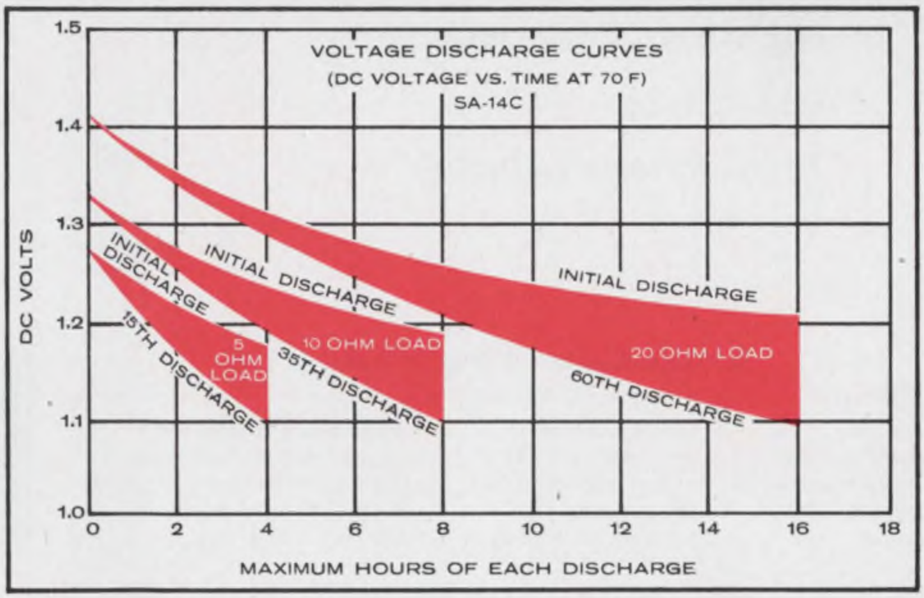
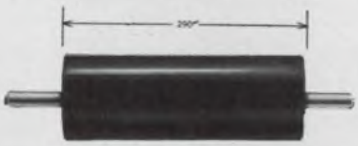


New molded-case miniature solid tantalum capacitors



New Type TAC solid electrolyte tantalum capacitors give you, in molded case construction, nearly twice the CV ratings per cubic inch that you can get in MIL-C-26655 metal case solids. They have a fully molded epoxy case only 0.105″ in diameter by 0.29″ long, precisely molded to facilitate automatic insertion.

Extended life and humidity tests indicate performance of the TAC is exceptionally high. You can use them with confidence anywhere you need a solid tantalum capacitor, including MIL specification environments.

Standard temperature rating is —55°C to +85°C; can go to +125°C with voltage de-rating of 33%. Values range from 18 mfd., 3 WVDC to .47 mfd., 50 WVDC.

CIRCLE 107 ON READER SERVICE CARD

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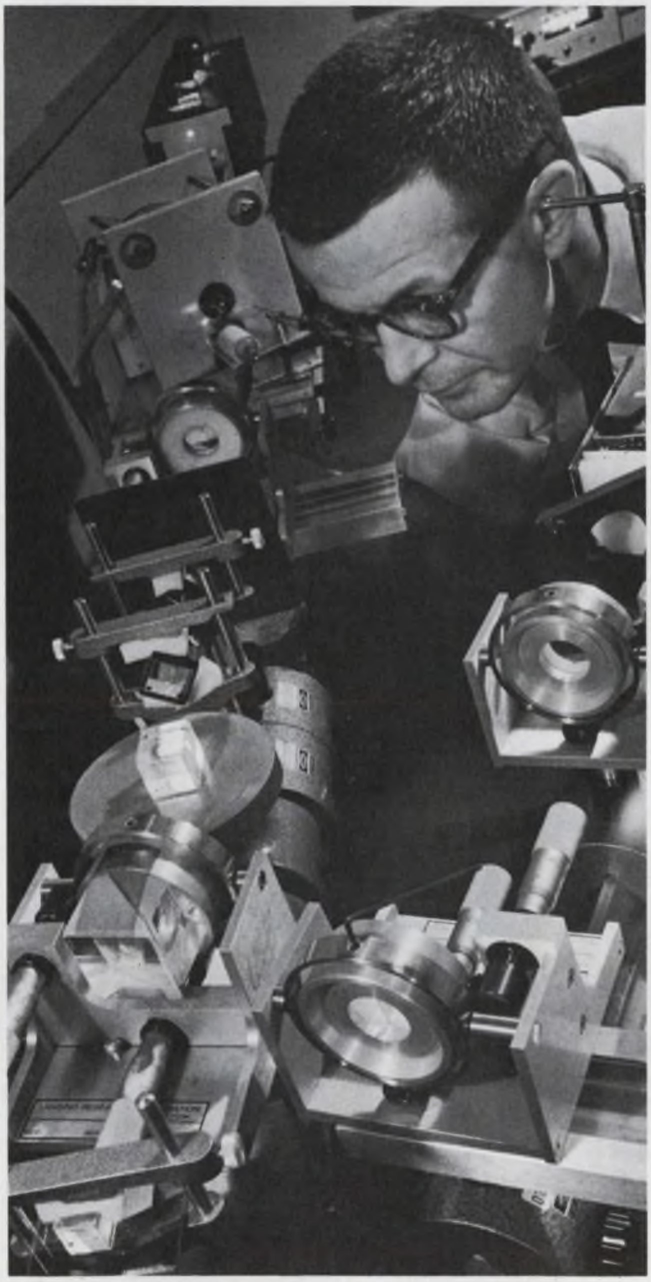
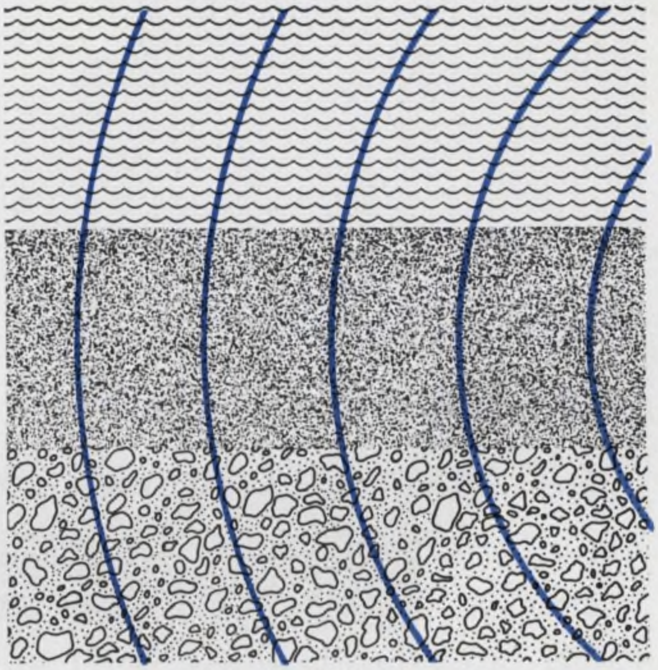
ON READER-SERVICE CARD CIRCLE 7

News



Subnanosecond laser pulses may advance art of optical ranging and computation. Page 17



Army studies use of soil, water, rails and skin for transmitting wartime messages. Page 22

Low-cost graphic display being tested for use with computer time-sharing 'utilities.' Page 36

Also in this section:

'Flame laser' uses burning CO to excite CO_2 in a sealed tube. Page 26

IR light emitted from two lasers in a cane helps the blind to 'see.' Page 44

Rainfall data may guide the siting of microwave facilities. Page 48

News Scope

Telephone networks claimed ready for future computers

The telephone and telegraph companies are ready and able to meet the growing demands for computer data transmission, according to a senior scientist of Bell Telephone Laboratories, Inc. Dr. John Pierce told a recent IEEE conference on communications in Minneapolis that the Bell System "is working hard to meet the varying and growing needs for digital transmission with the extensive communication network now in existence."

His comments followed in the wake of some impatience expressed in industry at the slowness of the common carriers in responding to the needs of computer-data transmission.

Dr. Pierce, an executive director at Bell's Murray Hill, N. J., facility, said the use of the existing network "is certainly more flexible, faster and cheaper than trying to build a separate network which could be extensive enough to serve the small user and the large user alike."

Among current Bell projects that would benefit the computer industry, Dr. Pierce listed:

- Switched networks capable of handling 3600 bits per second.
- Private voice-grade lines capable of 7200 bits per second.
- Common-user, 50-kilobit switched network service.
- The conversion of analog telephone channels to digital channels able to carry ten times as much traffic as analog.

He reported that, though the leased line is cheaper, the switched telephone network is the most flexible form of common carrier. It is already in operation and is capable of "far greater than teletypewriter speed," he said. Data-Phone sets can now send 2000 bits per second, but in the near future will offer 3600 b/s, Dr. Pierce stated.

For regular service over specific routes, he said, private-line circuits now offer a 150-bit channel for devices that operate up to 150 words a minute. Private-line, voice-grade facilities, however, can handle bit rates in the 2000 to 2400 range and are capable of expansion to 7200 or more b/s, Dr. Pierce noted.

Bell is now working on a common-user 50-kilobit switched network to communicate between computers or terminal devices and a computer. This, according to the scientist, would have a capability 12 times greater than that of a voice-grade line. He believes this will meet present commercial requirements, but conceded that it may not match future government needs.

Discussing the economic aspects of transmission, he stressed: "The more one can send over one transmission system, the cheaper a given amount of transmission will be."

He looked to new coaxial systems, terrestrial radio networks and huge microwave satellite communications links as immediate goals. Further in the future, Dr. Pierce foresaw transmission of communications by coherent laser light through buried tubes.

He also predicted that future telephone transmission will be mostly digital. Bell, he said, would soon cover the entire state of Massachusetts with its T1 transmission systems. These can send 1.5 million binary pulses per second for distances up to 50 miles.

Mariner V spacecraft on course for Venus

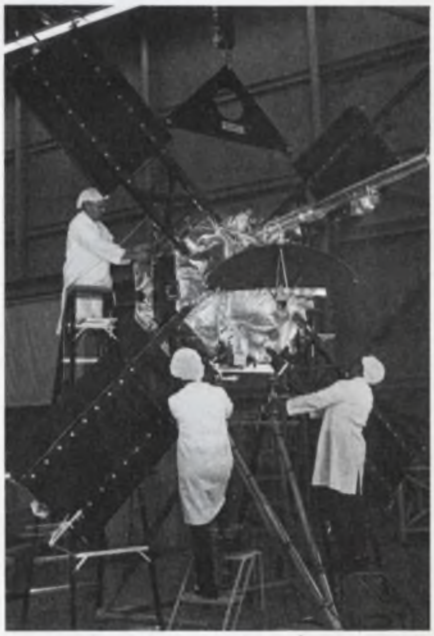
The 540-pound Mariner spacecraft launched earlier this month is "functioning beautifully" and is expected to rendezvous with Venus on October 19, according to a NASA spokesman.

Mariner V is now predicted to come within about 2500 miles of the planet on October 19, about seven times closer than Mariner II in December, 1962. The spacecraft's looping flight to Venus will cover nearly 217 million miles.

Mariner is trailing the Soviet Union's 2500-pound spacecraft, Venus 4, launched a couple of days earlier than Mariner. Experts believe that the Soviet spacecraft may be scheduled to reach Venus on Oct. 4, the tenth anniversary of the launching of Sputnik 1, or on Nov. 7, the fiftieth anniversary of the Bolshevik revolution. Others speculate that the Soviet craft will eject a landing capsule containing experimental devices. All the Soviet scientists said was that the spacecraft carries ultraviolet and infrared measuring instruments and will fly by the planet.

Experiments to be performed by Mariner V include investigations of the interplanetary magnetic field, the solar wind, charged particle fluxes, solar X rays and the abundance of electrons and hydrogen ions in space. When the spacecraft encounters Venus, additional experiments will investigate the concentration of hydrogen and oxygen in the planet's exosphere, the electron concentration in its ionosphere, the density of its atmosphere at various levels and the diameter and mass of the planet.

Of greatest interest to NASA scientists is the S-band occultation



Mariner V gets final checkup by NASA scientists before launch.

experiment, which aims to determine the density of the Venusian atmosphere.

This experiment is similar to that carried by the Mariner IV spacecraft. If it is successful, information gathered may be applied to the design of future Voyager missions to Mars and possibly Venus in the 1970s.

Sony shows 7-in. color TV with chromatron tube

A seven-inch portable color television set, which will incorporate the first commercial use of a chromatron picture tube in the U.S., will be marketed early next year by Sony Corp. of America

The receiver is 8 inches wide, 10 inches high and 13 inches deep. It weighs 18 pounds, operates on ac or with nickel-cadmium batteries and consumes less than 45 watts ac or 35 watts dc.

In the early days of television, the chromatron single-gun tube was in competition with today's three-gun color tubes as the industry standard, but it lost out because of production and financing problems. The chromatron tube, developed by Nobel prize-winner Ernest O. Lawrence, uses a grid of parallel wires rather than a shadow mask of tiny holes as in today's sets.

A company spokesman said that all production problems had been solved. Company engineers asserted that the chromatron system was about 85% efficient at emitting the color signal within the tube as opposed to about 15% to 18% in the three-gun tube.

Communication Satellite is planned in Europe

Comsat may be a highly useful communications link to many countries, but France views the satellite system as a U.S. tool.

Then why not develop her own communications satellite? France might like to, but it would cost too much.

The upshot has been a compromise arrangement: France and West Germany have formed a partnership to develop and launch a joint communications satellite. Called Symphonie, it is to be shot into space in late 1970.

A Europa H rocket and a launching station under construction in French Guiana are to be used. The satellite's period of rotation is due to coincide with the earth's, to keep Symphonie in synchronous orbit over the equator.

In that position, the satellite will be able to beam radio, TV, telephone and telegraph messages within Europe and betwen Europe and Africa, the Middle East and the eastern parts of North and South America. The West Coast will be out of range.

The cost of the project has been estimated unofficially at slightly more than $40 million, to be shared equally by France and West Germany.

Other countries have been invited to join the system. And one objective seems clear: Symphonie will enhance the European bargaining position when Comsat renegotiates its rights abroad in 1969.

RCA expands in Italy as color TV grows

A boom in color television is expected to start in Europe this year, and the Radio Corp. of America is moving to share in it. The company has announced the formation of RCA Colore S.p.A. in Italy to manufacture and sell color-Tv tubes to the member nations of the European Common Market.

The new enterprise is RCA's second expansion in Europe in the last year. Last August it announced plans to manufacture color tubes in Britain.

Several European countries are expected to begin color telecasts before the end of this year. They will include West Germany, the United Kingdom, France, Spain and the Netherlands.

RCA's president, Robert W. Sarnoff, forecasts that sales of color-TV sets will reach 300,000 by next year, nearly a million by 1970 and about 3.5 million by 1975.

"RCA's expansion program," he say, "is based on our belief that color television will develop in Europe along the same lines as in the United States."

Amateur radio producers group to merge with EIA

The Amateur Radio Industry Association, whose members represent firms producing about 90% of the nation's ham equipment, voted to merge with the Electronic Industries' Association.

The ARIA steering committee, comprising some 20 manufacturers of amateur gear, took the preliminary steps at a recent meeting with the representatives of the EIA.

As EIA members, the ARIA firms will be eligible to participate in activities of EIA Marketing Services, Engineering, International and Industrial Relationships departments.

New thesaurus to list 23,000 technical terms

A standard thesaurus of engineering and scientific terms used by the military, industry and the academic world will be published in September by the Dept. of Defense in conjunction with the Engineers' Joint Council.

The 1000-page volume, called *Thesaurus of Engineering and Scientific Terms*, will list more than 23,000 main terms, with generic relationships, cross-references and indexes. The new volume is intended to replace the *Thesaurus of Engineering Terms* issued by the Engineers' Joint Council in 1964.

Copies of the new volume can be ordered from the Engineers' Joint Council, 345 East 47 St., New York, N. Y. 10017. The price is $19.50 for a soft-cover version and $25 for the hard-cover. A magnetic-tape version with programs for computer manipulation will also be available.

Patent Office planning new abstract journal

A new abstract journal planned by the U.S. Patent Office will give scientists and engineers a fast review of the technical content of all patents. A prototype issue of the journal will be published around Oct. 1.

Commissioner of Patents, Edward J. Brenner, invited anyone who was interested to write for a copy "and give us the benefit of your appraisal of its usefulness and suggestions for its improvement."

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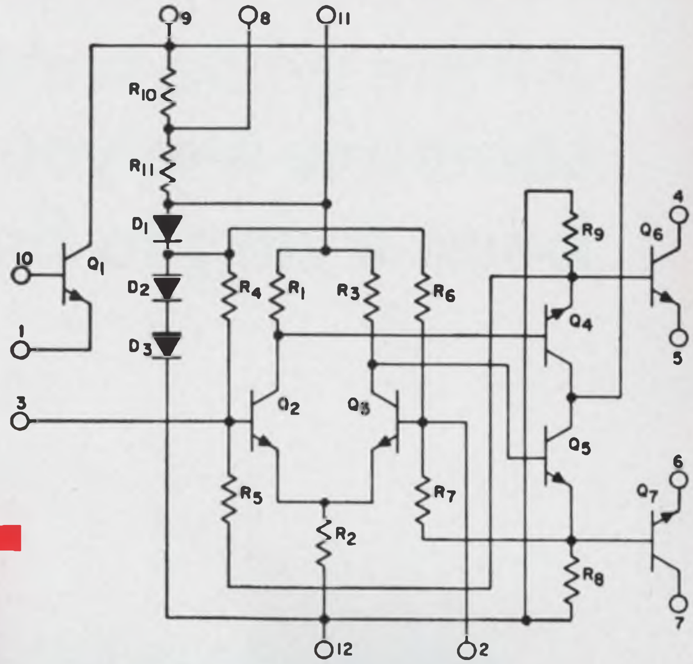

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Picosecond light pulses go begging

Electronic applications of ultrashort laser bursts await design of faster detectors and oscilloscopes

Richard N. Einhorn
News Editor

Laser systems capable of generating optical pulses less than 1 picosecond wide—the shortest events ever produced by man—may usher in a new era of technology in which electrical and physical measurements are improved by orders of magnitude. They may well provide resolution for optical radar and range-finding down to 0.03 cm over a distance of miles. They may even make possible computer elements with dump rates approaching 10^{12} bits per second and binary logic in time sequences on the order of 10^{-12} seconds.

Sheer conjecture? Hardly. Pulses almost this brief are being generated in many U.S. laboratories and also, it is reported, in the Soviet Union. One group at United Aircraft Research Laboratories, East Hartford, Conn., has measured 4-ps pulses directly using an optical correlation technique. A lower limit of 10^{-13} seconds for pulse generation has been predicted—equal in length to only 30 optical cycles. The U.S. Army Research Office is said to be so interested in the subject that it is planning a conference devoted to the theory and application of ultrashort pulses.

Dr. Charles H. Townes, who shared in the 1964 Nobel prize for physics for his role in pioneering the maser, commented recently on these innovations:

"In the long run, I think, short optical pulses will be very useful for optical memories, for coding and for communications. But it will require a long process of engineering development before we have other devices that will respond electrically to such short pulses.

"If devices that detect or utilize them are slow, then we can't take full advantage of them. However, now that we have these very short pulses, perhaps the other devices can be made better or faster."

This discrepancy in speed between state-of-the-art optical and electrical devices was illustrated by Anthony J. DeMaria, principal scientist, quantum physics, at United Aircraft:

"We put pulses of 1 to 10 picoseconds into special photodiode detectors. Coming out of the diodes are electrical pulses of the order of 90 ps at the half intensity point, with amplitudes of 60 volts, occurring, say, every 1 or 2 ns.

"When the output of our detectors is fed to a standard 1-GHz traveling-wave oscilloscope (Tektronix 519), we cause the scope to ring. Our pulses are even faster than a specially modified 519, which is said by the manufacturer to have a rise-time of 135 ps and a frequency response of 3 GHz."

Thus, generation of ultra-short pulses is pushing the technological limits of both photodetectors and traveling-wave oscilloscopes.

Generating these ultrashort pulses requires special equipment. Bell Telephone Laboratories uses CO_2 lasers in its experiments. Soviet scientists seem to favor semiconductor lasers at present, and have reported measuring down to 10^{-11} seconds.

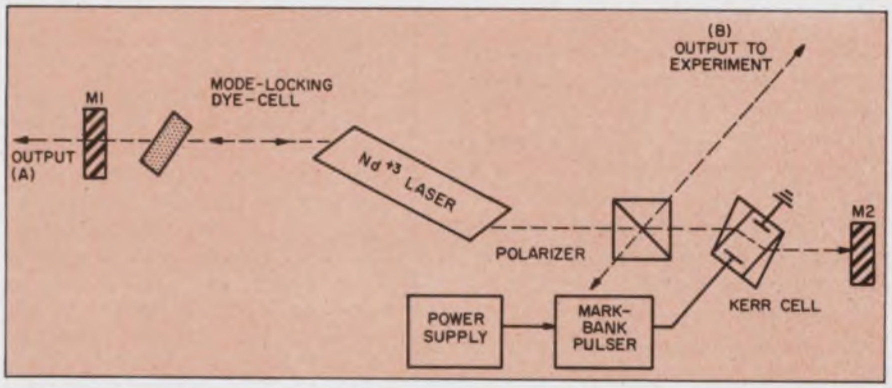
Q-switching improved

Up to now, the narrowest pulse widths obtainable with standard *Q*-switching techniques have been limited to approximately 10 nanoseconds because of the requirement for one or more passes through the active medium in order to build up the laser pulse. DeMaria[1] describes United Aircraft's technique for overcoming these problems.

His source is a *Q*-switched Nd^{+3} doped glass laser. DeMaria claims that with a 16.5-cm-long oscillator and a 1-meter-long glass rod as an optical amplifier, his group has obtained peak powers of 3.7 and 9.4 x 10^{10} watts for durations of 20 and 8 ps, respectively—to the best of his knowledge the highest peak power so far reported by any laboratory.

A cell containing a saturable organic dye solution is placed inside the laser cavity (see Fig. 1). A Kerr cell and a polarizer (Glan prism) are also placed in the cavity. The Kerr cell is initially unenergized and the polarizer is adjusted for maximum transmission.

The Kerr cell is filled with a transparent material, which, when placed in a strong electric field, refracts doubly, and acts as a fast shutter for light beams. The dye cell is in effect a *Q*-switch as well as a passive amplitude modulator. As the pulse propagates through the dye cell, the leading edge is heavily absorbed and atoms jump from the ground state of a two-level quantum system to the excited state. As a result, the dye tends to saturate. This means that it attenuates high-amplitude portions of the pulse far less than the low-energy por-



1. **Subnanosecond pulses** generated by laser oscillator are shaped by dye cell which attenuates low-amplitude portions more than it does high-amplitude portions. Saturable organic dye acts both as modulator and as Q-switch.

(**ps pulses,** *continued*)

tions. Then the passive modulator opens.

After the pulse has propagated through the system, the atoms return to the lower energy state, and the modulator closes. Reflecting the pulse back and forth between the two laser mirrors, *M1* and *M2*, continually sharpens the pulse until the harmonic content equals the over-all band-width of the system. Once this occurs, the pulse has reached its limit of narrowness.

The cell, then, phase-locks harmonically related longitudinal modes, oscillating in the laser cavity, to produce a train of optical pulses of a width limited only by the bandwidth of the phase-locked amplifying system. This approach is known as mode-locking. The dye solution in the laser cavity automatically adjusts its modulating frequency to the round-trip transit time, τ, of pulses bouncing back and forth between the laser's mirrors. Such modulation requires that the relaxation time of the absorber be shorter than τ. In addition, it must have an absorption line at the laser wavelength and it must have a line width equal to or broader than the laser line width.

Laser pulses spark gaps

The leakage radiation from the polarizer is focused onto the first gap of a Marx-Bank pulse generator (see box). When all the gaps break down, a fast-rise-time quarter-wave voltage pulse is applied across the Kerr cell. With the Kerr cell energized, the polarization of the pulse is rotated 45° for each pass. The pulse is eventually routed from the cavity by the polarizer.

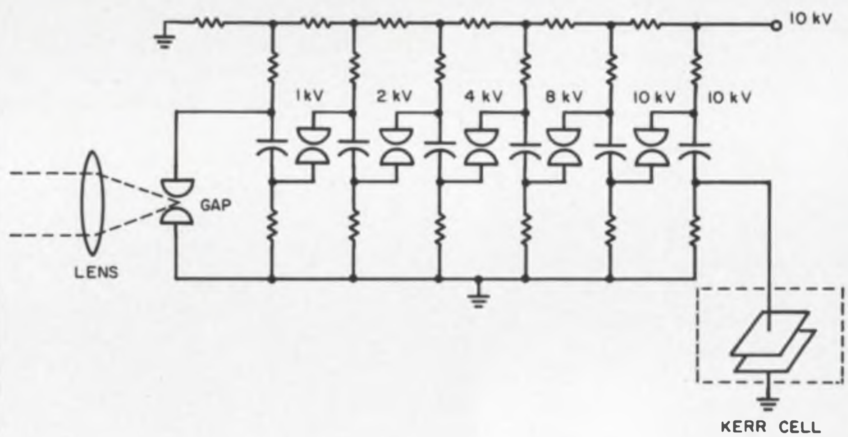
The glass Nd laser is well suited to the generation of ultrashort pulses. It has a spectral line that consists of three homogeneously broadened lines approximately 40 Å wide that are superimposed in a staggered fashion to yield a nonhomogeneously broadened line approximately 100 Å wide.

According to DeMaria, there are two reasons that a mode-locked Nd^{-3} glass laser should yield the highest available peak powers and the narrowest pulse widths:

- The peak power increases and the pulse width decreases as the number of phase-locked modes increases.
- Nd^{+3} in a glass host has the broadest line width of known laser media.

There are two other ways to mode-lock the laser oscillator than the use of passive modulators, DeMaria says. One is to use an active modulator; the other is to use the nonlinear gain characteristics of the inverted population. The former requires critical adjustment of mirror spacing and modulating frequency: the latter requires critical adjustment of the Q of the interferometer, the laser position and the gain of the system. Both of these methods also require compensation of the laser for optical-length perturbations of the feedback interferometer. This is crucial to the mode-locking of large solid-state lasers, owing to optical-length variation of the rods when the optical pumping flash occurs. Passive modulation, on the other hand, does not require any of these critical adjustments. *(continued on p. 20)*

Pulser races the speed of light



A device commonly used in high-energy physics experiments is now aiding the development of lasers that generate ultrashort pulses. The Marx-Bank generator, which delivers pulses with very short rise and delay times, enables the designer of a Q-switched laser to choose the region of an optical pulse train at which the system is to select a single pulse.

A Marx-Bank pulse generator is used to activate a Kerr cell, which is switched to maintain a laser-beam propagation medium in a low-Q condition. The circuit consists of an array of capacitors that are charged in parallel but discharged in series. A portion of the laser beam is focused through a lens, so that it breaks down an optical gap (analogous to a spark gap) from the top plate of each capacitor to the bottom plate of the preceding one. The resultant overvoltage propagates quickly down the chain (rise time of about 5 ns) until a high potential (10-50 kV) can be applied to the Kerr cell. The object is to "beat" the speed of light as it bounces back and forth between the laser mirrors, which are a fixed distance apart.

The discharge delay time of an overvoltaged spark gap is the sum of two components: the statistical time lag and the formative time lag. The first is the delay between the application of an overvoltage and the appearance of a free electron, which initiates a breakdown of the gap. The second is the time taken to establish a discharge current after the free electron has appeared.

The illumination of spark gaps in most Marx-Bank circuits comes from the preceding discharges of adjacent spark gaps: the first gap illuminates the second, the second illuminates the third, and so forth. This will work, according to United Aircraft scientists, if the spark spectrum of the electrode material includes wavelengths that are capable of generating photoelectrons of that material.

Better monolithic I. C. modules: Sometimes it pays to wait.

Even DIGITAL waited. Until now, despite the technological accomplishment, there was just no way to get the cost and performance of I.C. modules significantly less than the cost and performance of discrete component modules.

But things have changed. DIGITAL will deliver, in August, a new line of integrated circuit modules — functional logic arrays of high speed TTL's in dual in-line packages, designed to operate from dc to 10 MHz. The module line encompasses every basic system function, and features high fan out, high capacitance drive capabilities, and excellent noise margins.

Waiting has had these advantages: the I.C.'s are the latest, best, least expensive. Cost vs. performance are now vastly improved for the first time. Lowest cost per gate, for example. The technology of dual in-line TTL's has assets not available in previous I.C. modules.

The boards are identical in size to the FLIP CHIP™ modules, but with 36, rather than 18, pins. Pin sockets and mounting panels, as well as other standardized hardware, are available. All new hardware is compatible with the other FLIP CHIPS™.

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(**ps pulses,** *continued*)

Two of DeMaria's colleagues, H. A. Heynau, and A. W. Penney, Jr.,[2] pointed out that a mode-locked glass Nd^{+3} laser, in conjunction with fast photodetectors, can be used to evaluate electrical networks. The experimental arrangement shown in Fig. 2 has been used to generate, detect and observe the mode-locked laser pulses. The optical pulses were converted into electrical pulses by two specially housed diodes, an ITT F-4018 and an ITT F-4014. The rise times of these two diodes were calculated from optical pulse measurements to be 256 and 90 picoseconds, respectively. The oscilloscope used in these experiments was the modified Tektronix 519. It was necessary to use a traveling-wave oscilloscope because the relatively short pulse duration of the repetitive pulse train obtained from the mode-locked laser ruled out the inherently more sensitive, wider-bandwidth sampling oscilloscope.

The electrical pulses from the signal photodiode were applied directly to the coaxial deflection plates through a connector mounted on the side of the tube itself. This was done to prevent the delay cables from modifying the electrical pulses. The oscilloscope had to be triggered in advance of the signal by the triggering photodiode, which was chosen to offer less optical delay than the signal photodiode.

Electrical networks tested

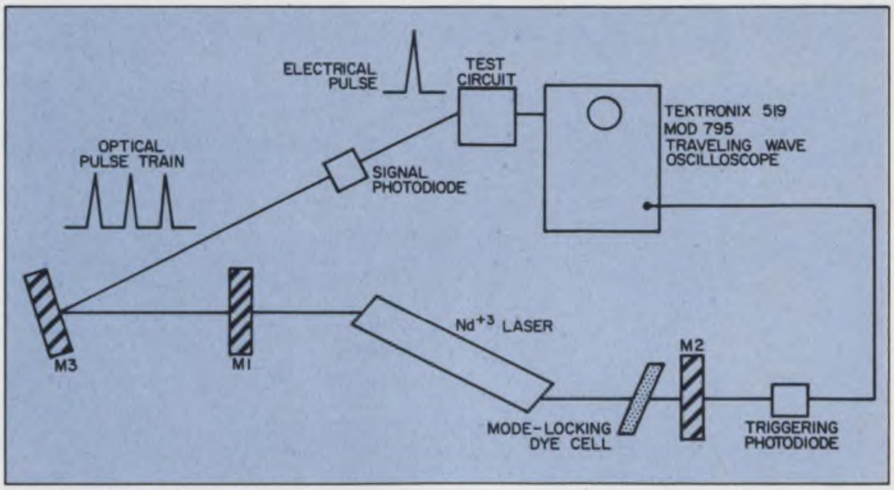
Heynau and Penney reported that they had evaluated several electrical networks, including coaxial cable and resistive impedance adapters, by means of mode-locked pulses.

While the results they obtained for the cables were generally in agreement with theory, they did find some anomalies, which, they say, warrant further study.

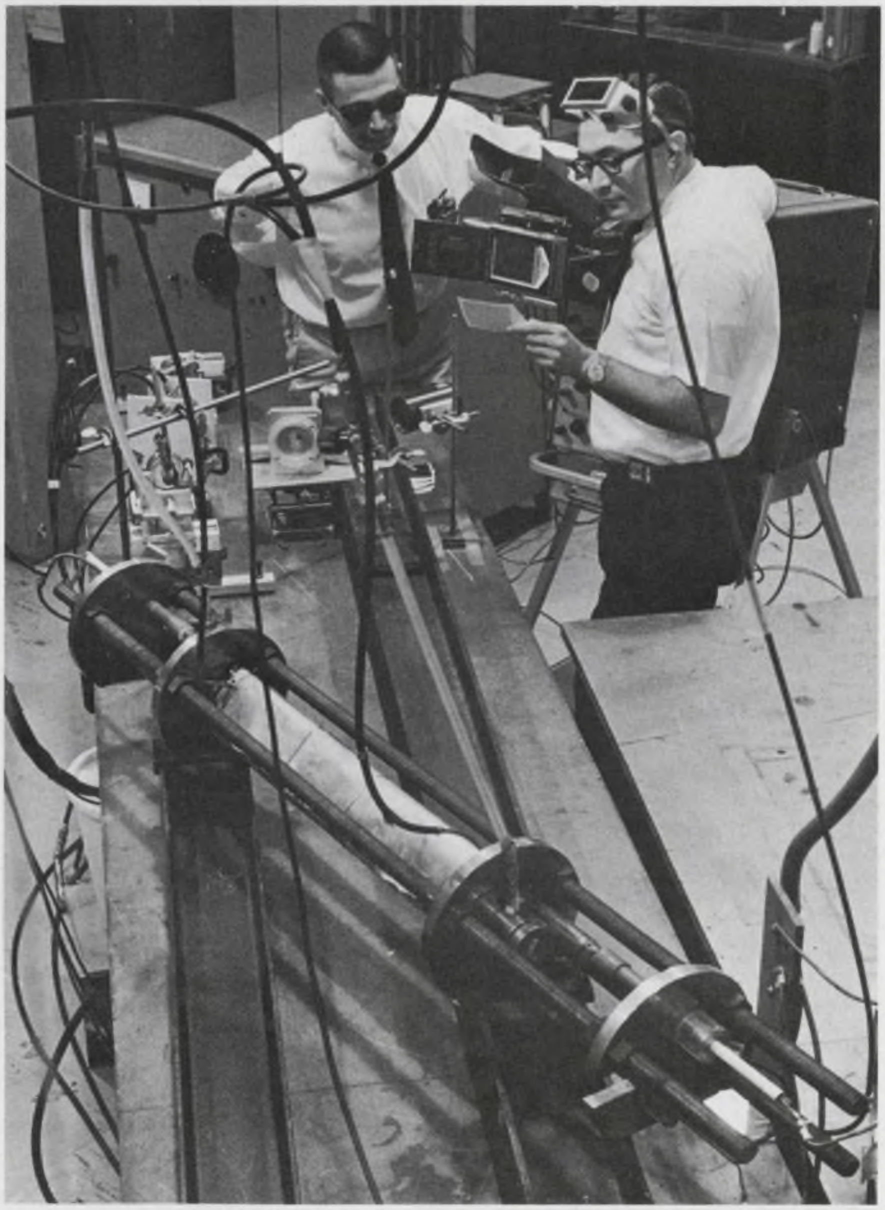
There were, however, no important disagreements in the case of the resistive adapters.

They suggest many other areas in which the ultrashort pulses could be used to great advantage:

- Evaluation of detectors, trans-



2. **Optical pulses** generated by mode-locked Q-switched laser exceed the response time of the photodiodes, which in turn respond faster than the fastest traveling-wave oscilloscope. A reference pulse triggers the oscilloscope in advance of the signal. This setup is used to test wideband devices.



Glass laser uses optical amplifier (foreground) to attain gigawatt bursts. A. J. DeMaria (right) examines photograph of pulse taken from oscilloscope.

ducers, wide-bandwidth systems—anything that handles extremely fast pulses.

- Development of new components and systems, such as detectors, detector housings, fast electrical pulse termination resistors and pads, and direct time-domain display oscilloscopes.
- Coincidence and anti-coincidence network checkout.
- Ultrashort, high-repetition-rate sampling gate pulse trains.

But there is more, much more, that the engineer can do with these pulses. In the words of DeMaria, "Short optical pulses are at the same stage microwaves were right after World War II."

Designers who are truly interested in advancing technology cannot fail to be alert to such bountiful gifts from the laboratories. One golden opportunity lies in the area of optical computers, where velocity-of-light measurements are always a consideration.

DeMaria comments, "If you have a pulse 1 nanosecond wide, physically that's roughly 1 foot long through space. Our pulses are 0.03 cm long—shorter than anything else that's around. Optical memories, optical logic, the whole field of computers—the implications are definitely there for the engineer."

The mind staggers at the thought of dump rates of 10^{12} bits per second or binary logic in time sequences of 1 picosecond.

If radar pulses of 1 nanosecond were available for ranging, engineers would be overjoyed, because 10-GHz microwaves in 1-nanosecond pulses would be equivalent to only 10 microwave cycles in length. With the ultra-short optical pulses it should become possible to measure distances of miles down to 0.03 cm—an accuracy almost beyond belief. ■ ■

References:

1. A. J. DeMaria *et al.*, "Generation and Amplification of an Ultrashort Optical Pulse," *1967 IEEE Conf. on Laser Engineering and Applications Digest of Tech. Papers* (New York: IEEE, pp. 23-24.
2. H. A. Heynau and A. W. Penny, Jr., "An Application of Mode-Locked, Laser-Generated Picosecond Pulses to the Electrical Measurement Art" (Paper presented to the IEEE International Convention, New York, 1967).

Far-out communications for unorthodox wars

Army studies use of soil, water, rails and skin to transmit messages when radio is impractical

Neil Sclater
East Coast Editor

Somewhere at some time in some near-impenetrable jungle country, two U.S. Army special forces may be closing in on an enemy camp from opposite sides. They have marched independently of each other for miles, and they must communicate now to make one final check before attacking. Conventional rf methods are out, because the signals might betray their presence to the enemy. Visual methods are impractical; the jungle is too dense. So the two forces use the surrounding soil and rock to relay their messages.

Implausible-sounding communications schemes like this are under investigation by the Army to meet the demands of unconventional warfare. Papers presented by the Army Electronics Command at the recent IEEE International Conference on Communication in Minneapolis outlined the following methods and reported they were showing promise for development:

- The transmission of messages through earth and water boundaries by means of audio frequency conduction current.
- Signaling through water, sand, pipes and railroad tracks by magnetic excitation.
- Communicating through soil and rock by seismic waves from transducers.
- Communicating with humans by "tapping" on the skin with low-current probes in prearranged codes.

Conduction-current signals used

Very efficient battery-operated dc-ac solid-state inverters are being used by the Army as audio-range signal sources. The experimental system is demonstrating the practicality of earth current systems in the 400- and 850-Hz ranges.

Experimentation with communications through earth dates to World War I, but solid-state electronics has made the method more feasible. The maximum range achieved so far in the Army experiments is only about 400 yards, but even this may prove useful for certain operations.

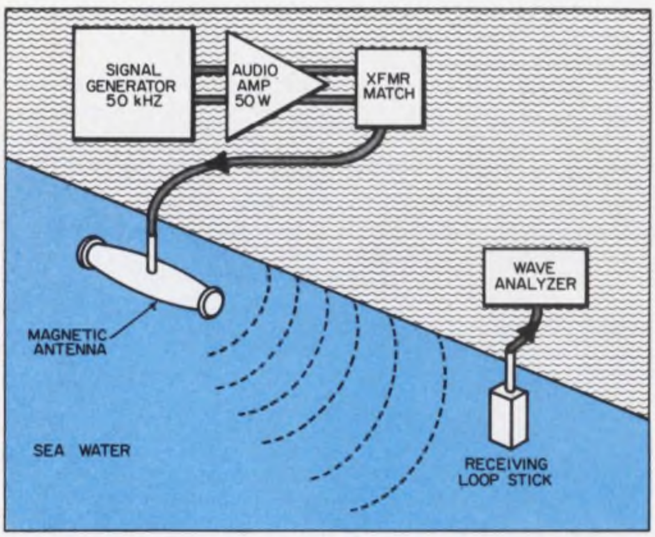
The method depends on the location of transmitting and receiving dipoles in a stream or river. Water acts as the transmission media. Water can also couple the audio signals to sandy or mud surfaces, which also may transmit the energy.

Army experimenters are using one transmitter, that is employing silicon-controlled rectifiers as switching elements in a power-conversion circuit. The power output of the transmitter operating at 400 Hz has been 120 watts. A newer 850-Hz inverter has an output power of 300 watts; it uses power transistors as the switching elements.

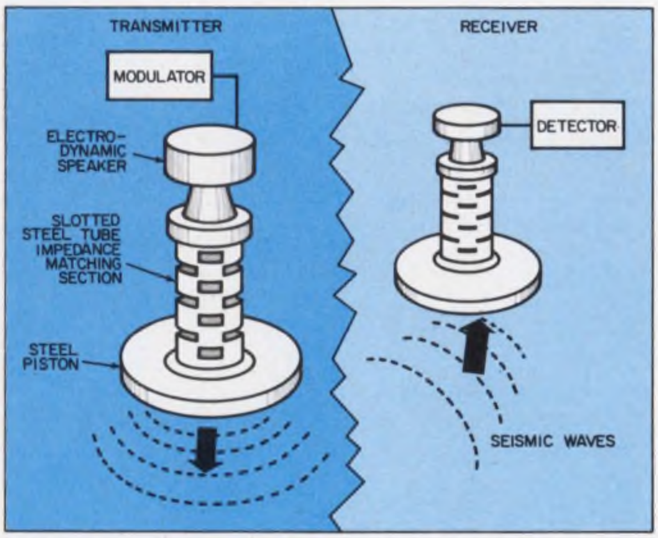
The audio signals are transmitted through dipole electrodes made up of 5-by-15-inch stainless steel plates mounted at the ends of a 10-foot fiber-glass pole. The electrode is placed below the surface of the water or in wet sand and is supplied with ac power through a 50-ohm cable.

The 400-Hz receiver is a wide-band transistor preamplifier in series with a low-Q tunable millivolt meter. The received signal is amplified so it can be heard through earphones. The receiving dipole electrodes are similar to the transmitting dipoles.

The receiver used in the 850-Hz test consists of a tuned amplifier

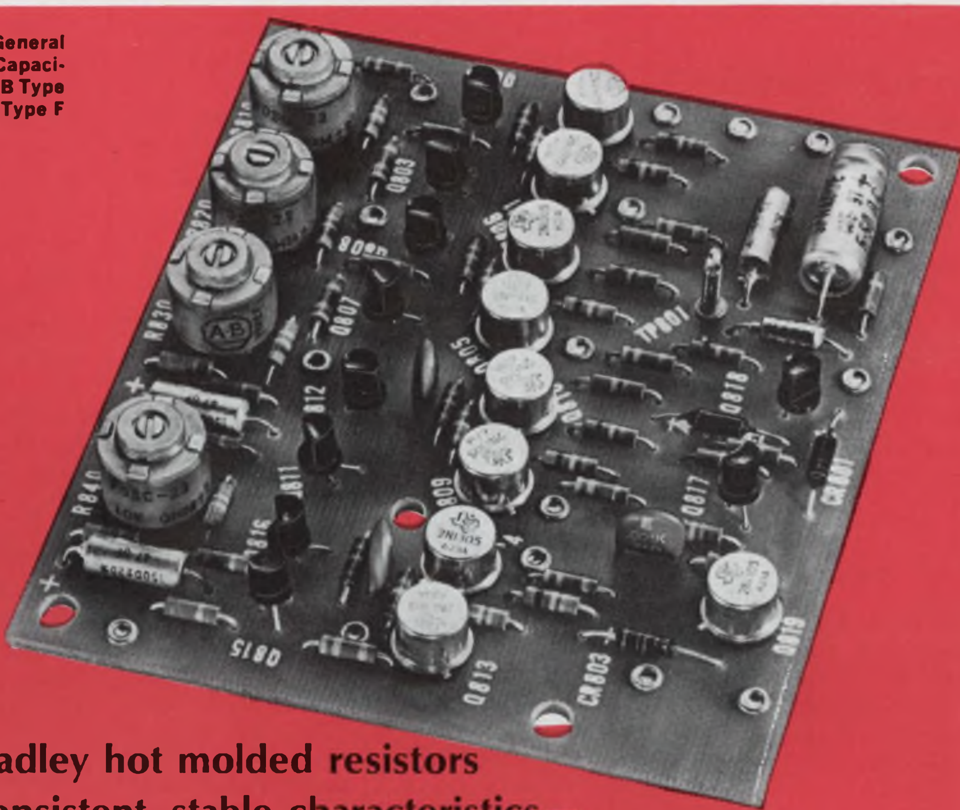


Magnetic excitation of sea water is used by the Army to transmit messages to a receiving loop stick more than 300 yards away. A similar setup transmits signals more than 10 miles when a railroad track is used as a duct.



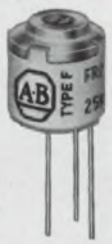
Continuous seismic waves transmit messages through soil and rock. Operating frequencies of about 80 Hz are modulated to permit reception at a mile and a half with the use of 200-W drive power.

Printed circuit board from General Radio Type 1680 Automatic Capacitance Bridge showing use of A-B Type CB ¼ watt fixed resistors and Type F ¼ watt adjustable resistors.



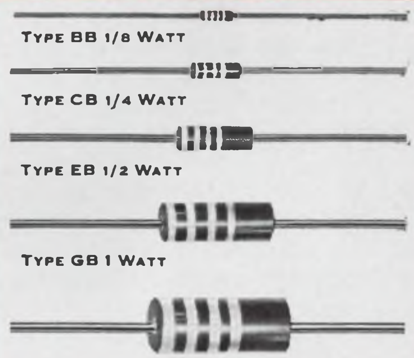
"we use Allen-Bradley hot molded resistors because their consistent, stable characteristics—month to month and lot to lot—ensure repeatable measurements by our instruments." GENERAL RADIO CO.

General Radio Type 1680 Bridge automatically measures capacitance and loss simultaneously, generates coded digital output data, and displays measured values in about one-half second. The basic accuracy is $\pm 0.1\%$ and the range is from 0.01 pF to 1000 μF.



Type F variable resistor with pin type terminals for mounting directly on printed wiring boards. Rated ¼ watt at 70°C. Total resistance values from 100 ohms to 5 megohms. Shown actual size.

A-B hot molded fixed resistors are available in all standard resistance values and tolerances, plus values above and below standard limits. Shown actual size.



TYPE BB 1/8 WATT

TYPE CB 1/4 WATT

TYPE EB 1/2 WATT

TYPE GB 1 WATT

TYPE HB 2 WATTS

Just as surely as automatic equipment saves its users' money when it is in operating condition, it is virtually worthless when failure of a component has made the entire device inoperative. To insure the reliable and accurate performance of their new automatic capacitance bridge, General Radio designers selected Allen-Bradley hot molded fixed and variable resistors.

Allen-Bradley resistors are made by a hot molding process using completely automatic machines developed by Allen-Bradley. This results in such precise uniformity from one resistor to the next—year in and year out—that long term resistor performance can be accurately predicted. Furthermore, there is no known instance of catastrophic failure of an Allen-Bradley hot molded resistor.

The same manufacturing technique is used with the Type F variable resistors. Their solid hot molded resistance track assures smooth control from the very beginning and which improves with use—and are completely devoid of the abrupt changes to be expected of wire-wound controls. In addition, A-B variable resistors are essentially noninductive, permitting their use at frequencies far beyond range of wire-wound units.

For more complete information on the full line of Allen-Bradley quality electronic components, please write for Publication 6024: Allen-Bradley Co., 1344 S. Second St., Milwaukee, Wis. 53204. In Canada: Allen-Bradley Canada Limited. Export Office: 630 Third Ave., New York, N. Y., U.S.A. 10017.

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(communications, ***continued*****)**

and null detector coupled to a wave analyzer. The receiving dipole, which is connected to a matching transformer, feeds this combination. Signal levels are indicated on the output meter of the detector's wave analyzer.

Signals from the 400-Hz system have been received closely at distances up to 220 yards.

The 850-Hz system is able to transmit signals that can be detected 750 yards away, but the ratio of the noise to signal has been high.

Magnetic excitation method

Buried pipes, railroad tracks, creeks, rivers, sea water and beaches are all possible transmission lines for magnetic-excitation communication. Magnetic couplers and antennas are being used to excite electrical currents and fields in man-made and natural substances on or below the earth's surface.

The Institute for Exploratory Research at Fort Monmouth, N. J., is experimenting with two forms of magnetic excitation: one in sea water and one through railroad tracks. The experimental frequences are within the range of 48 to 50 kHz.

The transmitting antennas in both types of experiment are made of a sheet of iron-loaded silicon rubber and a sheet of Mylar rolled together to form a core for a wire coil. This solenoid is then encased in a cylindrical fiberglass shell about a yard long.

The drive circuit for the transmitting antenna employs simple laboratory equipment. The output from a signal generator is fed into an audio amplifier. Then the output signal from the amplifier is matched to the transmitting antenna by a coil and a capacitor.

Signals are received by a loopstick receiving probe—a coil wound on a ferrite rod encased in a plastic box. A 20-foot coaxial cable connects the probe to a battery-operated wave analyzer, which is used as a detector. The input of the wave analyzer is shunted by a capacitor to tune the pick-up probe to resonate at the transmitted frequency.

Kenneth Murphy and Ronald Johnson, Army physicists, say that received signals in sea water are strongest one to two inches below the surface and range exceeds 300 yards.

The railroad track field tests have shown that signal attenuation is exponential and that a range of 10 miles can be obtained.

Seismic communications

Army investigators have found that while continuous-wave seismic signals, either amplitude- or phase-modulated, appear to have a communications potential, the problem is the conversion of primary power to useful elastic waves—a necessity for achieving effective range.

In their experimental work, the Army scientists devised two types of transducers, one for soft earth and the other for hard rock. One tunable receiver is being used to receive signals through both hard and soft media.

The transducers are essentially electrodynamic loudspeakers connected to a steel tube and piston assembly. When the unit is transmitting, force is transferred to the ground by the tube and piston. When receiving, the displacement of the seismic medium is transferred to the speaker by a reversal of this transmission process.

For soft media the speaker's resonant frequency can be varied from 83 Hz (loose sand and gravel) to 78 Hz hard clay). The soft-media transducers have a maximum driving power of 10 watts.

The hard-rock transducer has a normal operating frequency of about 80 Hz and a maximum driving power of 200 watts. The tube that connects the piston with the speaker on the transducers is slotted and acts as a quarter-wave transmission-line section. It matches the mechanical impedance of the medium piston boundary with the electrical impedance of the loudspeaker amplifier.

Army researchers have communicated on the surface over distances of about a mile and a half but believe this range can be improved. A pulse-amplitude-modulated-80-Hz signal was received with a signal-to-noise ratio of about 3 dB.

Sixty watts of power applied to the large transducer permitted communications through rocky soil over a distance of two-thirds of a mile.

Experiments have also been performed on transmitting signals through the ice of frozen lakes and from mines.

Skin as a transmission medium

The nerves of the skin are being considered by the Army as a "possible port of entry" for messages. The method uses electric currents to tap out signals on the skin's surface.

In experiments now being performed jointly by Fort Monmouth's Avionics Laboratory and Communications and Data Processing Laboratory, coded signals are being received by soldiers with electrical transducers strapped to their forearms. Current, adjustable by the soldier from 0.1 to 0.9 mA, is used as the stimulus.

Dr. John Hennessy and Dr. Herbert Bennett say that the investigations to date indicate that the electric tapping messages are effective both for primary communications and when used as a secondary cue in conjunction with an audio channel that has poor separation of noise and signal.

The best results in primary communications have been obtained when the signals were reinforced by time-delayed "shadow signals." The latter repeat the primary code and tests have shown that the delay time between the primary code and the "shadow" is best between 2 and 5 milliseconds.

The Army, according to Dr. Hennessey, would like to use skin communicators to direct men working on such assignments as disarming explosives. ■ ■

Messages are sent through the skin by pulsed low currents from electrodes on a transducer strapped to the forearm. Signals can be a primary source or can reinforce audio messages.

‘Flame laser’ requires no electrical supply

Burning CO gas radiates energy to excite CO_2 within a sealed tube—Other gases may work, too

Touch a match to a gas jet and, presto, out comes a laser beam.

That’s what happens in a new “flame laser” invented by Dr. Irwin Wieder, principal scientist for the Carver Corp., Mountain View, Calif. Dr. Wieder, who prefers to call his development a “chemioptical resonant pumped” laser, believes that it will prove significant because the resulting device needs no electrical source for operation.

In the present setup three 4-meter-long tubes are placed side by side. The center one is a quartz tube filled with carbon dioxide under partial vacuum (1 torr); the two outer ones, which are open to the atmosphere, hold long gas jets. Carbon monoxide is sent through the jets and lighted. As the CO burns, it combines with oxygen ($2CO + O_2 = 2CO_2$) in the air. As the chemical bond takes place, energy in the form of radiation is released at about 4.4 microns. This energy pumps up the CO_2 in the center tube to higher energy states. As this excited CO_2 drops to lower energy levels, laser action occurs in the infrared region at about 10.6 microns.

The present equipment is very inefficient, Dr. Wieder reports. Outputs are in the range of 1 milliwatt. This is accomplished with two burners, each about 4 meters long, and with flames about 7.5 cm long. Now that laser action has been achieved, Dr. Wieder intends to investigate some steps to improve efficiency, such as the use of reflectors and the substitution of CO_2 isotopes that offer transitions better matched to the radiation. He will also study the effects of changes in pressure of the active CO_2 gas.

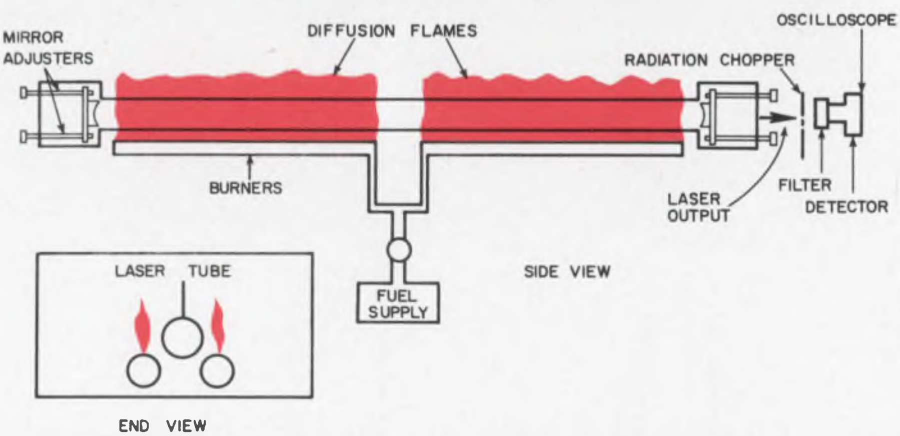
The most important possibility for this type of laser, Dr. Wieder believes, is for compact units in which the CO_2 could be permanently sealed. Then a supply of CO gas and a flame would allow operation. Other molecules and different fuels should also be capable of similar laser action. The energy transitions in this type of laser are those between different vibration-rotation energy levels of the CO_2. Flame processes are not completely understood by physicists, according to Dr. Wieder, and therefore further work must be done to find out what variations on the basic principles will prove feasible. He suggests that similar radiation processes are involved in explosions and that this might provide another type of excitation source for future lasers.

Dr. Wieder started his work on the flame laser before recent developments in CO_2 lasers, which are now the most powerful types available in the gas laser family. His interest in CO_2 centered on the presence of closely spaced vibration-rotation levels in CO_2 molecules, which appeared ideal for his flame-radiation experiments.

His intial experiments put the CO_2 in the same tube with the burning CO. This configuration did not prove successful, so he switched to the present three-tube setup.

The quartz tube that holds the lasing CO_2 has an inner diameter of 24 mm and a wall thickness of 1 mm. Germanium mirrors, with dielectric coating for 99.5% reflectivity at 10.6 microns, are used in the cavity.

Dr. Wieder’s work is being supported by the Mobil Oil Corp. as well as the Carver Corp. ■ ■



‘Flame laser’ requires no **electricity,** just a supply of CO gas to feed the burners and a match. Lasing action occurs in a 4-meter-long quartz tube filled with CO_2. The laser tube is sealed; the burner tubes are open to the atmosphere. Dr. Irwin Wieder checks the output (top).

Pentagon boosts intelligence activities

Washington Report

S. DAVID PURSGLOVE, WASHINGTON EDITOR

Electronic intelligence to be beefed up

The Pentagon and the White House are reported to be so impressed with electronic intelligence (Elint) that a substantial increase in funds and manpower is to be devoted to it.

Elint is relayed by the high-speed, unmanned and usually unarmed "winged rf probes" that have been flying "ferret missions" in Southeast Asia, over the fringes of China, Eastern Europe and the Soviet Union itself. These missions have brought back information on changes in codes, communications frequencies, IFF (identification, friend or foe?) procedures, radar locations and antiaircraft systems and tactics so rapidly that a new information-processing wing of the huge National Security Agency building near Washington is already swamped. The wars in Vietnam and the Middle East have confirmed the intelligence garnered by Elint.

Top officials of the National Security Agency, the electronics-intelligence organization operation by the Pentagon, asked Capitol Hill in January for some 50 new "supergrade" employees. Career government employees normally earn a maximum of $19,000 a year; supergrades receive up to $25,890 for their extra talent and positions over thousands of employees, many of them in normal "top" government grades. The House Manpower Subcommittee is keeping its own counsel on the agency's unusual request, but is expected to grant it. Observers remark that a request for 50 supergrades bespeaks a major new Elint program.

Ferret missions, generally flown by RB-66s and more recently by RF-4s also, have been in use since the end of World War II. So effective have they become that much of the money allocated to a new weapon system is tied up in electronic countermeasures (ECM) to prevent "ferrets" picking up false information. Hitherto Vietnam has been the only area where real hostile actions have enabled the Pentagon to correlate Elint data with the procedures taken by an actual enemy under attack. Elsewhere one of the agency's toughest tasks has been to elicit genuine counterintrusion measures and communications from the barrage of false signals and meaningless messages put up by military forces at the approach of an unidentified aircraft or vessel. Last month's critical flare-up in the Middle East, with real radar and genuine communications in use, gave the Pentagon an unparalleled opportunity to observe an electronically ordered battle based on Soviet doctrine and hardware.

Now the Pentagon has a twofold reason to beef up NSA. Elint ships and aircraft —maintaining surveillance from afar but definitely not within the six-day crisis zone, Pentagon officers insist— have proven their value and that their use should be increased. The second reason is that the Pentagon now expects the Soviet bloc to make many changes in its communications and counterintrusion procedures in the wake of the Arab-Israeli conflict. Thus a new round in Elint, ECM and ECCM is believed to be in the offing.

Technological Marshall Plan dead

There will be no major U.S. aid program of the sort that Italian Foreign Minister Amintore Fanfani has referred to as a "Technological Marshall Plan." For months, the White House has closed its collective ears and kept very still in the hope the thing would go away. On the contrary, however, European clamor about a "technology gap" that was somehow the willful fault of the U.S. and must be redressed by the

Washington Report CONTINUED

U.S. government has grown louder and more insistent. Finally, the White House broke its silence and sent the then Commerce Secretary-designate, Alexander Trowbridge, to Paris. Trowbridge put the message across obliquely—in an address to the American Chamber of Commerce in France—but he made it very clear.

Only Europe itself can redress the technological gap and the brain drain, Trowbridge said. He said an American aid program likely would not be much help because the roots of Europe's problem do not lie in technology; Europe has amply demonstrated its technological competence. Rather, he contended, the problem involves productivity, education, economies of scale, managerial environment, natural resources and markets. But, even if these were not the root problems, and a simple U. S. aid program would close the technology gap, Trowbridge asserted, the U.S. government still could not take on such a responsibility. The government cannot give away much American technology, Trowbridge pointed out, because most of it is private property.

The White House emissary was not entirely negative. Although he does not favor a formal government program for transferring information and hardware to Europe, he does favor—and will work for—more international conferences, joint undertakings and increased industry-to-industry contact. He believes Europe can pick up more U.S. technology and productive know-how by increasing its investment in U. S. industry. And, voicing what probably he believes is the crux of Europe's problem, Trowbridge stated bluntly that he would like to see Europe make better use of the technological information that it does receive. He suggested that this could be done through programs and centers similar to the U.S. Commerce Department's Office of State Technical Services—a program often likened to an Agricultural Extension Service for industry, with offices functioning in the manner of the County Agent's.

U.S. to define auto electronics role

Directions that the government will take in the rapidly developing highway-automobile electronics market are expected to be clear by late September. A number of Transportation and Commerce Department officials are planning to respond to IEEE's call for papers for its Sept. 21-22 Second National Automotive Conference in Detroit. Papers and exhibits at the Conference and presentations at collateral functions may spotlight several new programs now only in the planning stages, as well as survey the present Topics program and the traffic-safety spot-improvement program.

Topics (Traffic Operations Program to Increase Capacity and Safety) deals only with urban highways and is the government's first major move into city-streets projects. One of its chief interests is application of computers to receive and evaluate traffic flow data from remote locations and then control the flow of autos on urban freeways. The traffic-safety spot-improvement program identifies specific points of high accident probability and attempts to make them safer. This often involves traffic-counting and installing signal-regulating equipment. Both are programs of the Office of Traffic Operations in the Transportation Department's Bureau of Public Roads. Among the Office's avowed missions is the promotion of uniform traffic-control devices.

Proxmire proposes budget cuts

End the SST program, all but eliminate funds for post-Apollo projects, substantially reduce troops in Europe, cut deeply into "pork barrel" Federal highway and Corps of Engineers projects. These are recommendations of the majority party's current "whiz kid" in the Senate, William Proxmire (D-Wis.) The man believed by many of his colleagues to be the only senator who could give Robert F. Kennedy serious presidential competition, but who will probably provide his most valuable support, believes that post-Apollo funds can be cut by over $1 billion. He admits that such a cut "would postpone such projects as a soft landing on Mars, which has nothing to do with our present goals." On the Administration's request for $198 million to get the supersonic transport under way, Proxmire contends that, "at a time when we must carefully scrutinize the priority of our expenditures, we certainly can forgo this expensive frill."

Significance? Although turning a deaf ear to dove Proxmire in foreign affairs, the White House listens with respect on almost all money matters. Proxmire is Chairman of the Senate-House Joint Economic Committee and number two Democrat on the Senate Banking and Currency Committee.

NEWS

Opaque ruby passes pulsed laser beam

Two University of California physicists have passed light from a ruby laser through a ruby rod, which is ordinarily opaque to light on that wavelength when it emanates from an incoherent source.

Prof. Erwin L. Hahn of the Berkeley campus says that a short pulse above a critical amplitude propagates through an optically resonant medium as though it were transparent; below that critical threshold the light will be absorbed. He explains:

"As the light goes through, it is momentarily absorbed by the optical transition in the medium. But the energy absorbed from the leading edge of the pulse is later emitted back to the trailing edge. The light pulse thus goes through as though it hadn't given away any energy."

He compares it to bowling balls approaching a row of rigid pendulums: if the balls roll slowly, they lose all their energy. But if they are thrown fast enough to drive the first pendulum past the 180° point, it will swing around and smack the balls on the rear end. The balls are then sent on with renewed energy to the next pendulum.

"This is a rough analog of what the light pulse does," Hahn says, "and it also illustrates the threshold effect."

Hahn and his colleague, Samuel L. McCall, have observed these self-induced transparency effects only in ruby. He says, however, that the principle may make it possible to pass extremely short light pulses through other materials, provided that the width of the light pulses is short compared with the transverse relaxation time in the medium and the height is sufficient.

At room temperature the results are masked by an extremely fast transverse relaxation. Therefore, the researchers had to cool the experiment to 4.2° K, where the time constant is extremely long. With ultrashort pulses like those generated by DeMaria and others at United Aircraft Research Laboratories (see p. 17), these phenomena could be observed even at room temperature. ■ ■

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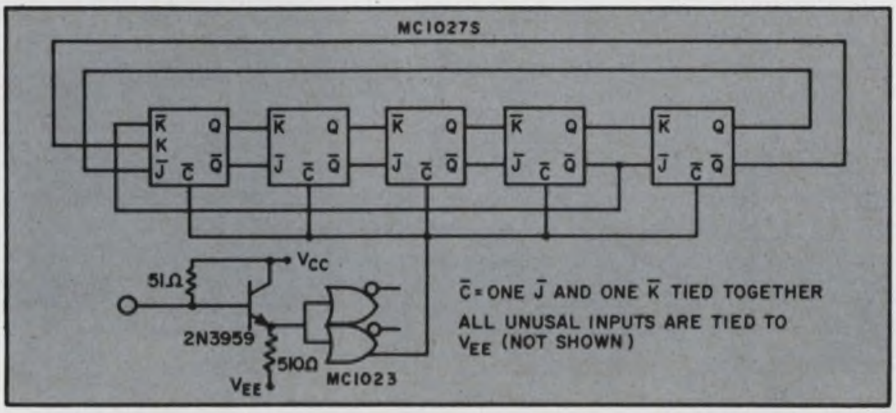

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Motorola's high-speed MECL II just smashed its own speed record ... with the introduction of the MC1027 integrated circuit J-K Flip-Flop. Specified for a toggle and shift frequency that's typically 120 MHz, this new circuit more than doubles the speed of any other J-K Flip-Flop now available in other logic families.

A new high-speed dual clock-driver, the MC1023, also announced with the flip-flop, is capable of driving 10 flip-flops or more, at high clocking rates – eliminating high-frequency drive problems for the designer. Together, the two units form the excellent high-performance Switchtail Ring Counter, shown above. Previously, this type of high-speed application would have been possible *only* with discrete components. Now, MECL II *makes it possible* with the advantages of size, weight and reliability that only Motorola integrated circuits can provide!

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CHARACTERISTIC	MC1027 J-K FLIP-FLOP	MC1023 DUAL CLOCK DRIVER
Toggle Frequency	120 MHz	—
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ON READER-SERVICE CARD CIRCLE 20

Low-cost display tested for computer 'utilities'

MIT laboratory terminal gives graphic input and output on memory CRT linked to a telephone line

The goal of a low-cost graphic display for time-shared computers is closer as a result of a recent development at the Massachusetts Institute of Technology. An on-line graphic terminal, now operating at the institute's Electronics Systems Laboratory, promises performance possible today only from more costly commercial graphic systems.

The MIT display console was designed by the laboratory for Project MAC, the institute's research program on time-shared computers. It sends and receives both alphanumeric characters and drawings.

The display can be fed by standard telephone lines. It includes a direct-view cathode-ray storage tube, a typewriter keyboard and a simple graphic input device.

The laboratory engineers believe that the prototype terminal could be built in large quantities for about $5000 each. This price is more expensive than that of a teletypewriter but is comparable to that for present commercial alphanumeric display stations.

The MIT laboratory is advancing the large-scale "public utility" computer concept, which calls for hundreds of low-cost remote terminals. While the engineers believe simple teletypewriter stations will continue to be useful, they assert that graphic man-machine "conversations" are essential in the computer utility to perform such services as design, problem simulation and industrial process control.

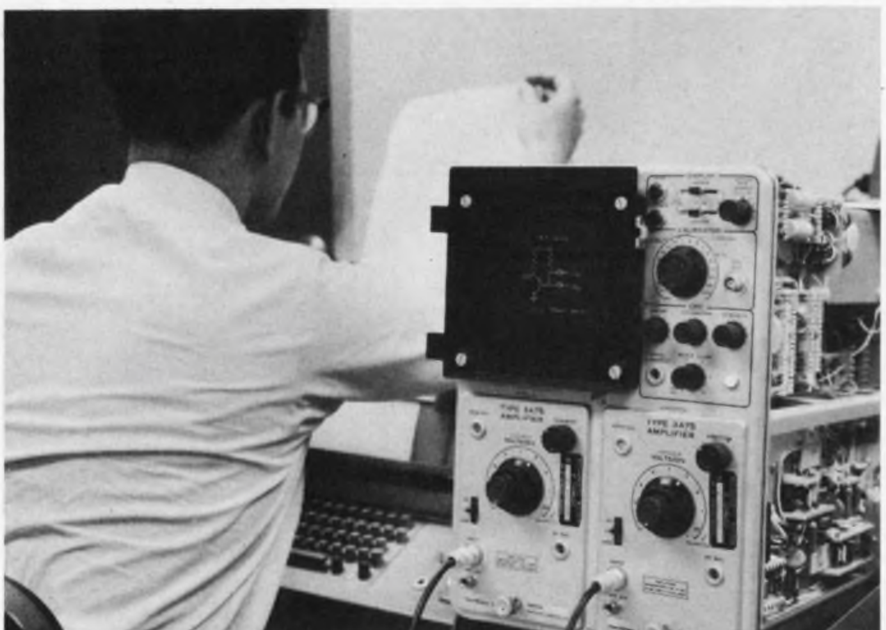
John Ward, assistant director of the systems laboratory, says: "Current commercially available, low-cost displays are unsatisfactory for the future needs of large-scale utility time-sharing. None of them offer, or are particularly well suited to providing, anything but an alphanumeric capability. They are essentially electronic typewriters."

Ward says that for graphic display, image storage is more promising than the "continuously refreshed" CRT display. He says that high-speed electronics for rewriting the picture are not needed (conventional displays must be refreshed by redrawing them 30 to 40 times a second to eliminate flicker from the CRT display). For more complicated pictures, Ward adds, the refreshing technique is costly, because the bandwidth of the internal display electronics must be increased to achieve the high speed required to form these pictures.

"By storing the picture created in image form as it comes off the telephone line, the only limit to picture complexity is the active area and resolution of the display device, and not the capacity of the memory or the writing rate," Ward notes.

Robert Stotz, Co-developer with Thomas Cheek of the laboratory's display, says: "The image of graphic input-output on the computer community is just beginning to be felt, but until low-cost graphic displays become readily available, this impact will be greatly impeded."

The low-cost display uses a standard high-resolution Tektronix five-inch storage tube, a 94-symbol standard keyboard, an electro-mechanical input device called the "mouse," and a control unit.



MIT's low-cost graphic display uses a modified Tektronix 564 oscilloscope. Thomas Cheek, co-developer of the system, checks the printout of input commands for test purposes. Hard copy will not be produced in final version.

Linked to phone line

The control unit connects with the telephone line, provides analog voltages to drive the display screen and establishes the format for the keyboards and graphical input signals to be sent to the computer.

The display station will connect, as a remote console, to the Project MAC time-sharing system by means of a dial-operated telephone line. The station's output data rate is 10 times that of a teletype.

Stotz says that one advantage of alphanumeric output on displays is that they more closely approximate human reading abilities. People can read much faster than the output of a teletypewriter.

New data are written only once, Stotz says, and they may be entered randomly on the display screen at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6A		40429	40430	TO-66
6A		40485	40486	modified 2-lead TO-5
6A		40431 (with integral trigger)	40432	modified 2-lead TO-5
15A		TA2834	TA2835	TO-66

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(**MIT display,** *continued*)

rates compatible with the low input bandwidth of the telephone line. Speed requirements on the electronics are reported quite modest.

The electronics package accepts serial binary signal trains of commands and data and uses them to program internal vector and symbol generators. These generators provide vertical and horizontal deflection voltages for the CRT.

The display uses two binary rate multipliers to draw lines. By intensification of the beam after each step, a series of closely spaced dots is formed. This is seen as a constant intensity line.

MIT investigators used unconventional techniques for pulse integration and analog-to-digital conversion. Pulses produced by each multiplier are shaped to have a constant amplitude and duration and are then fed to an operational amplifier connected as an integrator. The polarity of the pulses is controlled in accordance with the sign of the vector component. The resulting amplifier output is said to produce to the same discrete-step characteristics as the up-down counter and digital-to-analog converter combination used in more expensive displays.

Picture elements are constructed by connecting straight lines end-to-end. In so-called vector command, the incremental vector lengths are defined as 11-bit numbers (10 for magnitude, 1 for sign) that are loaded into horizontal and vertical registers. The information stored in these registers programs the binary-rate multiplier to produce synchronized, incremental x and y pulse trains. The pulse trains are fed into the operational amplifiers, where they are integrated and cause the CRT beam to trace out the desired line.

Matrix maintains intensity

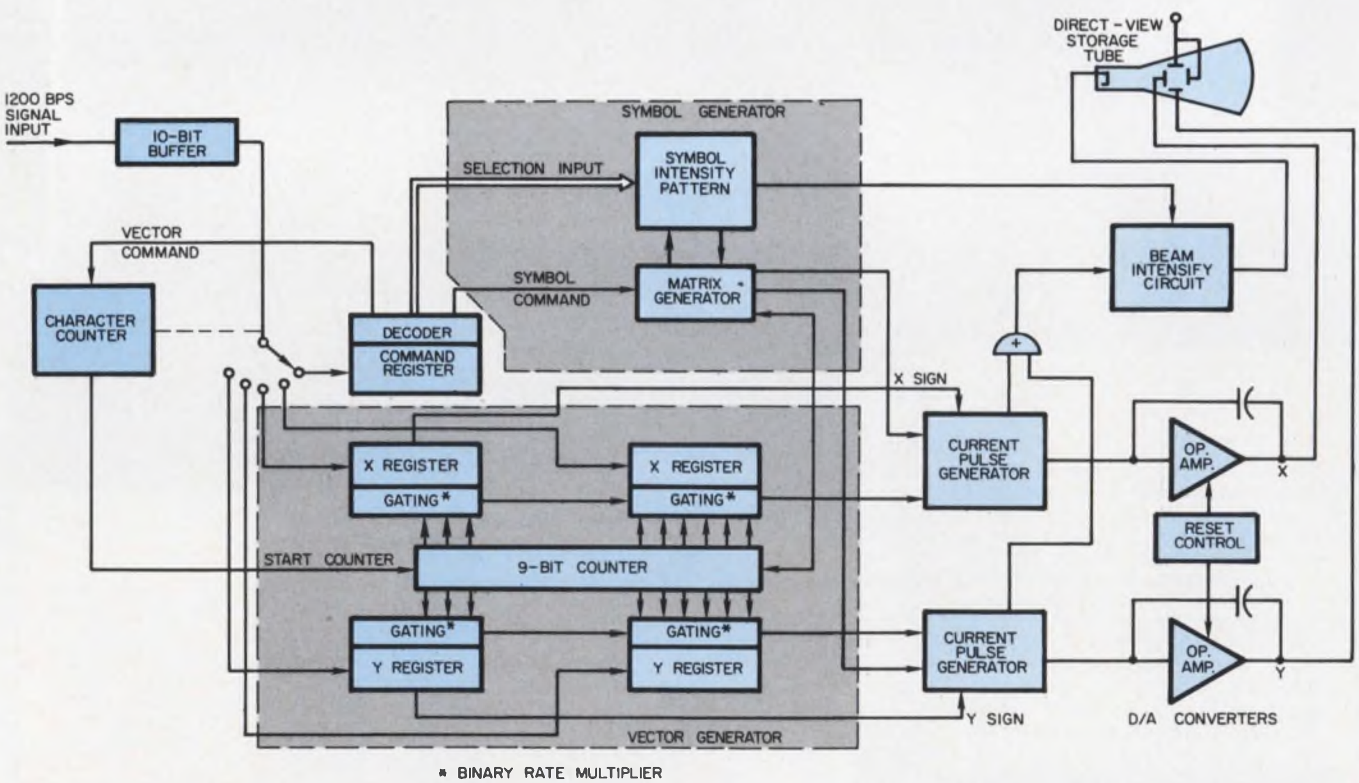
For characters, a pair of counters step the beam through a matrix pattern, and a diode memory holds the specific intensity patterns for each symbol. This action causes the CRT beam to blank and unblank as it moves through the matrix. The initial positioning for the first symbol in a line of text is established by a previous set point, permitting full flexibilty in choosing symbol locations.

A 7-by-9-dot matrix was chosen to display the 94 printable symbols of the standard code. A 96-word, 63-bit read-only memory for the symbol patterns was used. It is a 6720-bit diode matrix array on a single integrated-circuit chip.

Data transmission is in the form of fixed length characters with "stop" and "start" bits to insure continuous synchronization between source and receiver.

Lines can be placed on the cathode ray tube by means of the "mouse," a hand-held box moved around the screen. The mouse controls the position of a pointer or "cursor" that directs the electronics to give visible, but not stored visual, indications.

Wheels attached to potentiometers move with the motion of the mouse. Signals from the potentiometers are resolved into voltages that deflect the CRT beam. When the operator is satisfied that he would like to record the lines, he pushes a button. The vertical and horizontal components of the cursor's position are then digitized and sent to the computer. The program interprets the position values as either end points for drawing or location points for displayed data. ■ ■



MIT advanced remote display station is a prototype unit to demonstrate low-cost image storage techniques for application to utility time-sharing systems. It can send and receive both alphanumerics and drawings.

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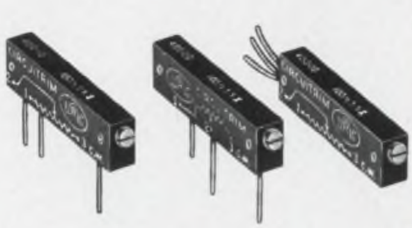
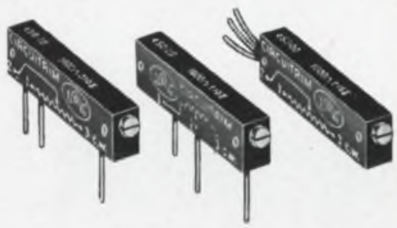
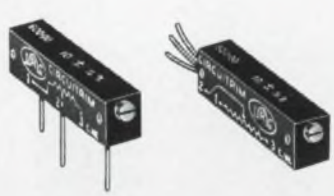
RECTANGULAR



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



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



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

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

½-INCH SQUARE

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

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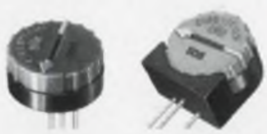
Series 150. Metal Glaze companion to wirewound model 100 above. Available in same configurations. 100Ω to 1 Meg. with choice of ±5, 10 and 20% tolerances.



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

SINGLE TURN ROTARY

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

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

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Industry's only 1/2" metal-cased multi-turn trimmer with 100 oz.-in. stop system and 1/4" diameter shaft. Maintains settings to ±0.1% under severe shock and vibration. Rear terminals for closest packaging. Many shaft and bushing variations.

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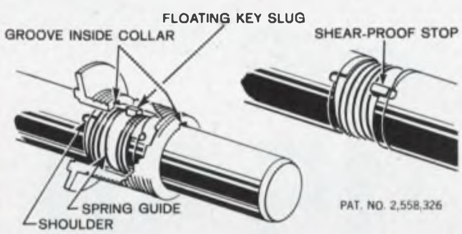
IRC's exclusive line of metal-cased multi-turn potentiometers offer rugged protection and superior shielding. Field tested and approved in every phase of the electronics industry, their case sizes and power handling capabilities are based on widely accepted standards for good design and packaging. Hermetically sealed, panel sealed and moisture sealed versions are also available.

Model	Case Dia.	Turns	Resistance Range (Ω)	Linearity Std. (±)	Power @40°C
7500	3/4"	10	50 to 250K	0.5%	3 W
7505	3/4"	5	25 to 125K	0.5%	2 W
1000	1"	10	500 to 250K	0.5%	3 W
1005	1"	5	250 to 125K	0.5%	2 W
1215	1"	15	500 to 450K	0.1%	4 W
1220	1"	20	750 to 600K	0.1%	5 W

Standard tolerance: ±5%. Temperature range: -55°C to 125°C. Closer tolerances and linearity available.

RUGGED STOP MECHANISM



Electrical and mechanical functions of IRC metal-cased multi-turns are separate. Positive 100 oz.-in. patented stop mechanism in the shaft and bushing prevents damage to internal parts and catastrophic failure. The wiper contact assembly is relieved of stopping action. This assures setting accuracy, stability and long rotational life.

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Laser cane helps blind avoid objects

An experimental "seeing-eye cane" that uses pulsed laser beams to guide blind persons around objects has been developed by scientists at RCA Laboratories in Princeton, N. J.

Infrared laser beams from two gallium-arsenide diodes embedded in the cane are continuously reflected from two points—three and six feet—in front of the cane back to two built-in photoelectric cells.

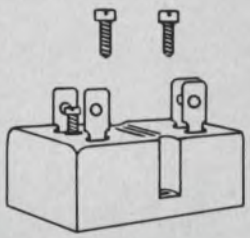
The cells activate two pins in the cane handle, and the pins vibrate continuously in the user's hand.

The sudden intrusion of an obstacle in front of the cane scatters the laser beams and interrupts the vibration, thereby alerting the user.

The cane weighs less than 5 pounds and can be operated for 10 hours before its 1/2-C-size batteries must be recharged. Each diode has a peak output of 5 watts and is pulsed 20 times a second.

RCA says it is investigating an advanced version that would use an array of diodes to generate laser beams. An array of detectors would see only the return from the laser in the corresponding array position. The user would, in effect, be provided with a contour map of the area ahead of him. ■ ■

Experimental laser cane for the blind sends out two beams (dotted lines) three and six feet ahead of the user.



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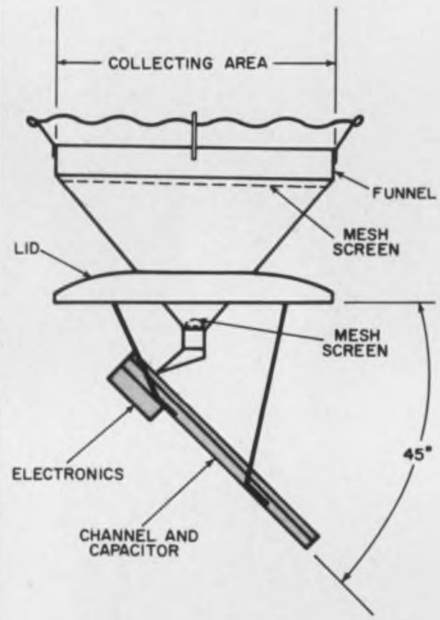
Rain data array aids microwave studies

An unusual measuring system that provides practically instantaneous data on the density and distribution of rainfall is reported by Bell Telephone Laboratories, Inc.

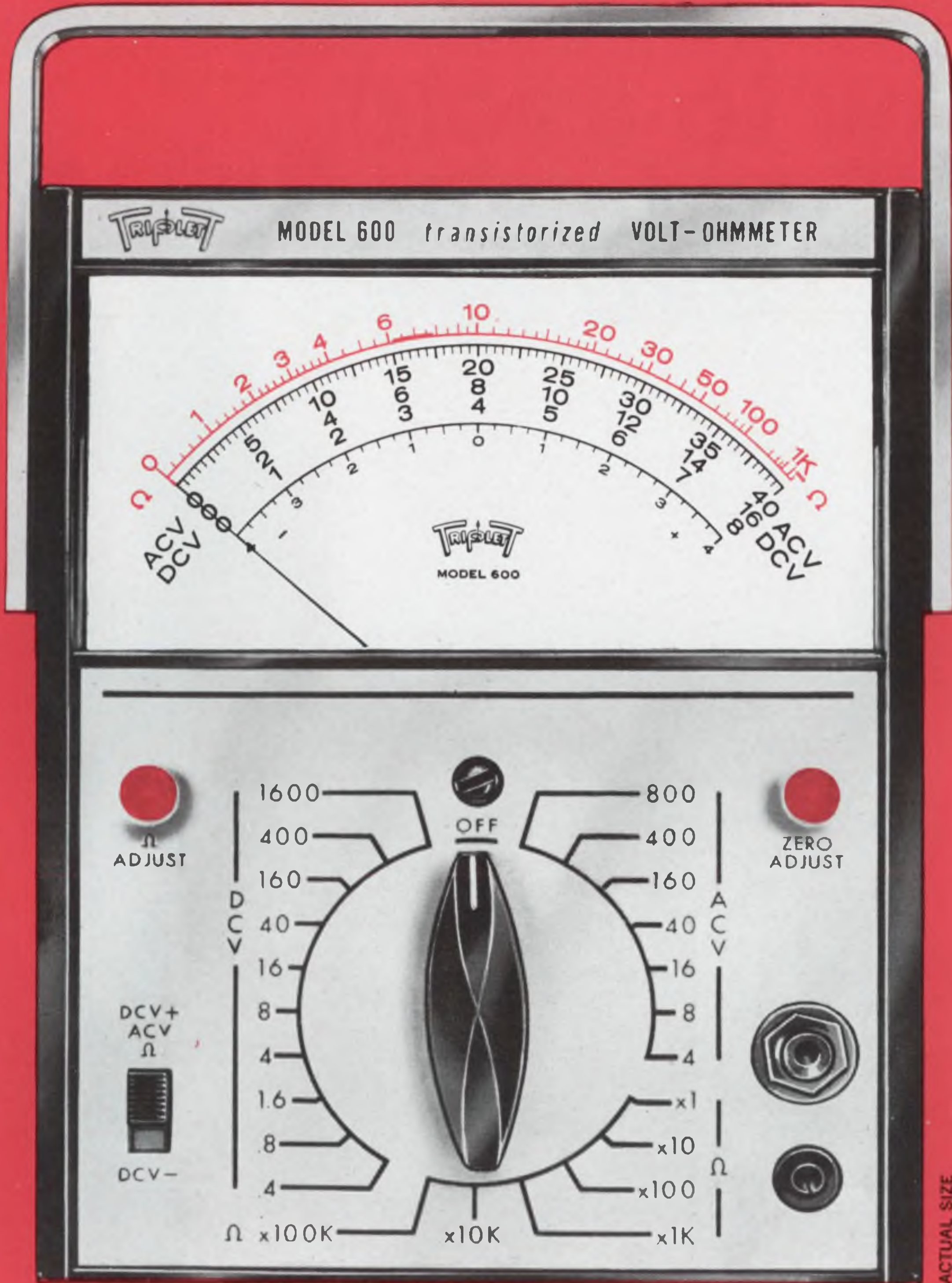
Studies have shown that rain in the path of a microwave beam may scatter and attenuate the signals, particularly in the 10- to 100-GHz region.

Bell engineers have set up an array of 100 continuously measuring rainfall-rate gauges distributed in a 50-square-mile area surrounding the company's Crawford Hill Laboratory at Holmdel, N. J.

In each rain gauge, rainfall is funneled into an inclined channel



that runs between the electrodes of a capacitor. Changes in the volume of flow are measured by the capacitor, which in turn causes variations in the frequency of a signal produced by an oscillator on a telephone line. The 12-inch-long capacitor flow meter, with a signal-producing electronic package attached, is able to sense and measure rapidly rain activity from the first drop to rates in excess of 10 inches per hour. The information from the gauges is transmitted over telephone lines to recording equipment at the Crawford Laboratory for analysis. ■ ■



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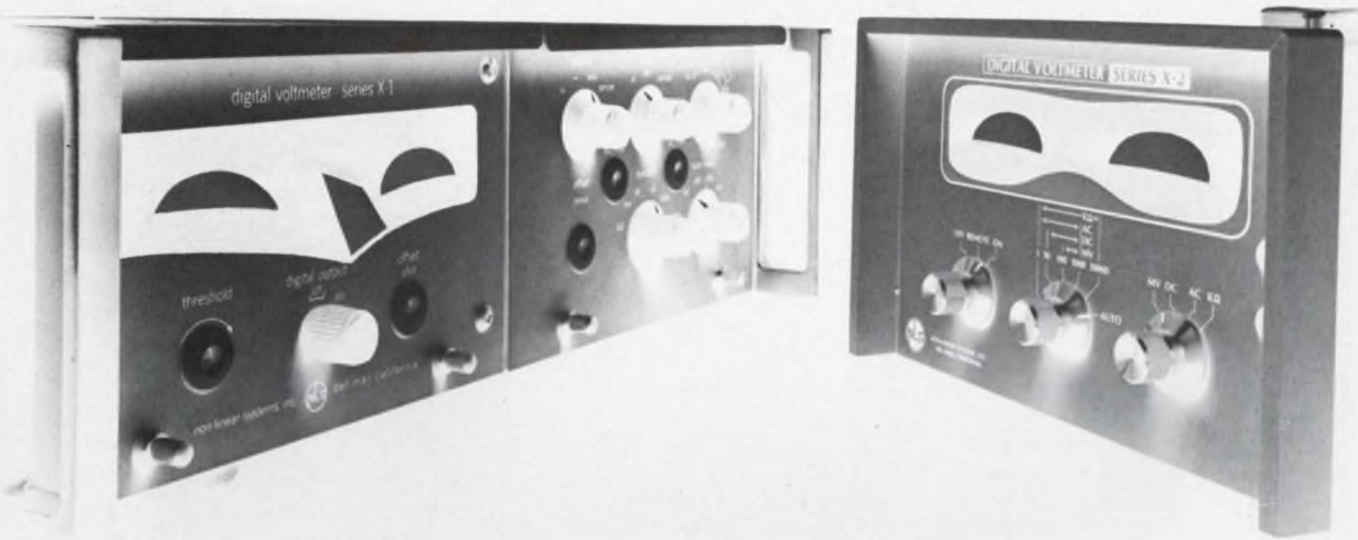

X-2: *Holy Accuracy, X-1, how do you do it? . . .*

X-1: Fear not, *X-2*, if you don't become a college dropout, you too, can achieve .005% *Accuracy.*

X-2: *You were designed to compete with those $4,000 voltmeters, but I've got IC's.*

X-1: When I was in school, *X-2*, those IC's were costly and unavailable; however, with all your IC's, you can't give 23 millisecond readings!

X-2: *Well, X-1, I haven't had my logic courses yet. Can you integrate?*

X-1: I don't need to integrate, *X-2*, because I have an Active Filter that saves customers (who think they need a 5-digit integrator) $1,700.

X-2: *You got me there, X-1, but if the customers don't need your .005% accuracy and high speed for $2,450, they can buy me for $980, and I'm half rack size too!*

X-1: Naturally, you're half rack size because you don't have Scan Counter, Range Memory, Range Hysteresis, Range and Polarity memory logic, and my Exclusive Threshold control.

X-2: *Holy features, X-1! Those other DVM's* must be *overpriced!*

X-1: We must not cast moral judgments on the integrity of our competition, *X-2*.

X-2: *You're such a good teacher, X-1 . . .*

X-1: Remember, *X-2*, that together, that is, you at $980, and me at $2,450, can conquer 80% of the requirements in DVM city.

Next month — Will the Joker win out? **See X-3.**

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FOR X-1, ON READER-SERVICE CARD CIRCLE 102

FOR X-2, ON READER-SERVICE CARD CIRCLE 103

Letters

Pole-zero cancellation: analysis is expanded

Sir:

I read with interest your description of the pole-zero cancellation used by Thomas Emmen of Ortec to prevent baseline weave following RC differentiation of an exponential pulse [see "Computers, ICs help physicists probe nature," ED 6, March 15, 1967, pp. 42-48]. This technique is indeed quite worth while and permits spectral measurements to be made at high counting rates.

I believe the first time this technique was used was in a nuclear pulse amplifier, which I designed and described at the San Diego, Calif., meeting of the IEEE Nuclear Science Group in the fall of 1963. This was published in the January, 1964, issue of the *IEEE Transactions on Nuclear Science* ["Gamma Amplifier-Discriminator," Vol. NS-11, No. 1, pp. 323-328], although the mathematics was not described at that time. My amplifier is different [from Emmen's] in that I use delay-line pulse-shaping instead of RC shaping. Figure 1 shows the RC circuit which you described; Fig. 2 shows my delay-line circuit. In both circuits a fraction of the input signal is added to the shaped output signal.

The following analysis develops the mathematical description of this circuit and shows that proper setting for the potentiometer is a function of the delay-line loss, α, and the ratio of the two time constants involved.

Time period I: $t < T_2$

Analysis of the circuit is done in two time regions. The conditions for the first are shown in Fig. 2. Here $t<T_2$, where T_2 is the two-way transit time of the delay line. Since the input of the amplifier is a virtual ground:

$$e_2(t) = e_1(t)\left[\frac{R_0(2R_0)/(R_0+2R_0)}{2R_0+[R_0(2R_0)/(R_0+2R_0)]}\right]$$

$$= e_1(t)/4;$$

$$i_3(t) = e_1(t)/4R_0;$$

$$i_1(t) = e_1(t)/8R_0;$$

$$i_2(t) = Ke_1(t)/R_2;$$

$$e_0(t) = -R_F[i_1(t) + i_2(t)]$$

$$= -R_F\, e_1(t)[1/8R_0 + K/R_2]$$

$$= [-(R_F/8R_0)][e_1(t)]\{1+[K/R_2/8R_0)]\}.$$

Note that if $K = 0$, or the cancellation circuit is removed, this last expression reduces to:

$$e_0 = -(R_F/8R_0)e_1,$$

which is the usual value.

It should be observed that in the time interval $t<T_2$, the shape of the pulse is not changed.

Time period II: $t \geqq T_2$

When the signal has propagated down the line and hit the shorted end, it inverts and propagates back up the line with a total loss of α. Thus, after $t = T_2$ (Fig. 3):

$$i_3(t) = -\alpha\, i_3(t-T_2)u(t-T_2)$$

$$= [-\alpha\, e_1(t-T_2)/4R_0]u(t-T_2).$$

Half of this current goes back to the source, so that the portion that joins $i_1(t)$ is:

$$[-\alpha\, e_1(t-T_2)/8R_0]u(t-T_2).$$

The output of the amplifier is now:

$$e_0(t) = -R_F\{[e_1(t)/8R_0] + [Ke_1(t)/R_2] - [\alpha\, e_1(t-T_2)/8R_0]u(t-T_2)\}.$$

In a nuclear-pulse-amplifier application, the signal $e_1(t)$ is of the form:

$$e_1(t) = E_1\epsilon^{-t/T_1}.$$

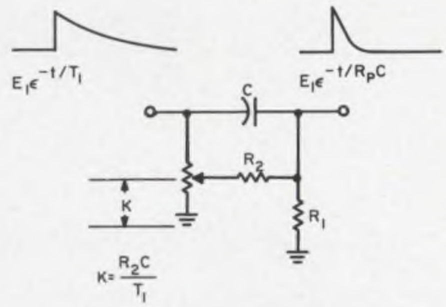
Thus:

$$e_0(t) = [(-R_FE_1)/8R_0]\{\epsilon^{-t/T_1} + (8R_0K/R_2)\epsilon^{-t/T_1} - \alpha\exp-[(t-T_2)/T_1]\}$$

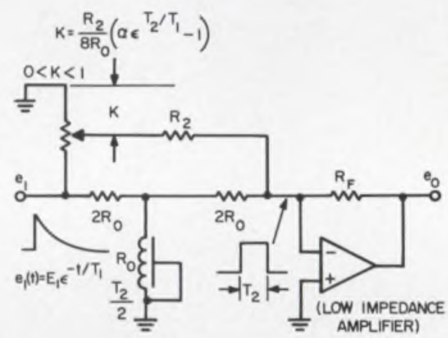
$$= [(-R_FE_1)/8R_0]\epsilon^{-t/T_1}[1 + (8R_0\,K/R_2) - \alpha\,\epsilon^{T_2/T_1}].$$

For perfect baseline cancellation,

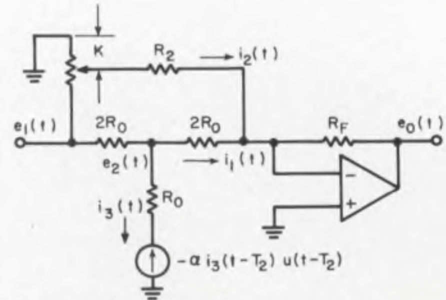
(continued on p. 54)



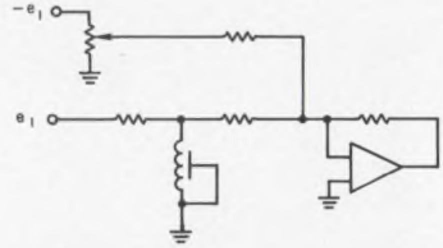
1. **RC compensation** brings the output signal to zero quickly in a pulse-counting system so that amplitudes of succeeding pulses are accurately indicated.



2. **Delay-line pulse-shaping** accomplishes a similar function to RC compensation. Note that T_2 is the two-way transit time through the line. This circuit shows conditions for $t < T_2$.



3. **Equivalent circuit** for $t \geqq T_2$.



4. **Inverted compensation** scheme.

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The 7850 Series system includes a preamplifier power supply, a driver amplifier power supply and a cabinet to house the complete unit. The frequency response of the recorder is 160 Hz for 10 div p-p deflection and 60 Hertz maximum for full scale deflection. Maximum ac or dc non-linearity is 0.5% full scale. Additional features include: 14 electrically-controlled chart speeds; built-in paper take-up; low ink supply warning light; plug-in ink supply cartridge that may be replaced while the recorder is in operation and complete modular construction of all components for easy maintenance:

For complete information on the 7850 system, optional and related equipment, contact your local HP Field Office or write Hewlett-Packard Company, 175 Wyman St., Waltham, Mass. 02154.

HEWLETT hp PACKARD

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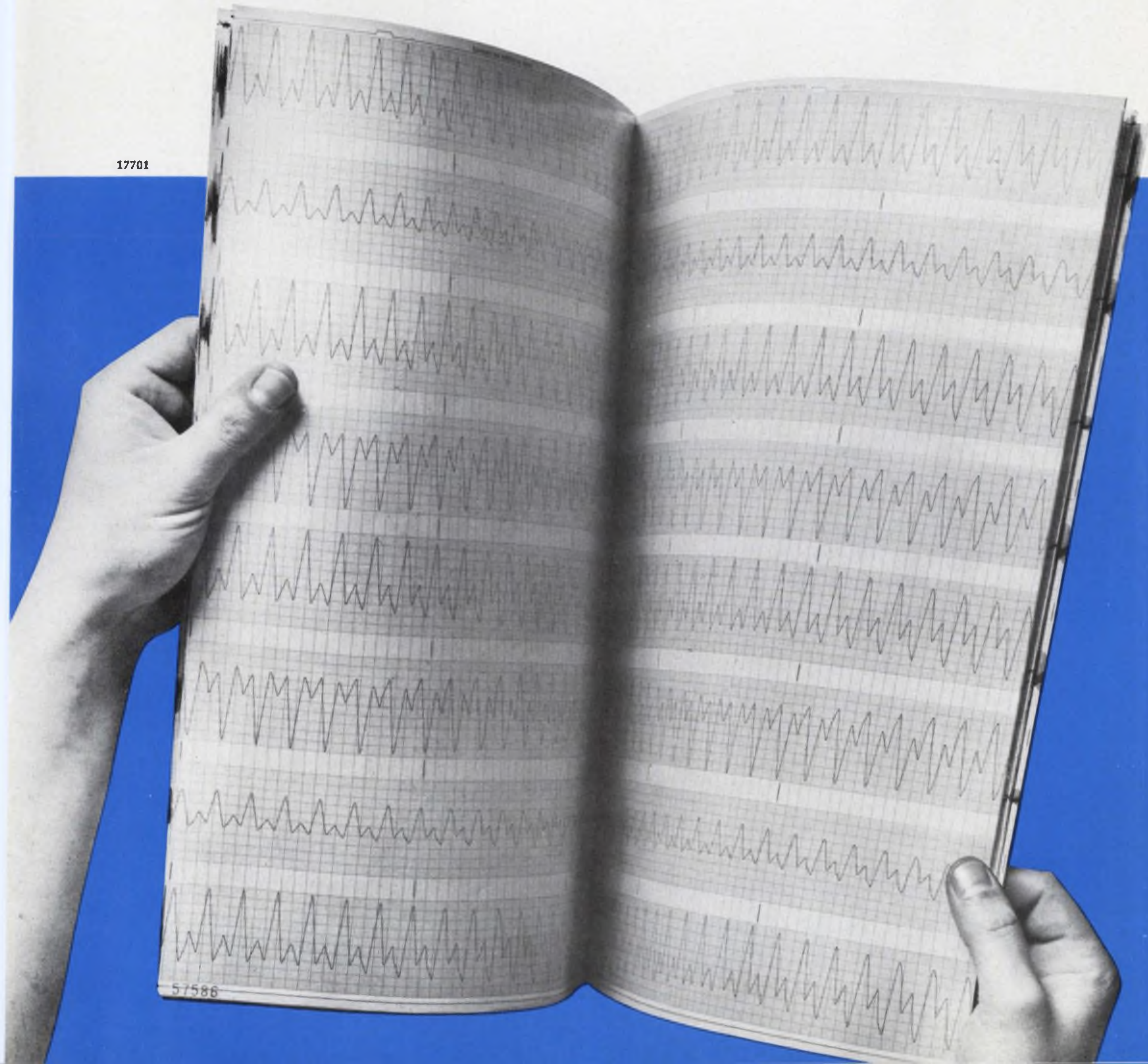
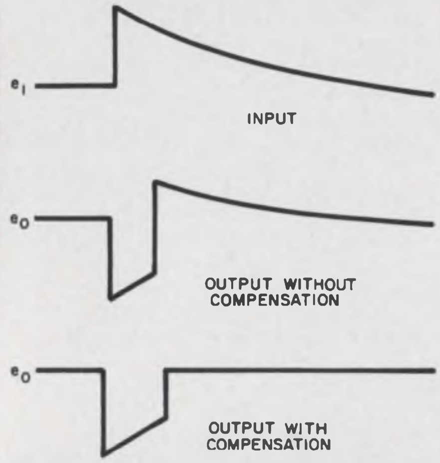


(continued from p. 52)



5. **Waveshapes** with and without compensation. Note the slow exponential return to zero of the output when no compensation is used.

this voltage should be zero. This can be accomplished if:

$$1 + 8R_0 K/R_2 = \alpha \epsilon^{T_2/T_1};$$

that is to say, if:

$$K = (R_2/8R_0)(\alpha \epsilon^{T_2/T_1} - 1).$$

It can be seen that the amount of compensation required depends on the line loss, α, and on the ratio of T_2/T_1, the clipping time to the decay time of the input signal.

If the line is very lossy, or if the input decay time is very long, it may be necessary to apply an inverted signal to the compensating potentiometer, as shown in Fig. 4. This signal can usually be obtained within the preceding amplifier stage and does not have to be of the same amplitude.

Waveshapes of the input and the output with and without compensation are shown in Fig. 5.

(*This work was performed under the auspices of the U.S. Atomic Energy Commission.*)

Curtis Sewell, Jr.
University of California
Lawrence Radiation Laboratory
Livermore, Calif.

Lf neutralizing circuit has to be corrected

Sir:

Figure 1 of our article on stabilizing power tubes ["Stabilize power tubes at uhf and vhf," ED 10,

(continued on p. 56)

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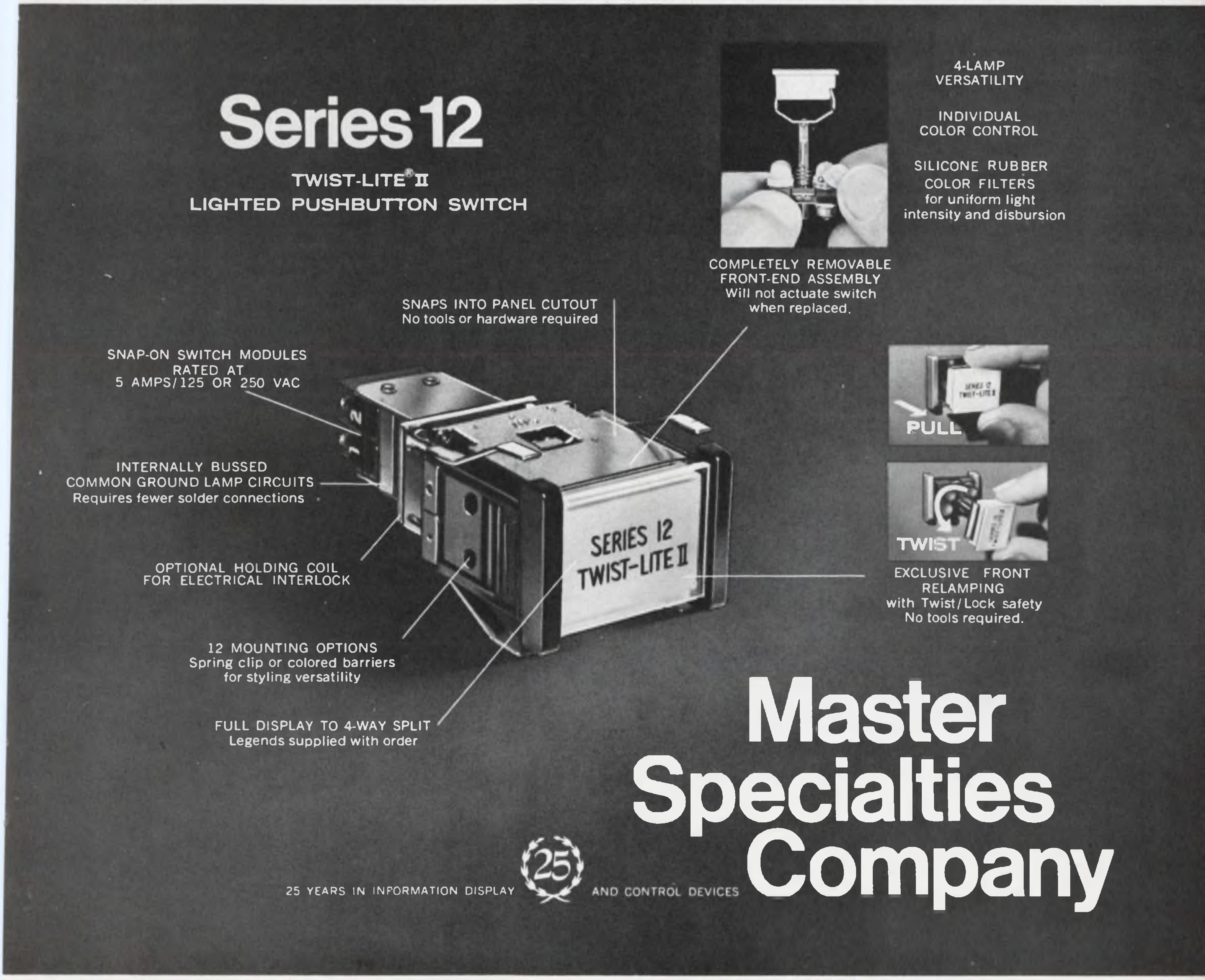

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LETTERS

(continued from p. 54)

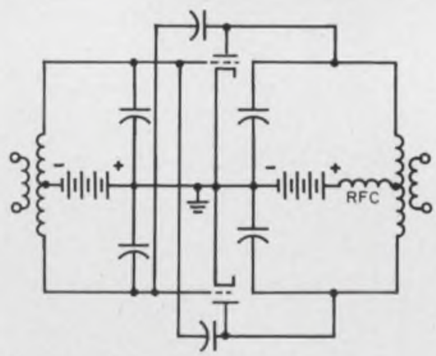
May 10, 1967, p. 64] is incorrect. Your reader's comment that a solder dot is missing is not the error, however.

It is not desirable to tie the coil center tap directly to the capacitor center tap. Very seldom are the components so well balanced that the zero potential points actually are at the center. It is better to ground the capacitor center tap and feed the center of the coil with a choke. This allows the coil to move its zero potential point where the circuit wants it to be. All these comments are for the general case. Sometimes more ingenuity is required with this part of the circuit to suppress a parasitic. The correct diagram for our article is printed below.

Please note that there is an error in the grid circuit as well. There is no dc return to the control grid, as shown in the published article. This correction, too, has been incorporated in the revised circuit diagram.

We certainly apologize for the erroneous diagram we submitted and for any inconvenience this may have caused.

Robert I. Sutherland
Supervisor
EIMAC, Div. of Varian Associates
San Carlos, Calif.



Typical neutralizing circuit for If is a version of a capacitance bridge. This circuit corrects errors in the schematic published in ED 10, May 10.

Accuracy is our policy

In "Coupling circuit has dc dead zone," in the Ideas for Design section of ED 10, May 10, 1967, p. 96, there is an error in Fig. c. A solder dot should provide connection between $B+$ and $R1$, $R2$ and $R3$.

EDITORIAL

It isn't the retrieval, it's what you retrieve

The Government has been trying hard to spend money on information retrieval. Too many engineers and scientists working on important projects have complained about the difficulty of obtaining the information they need for the job.

Much of the Government's money has gone to serious-minded scholars who puff on their pipes and contemplate great abstractions. They dream of the day when every library will be stored on a computer and all the computers will be interconnected by satellites, lasers and such. This is pretty safe musing, they realize, for by the time it all becomes reality their own work will have become securely irretrievable.

Fortunately, the Government seems to be changing its tack. Work is being done on a few systems more firmly based on what is feasible now. All the same, we believe the whole focus is on the wrong end of the pipeline.

It is the *input* to the information system that is the bigger problem, not the retrieval.

With some diligence, an engineer can amass quite a pile of material on his problem from libraries, department files and research organizations. But the quality of this material is what's at fault. How much of it really explains the theory clearly; or links the theory to practical possibilities? This kind of immediately useful information is hard to find.

When the authors of a recent theoretical article were asked to write about a real system problem and show how to apply their theory to it, they declined. It would be a monumental task, they said —and, besides, it wasn't covered by their Government contract. Their theoretical triumph is now on the library shelves, and it can be retrieved quite easily by any one of a number of key words. But it won't do systems engineers much good.

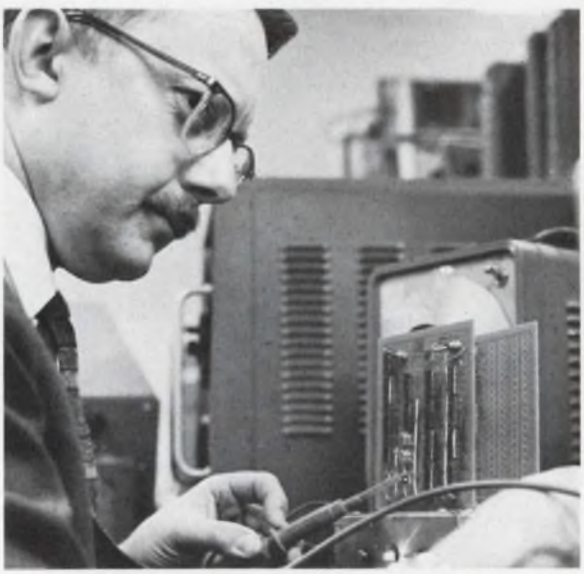
Too many books ostensibly written to update engineers keep their readers at bay by crafty tricks: an unexplained symbol or impenetrable technical jargon. Obviously the reader should have taken the same courses as the author (a PhD teaching at a leading engineering school). The sad thing is that often these blocks to understanding could have been removed quickly with a couple of simple sentences or examples.

The information problem won't be solved until engineers and scientists stop tolerating poor communication. Incomprehensibility does not equal brilliance. Only when this is realized will investments in information retrieval begin to pay off.

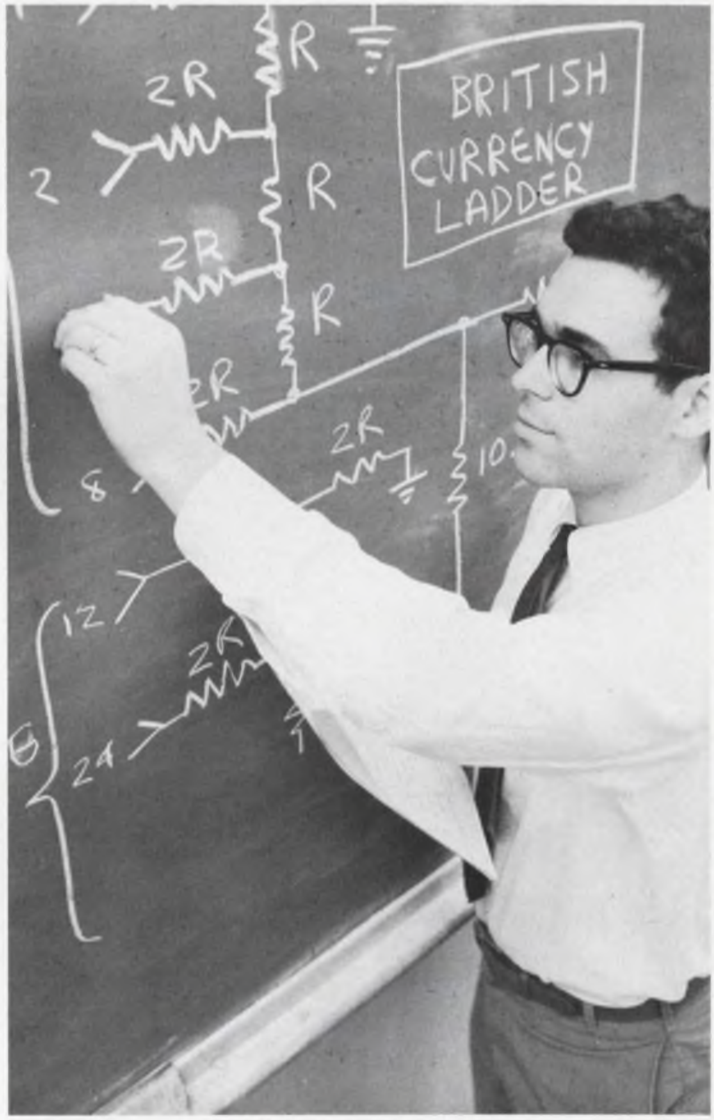
ROBERT HAAVIND

Technology

Diode model is analyzed by computer as a single junction of a transistor. Page 80



Digital frequency comparators are made with a few flip-flops and gates. Page 62



Ladder networks for D/A and A/D converters involve solving only 3 linear equations. Page 68

Also in this section:

Resistor-thermistor networks are easy to synthesize by the direct method. Page 74

Mismatching for low noise in amplifiers is a one-step operation with a nomograph. Page 86

Semiannual index of articles for January to June, 1967. Page 89

Make IC digital frequency comparators

with just a few flip-flops and gates. Here are three designs that yield phase and frequency relationships.

Digital integrated logic can be a powerful tool for measuring frequency and phase relationships between two unknown frequencies. Many digital circuits designed for this purpose, however, tell which of the two input signals is higher in frequency, but give no phase information if the frequencies are equal. Others give phase information alone and require the two frequencies to be equal or very nearly so; when the frequencies are far apart, some even give ambiguous results.

Here are three circuits that determine without ambiguity which of two inputs is higher in frequency, and for equal frequencies indicate the signals' relative phases. All three circuits can be designed with just a few integrated components of any logic type.

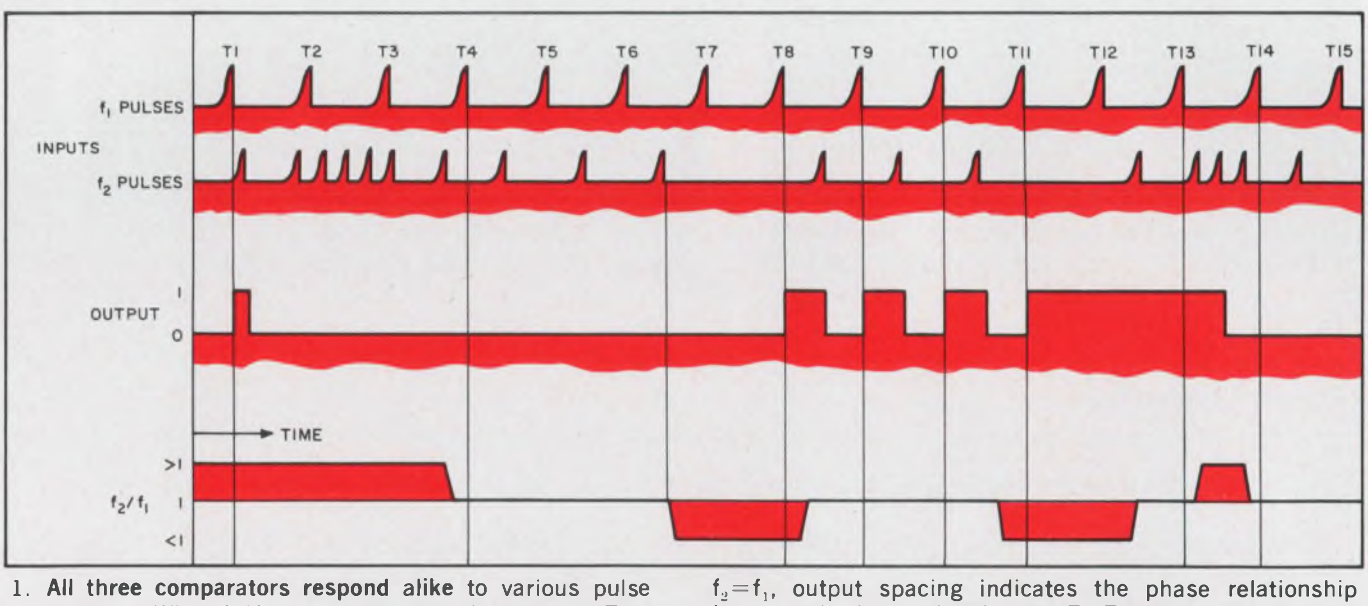
Figure 1 shows a number of possible pulse trains on the input of the comparator. The three circuits (Figs. 2, 3 and 4) are all logically equivalent; their output is that shown in Fig. 1.

Hermann Ebenhoech, Consumer Application Engineer, Fairchild Semiconductor Div., Fairchild Camera and Instrument Corp., Mountain View, Calif.

The output is *0* when f_2 is greater than f_1; is *1* when f_2 is less than f_1; and switches between *0* and *1* when f_2 equals f_1. The three conditions of the output are termed high state, phase state, and low state, respectively. The relative widths of the square waves generated by the switching indicate the phase relationship of the two signals.

For the comparator's output to change from the phase state to either the low state or the high state, two or more pulses must impinge on one input before a pulse impinges on the other input. Three or more successive pulses on one channel can change the output from high state to low state or vice versa; while two, and only two, consecutive pulses lead from either of these outer states to the phase state. Thus, when used to match frequencies, the system has built-in error detection: the adjustable frequency must be brought up or down to, and just a shade past, the frequency with which it is matched, to drive the comparator into its phase state.

The first circuit (Fig. 2) uses flip-flop 2 (*FF2*) as the output. It is allowed to change states only if *FF1* is in the *1*-state. *FF2*'s output levels are fed



1. **All three comparators respond alike** to various pulse train inputs. When $f_2/f_1 > 1$, output stays low (see T1-T4). When $f_2/f_1 < 1$, output stays high (see T11-T13). When $f_2 = f_1$, output spacing indicates the phase relationship between the input signals (see T8-T11). In this chart, f_1 is constant for clarity. In fact, it needn't be.

Fairchild Semiconductors' Hermann Ebenhoech checks out a digital design that incorporates one of his digital comparator circuits.

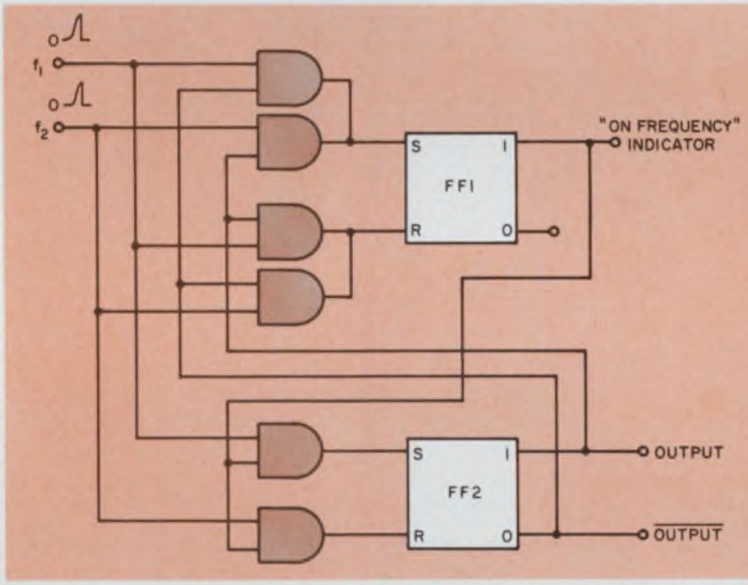
back to the control gates of *FF1*, to prevent it from changing to *0* during the phase state.

FF1 does not change if both frequencies are equal. *FF1* can thus indicate the frequencies' equality. If, however, f_1 is not equal to f_2, then *FF1* prevents *FF2* from changing its state. Two pulses are required to restore the system to the phase state.

This circuit has the advantage of indicating a frequency match without additional components. The output of *FF1* is quiescent if the frequencies are equal, and switches if they are unequal. (Circuits 2 and 3 both use an additional gate to indicate a frequency match.)

The second circuit (Fig. 3) uses R-S flip-flops with inhibit terminals. A pulse on an input will have no effect if the neighboring inhibit terminal is at a high potential.

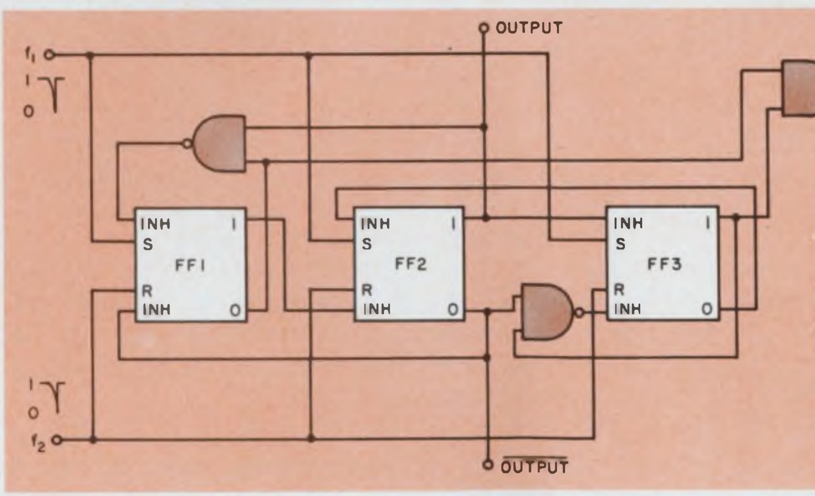
FF2 is the output flip-flop. In the phase state,



TRUTH TABLE FOR THIS CIRCUIT

STATE BEFORE TRIGGER SIGNAL		TRIGGER SIGNAL ON INPUT LINE		STATE AFTER TRIGGER SIGNAL	
FF1	FF2	f_1	f_2	FF1	FF2
0	0	*	–	1	0
0	0	–	*	0	0
0	1	*	–	0	1
0	1	–	*	1	1
1	0	*	–	1	1
1	0	–	*	0	0
1	1	*	–	0	1
1	1	–	*	1	0

2. **This circuit indicates a frequency match** without the need for additional components (left). Its truth table (right) uses a star to indicate a pulse on the input lines. A dash indicates no pulse.

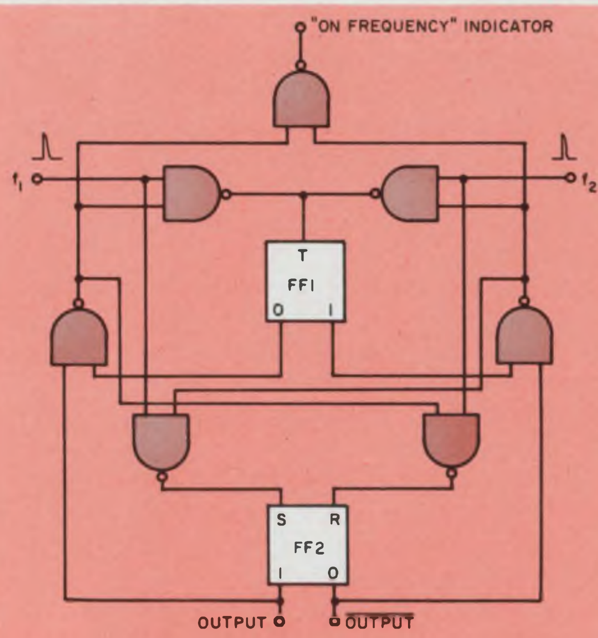


TRUTH TABLE FOR THIS CIRCUIT

STATE BEFORE TRIGGER SIGNAL			TRIGGER SIGNAL ON INPUT LINE		STATE AFTER TRIGGER SIGNAL		
FF1	FF2	FF3	f_1	f_2	FF1	FF2	FF3
0	0	0	*	–	0	0	1
0	0	0	–	*	0	0	0
0	0	1	*	–	0	1	1
0	0	1	–	*	0	0	0
0	1	1	*	–	1	1	1
0	1	1	–	*	0	0	1
1	1	1	*	–	1	1	1
1	1	1	–	*	0	1	1

ALL OTHER COMBINATIONS NOT ALLOWED

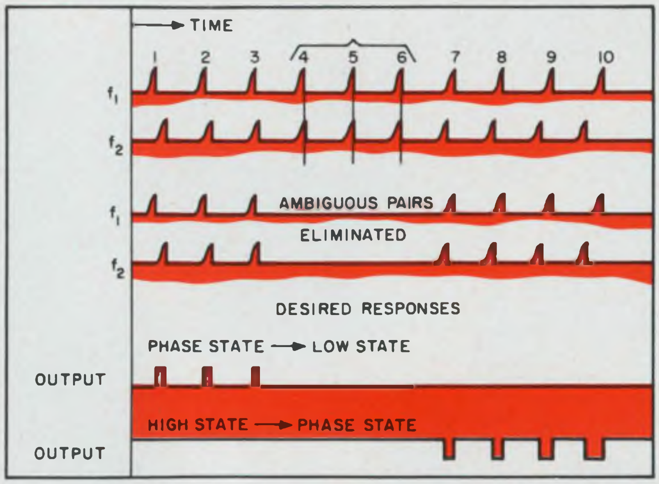
3. **This circuit handles square wave inputs** if it is built with capacitively coupled flip-flops. A high potential on an inhibit terminal (INH) nullifies the effect of the adjoining input signal.



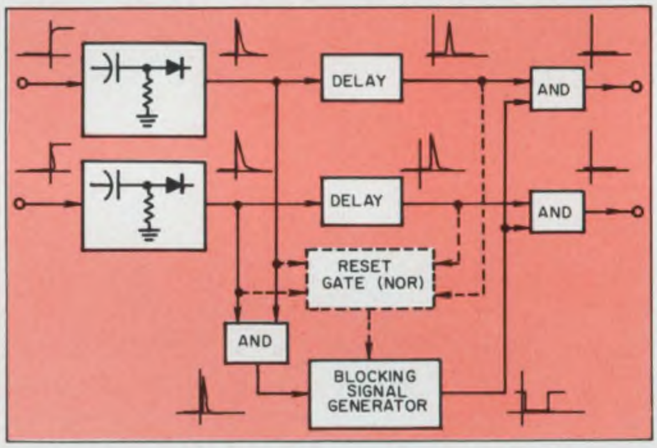
TRUTH TABLE FOR THIS CIRCUIT

STATE BEFORE TRIGGER SIGNAL		TRIGGER SIGNAL ON INPUT LINE		STATE AFTER TRIGGER SIGNAL	
FF1	FF2	f_1	f_2	FF1	FF2
0	0	*	–	1	1
0	0	–	*	1	0
0	1	*	–	0	1
0	1	–	*	1	1
1	0	*	–	0	0
1	0	–	*	1	0
1	1	*	–	0	1
1	1	–	*	0	0

4. **Both flip-flops change state in** synchronization if f_1 and f_2 are equal. This circuit has the same number of parts as the one in Fig. 2, but it does require an additional gate if it is to indicate a frequency match. Its four lower gates can be on one chip.



5. **Ambiguous pairs of pulses never reach** the comparator. The double-pulse eliminator nabbed pulses 4, 5 and 6 yet the comparator showed the state change.



6. **The double-pulse eliminator prevents** two simultaneous pulses that appear on the two inputs from passing to the comparator.

FF1 and *FF3* are quiescent and their outputs are combined to indicate a frequency match.

Since, in this circuit, the inputs are fed directly to the flip-flops, there are no feedback paths as in circuits 1 and 3. Thus this circuit, if built with capacitively coupled flip-flops,* can handle square-wave input signals. (The other two circuits must be fed short, sharp pulses.)

The third circuit (Fig. 4) has the same number of gates and flip-flops as circuit 1. Both its flip-flops change state in synchronization if f_1 and f_2 are equal. The four gates can be contained in one quad unit.†

All three circuits can be designed with any kind of logic provided that the appropriate flip-flops—R-S (or T)—are available in that logic.

The response of an R-S flip-flop and a J-K flip-flop to pulses occurring simultaneously on both inputs are in contrast to the response desired (see Fig. 5). If the pulses on the two input lines occur simultaneously, the dual pulse eliminator will prevent them from passing on to the comparator; hence the comparator will not accept ambiguous input signals. Its frequency range is increased and the upper frequency limit is set by the time delay of the actual circuits.

The block diagram of the double-pulse eliminator is given in Fig. 6. The differentiators are not essential, but they make possible the acceptance of noncritical waveforms. The delay between points *A* and *B* permits the blocking signal to reach the output gates ahead of the pulses. The blocking signal generator can take the form of a monostable or bistable multivibrator, or equivalent. In the case of the bistable solution, resetting is accomplished with the NOR gate.

In cooperation with the frequency eliminator, all three systems will perform well up to the frequency limits set by the switching times of the logic families employed in their construction. ■ ■

*Editor's note: Fairchild's DTμL 950, for instance.
†Editor's note: Fairchild (DTμL 946), Motorola (MC 946) and Texas Instruments—all market quads.

Five new op amps from TI expand your linear IC spectrum

Operational Amplifier Selection Guide

Typical Characteristics	SN523A SN5231L	SN524A SN724	SN525 SN725	SN526 SN726	SN5510	NEW SN5511	NEW SN52702	NEW SN52709	NEW SN52710	NEW SN52711
Open-loop voltage gain, dB	72	63	90	66	40	65	68	93	64	64
Bandwidth (-3 dB), kHz	180	140	45	120	40,000	4000	–	–	–	–
Input impedance, kΩ	15	1000	140	1000	6	5	25	400	–	–
Input capacitance, pF	55	60	250	50	7	–	–	–	–	–
Differential-input offset voltage, mV	2.2	12	1	3	3	1	2	3	2	1
Differential-input offset current, μA	0.5	0.02	0.016	0.006	3	3.2	0.7	0.05	1	0.5
Differential-input offset voltage temperature coefficient, μV/°C	9	25	5	10	10	2	5	–	5	5
Maximum common-mode input voltage range, V	±5	±5	±7	±7	±1	±2.6	0.5 to −4	±10	–	–
Common-mode output offset voltage, V	0.5	–	0.25	0.22	3.1	.35	–	–	–	–
Output impedance, Ω	200	200	10k	–	35	770	200	150	200	200
Maximum peak-to-peak output voltage, V	24	15	18	11.7	4.0	5.0	10.6	26	–	–
Common-mode rejection ratio, dB	90	55	100	77	85	95	80	90	–	–
Total Power dissipation, mW	100	120	100	132	165	170	70	80	110	130
Input current, μA	5	0.08	0.45	0.05	40	3.2	4	0.2	25	25

With the addition of five new IC operational amplifiers, Texas Instruments provides linear system designers with the broadest range of performance characteristics available today. Now you can select an IC amplifier suited to your particular requirements of performance and price. Some of the new circuits challenge the finest discrete-component amplifiers in performance. Others cost less than a third as much as discrete-component equivalents. All offer the advantages of smaller, simpler, more economical systems and vastly increased reliability.

New video differential amplifier offers unsurpassed stability

The new SN5511 differential video amplifier provides excellent operational amplifier performance at frequencies extending into the low VHF range. It offers a flat 30 dB closed loop gain from dc to 30 MHz, an extremely low offset voltage of 300 mV typical, and a minimum of 80 dB common mode rejection.

Stability and versatility are enhanced by provisions for external compensating networks and gating, to clock the circuit on and off under minimal interface conditions. The external compensating networks may also be used to adjust frequency response and offset.

Circle 260 for data sheet.

New general-purpose operational amplifier costs 30% of discrete equivalent

The SN52702 is a high gain bandwidth IC amplifier that offers distinct size and reliability advantages over discrete component counterparts, at about one-third the cost.

Matching of components within the chip assures excellent thermal stability. Drift is only 5 μV/°C and offset is typically 6 mV. Further stability is provided by both lead and lag external compensation.

Circle 261 for data sheet.

New "premium" op-amp offers superior performance for critical applications

The SN52709 IC has nearly twice as many components on the chip as conventional amplifiers . . . and correspondingly superior electrical characteristics. When compared with earlier IC amplifiers, differential input offset is an order of magnitude lower, output voltage is 2½ times higher, and large signal voltage gain is 20 times higher. Input impedance is ten times higher and output impedance is 50 percent lower. Two frequency compensating arrangements are provided.

The SN52709 is the new standard of performance for analog computer and other critical applications.

Circle 262 for data sheets.

New differential comparator features fast response

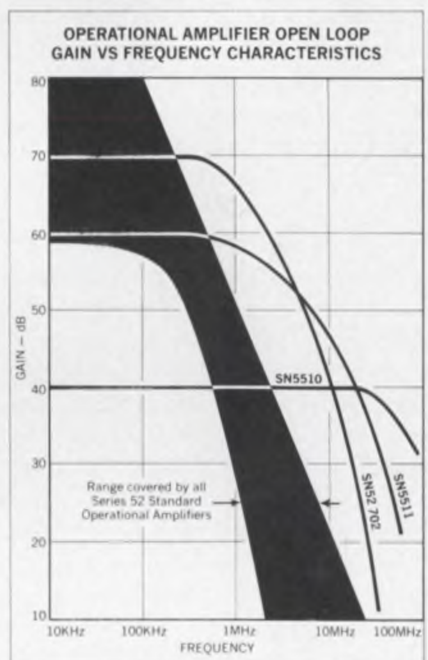
High speed is the big advantage of the SN52710. It responds in 40 nsec when a 5 mV overdrive is supplied. Low offset (6 mV max), high voltage gains (typically 1500), and high output level (4 V), are other features.

Circle 263 for data sheet.

New dual comparator can stretch output pulses and sense amplitude variations

The SN52711 is more than just two differential comparators in a single package. It can stretch output pulses and function as an amplitude-discriminating sense amplifier with an adjustable threshold. Despite these capabilities the cost is less than two comparable differential comparators.

Circle 264 for data sheets.



To learn more about these and other linear integrated circuits, contact your local TI sales engineer or authorized distributor . . . or write us at P. O. Box 5012, Dallas, Texas 75222.

TEXAS INSTRUMENTS
INCORPORATED

Ladder networks are easy to design

for D/A and A/D converters by a method that involves the solution of only three simple algebraic equations.

The design of ladder networks in analog-to-digital and digital-to-analog converters need not be a tough job. Even if an oddball binary code or a mixture of binary codes is involved, the procedure can be simplified to three linear equations. The resultant ladder network is built with identical resistive blocks or stages.

Since the circuit is constructed of resistors only, it does not have added frequency-sensitive elements, such as capacitors and inductors. No matter how many stages are added to the network, the resistive value at each node, looking either above or below, is the same: R.

The equations help to find the numerical values of the terminating resistor and the coupling resistors. Only two of these equations are needed for a ladder with identically coded binary inputs. All three equations are needed when the inputs are in different binary codes.

Ladder networks provide step attenuation in the converters. For the simpler case of identically coded binary inputs, consider the network in Fig. 1. This circuit will help establish the relationship between the base of the code and the component values of the ladder. Each of the four inputs makes twice the weighted voltage (or current) contribution of the previous input as the inputs approach the first input (1), the most significant digit. For example, an input at 1 contributes twice as much to the output as an input at 2.

This circuit is a basic building block. It can form one stage of a ladder network. The effects of loading by subsequent stages can be found by examining its equivalent circuit.

Terminating resistor matches ladder

A Thévenin generator equivalent of the ladder in Fig. 1 is shown in Fig. 2a. Note that the terminating resistance of the circuit in Fig. 1 is $2R$. It turns out to be a matched termination, since it simulates an infinite length of ladder sections; therefore there is no reflection from the termination. The fact that $2R$ is the proper termination can be seen from the analysis of the last stage (Fig. 2b): the $2R$ termination makes the equivalent value of the last stage equal to R, too. By the same procedure, it can be shown that all other stages have the same equivalent value of R. The voltage sources that represent the input lines are assumed to be ideal; hence they have zero impedances. Therefore the input resistance—the Thévenin source resistance in Fig. 2a—is also equal in value to R:

$$R_S = R. \qquad (1)$$

As already stated, all nodes of the network present the same impedance, R. Consequently, the outputs are determined only by how many stages separate them from the final output. This fixes the number of voltage dividers that they have to go through.

The Thévenin voltage equivalent, e_s, is the unloaded output voltage of the ladder network. The applied input voltages contribute successively less and less as one proceeds farther down the ladder inputs. The first input, e_1, looks into a voltage divider, shown in Fig. 2c. The grounded $2R$ resistor in the figure represents the load for the remainder of the ladder. Therefore e_1 contributes $e_1/2$ at the output. The voltage dividers for e_2, e_3, etc. can also be worked out. The final results show the relative voltage contributions at the input to be $e_2/4$, $e_3/8$, etc. Therefore the output is:

$$e_s = \frac{e_1}{2} + \frac{e_2}{2^2} + \frac{e_3}{2^3} + \cdots + \frac{e_N}{2^N}. \qquad (2)$$

e_N is the last input to the ladder network. In A/D or D/A ladders e_1 through e_N are generally equal voltages.

The loading of a ladder with various load resistors, R_L, will affect the output voltage range, but not linearity. As Eq. 2 shows, the output depends linearly on the inputs.

These considerations reduce the ladder in Fig. 1 to a voltage source and resistance that can be loaded down by other ladder groups through coupling resistances or a terminating resistance.

In fact, the ladder, as reduced in Fig. 2a, be-

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comes one input to a larger ladder, shown in Fig. 3. Each input to the network in Fig. 3 is another ladder. The problem is to determine the values of the coupling resistances and terminating resistances, so that each input contributes the desired weighting. This weighting is referred to as the base, b, of the ladder.

For example, a BCD ladder would have a weighting or base of 10 between ladder groups. To design a ladder to this or any other base, the values of X and Y in Fig. 3 must be determined. Analysis will show that X and Y are simple functions of the base.

Base is related to input weighting

To derive the basic equations, the problem may be phrased: Solve for X and Y so that each source contributes at the output of the network b times the voltage of the previous input, going down the ladder in Fig. 3. For example, $e_{s(n-2)}$ should contribute b times as much as $e_{s(n-1)}$ to the total output.

Since the Thévenin equivalent of the network can be loaded without affecting the linearity of the output response, as Eq. 2 demonstrates, R_L may for convenience' sake be set equal to X, the terminating resistance. X is selected so that Y, in series with X and in parallel with R, is equal to X, as shown in Fig. 4. Solve for Y in terms of X:

$$X = Y + XR/(R+X) \qquad (3)$$

$$X - XR/(R+X) = Y \qquad (4)$$

$$Y = X^2/(R+X). \qquad (5)$$

It is permissible to normalize by setting R equal to 1. The coupling resistance, Y, and the terminating resistance, X, will then simply be multiples of unity, making the algebra simpler. So, when $R = 1$ in Eq. 5:

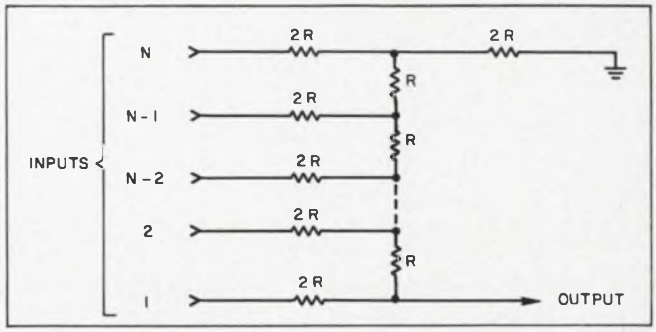
$$Y = X^2/(1+X). \qquad (6)$$

Now solve for the relative values of X and Y, so that $e_{s(n-1)}$ contributes b times the voltage contributed by e_{sn} at node 2 in Fig. 3. To do this, the voltage divisions must be calculated.

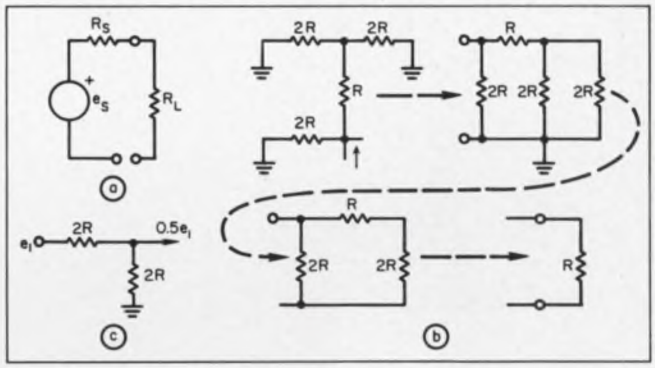
At node 2, the configuration that appears looking up the ladder and the one that appears looking down it are both the same as that shown in Fig. 4. These two like configurations in parallel with each other yield an equivalent resistance of $X/2$, since the input resistance of each is X. The voltage $e_{s(n-1)}$ is distributed between the two sections. The effective resistance of the voltage divider is given by:

$$\frac{X/2}{(X/2)+R} = \frac{X}{X+2R} = \frac{X}{X+2} \text{ for } R = 1. \qquad (7)$$

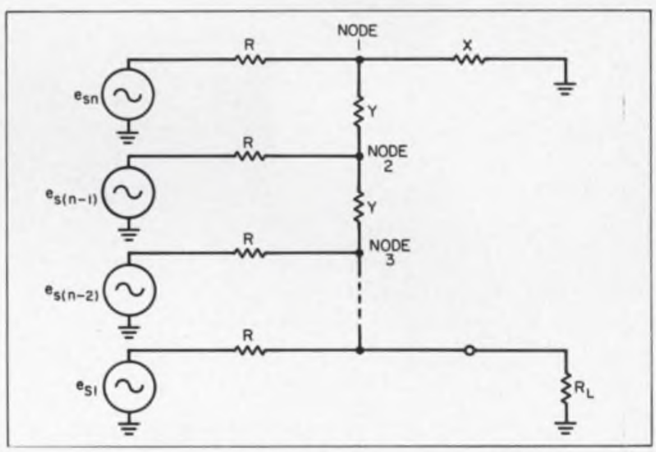
The input voltage e_{sn} is also divided between two sections: one consists of the terminating resistance, X, the other is the last stage of the ladder. The equivalent resistance at node 1 of the ladder is again given by:



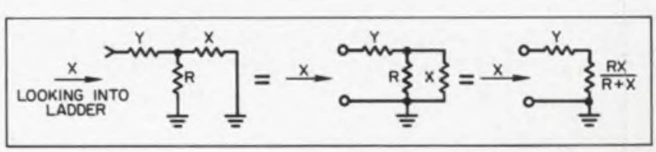
1. **Each input of this binary ladder,** contributes twice the voltage provided by the one above it: $e_{out} = e_1/2 + e_2/4 + \cdots + e_N/2^N$.



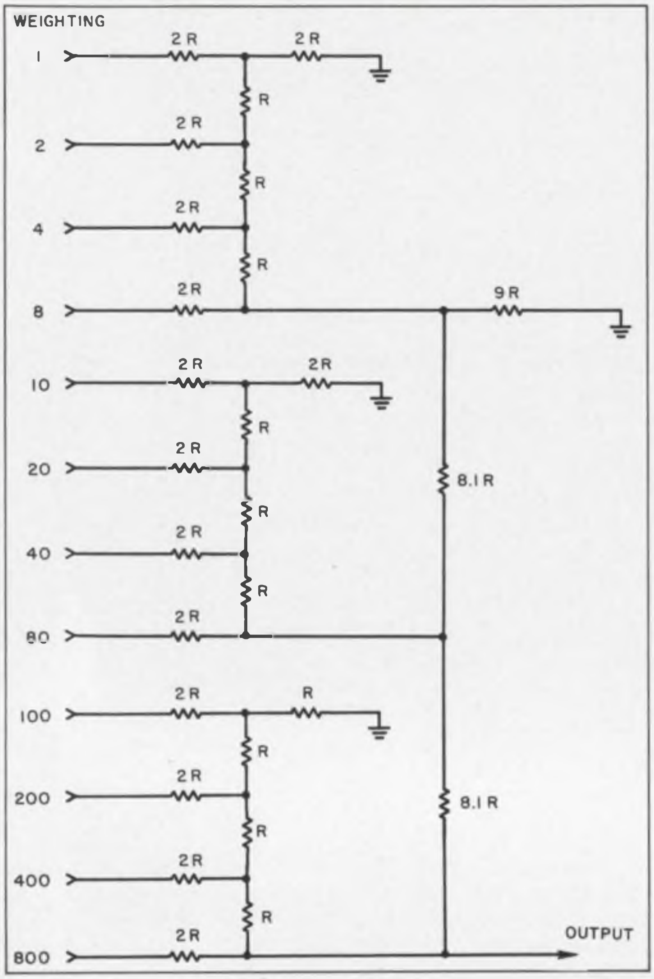
2. **The effects of loading on the ladder** by subsequent stages are estimated with its equivalent circuit (a). The equivalent resistance is found by removing the voltage sources (b) and assuming zero source resistances. The equivalent voltage, e_s, is the sum of the applied inputs. The analysis of the first input (c) shows that its contribution is $e_1/2$.



3. **Each input of this network is a stage** shown in Fig. 2. The terminating and coupling resistances (X and Y, respectively) determine the weighting, or the base, of the ladder, that adjusts the contributions of the inputs.



4. **This circuit is the configuration that appears** at any node in Fig 3, up or down on the ladder. The terminating resistance, R_L in Fig. 3, has been replaced by X, to simulate an infinite series of sections.



5. **Binary-coded decimal ladder has a base of 10.** The coupling resistors were found with Eqs. 14 and 15. The output voltage is proportional to the 12-bit BCD input.

$$\frac{X/2}{(X/2)+R}=\frac{X}{X+2R}. \qquad (8)$$

The contribution of e_{sn} to the voltage at node 2 is determined by the two divisions through the voltage dividers at nodes 1 and 2. The division at node 1 is by $X/(X+2R)$. The division at node 2 is performed by the circuit in Fig. 4. To find the dividing factor, the voltage drop across the parallel combination of R and X must be found. The value of e_{sn} at node 2 is modified by the product of the two factors:

$$\frac{X}{X+2R}\left[\frac{RX}{R+X}\Big/\left(Y+\frac{RX}{R+X}\right)\right]. \qquad (9)$$

Equation 9 may be normalized by letting $R = 1$:

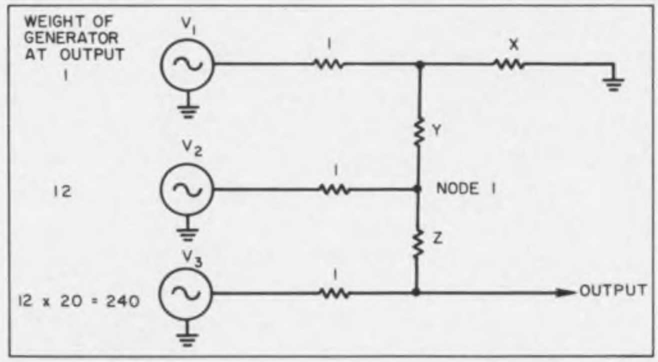
$$\frac{X}{X+2}\left[\frac{X}{Y(1+X)+X}\right]. \qquad (10)$$

The aim is to develop a ladder so that $e_{s(n-1)}$ contributes b times the voltage contributed by e_{sn} at the output. Hence:

$$\frac{X}{X+2}=b\,\frac{X}{X+2}\left[\frac{X}{Y(1+X)+X}\right]. \qquad (11)$$

Simplifying Eq. 10 and solving for Y gives:

$$Y=(bX-X)/(1+X). \qquad (12)$$



6. **In mixed-base ladders** the relative weights between adjacent stages (1, 12 and 20) are used to compute the coupling resistances, Y and Z. The weight of the last input is 12 x 20 = 240, relative to the first stage. The stages of the network are shown in their equivalent-circuit form.

Equations 6 and 12 yield the value of resistor X:

$$(bX-X)/(1+X)=X^2/(1+X). \qquad (13)$$

Therefore:

$$X=b-1, \qquad (14)$$

and:

$$Y=X^2/(1+X)=(b-1)^2/b. \qquad (15)$$

Equations 14 and 15 provide the values of resistors X and Y for any base b.

To check the results, consider a simple example. The most common base is 10 in binary-coded decimal ladders. Solving for X and Y gives:

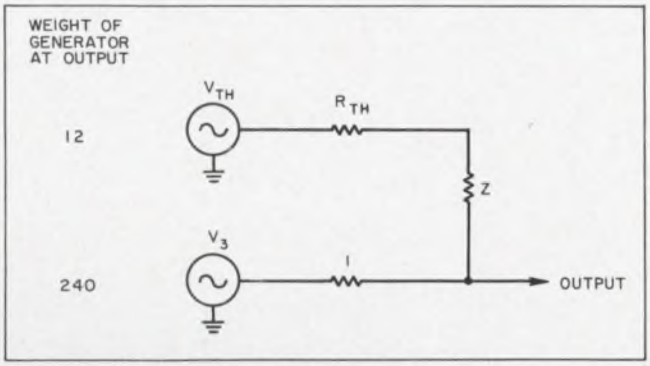
$$X=b-1=10-1=9;$$
$$Y=(b-1)^2/b=8.1.$$

The ladder, shown in Fig. 5, has three 4-input decade groups, coupled by $8.1R$ resistors. The size of the ladder is limited only by the realistic considerations of voltage source tolerances, resistor tolerances, temperature and aging characteristics. Each group accepts binary numbers between *0000* and *1001* (0 to 9 in decimal). The output voltage is proportional to the 12-bit BCD number.

Mixed bases require third equation

The problem of constructing a ladder network with mixed bases will now be examined. Equations 14 and 15 can be used to solve for the termination resistance X and the first coupling resistance Y. If succeeding groups of inputs have the same base, Y is the same for these groups. But when the base is different, a third equation is required for the coupling resistors.

Consider, for instance, a ladder that converts British currency expressed in binary code, into an analog voltage. The currency has 12 pennies to the shilling and 20 shillings to the pound. This calls for a ladder where the first binary group has a weight of 1, the second has a weight of 12 relative to the first group, and the third a weight of 20 relative to the second group. The weight of the third group is 240 relative to the first group. The relative weights of adjacent groups are used



7. **The last coupling resistor, Z,** is found with a further simplification. A new equivalent circuit of the network is formed, to show how it appears to the last stage. Again, zero source resistances are assumed for all voltage sources, for the sake of simplicity.

to compute the coupling resistance between the groups.

The first group will count up to 12, the second up to 20, and the third up to any number limited by component tolerances. For example, the maximum amount of currency may be 16 pounds.

Figure 6 shows the ladder with each group reduced to its Thévenin equivalent circuit. The source resistance of each generator is normalized to unity. Resistors X and Y are found with Eqs. 14 and 15 ($b = 12$ between the first and second stages):

$$X = b-1=12-1=11;$$
$$Y = (b-1)^2/b=121/12=10.0833.$$

To solve for Z, the first two input groups must be converted into a common Thévenin generator and resistor, as shown in Fig. 7. The new equivalent circuit simulates the effect of the weight-12 generator in Fig. 6. The resulting two inputs to the output terminals are then multiplied with the proper weighting function and summed.

To find the Thévenin equivalent of the first two stages, remove Z in Fig. 6 and calculate the equivalent resistance, R_{TH}, and voltage, V_{TH}. Note that sources V_1 and V_2 have zero source resistances. It is also possible to assume that V_1, V_2 and V_3 are all 1-volt sources. Looking into node 1 with Z removed:

$$R_{TH} = \frac{1(X)/(1+X)+Y}{[1(X)/(1+X)]+Y+1}; \quad (16)$$

$$V_{TH} = V_2\frac{1(X)/(1+X)+Y}{[1(X)/(1+X)]+Y+1} = V_2 R_{TH}; \quad (17)$$

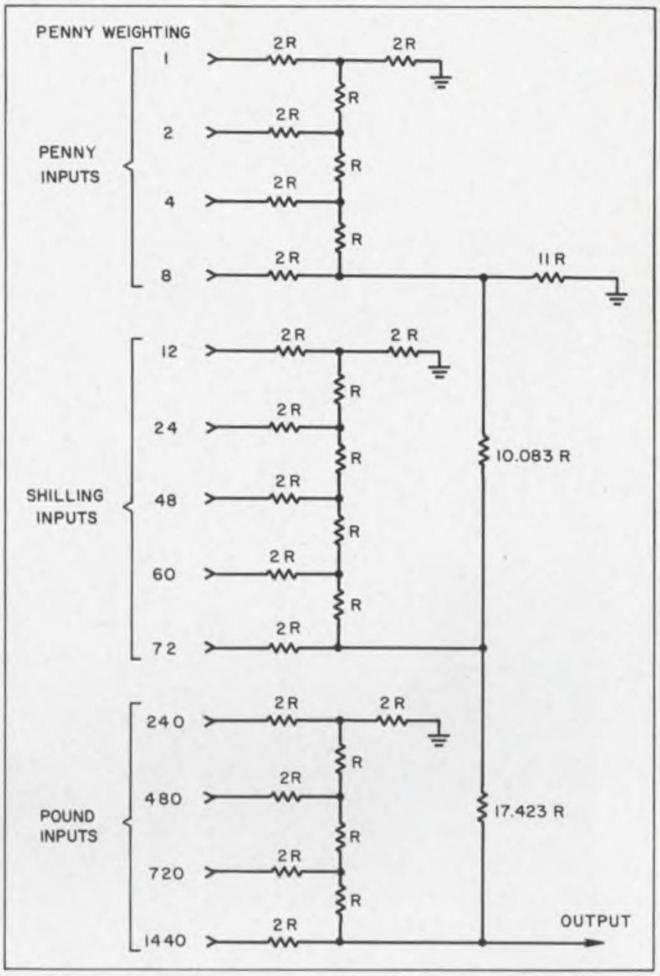
$V_2 = 1$ (normalized)

$$\therefore V_{TH} = R_{TH}. \quad (18)$$

To find Z, solve for the equation of the two voltage contributions at the output of the circuit in Fig. 7:

$$b\,V_{TH}/(R_{TH}+Z+1)=V_3[(Z+R_{TH})/(R_{TH}+Z+1)]; \quad (19)$$

$$b\,V_{TH} = V_3(Z+R_{TH}); \quad (20)$$



8. **Mixed-base ladder converts** binary representation of British currency to analog voltages. The relative weights of adjacent groups are used to compute the coupling resistances.

$$Z = (b\,V_{TH}-V_3R_{TH})/V_3=[(b-V_3)R_{TH}]/V_3; \quad (21)$$

$V_3 = 1$ (normalized)

$$\therefore Z = (b-1)R_{TH}. \quad (22)$$

From Eqs. 16 and 22 R_{TH} and coupling resistance Z are:

$$R_{TH} = (12/13+10.083)/(12/13+10.083+1) = 0.917;$$
$$Z = (20-1)0.917=17.423.$$

The complete British-currency ladder is shown in Fig. 8.

In summary, the three equations are:

- $X = b - 1$ — to find the ladder's terminating resistance.
- $Y = (b-1)^2/b$ — to find the coupling resistance for a single-base ladder, or the first coupling resistance in a mixed-base ladder.
- $Z = R_{TH}(b-1)$ — to find the second and succeeding coupling resistances in mixed-base ladders.

R_{TH} is the Thévenin resistance looking back into the ladder toward the termination resistance.

All these equations are based on normalized source resistances in the ladder groups. ■ ■

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ELECTRICAL CHARACTERISTICS – IN5315 – SPECIFICATIONS AT 25°C (UNLESS OTHERWISE SPECIFIED)

SYMBOL	DESCRIPTION	MIN.	MAX.	UNITS
BV	Breakdown Voltage at 10 uA		100	volts
VF	Forward Voltage Drop at 0.1 mA	0.430	0.490	volts
V_F	Forward Voltage Drop at 1 mA	0.540	0.600	volts
V_F	Forward Voltage Drop at 10 mA	0.650	0.710	volts
V_F	Forward Voltage Drop at 100 mA	0.750	0.900	volts
V_F	Forward Voltage Drop at 200 mA		1.00	volts
I_R	Reverse Current at 50 volts at 25°C		50	na
C	Capacitance at 1 volt		2.5	PF
Reverse Recovery to:	1.0 mA $I_F = 10$ mA,			
Circuit: Nanosecond Circuit	$I_R = 10$ mA		4	nsec

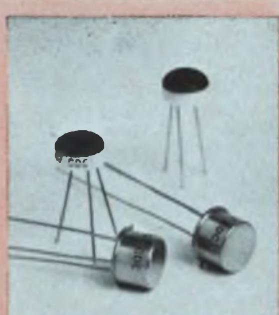
ELECTRICAL CHARACTERISTICS – IN5316 – SPECIFICATIONS AT 25°C (UNLESS OTHERWISE SPECIFIED)

SYMBOL	DESCRIPTION	MIN.	MAX.	UNITS
BV	Breakdown Voltage at 10 uA	100		volts
VF	Forward Voltage Drop at 0.1 mA	0.460	0.520	volts
V_F	Forward Voltage Drop at 1 mA	0.570	0.630	volts
V_F	Forward Voltage Drop at 10 mA	0.690	0.750	volts
V_F	Forward Voltage Drop at 100 mA		1.00	volts
I_R	Reverse Current at 50 volts at 25°C		50	na
C	Capacitance at 1 volt		2.5	PF
Reverse Recovery to:	1.0 mA $I_F = 10$ mA,			
Circuit: Nanosecond Circuit	$I_R = 10$ mA		4	nsec

DEVICE	1-99	100-999
1N5315	$1.60	$ .98
1N5316	1.40	.93

On Reader Service Card Circle 70

NEW EPOXY TRANSISTORS



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DEVICE	1-99	100-999	1000
2N2369	$ .70	$ .47	$ .30
2N3638	.46	.31	.28

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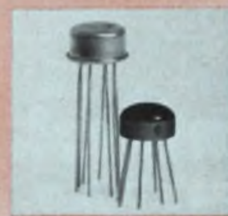
EPOXY MATCHED:
DUAL CHIP TRANSISTORS



These devices contain 2 isolated NPN Silicon Matched Transistors. They are designed primarily for small signal, low power audio frequency and general purpose differential amplifier applications in industrial service.

METAL CAN TRANSISTOR	EPOXY EQUIVALENT		
Device	Device	1-99	100-999
2N2639	CS2639	$6.00	$4.00
2N2640	CS2640	5.00	3.33
2N2641	CS2641	3.50	2.33
2N2642	CS2642	8.00	5.35
2N2643	CS2643	7.00	4.65
2N2644	CS2644	4.00	2.67

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Buffer	CMC219001	Epoxy TO-5	$ .80	$ .54	$ .36
Dual 2-Input Gate	CMC219141	Epoxy TO-5	.80	.54	.36
JK Flip-Flop	CMC219231	Epoxy TO-5	1.50	1.00	.67

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Synthesize resistor-thermistor networks

to match any desired voltage-ratio-vs-temperature characteristic. It's easy with the direct method.

Part 2 of a two-part article

An accurate and simple approach to designing thermistor-resistor networks is based on three points on the voltage-ratio-versus-temperature curve, which are used to match performance to specifications. Part 1* described the principles of the direct method and its application to networks where the resistance varies with temperature. Now consider networks where the voltage or current ratio varies with temperature.

The synthesis of the transfer ratio involves only a few algebraic manipulations. The circuit that is developed in this way is one of two standard types.

These two basic resistor-thermistor networks are shown in Figs. 1 and 2. The network of Fig. 1 yields a V_o/V_{in} that increases with temperature when negative temperature coefficient (NTC) thermistors are used, and decreases with temperature when positive temperature coefficient (PTC) thermistors are used. The network of Fig. 2, on the other hand, yields a V_o/V_{in} that decreases with temperature for NTC thermistors and increases with temperature for PTC thermistors, or positors.

NTC thermistor yields increasing V_o/V_{in}

To apply the direct method of resistor-thermistor network synthesis to match a desired voltage-transfer-ratio-vs-temperature curve, consider first the NTC-thermistor network of Fig. 1. The voltage ratio as a function of temperature, $V_o/V_{in}(T)$, is:

$$\frac{V_o}{V_{in}}(T) = \frac{R4}{R4 + R3 + R2\,R1(T)/[R2 + R1(T)]}. \qquad (1)$$

Since the impedance level has no effect on the voltage ratio, three of the resistance values can be referenced to the fourth such that $R3 = n_3 R4$, $R2 = n_2 R4$ and $R_0 = n_0 R4$. Substituting these into Eq. 1 yields:

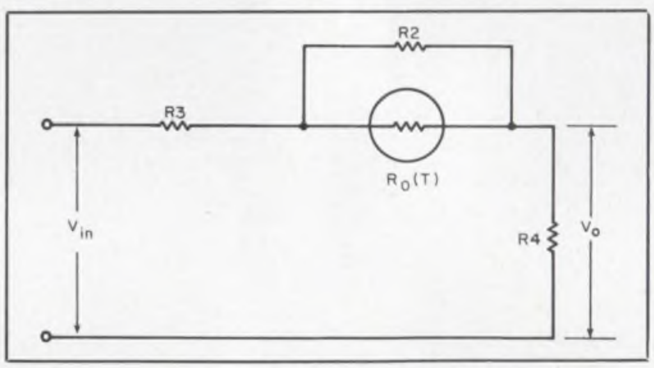
$$\frac{V_o}{V_{in}}(T) = \frac{R4}{R4 + n_3\,R4 + \dfrac{n_2\,n_0 R4^2 r(T)}{n_2\,R4 + n_0\,R4\,r(T)}} \qquad (2)$$

Hence, all the resistance values are referenced to $R4$, leaving V_o/V_{in} unchanged. A more useful form of Eq. 2 is:

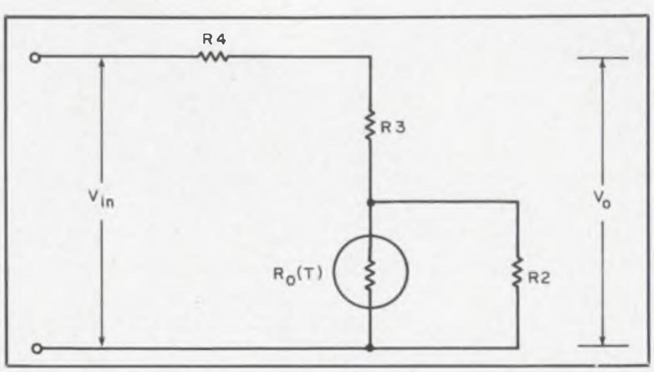
$$V_{in}/V_o(T) - 1 = n_3 + n_0\,n_2\,r(T)/[n_2 + n_0\,r(T)].$$

If $\theta(T)$ is defined as equal to $V_{in}/V_o(T) - 1$, this equation becomes:

$$\theta(T) = n_3 + n_0\,n_2\,r(T)/[n_2 + n_0\,r(T)]. \qquad (3)$$



1. The ratio V_o/V_{in} of this network increases with temperature when an NTC thermistor is used. For positive temperature coefficient thermistors, the opposite is true.



2. The ratio V_o/V_{in} of this network decreases with temperature when an NTC thermistor is used. For positors, the opposite is true. The design of this and the circuit in Fig. 1 uses three simple equations.

*See "Ease thermistor-resistor network design," ED 13, June 21, 1967, pp. 60-64.

Victor Weisenbloom, Electronic Engineer, Raytheon Co., Sudbury, Mass.

To match a given V_o/V_{in}-vs-temperature characteristic, a set of three equations must be generated to solve for the normalized unknowns, n_0, n_2 and n_3. Picking three points, $Av(T_1)$, $Av(T_2)$, $Av(T_3)$, on the desired characteristic, where $Av = V_0/V_{in}$, yields (through Eq. 3) three values of θ: $\theta(T_1) = C_1$, $\theta(T_2) = C_2$, $\theta(T_3) = C_3$. Furthermore, finding $r(T)$ on the thermistor manufacturer's normalized curves (Fig. 3) at the respective temperatures yields $r(T_1) = r_1$, $r(T_2) = r_2$ and $r(T_3) = r_3$.

The "generated" form of Eq. 3 then becomes:

$$C_1 = n_3 + n_2\, n_0\, r_1/(n_2 + n_0\, r_1);$$
$$C_2 = n_3 + n_2\, n_0\, r_2/(n_2 + n_0\, r_2);$$
$$C_3 = n_3 + n_2\, n_0\, r_3/(n_2 + n_0\, r_3).$$

This set is of the same form as that established as Eq. 6 in Part 1 for the case of resistance that varies with temperature. Therefore:

$$\left.\begin{aligned} n_0 &= (C_1 - C_2)(r_1X + 1)(r_2X + 1)/(r_1 - r_2), \\ n_2 &= n_0/X, \\ n_3 &= C_1 - r_1 n_0/(1 + r_1X), \end{aligned}\right\} \quad (4)$$

where:

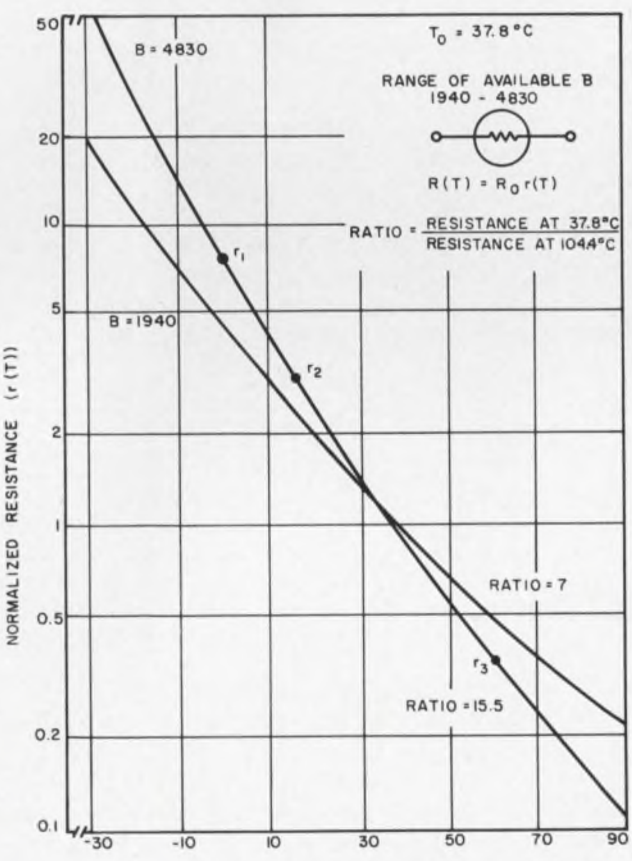
$$X = (Q-K)/(r_1K - r_3Q),$$
$$K = (C_1 - C_2)/(C_2 - C_3),$$
$$Q = (r_1 - r_2)/(r_2 - r_3).$$

Once n_0, n_2 and n_3 have been calculated, they can all be multiplied by any constant $R4$, thus adjusting the impedance level while leaving the voltage ratio unchanged. The constraints on the values of the normalized resistors n_0, n_2 and n_3 are the same as those established in Part 1 for the normalized resistors. This network (summarized in Fig. 4a) is highly suitable for a voltage transfer ratio that increases with temperature, and guarantees a match at three points on the desired characteristic.

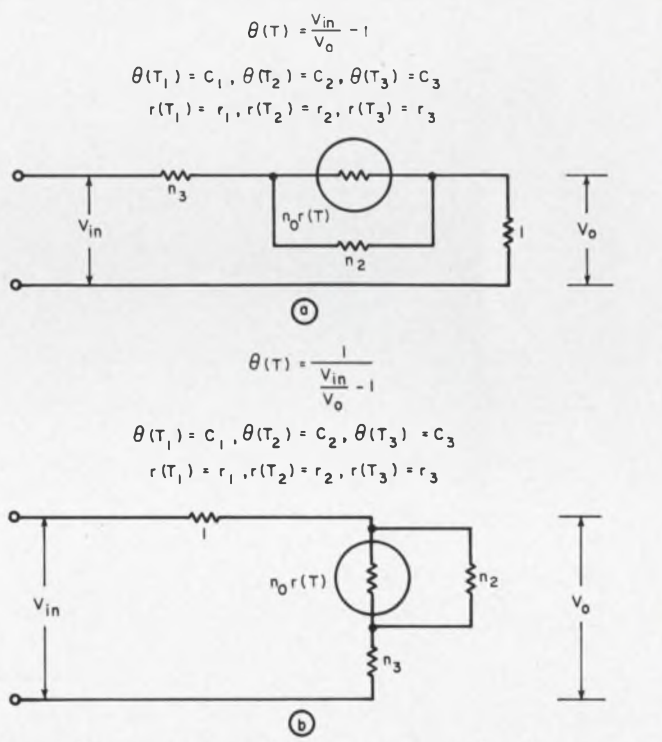
Modified circuit yields decreasing V_o/V_{in}

For a voltage transfer ratio that decreases with increasing temperature, consider the NTC-thermistor network of Fig. 2. If three points are picked from the desired characteristic, an analysis similar to that for the network of Fig. 1 will guarantee a match at those three points. The derivation finds the element values in terms of the points on the desired characteristic and the corresponding points on the manufacturer's universal thermistor curve. The end result is again three equations (of the form of Eqs. 4), which are used to synthesize the required network. Once n_0, n_1 and n_2 are known, they can all be multiplied by any convenient constant to adjust the impedance level. The technique is summarized in Fig. 4b.

In essence, therefore, for a monotonically in-



3. **Range of available thermistor constant (B) is shown** on the thermistor manufacturer's universal curves. From these curves the designer determines which value of B is most useful for a specific application.



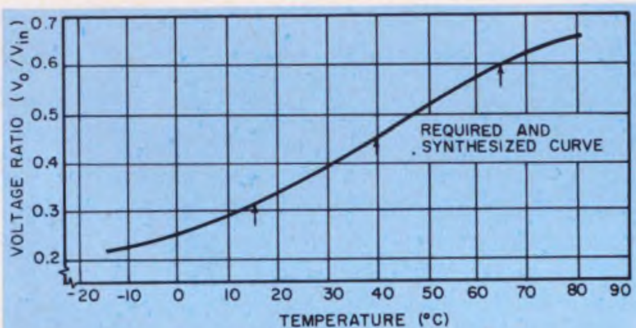
Q	K	X	n_0	n_2	n_3
$\frac{r_1 - r_2}{r_2 - r_3}$	$\frac{C_1 - C_2}{C_2 - C_3}$	$\frac{Q - K}{r_1K - r_3Q}$	$\frac{(C_1 - C_2)(r_1X+1)(r_2X+1)}{r_1 - r_2}$	$\frac{n_0}{X}$	$C_1 - \frac{r_1 n_0}{1 + r_1 X}$

CONSTRAINTS $Q \geq K$, $r_1 > r_3$ $\quad C_1 \geq \frac{(C_1 - C_2)(r_2X+1)r_1}{r_1 - r_2}$

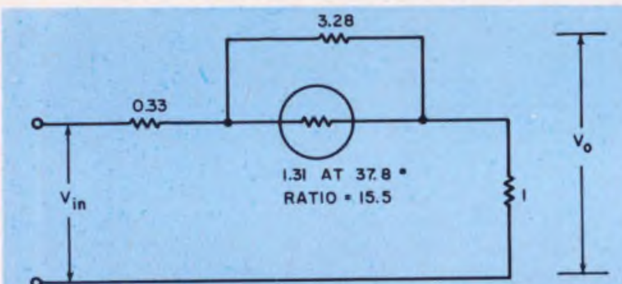
4. **Direct method of voltage-ratio synthesis is the same** for both increasing (a) and decreasing (b) V_o/V_{in}.

Table. Slope data for Fig. 5

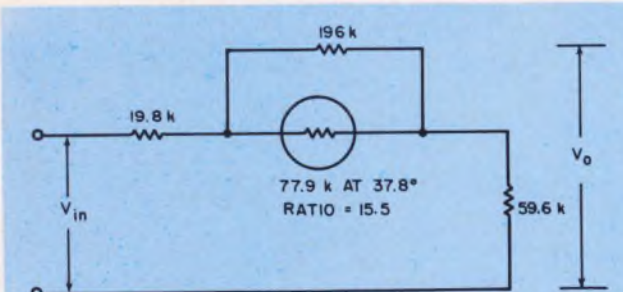
Temperature (°C)	Slope	Rate of change of slope
0	3×10^{-3}	——
10	3.5×10^{-3}	5×10^{-4}
20	5×10^{-3}	1.5×10^{-4}
30	6×10^{-3}	1×10^{-4}
40	6.5×10^{-3}	0.5×10^{-4}
50	6×10^{-3}	0.5×10^{-4}
60	5×10^{-3}	1×10^{-4}
70	4×10^{-3}	1×10^{-4}
80	3×10^{-3}	1×10^{-4}



5. **Three points are chosen on the voltage-ratio-vs-temperature characteristic** that is to be matched. One of these is at the point of maximum slope, and the others are where rate of change of the slope is greatest.



6. **All resistance values are related to resistor R4** (value of 1) in the normalized network produced by the direct method of voltage-ratio-vs-temperature synthesis.



7. **Normalized network is converted into a practical network** by selecting an available thermistor and multiplying the normalized resistor values by the ratio of the actual thermistor's resistance to that of the normalized thermistor.

creasing or decreasing voltage ratio, V_o/V_{in}, the networks of Figs. 1 and 2 can be synthesized by the procedure just described. If a given V_o/V_{in} characteristic is decreasing to a minimum and then increasing with temperature, a combination of the two networks can be used.

Design example demonstrates technique

As an example of applying the technique described, assume that the voltage-ratio-vs-temperature characteristic of Fig. 5 is to be synthesized. Since the voltage ratio is increasing with increasing temperature, the network in Fig. 1 will provide a three-point match, assuming that the constraints are satisfied. The elements n_3, n_2 and n_0, normalized with respect to $R4$ are found by the direct method, and an arbitrary impedance level assigned on the basis of thermistor availability.

The three points on the curve of Fig. 5 that are to be matched are chosen—one at the point of maximum slope, and the other two at the points of maximum rate of change of the slope. On the assumption that the region of interest is from 0° to 75°C, the slope is calculated and tabulated in the table in 10° increments. The table shows that the maximum slope occurs at 40°C, and the maximum rate of change of slope occurs at approximately 15° and 65°C. Hence, for the purpose of calculating $\theta(T)$, choose $V_o/V_{in}(15°) = 0.315$, $V_o/V_{in}(40°) = 0.455$, and $V_o/V_{in}(65°) = 0.6$. From Fig. 4a, therefore, θ is calculated as:

$$\theta(15°) = 2.18 = C_1;$$
$$\theta(40°) = 1.2 = C_2;$$
$$\theta(65°) = 0.67 = C_3.$$

If a thermistor with a ratio of 15.5 is chosen, r_1, r_2 and r_3 are found on the manufacturer's universal curves at temperatures $T_1 = 15°C$, $T_2 = 40°C$ and $T_3 = 65°C$, respectively, to be:

$$r_1 = 3.3; \quad r_2 = 0.91; \quad r_3 = 0.29.$$

Once r_1, r_2, r_3 and C_1, C_2, C_3 are known, Fig. 4a gives:

$$Q = (r_1 - r_2)/(r_2 - r_3) = 2.39/0.62 = 3.85;$$

and

$$K = (C_1 - C_2)/(C_2 - C_3) = (2.18 - 1.2)/(1.2 - 0.67) = 0.98/0.53 = 1.85.$$

Since the constraints that $Q > K$ and $r_1 > r_3$ are satisfied, the analysis can be continued:

$$X = (Q - K)/(r_1 K - r_3 Q) = (3.85 - 1.85)/(6.1 - 1.12) = 0.4;$$

$$n_0 = (C_1 - C_2)(r_1X+1)(r_2X+1)/(r_1-r_2)$$
$$= (0.98)\ (2.32)\ (1.38)/2.4$$
$$= 1.31;$$
$$n_2 = n_0/X$$
$$= 1.31/0.4$$
$$= 3.28;$$

and finally

$$n_3 = C_1 - [r_1 n_0/(1+r_1X)]$$
$$= 2.18 - \{(3.3)(1.31)/[1+(3.3)(0.4)]\}$$
$$= 0.33.$$

The solutions then are $n_0 = 1.31$, $n_2 = 3.28$ and $n_3 = 0.33$. The synthesized network is that of Fig. 6.

The impedance level is now adjusted by choosing a commercially available thermistor with a ratio of 15.5. On the assumption that the network impedance in this example is to be high, a thermistor where $R_0 = 77.9\ k\Omega$ at 37.8°C is chosen. To adjust for this impedance level, all the impedances in Fig. 6 must be multiplied by $77.9\ k\Omega/1.31 = 59.6\ k\Omega$. The completed network appears in Fig. 7.

The voltage ratio of the synthesized network can be calculated for purposes of comparison with the original required characteristic:

$$\frac{V_o}{V_{in}} = \frac{59.6\ k\Omega}{79.4\ k\Omega + 153r(T) \times 10^2/[196 + 77.9r(T)]}.$$

The data are plotted on the same set of axes as the given characteristic (Fig. 5). The error in the region of interest is shown to be negligible. ■ ■

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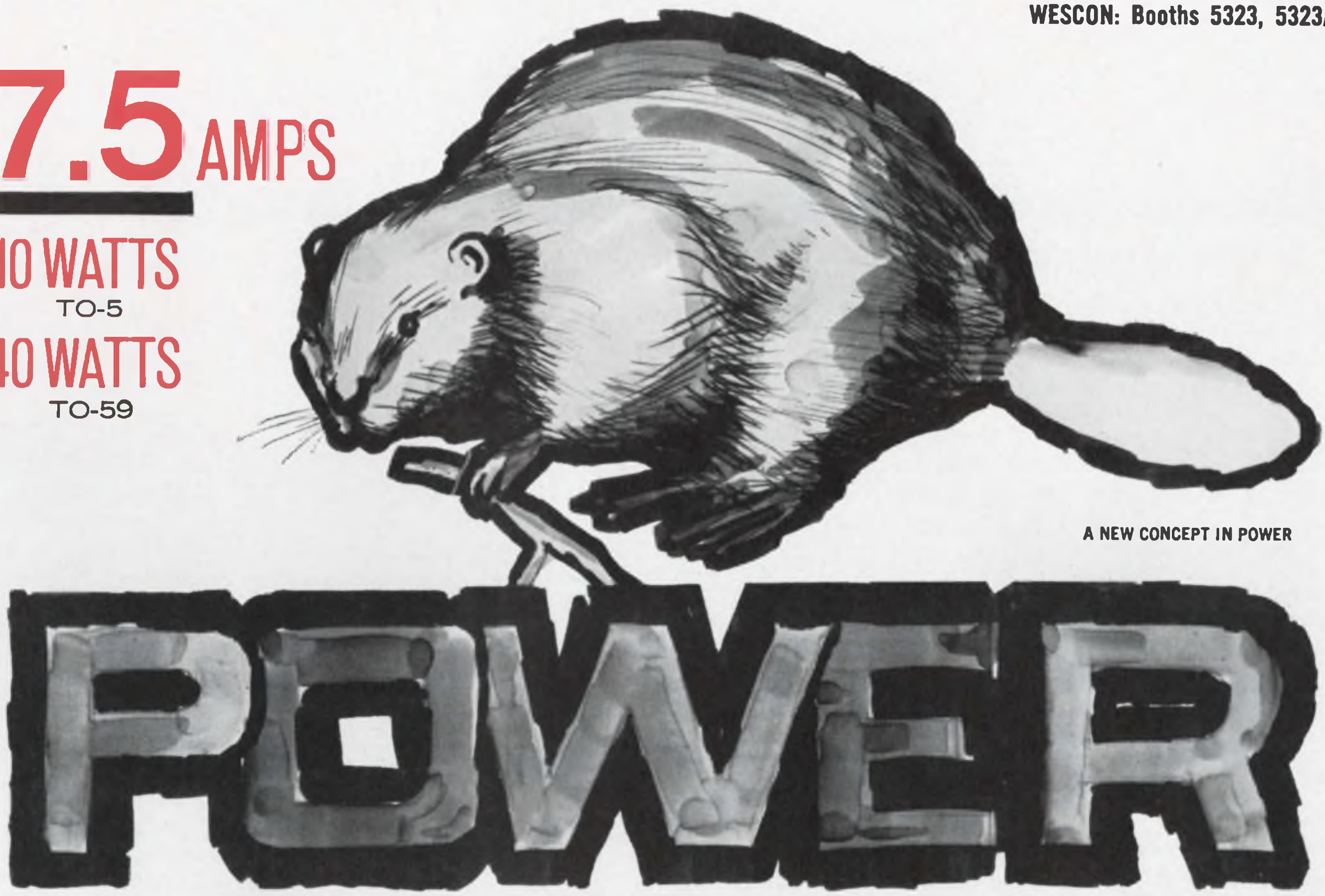
WESCON: Booths 5323, 5323A

7.5 AMPS

10 WATTS
TO-5

40 WATTS
TO-59



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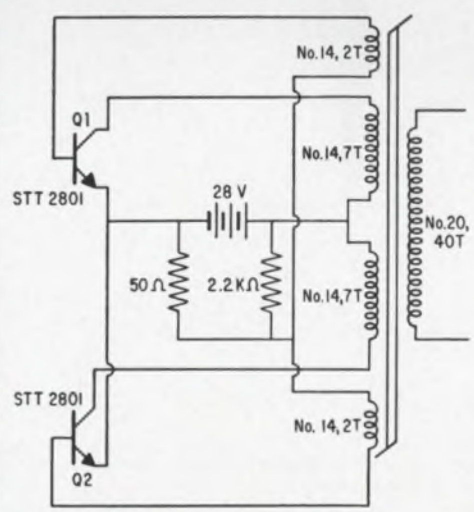
	Case	$V_{CEO(sus)}$	V_{EBO}	I_C max.	P max. (100°C)	h_{FE}	h_{FE} min.
		Volts	Volts	Amps	Watts		
STT 2400	TO-5	150	12	7.5	10	30-90	
STT 2401	TO-5	120	12	7.5	10	30-90	
STT 2402	TO-5	120	12	7.5	10	50-150	10 @ 6 Volts
STT 2403	TO-5	100	12	7.5	10	30-90	
STT 2404	TO-5	80	12	7.5	10	30-90	
STT 2405	TO-5	60	10	7.5	10	30-90	
STT 2406	TO-5	30	10	7.5	10	25 min.	
STT 2800	TO-59	150	12	7.5	40	30-90	
STT 2801	TO-59	120	12	7.5	40	30-90	
STT 2802	TO-59	120	12	7.5	40	50-150	10 @ 5 Volts
STT 2803	TO-59	100	12	7.5	40	30-90	
STT 2804	TO-59	80	12	7.5	40	30-90	
STT 2805	TO-59	60	10	7.5	40	30-90	
STT 2806	TO-59	30	10	7.5	40	25 min.	
TEST CONDITIONS	I_C	200mA				2A	5A
	I_B		10mA				
	V_{CE}					15V	



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ON READER-SERVICE CARD CIRCLE 40

Diode model is analyzed by computer

as one junction of a transistor. Analysis covers both linear and nonlinear circuit operation.

Part 3 of a three-part series

Computer-aided circuit design requires good device models and accurate numerical values.

The modeling procedures for transistors were described in part 1 of this series.* Part 2 showed how numerical values were assigned to the transistor model.† This final part describes the construction of the diode model and the measurements that determine the parameters.

The diode model shown in Fig. 1 is one junction of the transistor model. Like the transistor model, it covers both small-signal linear and large-signal nonlinear operation, accounting for both ac and dc components. A general description of the model, which is taken from *NET-1 Network Analysis Program 7090/94 Version* by Malmberg, Cornwell and Hofer is given in Part 1.

Five parameters define diode model

The five parameters in Fig. 1 define the equivalent circuit of the diode. The diode resistances are R_B, the semiconductor bulk and contact resistance, and R_C, the junction ohmic leakage resistance.

The current generator, I, represents the diode junction current. It is related to junction voltage v by the equation:

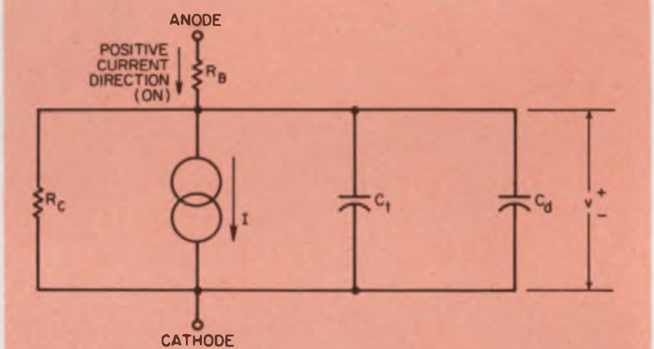
$$I = I_S[\exp(qv/Mkt) - 1], \qquad (1)$$

where:

I_S = the diode saturation current,
q = electron charge,
M = emission constant (the factor by which the junction voltage and dynamic resistance are larger than the ideal values given by using qv/kT),
k = Boltzmann's constant,
T = junction absolute temperature in °K,

*See "Use a good switching transistor model," ED 12, June 7, 1967, pp. 54-59.
†See "Assign the correct numerical values," ED 13, June 21, 1967, pp. 60-66.

Nathan O. Sokal, President, and **Joseph J. Sierakowski**, Senior Engineer, Design Automation, Inc., Lexington, Mass., and **Jonathan J. Sirota**, Vice-President, Memory Technology, Inc., Waltham, Mass.



1. **Diode equivalent circuit** is one junction of the transistor model.

v = bias voltage (positive for forward bias, negative for reverse bias).

C_t is the junction transition (depletion-layer) capacitance, a small-signal capacitance which is a nonlinear function of junction voltage v:

$$C_t = D/(V_Z - v)^N, \qquad (2)$$

where:

D = proportionality constant,
V_Z = junction contact potential (a positive number),
N = junction grading constant.

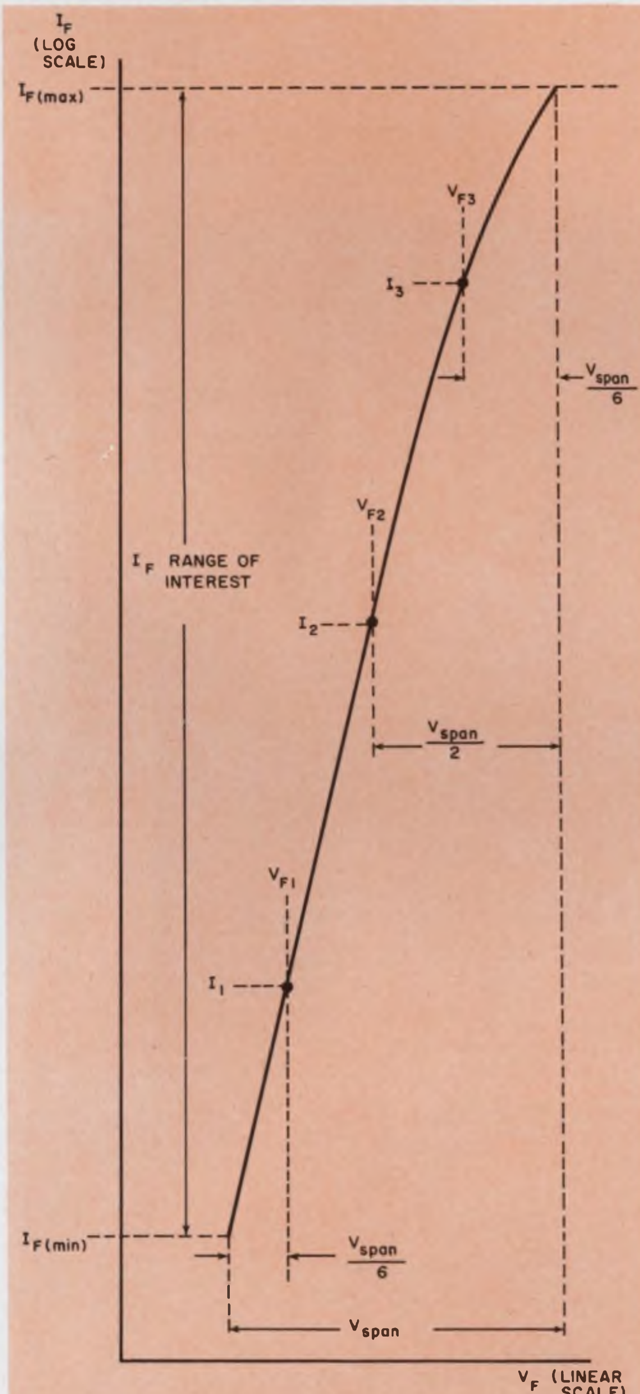
C_d is the junction diffusion capacitance, a small-signal capacitance which is a function of junction current I:

$$C_d = q(I + I_S)/2\pi MkTF, \qquad (3)$$

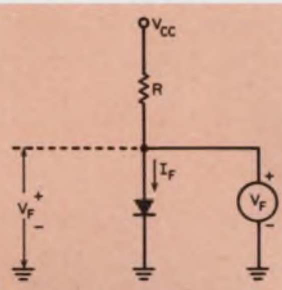
where F is the intrinsic diode cutoff frequency.

The charge stored in the diffusion capacitance at a forward current I is $I/2\pi F$. This can be verified simply by integrating C_d from zero current to the current I, expressing both C_d and v as functions of I. Thus $F = 1/2\pi\tau$, where τ is the commonly used "charge storage factor" in $Q_{STORED} = I\tau$. The effect of transition capacitance on the apparent variation of cutoff frequency with I is similar to that discussed in Part 2 for the transistor cutoff frequencies.

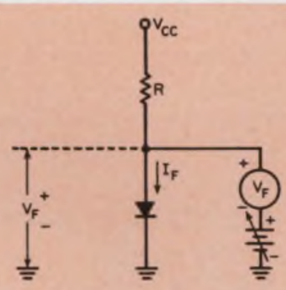
The terminal voltage on the diode is defined as V_F in the forward direction and V_R in the reverse. As with the transistor parameters, three points on



2. **Diode dc characteristics** are measured at three points on the forward conduction curve.



3. **Direct reading circuit** gives diode characteristics but readings must be readable to ±1 mV or better.



4. **Null measurement circuit** gives voltage difference values for insertion directly into model equations.

Table: Diode constants and variables

Symbol	Brief description
C_A	Average value of transition capacitance
C_d	Junction diffusion capacitance
C_m	Measured diode diffusion capacitance
C_t	Junction diffusion capacitance
$*D$	Transition capacitance proportionality constant
$*F$	Diode cutoff frequency
$*F'$	Apparent cutoff frequency
I_F	Forward current
I_R	Reverse current
I_S	Diode saturation current
k	Boltzmann's constant
M	Diode emission constant
$*N$	Junction grading constant
q	Electron charge
R_B	Diode ohmic series resistance
R_C	Junction ohmic leakage resistance
T	Junction absolute temperature
T_S	Diode storage time in test circuit
v	Junction voltage
V_{CC}	Dc supply voltage in test circuit
V_F	Forward terminal voltage
V_R	Reverse terminal voltage
V_T	Diode test voltage
$*V_Z$	Junction contact potential
τ	Charge storage factor

*Not used in dc steady-state calculations. Can be ignored if only dc steady-state analyses are being performed.

the diode forward conduction characteristics are needed: (V_{F1}, I_1), (V_{F2}, I_2), and (V_{F3}, I_3). The points should span the region of interest, as shown in Fig. 2. The measurement can be made either by the direct method (Fig. 3) or by the null method (Fig. 4).

The direct method can be used if the diode forward voltage can be read to a precision (not accuracy) of ± 1 mV. V_{CC} should be much larger than V_F. Choose R as $R < (V_{CC(max)} - V_{F3})/I_3$. Measure the desired three points on the diode forward characteristic by varying V_{CC}.

The null method uses two sources, V_{CC} and V_1. $V_{CC} >> V_F$. The voltages should be measured with either a direct-coupled oscilloscope with 5-mV/cm sensitivity or a digital voltmeter with a resolution of 1 mV or better:

Measurement is performed in four steps:

- With V_1 equal to zero, measure V_F at I_1. This is V_{F1}.
- Adjust V_1 so that the voltmeter reads zero. V_1 is now set to V_{F1}.
- Increase the current to I_2. The voltmeter reading is $V_{F2} - V_{F1}$.
- Repeat step 3 at a higher current to obtain $V_{F3} - V_{F1}$ at I_3.

These readings are used directly in the equations which follow to determine the forward conduction parameters of the diode.

To determine the reverse bias parameters, a curve of the reverse current versus reverse voltages should be used for the reverse voltage range of interest, as in Fig. 5. The curve need not be extremely accurate because the reverse leakage is usually of minor importance; any value larger than a megohm will usually suffice.

Equations for diode dc parameters

All measured quantities go directly into the equations that follow:

$$M = \frac{(V_{F3} - V_{F1})\,[(I_2 - I_1)/(I_3 - I_1)] - (V_{F2} - V_{F1})}{\dfrac{kT}{q}\left[\left(\dfrac{I_{C2} - I_{C1}}{I_{C3} - I_{C1}}\right)\ln\left(\dfrac{I_{C3}}{I_{C1}}\right) - \ln\left(\dfrac{I_{C2}}{I_{C1}}\right)\right]}; \qquad (4)$$

$$R_B = [(V_{F3} - V_{F1}) - (MkT/q)\ln(I_3/I_1)]/(I_3 - I_1); \qquad (5)$$

$$I_S = I_2/\{\exp[(q/MkT)\,(V_{F2} - I_2R_B)]\}; \qquad (6)$$

$$V_{F2} = (V_{F2} - V_{F1}) + V_{F1}; \qquad (7)$$

$$q/k = 1.161\times 10^4;$$

$$T = {}^\circ\mathrm{C} + 273.2.$$

If three points are known, use Eqs. 4 through 7.

If only two points are known, assume a value for R_B. An approximate value can be taken from the forward conductance specification. If it is known that a current I flows with $V_F = 1$ volt, it can be assumed that approximately 0.25 volt is due to IR_B drop. Then:

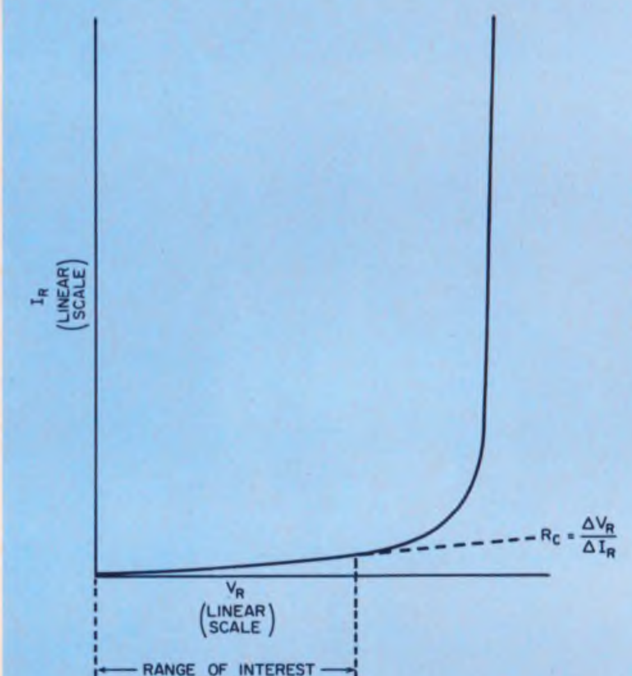
$$R_B \approx 0.25/I. \qquad (8)$$

When only two points are known, M is taken from:

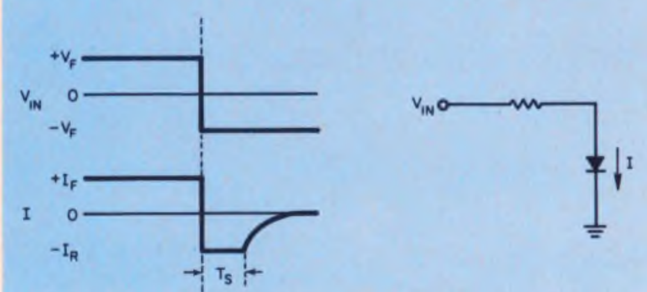
$$M = (q/kT)\{[(V_{F2} - V_{F1}) - R_B(I_2 - I_1)]/\ln(I_2/I_1)\}. \qquad (9)$$

If only one point is known, assume values for both R_B and M. To simulate a diode with low voltage drop and dynamic resistance, M can be chosen between 1.0 and 1.5. A diode with high voltage drop and dynamic resistance can be simulated by choosing M between 1.5 and 2.2. I_S is again found from Eq. 6. R_B can be assumed as before.

The usual range for the values of M, R_B, and I_S are 1.0 to 2.2 for M, 10^{-5} to 10^{-1} kilohm for R_B, and 10^{-12} to 10^{-6} mA for I_S (silicon), and 10^{-8} to 10^{-2} mA for I_S (germanium).



5. **Diode reverse current characteristic gradient** is used to determine R_C, the junction ohmic leakage resistance.



6. **Storage time is measured** to determine cutoff frequency. It is measured from the I_F/I_R transition to the point where I_R begins to decrease.

R_c is found from the reverse characteristics of the diode with the best straight-line fit over the voltage range of interest, as in Fig. 5.

$$R_c = \Delta V_R / \Delta I_R. \qquad (10)$$

The diode transition capacitance is found by the same procedures as are used in Part 2 to determine the transistor transition capacitances.

Diode cutoff frequency is derived from storage time

The diode cutoff frequency can be found from the diode storage time, T_S, when the diode is switched from a forward current, I_F, to a reverse current, $-I_R$, as in the test circuit of Fig. 6. The measurement should be made at values of I_F and I_R close to the values intended for actual circuit operation, if possible. The test current is assumed to switch instantaneously from I_F to $-I_R$. T_S is measured from the time of the I_F-to-I_R transition to the time that the reverse current magnitude begins to decrease, as shown in Fig. 6. If no clearly defined region of constant reverse current exists, T_S can be measured to the time that the junction voltage becomes zero. Time zero can be taken as the middle of the I_F-to-I_R transition. Note that this definition of storage time is not the same as another one in common use—the time until the reverse current (charging the transition capacitance to a reverse voltage) has decreased to a specified value, on the order of 10% of I_R.

As with the transistor cutoff frequencies, direct observation of the diode intrinsic cutoff frequency is obscured by the effect of C_t shunting C_d. Both these capacitances are varying during the turnoff transient. The apparent cutoff frequency is:

$$F' = \{\ln[1 + (I_F/I_R)]\}/2\pi T_S. \qquad (11)$$

If the transition capacitance, C_t, is small compared with the diffusion capacitance, F' will be close to F. The shunting effect of C_t can be accounted for approximately by hand calculation, if desired, as follows.

The intrinsic cutoff frequency is:

$$F \approx F'/[1-(F'/F_A)], \qquad (12)$$

where:

$$F_A = [q(I + I_S)]/2\pi M\, k\, T\, C_A. \qquad (13)$$

Here C_A is the value of the transition capacitance averaged over the storage time interval. It can be taken as the capacitance at a forward bias of V_F, which is the voltage at a forward current of $I_F/2$.

$$C_A = C_m[(V_Z - V_T)/(V_Z - V_F)]^N. \qquad (14)$$

Usually $I_S << I$ and can be ignored. In Eq. 13 I can be taken as $I_F/2$, so that:

$$F = \frac{F'}{1 - [F'\, 2\pi M\, (kT/q)\, C_A]/(I_F/2)}$$

■ ■

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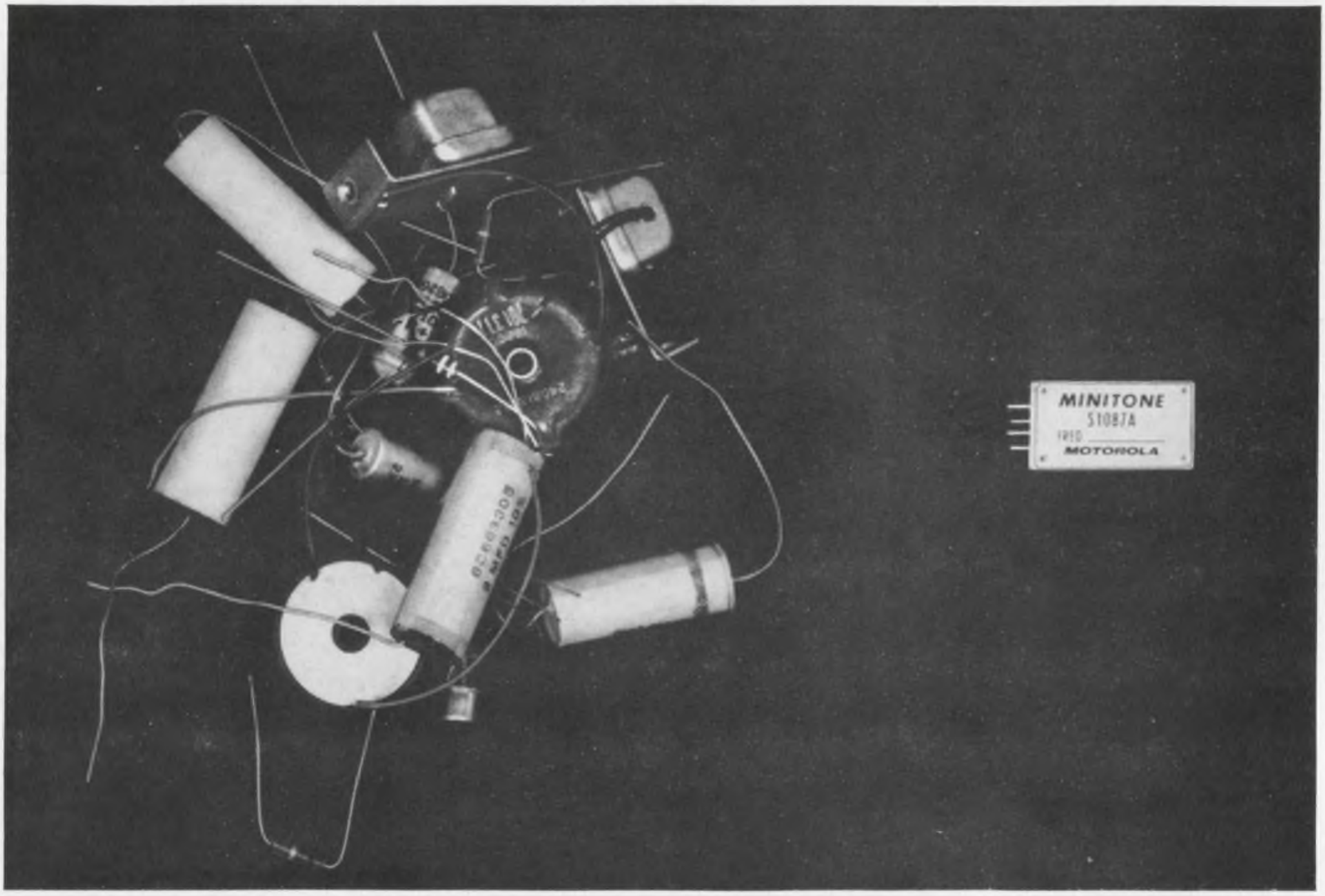

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Mismatching for low noise

in amplifiers becomes simple with a nomograph that shows the lowest noise figure in one step.

In many systems the main design objective is low noise, instead of maximum power transfer. A deliberately created mismatch between an amplifier and its source will achieve this objective, provided that the mismatch ratio is the proper one. To find the ratio, use the nomograph below.

The theoretical explanation rests on a simple equation[1] that computes the noise figure:

$$F = 1 + (R_s/R_L) + R_n(1 + R_s/R_L)^2/R_s,$$

where:

R_s = source resistance,
R_L = input impedance of transistor, in parallel with the resistive component of the tuned circuit,
R_n = equivalent noise input resistor[2] of transistor.

The circuit in the figure helps to interpret the symbols.

The actual noise resistor of a transistor need not be known if a noise figure can be measured for any specific match or mismatch between R_s and R_L.

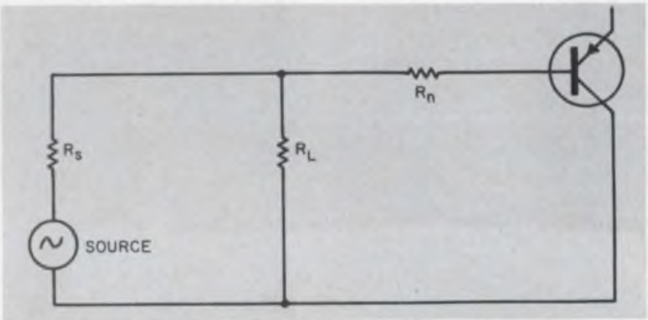
The noise figure is plotted in the nomograph for any mismatch ratio, R_s/R_L, as well as for different transistor noise resistors, R_n. R_n is normalized to the input resistance R_L. Since there is an optimum R_s/R_L for each R_n/R_L curve, there is only one R_n/R_L curve that applies to a given situation.

Herbert S. Antman, Research Engineer, Edo Corp., College Point, N. Y.

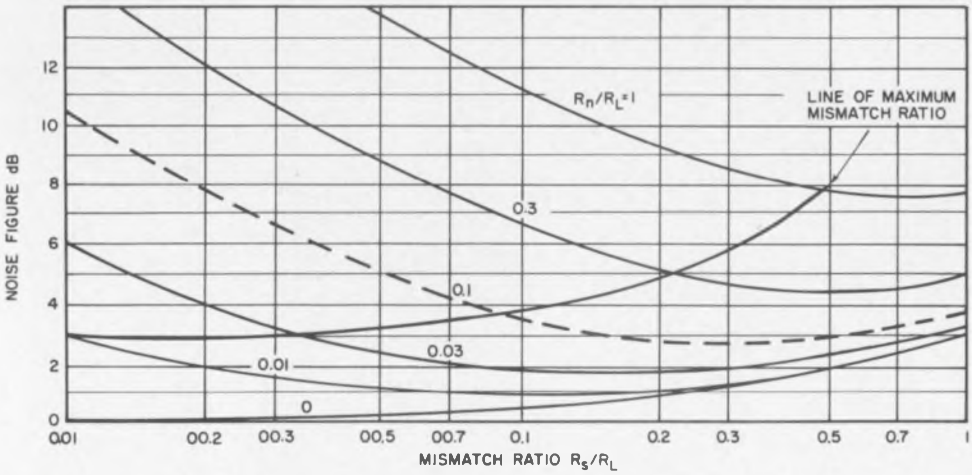
Assume, for example, a noise figure of 3.8 dB for the matched condition, $R_s/R_L = 1$. The 0.1 R_n/R_L curve intersects this point in the graph. The null point of this curve occurs at a mismatch ratio of 0.3 for R_s/R_L or 3.3 for R_L/R_s. This optimum ratio improves the noise figure to 2.8 dB. In fact, there is no loss in sensitivity for mismatch ratios extending from the $R_s/R_L = 1$ line to the point where the curve of maximum mismatch ratio intersects the noise figure curve. For $R_n/R_L = 0.1$, this range of mismatch ratio extends from $R_s/R_L = 1$ to $R_s/R_L = 0.09$. ■ ■

References:

1. Mischa Schwartz, *Information Transmission, Modulation, and Noise* (New York: McGraw-Hill Book Co., 1959), Chap. 5.
2. W. A. Rheinfelder, *Design of Low-Noise Transistor Input Stages* (New York: Hayden Pub. Co., 1964).



Typical preamplifier circuit includes the source and the amplifier. For optimum noise figure, a deliberate mismatch is introduced between the two.



Noise figure and mismatch ratio are related in this graph. The dashed curve illustrates the example in the text. Once a noise figure has been measured for any known match, the optimum noise figure and the appropriate mismatch ratio can be read off.

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ELECTRONIC DESIGN semiannual index of articles

January-June, 1967

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Automatic Controls and Servos

Careers and Management

Circuits and Mathematical Analysis

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- Automatic Controls and Servos
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- Circuits and Mathematical Analysis
- Communications
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- Tubes

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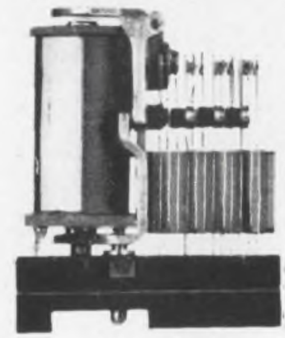
Nobody but AE makes a Class E relay with all these terminals.



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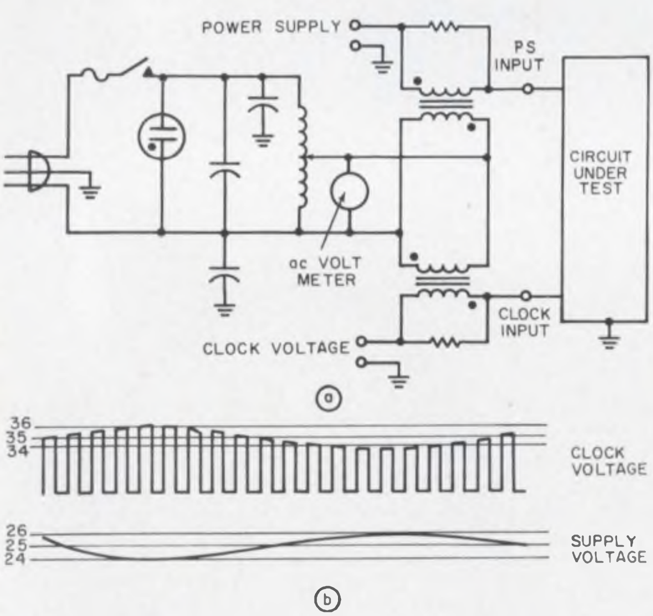
ON READER-SERVICE CARD CIRCLE 47

Dc voltage modulator uses line frequency

A circuit had to be tested at two extremes of supply voltage and two extremes of clock voltage. The worst-case conditions were determined to be low supply voltage with high clock voltage, and high supply voltage with low clock voltage. To speed up the testing of the circuits at the worst-case conditions, the following modulator (Fig. 1a) was devised. The nominal voltage of the power supply was 25 ± 1 volts dc and the clock voltage 35 ± 1 volts dc.

Action in the circuit under test took place between 20 kHz to 200 kHz. Line frequency of 60 Hz was used to vary the voltages through their spread of ± 1 volt. The 115-volt line voltage was fed to a Variac to control the input voltage to two 2.5-volt filament transformers. Approximately 30 volts' input to these transformers produced the required 2-volts peak-to-peak for modulation. The filament transformers are connected out of phase to produce the worst-case conditions of 26-volt supply and 34-volt clock and 24-volt supply and 36-volt clock (Fig. 1b).



1. **Power-frequency modulator** uses a Variac and two filament transformers to vary out of phase two signal levels by ± 1 volt. The resultant wave shapes are shown in (b).

The ac voltmeter at the variable transformer's output can be used to monitor the 2-volt peak-to-peak modulation. If a regulated 115 volts ac is used, this would not be necessary. An oscilloscope would then be required on the initial setup to determine the correct Variac setting to produce the 2-volt peak-to-peak.

A. Hirsch, Production Test Supervisor, Philco-Ford Microelectronics Div., Santa Clara, Calif.

VOTE FOR 110

Composite amplifier has improved dc bias stability

An economical amplifier with high input impedance and almost complete insensitivity to normal bias and source drift can be designed without the need for matched transistor pairs or balancing circuits. The design for this circuit is based on a Darlington, or composite, configuration with a constant-current source, as shown in Fig. 1a.

Amplifiers with good low-frequency response can be constructed in several ways. One of the most common circuits (Fig. 1b) requires a capacitor for input coupling. The resulting low-frequency response is determined by the effective impedance in series with this capacitor. Because of the shunting effect of the bias network, however, this circuit has the disadvantage of limiting the input impedance. The approach also presents temperature sensitivity and stability problems.

On the other hand, dc amplifiers with high input impedances and good temperature versus output dc-level stability are possible with differential amplifiers. For many applications, however, the cost of the matched transistors or balancing circuits required by this approach is a drawback.

The asymmetrical circuit in Fig. 1a eliminates the need for paired transistors or potentiometers. Instead of comparing two signals, this circuit compares the input with ground. The emitter of $Q3$ will always be at $E_{in} - 3\ V_{be}$. Slow variations of voltage at E_{in} are tracked at the emitter of $Q3$ with negligible current drain from the constant-current source. Rapid shifts in E_{in} (signal frequencies) are bypassed through the capacitor C,

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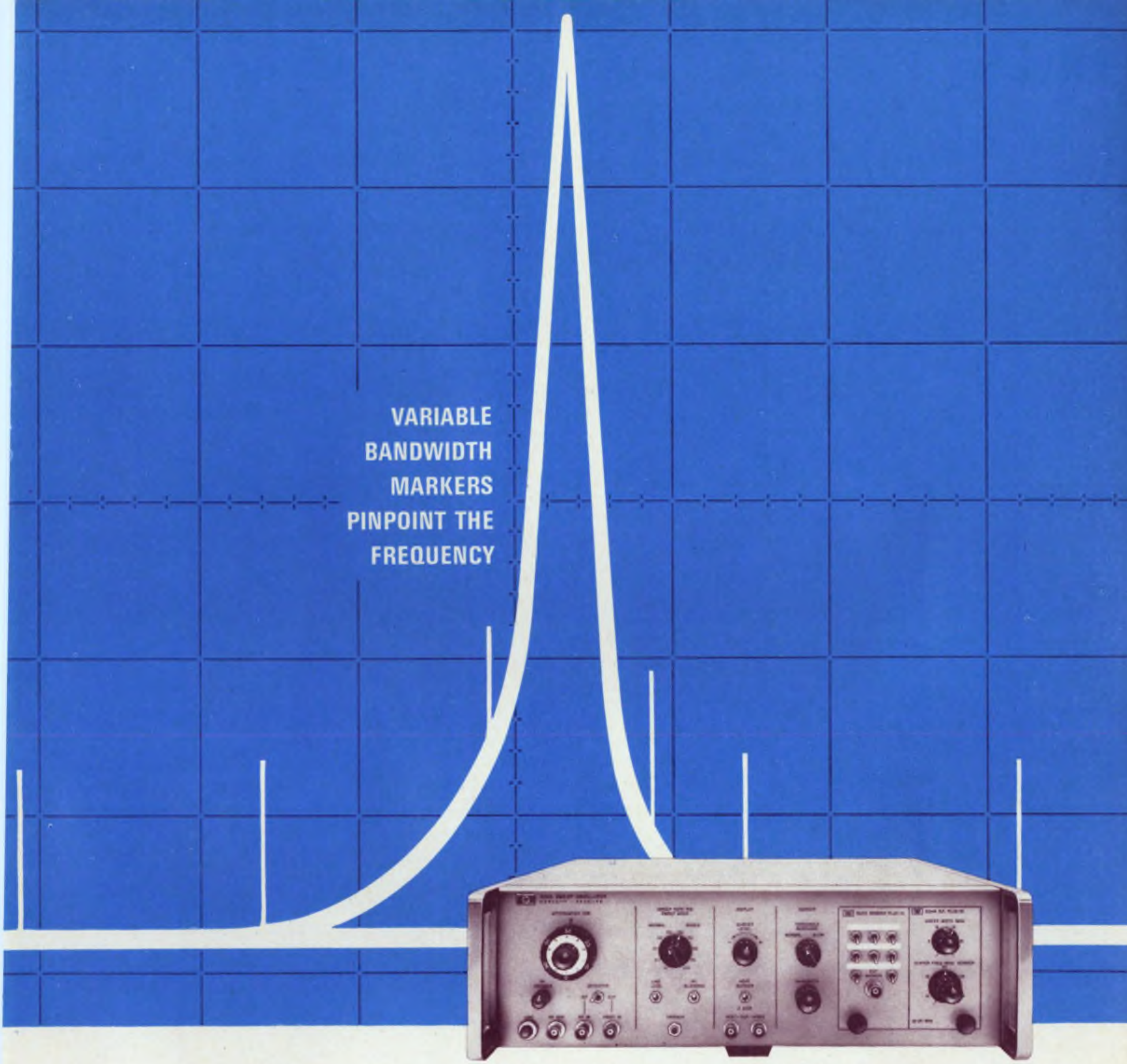

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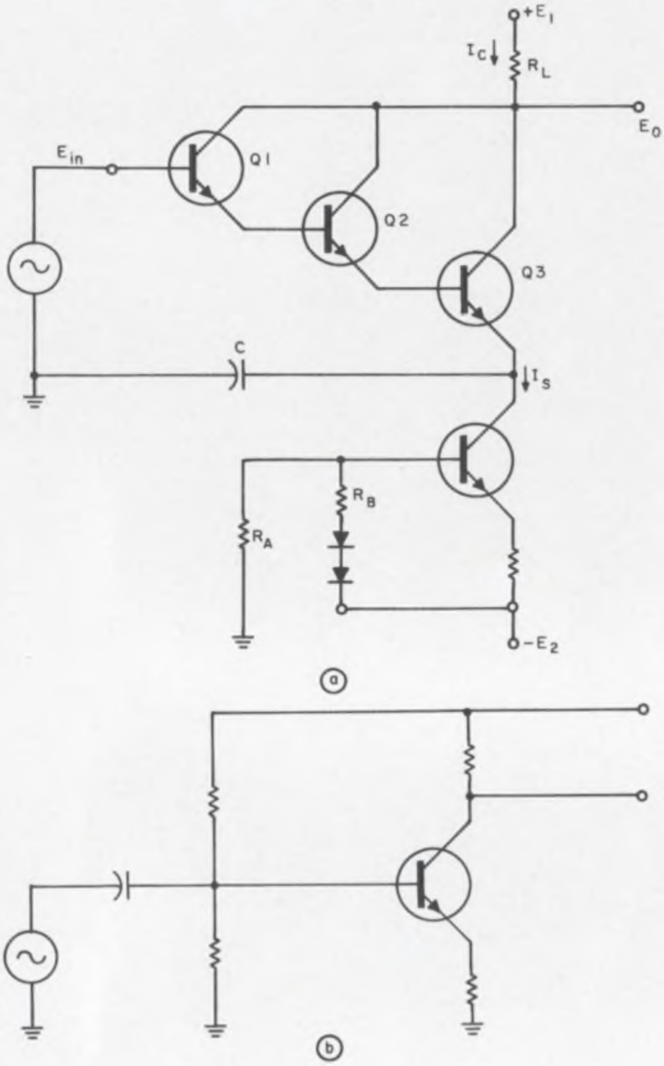


1. **A simple dc amplifier** (a) has high input impedance, is insensitive to bias and source drift, and uses neither the matched transistors nor the balancing circuits usually required to improve operation of a standard circuit (b).

however, and amplification results. Since slow changes at the emitter of *Q3* draw negligible current from the source, the dc level at E_o is $E_1 - I_C R_L$ for no-signal input.

Tying all the collectors of the transistors together helps to make the circuit less sensitive to α temperature variations. With only one transistor:

$$E_o = E_1 - E_R$$
$$E_R = I_C R_L$$

where $I_C = \alpha I_S$. Then:

$$\Delta E_R / E_R = \Delta\alpha / \alpha.$$

With three transistors, on the assumption that $\alpha_1 = \alpha_2 = \alpha_3 = \alpha$:

$$E_R = I_C R_L (\alpha^3 - 3\alpha^2 + 3\alpha),$$

and

$$\Delta E_R / E_R = [3(\alpha - 1)^2 / (\alpha^2 - 3\alpha + 3)] [\Delta\alpha / \alpha] < \Delta\alpha / \alpha.$$

A temperature-compensating feature of this circuit is the use of the diodes in the constant-current source. The number of diodes for effective compensation depends on the ratio $R_B / (R_A + R_B)$.

The input impedance depends primarily on the number of transistors in cascade, the value of load resistance R_L, the collector resistance of the first stage and the signal frequency.

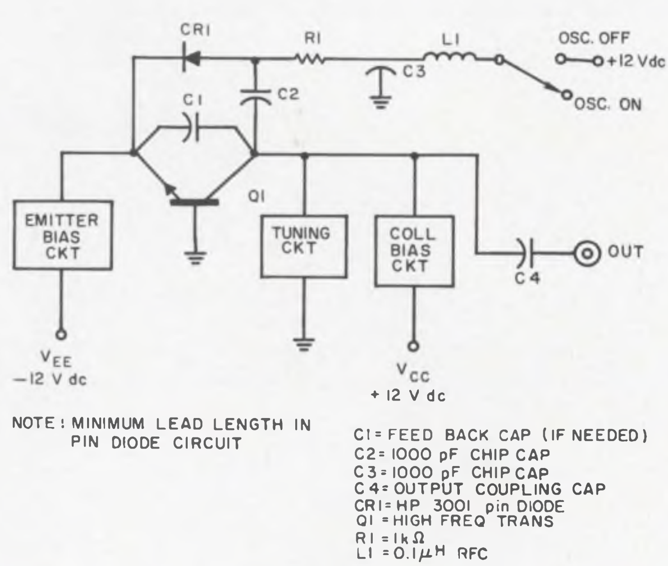
As a result of the Miller effect on the upper frequency limit, the composite configuration is limited to low-frequency applications. In this design, however, the high input impedance at low signal frequencies and the α insensitivity feature were selected as more desirable than extended frequency response. The upper frequency limit of the circuit can be extended by adding a cascoded common-base second stage, making the configuration less sensitive to the base-collector capacity of the composite stage.

Carlos A. Riveros, Systems Development Div., International Business Machines Corp., San Jose, Calif.

VOTE FOR 111

Pin diode switches microwave oscillator

Turning a microwave solid-state oscillator on or off by such conventional means as removing the dc bias or gating the emitter to ground causes a deterioration in turn-on time. The deterioration is due to the heating and cooling of the transistor junction by collector-current flow and cutoff when the dc bias is removed. After turn-on, this thermal effect causes a time lag before the oscillator comes back to frequency. If the oscillator could be turned on and off while maintaining collector-current flow, then the thermal effect would be eliminated.



Microwave oscillator is switched on and off by applying and removing forward bias to the pin diode, CR1.

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The turn-on time would also be very rapid (about 50 ms), with a frequency error of approximately 500 kHz for an oscillator operating at 1500 MHz.

This can be accomplished by placing a pin diode (HP3001) in the feedback circuit of the oscillator (see schematic) either in place of or parallel with an existing feedback capacitor, depending on the amount of feedback the oscillator requires initially. When a forward bias is applied to the pin diode, its resistance will drop from 10 kΩ to about 10 ohms, producing sufficient loss in the feedback circuit to stop the oscillator functioning while maintaining collector-current flow (except for a small amount of current which will be drawn by the pin diode circuit).

To turn the oscillator off apply +12 volts to the pin diode circuit. Remove the +12 volts and the oscillator will turn on.

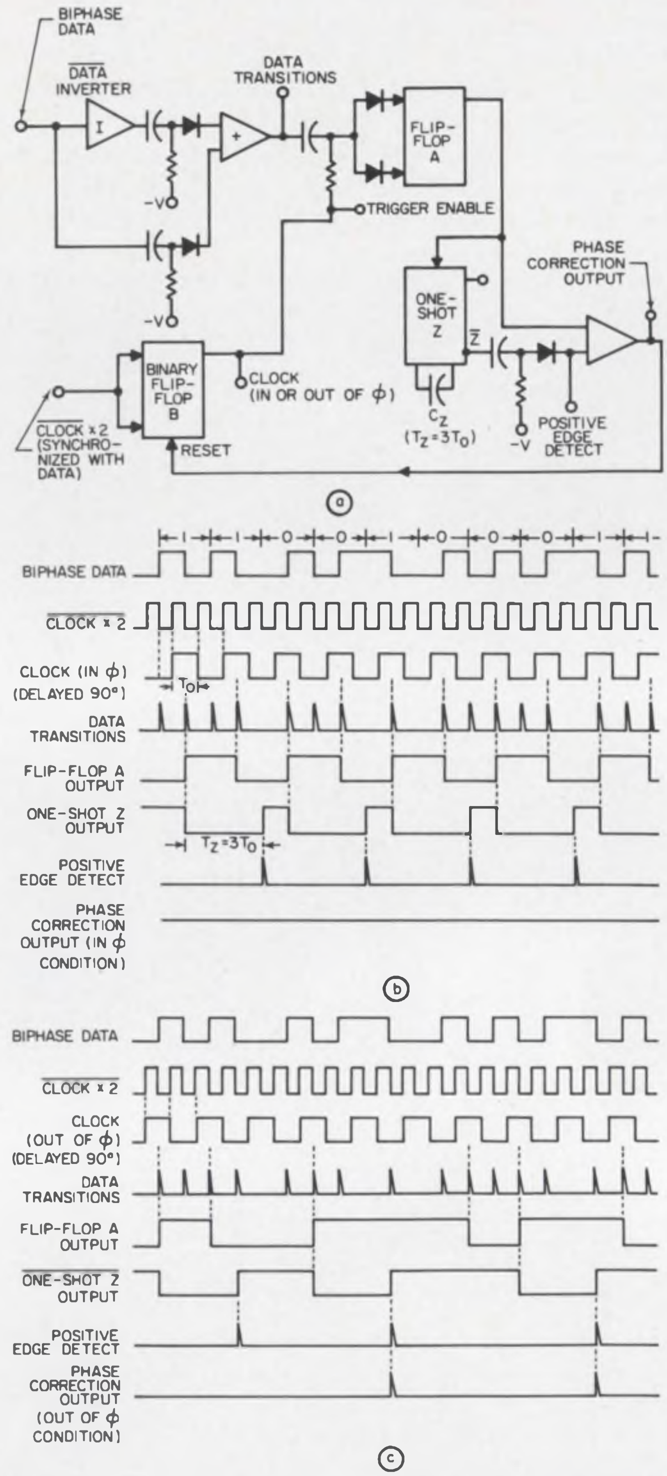
August Barone, Engineering Associate, Cutler-Hammer, Airborne Instruments Laboratory, Melville, N. Y.

VOTE FOR 112

Logical clock phase correction for PCM data

A simple logical method, employing pulse width detection, corrects any improper phase relationship between received PCM data and a clock signal generated by a PCM telemetry system and synchronized with the data bit frequency. An incorrect phase relationship usually occurs when the telemetry system handles a biphase form of PCM data. When the system clock is out of phase with the data, the wrong information will be decoded by the telemetry decommutation system. Usually the error will be an inversion of the actual incoming data. The telemetry unit may never acquire proper frame synchronization if this incorrect phase relationship exists, since a unique synchronization code may never be recognized.

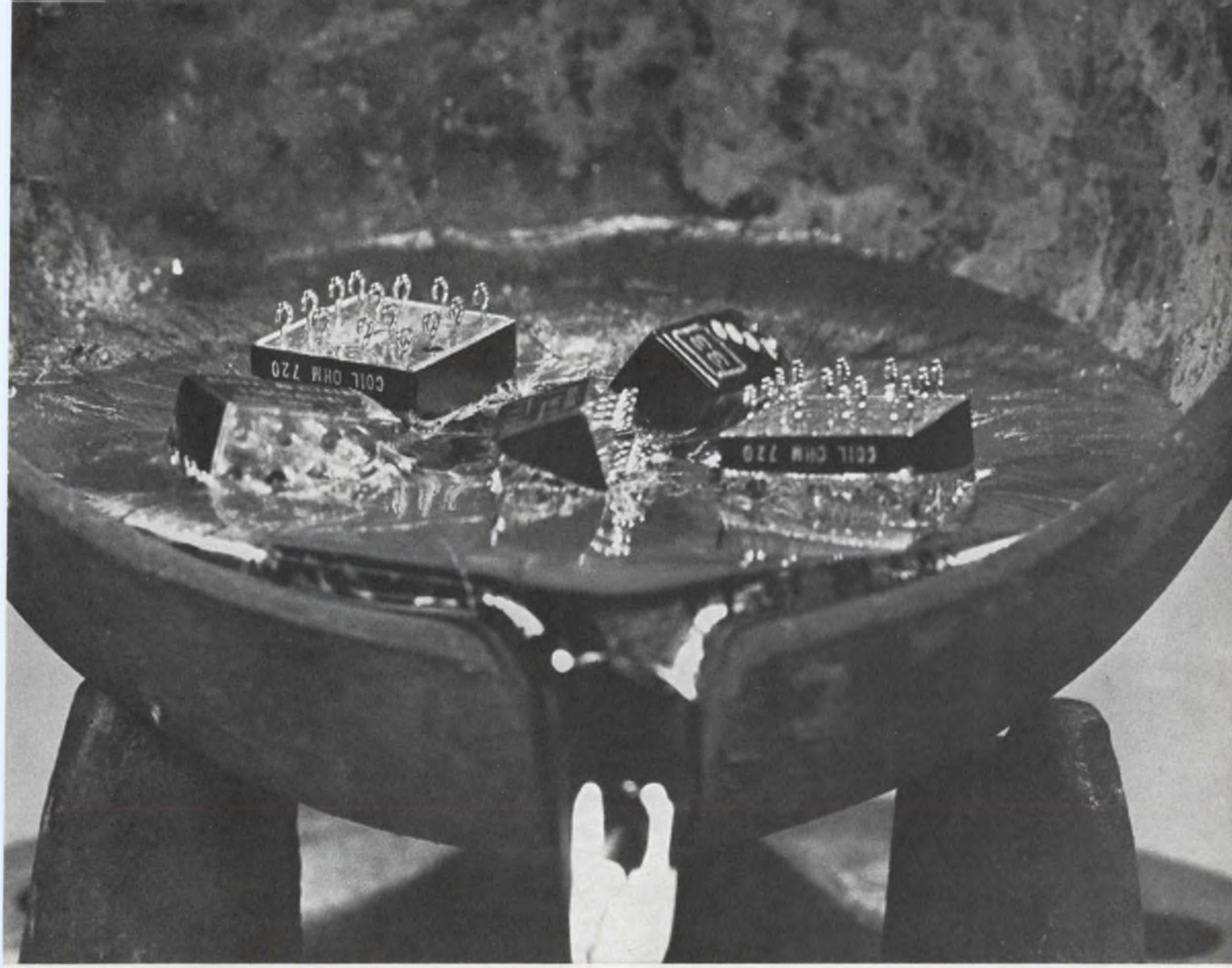
Biphase PCM data contain data transitions every clock period regardless of data content. If the data are sampled at the 180° point of every clock period, a positive-going transition in the data at this time indicates a *0* data bit, while a negative-going transition indicates a *1* data bit. The telemetry system clock would usually be synchronized with the incoming data transitions; therefore, with either a *1* or *0* data bit. The bit-synchronized clock would thus be either in phase or 180° out of phase with the received data. Once the phasing problem is solved for biphase data, however, this type of data is much more useful than other PCM formats. This stems from the fact that biphase data contain data transitions every



Clock phase correction for biphase PCM data is performed by the circuit shown in (a). Timing diagrams for in-phase and out-of-phase conditions appear in (b) and (c), respectively.

bit time. This allows a telemetry clock servo system to achieve bit and frequency synchronization faster than with the other data formats, since there are more correction signals available per unit time. Frame synchronization can also be achieved sooner, so that fewer useful data are lost.

Input signals required (see Fig. 1a) are the



digital form of the biphase input data, and a $\overline{clock \times 2}$ signal, which is twice the frequency of the basic clock signal, inverted and synchronized with the data (a bar above the signal indicates inversion). The $\overline{clock \times 2}$ signal should be available in most PCM systems, since the basic data clock would usually be generated by a high-frequency oscillator with a frequency divided down by a binary counter chain. This chain would be synchronized with the data transitions. The $\overline{clock \times 2}$ signal taken from this counter chain is used as a trigger input for the binary flip-flop *B*, shown in Fig. 1a. Flip-flop *B* will then generate the basic data clock, delayed by 90°, either in phase or 180° out of phase with the data (Figs. 1b and 1c). The biphase *data* signal and the biphase $\overline{data}$ signal generated by the inverter amplifier are differentiated at the input of the OR gate to detect the positive- and negative-going transitions of the data. All the data transitions, which will be detected at the output of the OR gate, are then used as the binary trigger input for flip-flop *A*, and the clock signal is used as the *Trigger Enable* input for *A*. The output of *A* will change state whenever there is a data transition present and the clock is in a *1* state. When the clock is in the "*In* ϕ" condition, the output of *A* will be a square wave, one-half the basic clock frequency (as shown in Fig. 1b). The leading edge of *A* output is used to trigger one-shot *Z* which produces a pulse three times as long as the clock pulse width. The positive edges of the one-shot $\overline{Z}$ pulse are then detected, and gated with the *A* output. Since the pulse width of the one-shot $\overline{Z}$ signal is always greater than the *A* output in the "*In* ϕ" condition, the positive edges of the $\overline{Z}$ signal always occur when *A* output is in the *0* state; hence, there is no phase correction output from the AND gate (Fig. 1b). However, when the clock is 180° out of phase with the data, the *A* output (as shown in Fig. 1c) will no longer be a symmetrical square wave, because there is no longer a definite periodic coincidence of data transitions with the clock in the *1* state, as in the "*In* ϕ" condition. Therefore, the pulse width of *A* can be greater than the $\overline{Z}$ pulse width, and the detected, positive edges of the $\overline{Z}$ signal can occur when the *A* output is in the *1* state (Fig. 1c). When these two signals are coincident, a phase correction output will be generated at the output of the AND gate and this signal can then be used to reset binary flip-flop *B* to correct the clock phase.

The data frequency at which the design will operate depends only on the value of capacitor C_z. This value should be chosen so that $T_z = 3T_o$, where T_z = pulse width of one-shot $\overline{Z}$ signal and T_o = pulse width of clock signal.

Stanley Teich, Computer Engineer, Grumman Aircraft Engineering Corp., Bethpage, N. Y.

VOTE FOR 113

Transfer function plotted on a storage oscilloscope

A convenient method of plotting characteristics of potentiometers or other networks requires only a storage oscilloscope or an X-Y plotter and a variable dc power supply.

Suppose the transfer function of a loaded potentiometer is to be plotted as a function of shaft angle or position, as in Fig. 1a.

The transfer function equation of this network, neglecting external loading at e_o, is:

$$e_o/e_i = [x(a+1-x)]/[a-x(1-x)],$$

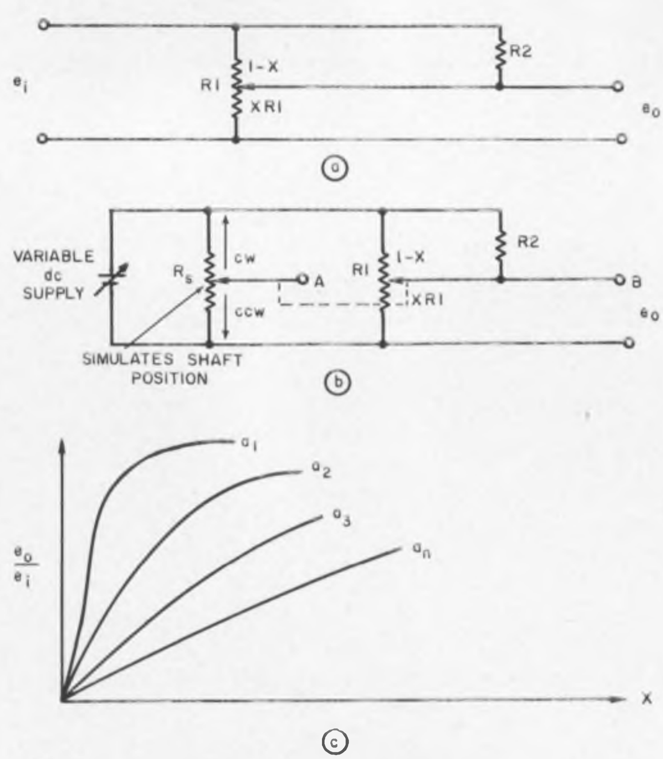
where:

x = some fraction of full shaft rotation,
$a = R2/R1$.

The equipment for generating the transfer function is shown in Fig. 1b.

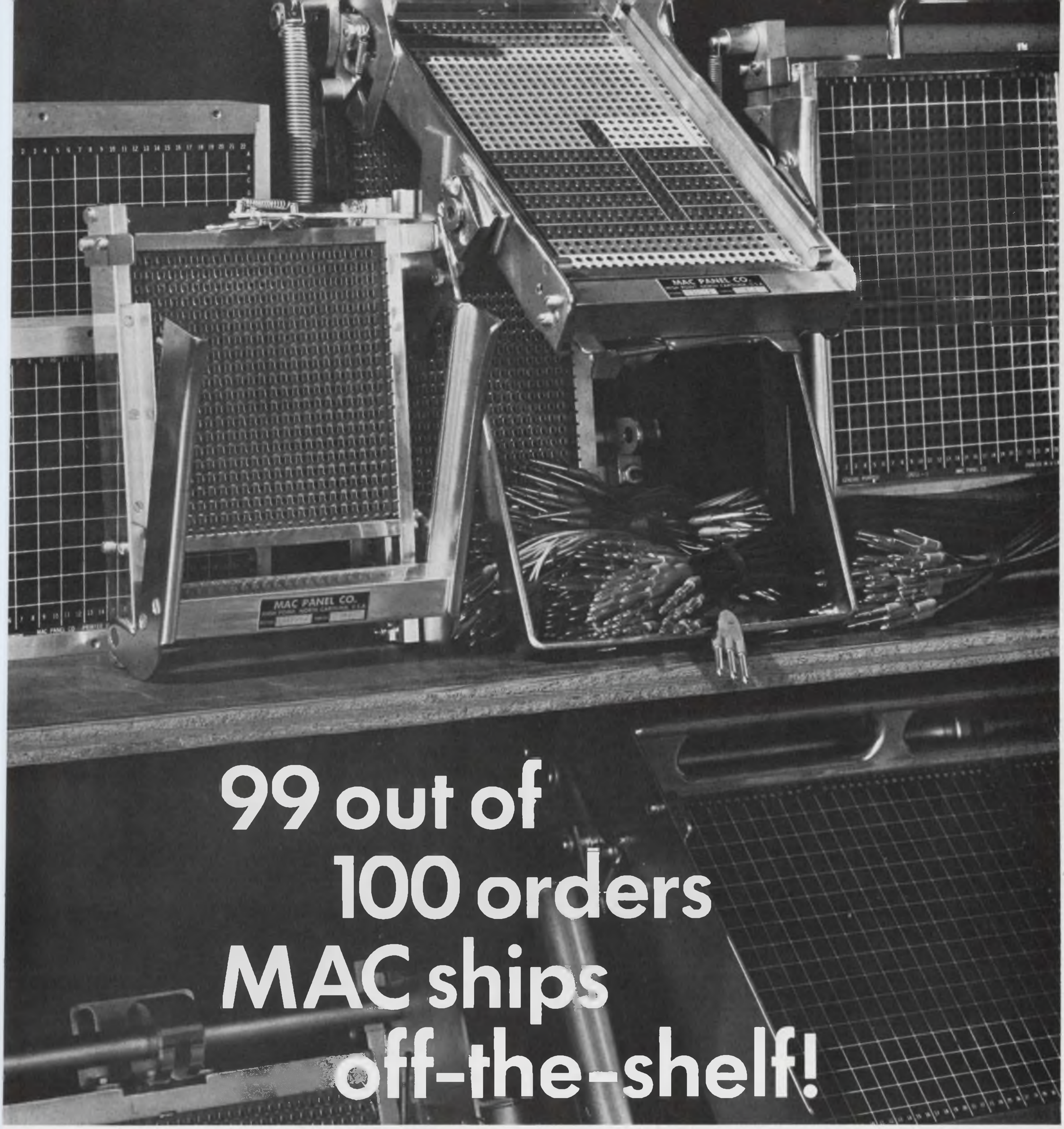
Potentiometer R_s, which is equal to *R1* unloaded (i.e., without *R2*), is ganged with *R1* on the same shaft.

Connecting points *B* and *A* of Fig. 1b to the



Transfer function of loaded potentiometer R1 (a) can be plotted on a storage oscilloscope or an X-Y plotter with the circuit shown in (b). A set of transfer function curves vs potentiometer setting appears in (c).

ON READER-SERVICE CARD CIRCLE 52



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MAC Panel Co., Box 5027, High Point, N.C. 27261 oscilloscope's y and x inputs, respectively, and rotating the ganged potentiometers result in the pattern of Fig. 1c. Many curves can be plotted simply by changing a. They can also be displayed simultaneously. Various other network and transfer functions may be displayed in a similar way.

Ron Tolmei, Graduate Student, University of Vermont, Burlington, Vt.

VOTE FOR 114

Temperature monitor tracks voltage drifts

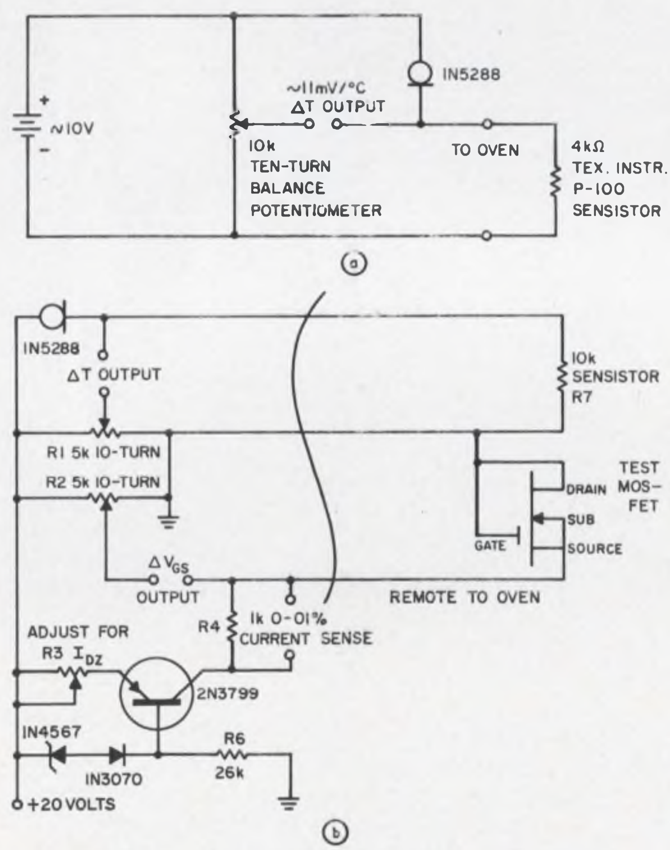
An X-Y plot of FET or transistor parameters versus temperature is often needed to determine circuit performance completely. One instance is with the gate voltage drift of a FET when it is biased at a particular drain current. The X-Y plot can be used to advantage to find the proper bias current.

The temperature-monitoring circuit uses a current-limiting diode and a silicon resistor in the simple configuration of Fig. 1a. The current-limiting diode (Motorola 1N5288 or Siliconix CL4710) provides a constant current, independent of power supply variations, for a silicon resistor. The latter has a positive temperature coefficient of 0.7%/°C and is placed in the oven close to the device under test. The balance potentiometer provides a reference zero for the temperature read-out. As shown, the sensitivity is approximately 11 mV/°C. This can be modified by changing the current-limiting diode or the Sensistor.

A typical use is shown in Fig. 1b. This circuit checks p-channel enhancement MOSFETs for gate voltage drift at a specific drain current. In one actual application, this setup provided the means for adjusting the drain current to the point where the V_{GS} drift was less than 0.25 mV for a 50°C temperature change. (The device used was a GI MEM551.)

Thomas H. Lynch, Technical Staff, Bunker-Ramo Corp., Canoga Park, Calif.

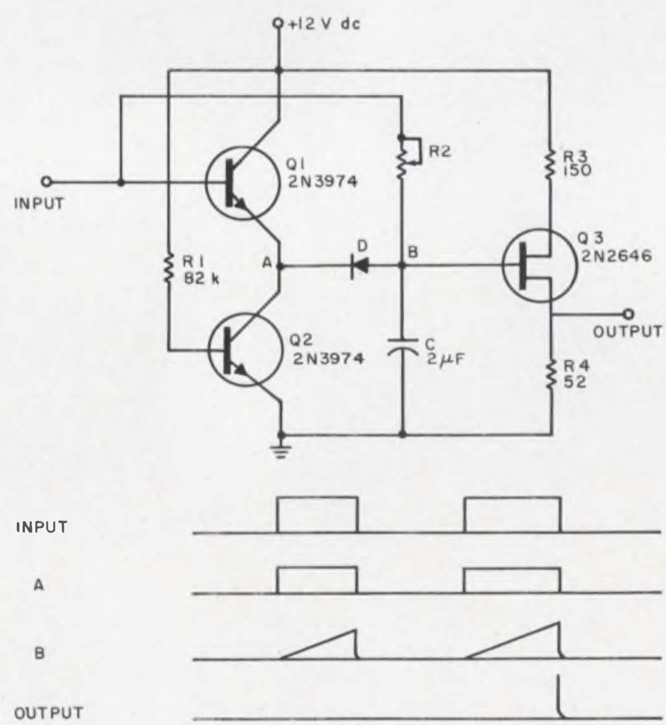
VOTE FOR 115



1. **Simple temperature-monitoring circuit** (a) is used to check p-channel enhancement MOSFET gate voltage drift versus temperature in the complete test circuit (b). The drain current is adjusted with potentiometer R3 until the desired drift characteristics are achieved.

Simple circuit recognizes pulse width and amplitude

The illustrated circuit produces an output pulse when pulse widths of predetermined magnitude, or greater, are presented at the input.



Output pulse is generated by the circuit only when the input pulse exceeds predetermined widths and amplitude. Value of C and the setting of pot R2 determine the minimum pulse characteristics required to produce an output.

A pulse appearing at the input also appears at point *A*, reverse-biasing diode *D*. Capacitor *C* then commences to charge through *R2*. Charging continues as long as the original pulse is present. Selecting *R2* and *C* will permit unijunction *Q3* to fire for pulses of a specified width or greater.

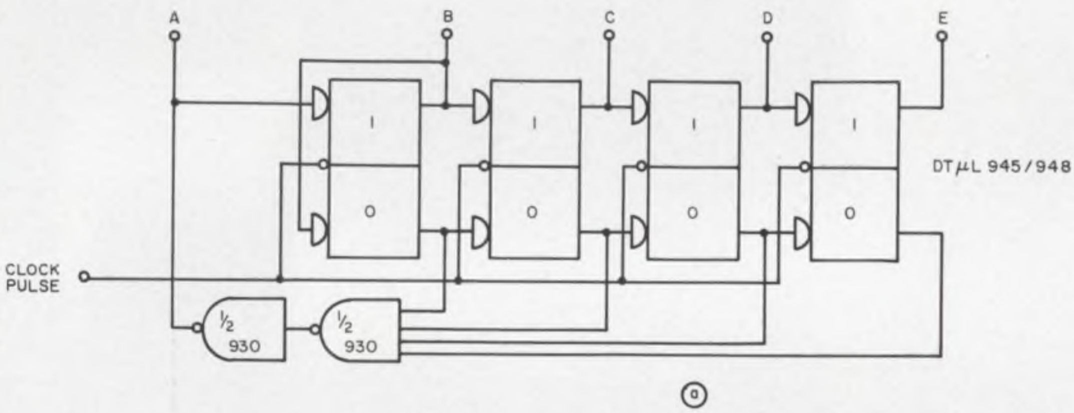
The input pulse amplitude must be greater than η times $B+$ to fire *Q3* (where η is the intrinsic stand-off ratio of the unijunction). The width of input pulse that is recognized is adjusted by *R2*. To recognize pulse widths on the order of 50 ms, a potentiometer of about 40 kΩ is adequate.

If the input pulses are too narrow to fire the unijunction, point *A*, which follows the input, will go low. The diode will then be forward biased and *C* will discharge through *D* and *Q2*, preparing the circuit for sequential pulses.

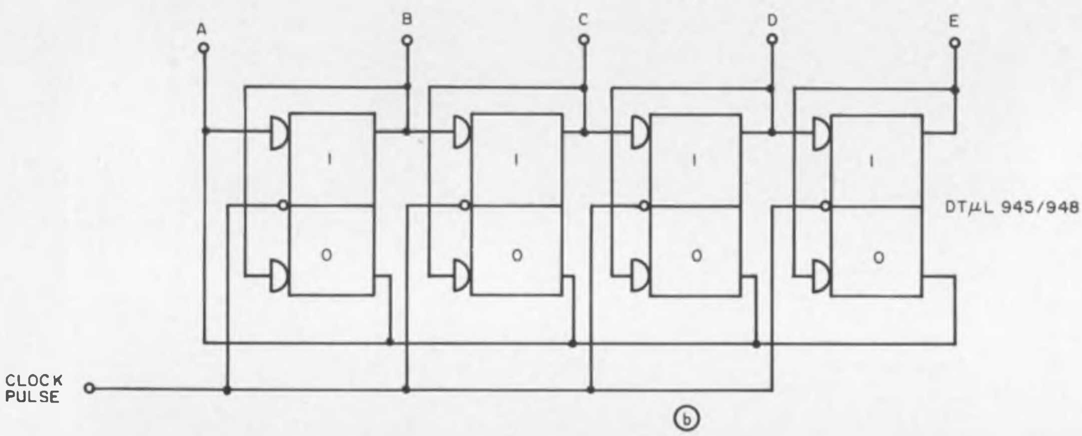
Ben A. Tripp, Test Set Engineer, Northern Electric Co., Ltd., London, Ont., Canada.

VOTE FOR 116

Five-bit counter saves a package



A	B	C	D	E
1	0	0	0	0
0	1	0	0	0
0	0	1	0	0
0	0	0	1	0
0	0	0	0	1
1	0	0	0	0



S	C	Q	$\overline{Q}$
H	H	AMB	
L	H	L	H
H	L	H	L
L	L	NC	

1. **Five-bit shift counter** has four-bit gate and inverter to complete the ring (a). Modified counter omits gate and inverter and by wire ORing all 0 outputs keeps them all low if any one is low (b).

The generally accepted method for constructing a five-bit counter is outlined in Fig. 1a. Figure 1b shows a new method that saves one package containing a four-input gate and an inverter.

The DTμL 945/948 clock-gated flip-flops operate on the master-slave principle. Information enters the 'master' when the trigger input voltage is high and transfers to the 'slave' when it goes low. Thus, in Fig. 1b, when *BCDE* are all *0*, all *1* outputs are low and all *0* outputs are high. *E* will not change until the clock transformation is complete. Hence the low set input for the first flip-flop will have no effect until the next clock. The *0* outputs are wire ORed; thus *B* will not reset until all the outputs are low.

Uses for this counter might be as a bit feedback shift counter or, with an additional flip-flop, as a biquinary or decade counter.

Orville L. Lykins, Systems Engineer, Fairchild Semiconductor, Mountain View, Calif.

VOTE FOR 117

IFD Winner for April 1, 1967

James F. Teixeira, Sylvania Electronic Systems, Inc., Applied Research Laboratory, Waltham, Mass. His Idea, "Two-transistor circuit makes dc-coupled full-wave rectifier," has been voted the $50 Most Valuable of Issue Award.

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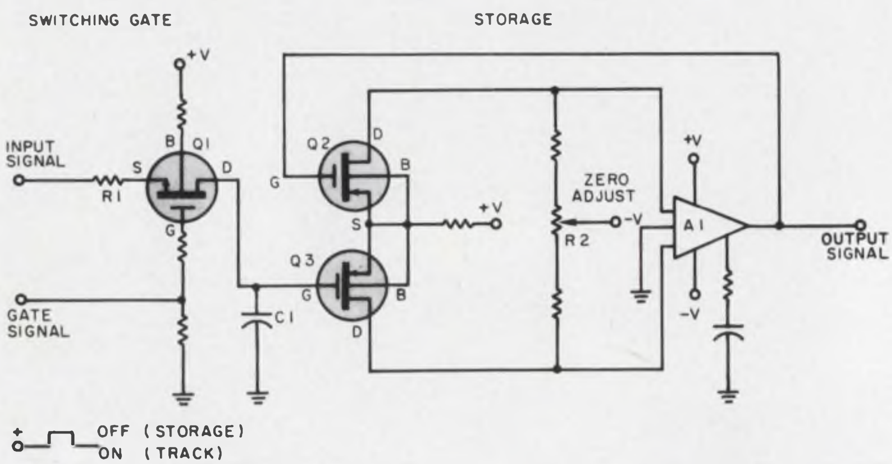
MOS-FET memory stores signal for 10^6 s



Problem: Design a system that can maintain the signal voltage at the output of an analog amplifier when the input signal is interrupted or removed. For some automatic control and instrumentation applications, it is desirable to store and read out the last input received prior to signal interruption so that no information is lost during the absence of input. In addition to a single-storage mode, the unit must have a tracking mode of operation, during which the output voltage of the unit must duplicate the input voltage.

Solution: Use MOS-FET (metal oxide semiconductor field-effect transistor) devices as voltage-controlled switches in a memory circuit and trigger them by an external voltage-sensing device. The circuit makes use of the zero offset switching capability and extremely high input impedance characteristics of MOS-FET devices.

The memory unit is composed of three main parts: a filter (*R1*, *C1*) that removes unwanted voltage variations or noise; an analog signal gate (*Q1*) that switches the unit between its two modes of operation (tracking mode and storage mode); and a highly accurate unity-gain storage device (*Q2*, *Q3*, *R2 A1*) that privides a duplicate of the input voltage at its output terminals.

When the input signal is applied, an external sensing device turns input gate *Q1* on and places the unit in its tracking mode of operation. The voltage on capacitor *C1* represents the desired signal data and is applied to the unity-gain amplifier, which consists of a pair of MOS-FET devices, *Q2*, *Q3*, and an integrated operational amplifier, *A1*. Balance control *R2* cancels any amplifier offset voltage.

Upon loss of the input signal, the input gate is switched off by an external voltage-sensing device. This action converts the unit from a tracking mode to a storage mode of operation. The last signal level received prior to signal dropout is stored in capacitor *C1* and maintained at the output terminals of the circuit. Leakage of charge from capacitor *C1* through the two MOS-FET devices, *Q1* and *Q3*, is impeded by the extremely high input and gate-off impedances of the MOS-FET devices. Since the time constants of the capacitor-MOS-FET impedances are extremely high, the voltage on the capacitor decays very slowly and can be considered essentially constant during the relatively short signal-dropout periods. When the input signal returns, the circuit is switched back into its tracking mode of operation by the external voltage-sensing device.

Selection of a capacitor of proper material has resulted in time constants in the order of 10^5 to 10^6 seconds—values much larger than the longest signal-dropout time anticipated.

The choice of time constant at the memory input is determined by the following:

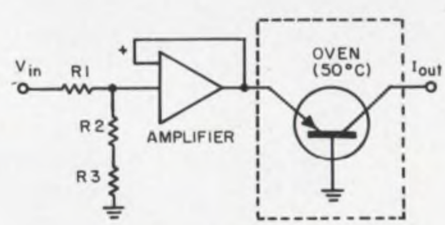
- Amount of smoothing required.
- Amount of decay encountered during the gates' switching time.
- Expected time between signal dropouts.
- Time derivative of input signals.

Inquiries concerning this innovation may be directed to: Technology Utilization Officer, Marshall Space Flight Center, Huntsville, Ala. 35812 (B66-10603).

Microcurrent generator accurately controls 1 pA

Problem: Control accurately the output of a current generator in the range of 10^{-11} to 10^{-3} amperes, to test low-current devices such as ion chambers.

Solution: Use operational amplifiers, current dividers and a transistor in a design that provides a current output that equals antilog (V_{in}/K), where K is determined by circuit parameters, and can be controlled accurately.



The microcurrent generator in the figure meets this requirement; i.e., $V_{in} = K \log V_{out}$. The voltage divider, *R2*, is used to set the value of *K*. For this particular circuit to produce a current change of one decade, SPERRY

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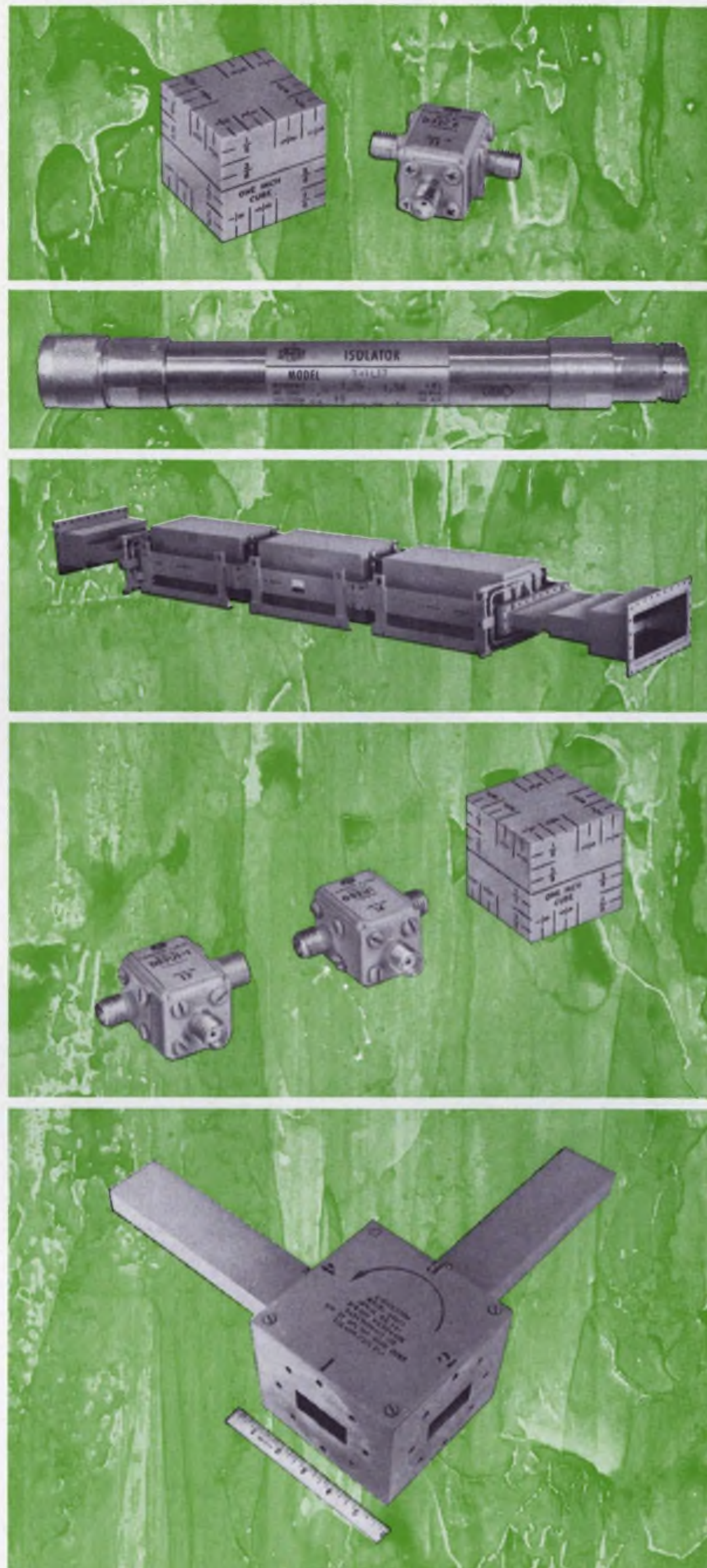

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the voltage at the output of the operational amplifier must change by approximately 60 mV. Stabilizing the transistor by placing it in a temperature-controlled oven at 50°C provides a low-current limitation of the circuit of 10^{-10} ampere. The circuit is adjusted so that each time the input voltage changes 2 volts in range, a one-decade change in current is produced. For example, a change from 2 to 4 volts provides a current change of one decade; a change from 2 to 8 volts causes a current change of 3 decades.

For the circuit shown:

$I_{out} = 10^{-11}$ antilog$[(V_{in}/2)+2)]$.

Compensation networks may be added to improve the accuracy at the lower current levels.

For further information, contact Technology Utilization Officer, AEC-NASA Space Nuclear Propulsion Office, U.S. Atomic Energy Commission, Washington, D. C. 20545 (B66-10706).

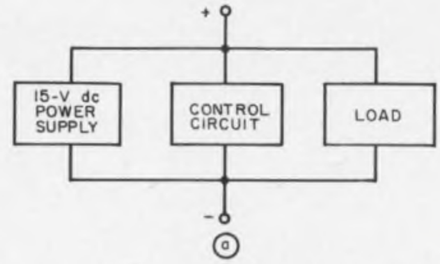
Switching transistor controls dc voltages

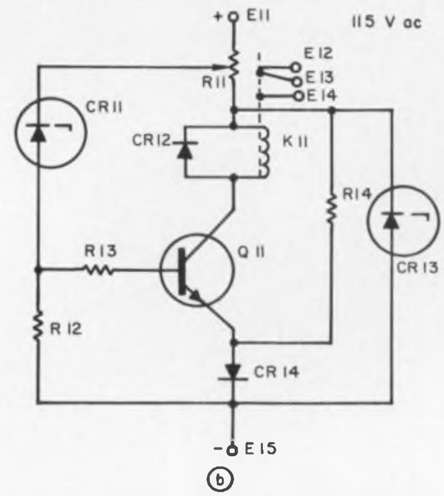
Problem: Design a sensing and controlling circuit for dc voltages using relay coils, in which the current in the relay coil is held to zero for all input voltages up to slightly below the threshold level.

The primary disadvantage of relay coils is that a current, proportional to the sensed voltage, is always in the relay coil, which tends to make the circuit susceptible to external disturbances such as electrical noise and mechanical vibrations.

Solution: A circuit in which the control relay is driven by a switching transistor that is biased to cutoff for all input up to slightly less than the threshold level.

In the block diagram (a), the control circuit (b) is used for





very accurate control of the 15-V dc supply that powers the load. For an input voltage of 15 volts, Zener diode *CR13* will conduct and regulate the voltages across relay *K11* and resistor *R14*. A constant current will be maintained in diode *CR14*. The forward voltage in *CR14* will be at the same level as the emitter of switching transistor *Q11*. *R11* is adjusted so that Zener diode *CR11* does not conduct. Under these conditions the base of *Q11* will be at zero volts. *Q11* will be cut off and the voltage across *K11* will be zero.

As the input voltage increases above 15 volts dc, *CR11* will conduct and a potential difference, ΔV, will appear at *R12*. When this potential difference exceeds the *Q11* base-to-emitter voltage, the current in *Q11* activates relay *K11*. When *K11* is activated, contacts *E12* and *E13* are broken. This cuts off and locks out the 15-volt power supply controlled by the control circuit.

For further information, contact Technology Utilization Officer, AEC-NASA Space Nuclear Propulsion Office, U.S. Atomic Energy Commission, Washington, D. C. 20545 (B66-10591).

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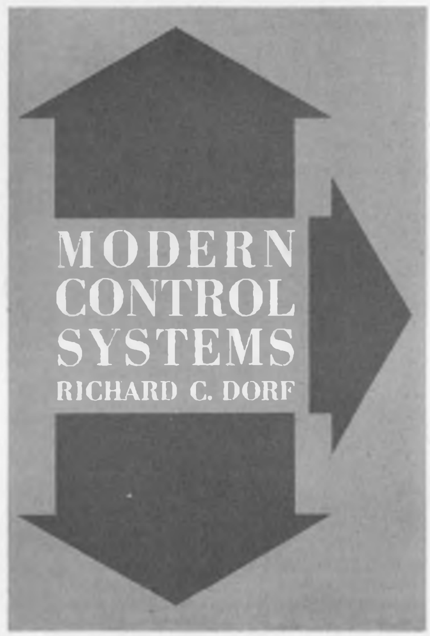
Book Reviews



Feedback control theory

Modern Control Systems, Richard C. Dorf (Addison-Wesley Publishing Co, Reading, Mass.), 387 pp. $12.50.

In addition to well known techniques such as Bode diagrams, root locus, Nyquist criterion, Nichols diagrams and others, the book introduces new concepts in control systems analysis such as parameter sensitivity, state variables, and applications of computers.

Like most books on the subject, the practical side of this one—how to write transfer functions for a variety of physical systems, or how to fill the boxes on the block diagram with functions of the complex variable, *s*—leaves much to be desired. In fact, its shortcomings point up the need for a book of this kind.

The various analytical techniques, however, are well presented and the book should be of interest both to the control engineer and to circuit designers, provided the latter can adopt the simple approach of a servo engineer to the feedback problems.

—Peter N. Budzilovich

Elementary circuit problems

Circuit Problems and Solutions, Vol. I: *Elementary Methods*, Gerald Lippin (Hayden Book Co., New York), 190 pp. $3.95.

Here is an elementary guide for the student or hobbyist. Any point on basic electrical circuit theory can be found with ease—followed by problems and their solution. The reader needs to be familiar only with trigonometry and algebra.

The language is clear and concise. Lippin goes all the way through series-parallel resistance circuits and their solution by loop equations and Kirchoff's Laws. He then briefly covers magnetism and electromagnetism. The *j* operator is explained graphically and ac theory step by step. One chapter is devoted to time constants and the last to filter circuits.

Quality control program

Zero Defects: A New Dimension in Quality Assurance, James F. Halpin (McGraw-Hill, New York), 228 pp. $10.50.

This book is a management tool aimed at the improvement of the quality of goods and services procured or produced. It works toward reduction of defects by endeavoring to instill a constant, conscious desire to do the job right the first time. A how-to-do-it manual for establishing a ZD program, it outlines the stages of such a program step by step. The book is written so that the reader can select the specific techniques best suited to his particular organization.

Latest SCR developments

Silicon Controlled Rectifiers, Allan Lytel (Howard W. Sams, Indianapolis), 128 pp. $2.75.

This handbook explains the principles of operation of SCRs and tells how they are used in numerous practical control circuits. Phase-shift control of ac and dc power is clearly explained and examples of these circuits are given. The book discusses such circuits as ring counters, temperature controls, and voltage regulators. The chapter on SCR testing will be useful to anyone who works with SCRs.

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Process-control systems

Process-Control Systems, F. G. Shinskey (McGraw-Hill, New York), 367 pp. $16.50.

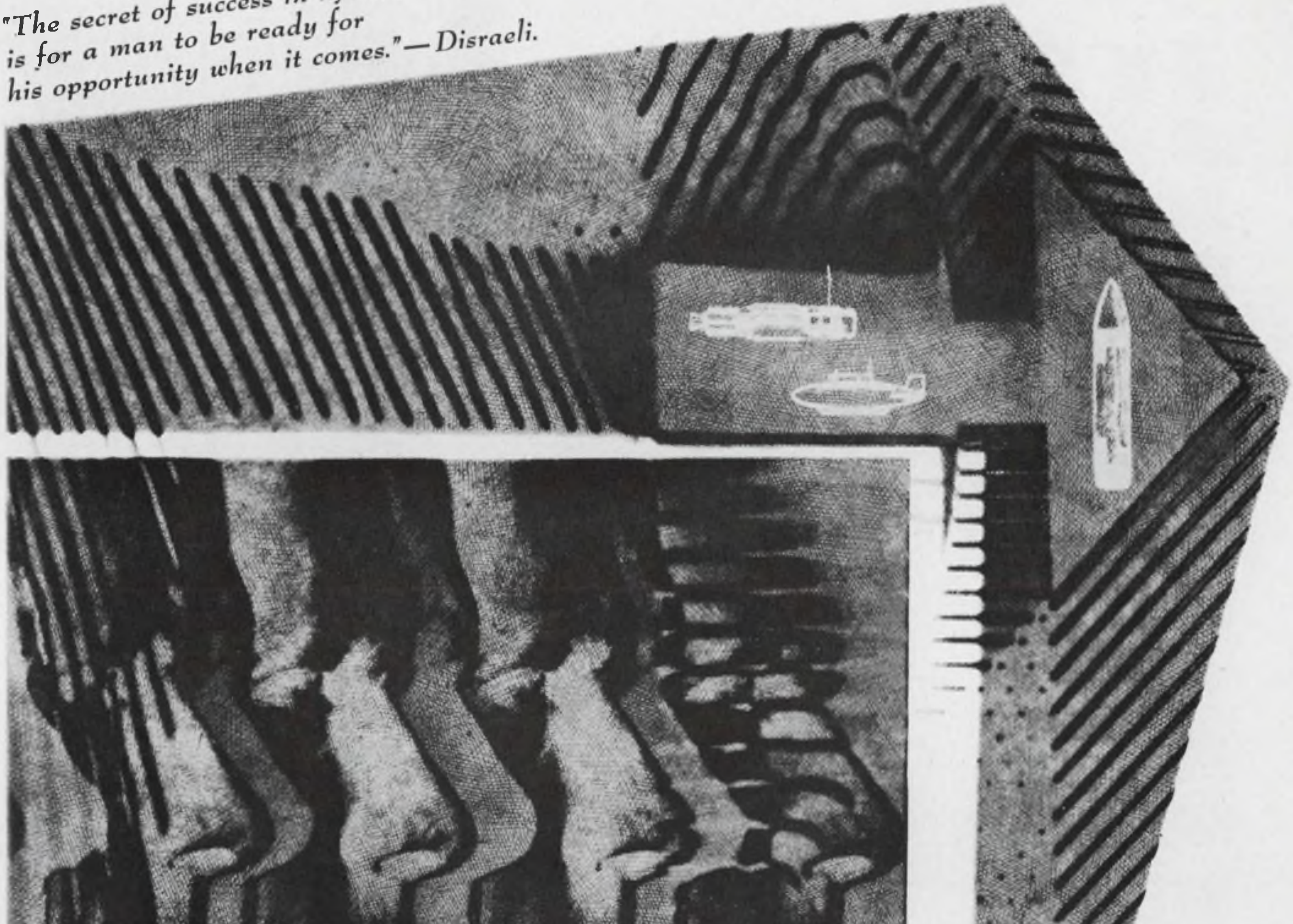
Here is a practical approach to the design of process-control systems. It is based on the time-domain principle rather than on operational calculus. Using this approach with time plots and simple numerical operations, the most complicated control loops can be analyzed and their performance predicted with "pencil-and-paper" methods. Beginning with a basic description of the properties of simple processes under feedback control, the book gradually introduces more advanced considerations. In this way it develops a procedure for designing complicated systems for the control of multivariable processes. Numerous examples of real applications are given.

Transistor circuit design

Transistor Circuit Engineering, Basil L. Cochrun (Macmillan, New York), 445 pp. $13.95.

This book is primarily devoted to the engineering design aspects of linear circuitry. The reader is expected to understand basic circuit theory and the physics of semiconductors. Following a review of these, the author develops the intrinsic characteristics of a hybrid-π model from a circuit theory viewpoint, using flowgraphs and the superposition concepts of impedance. Variation of the intrinsic parameters of the model with temperature and operating point are then considered in conjunction with biasing—a topic which leads logically to the consideration of extrinsic parameters. Low-frequency amplifiers and low-frequency RC active filters are considered; then high-frequency amplifiers, both wide- and narrow-band, are taken up in turn. Noise, a common denominator of the limitations for all frequencies, is the next consideration. The final chapters examine feedback and stability and provide a modern development of field-effect transistors. Appendices are devoted to the latest techniques.

"The secret of success in life... is for a man to be ready for his opportunity when it comes."—Disraeli.



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ON CAREER INQUIRY FORM CIRCLE 901

Silicon integrated devices

Fundamentals of Silicon Integrated Device Technology, Vol. 1: Oxidation, Diffusion and Epitaxy, R. M. Burger and R. P. Donovan, eds. (Prentice-Hall, Englewood Cliffs, N. J.), 495 pp. $15.00.

This is the first volume of a series on the fundamentals of silicon integrated devices. It describes the practices and theories associated with three of the basic technologies employed in the fabrication of silicon integrated devices. The aim has been to provide a source of information for both the novice and the experienced practitioner. Much practical detail on implementing each process is included. The authors have attempted to identify both the capabilities and the limitations of oxidation, diffusion and epitaxy.

Carrier telephony

Basic Carrier Telephony, David Talley (Hayden Book Co., New York), 198 pp. $4.95.

This is a basic course in the principles and applications of carrier telephony and its place in the overall communications picture. An expanded and updated edition, it reflects important state-of-the-art developments and includes a new chapter on pulse-code-modulation carrier systems. Abundantly illustrated and requiring a minimum of mathematics, it should be useful to all those in the communications and electronics fields, particularly those responsible for engineering, operating and maintaining telephone services.

Radar techniques

Introduction to Radar, Denis Taylor (Philosophical Library, Inc., New York), 125 pp. $4.75.

This pocket book on radar and radar techniques begins with an account of their development during World War II. It discusses various later uses and applications, leading up to how such developments are affecting the modern world.

The material is presented such that the scientific and technical aspects should be easily grasped by a general reader.

Dr. Harold Goldberg, Vice President and Director, LTV Electrosystems; General Manager, Garland Division; co-author of "Principles of Guided Missile Design."

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ON CAREER-INQUIRY FORM CIRCLE 904

Electronics and electricity

Electronics One-Seven and *Electricity One-Seven*, Harry Mileaf, ed. (Hayden Book Co., New York), 992 pp. and 976 pp. Available as set of 7 individual paperbound vols.: \$20.95 and \$16.95 set, \$3.45 and \$2.75 ea.; or all 7 vols. in single cloth binding: \$14.96 and \$12.76, respectively.

Electronics One-Seven is a course on basic electronics. To teach a technology in a constant state of change, a special presentation has been adopted. Instead of using equipment which may become outdated as a starting point, the course begins with the concept of the electronic signal. Then electronic systems are seen as a series of "building blocks" that produce desired effects on the signal. This approach is thus oriented toward the functional purposes of equipment.

Electricity One-Seven is a course in the fundamentals of electricity. With only a minimum of mathematics, a reader can gain an understanding of the theory and practical background of electricity and electrical devices. Emphasis is on modern scientific concepts and interdisciplinary relationships.

Communication satellites

Communication Satellite Systems Technology, Richard B. Marsten, ed. (Academic Press, New York), 1051 pp. \$12.00.

This collection of technical papers surveys communication satellite systems. The first three chapters cover the present state of the art. Commercial systems, military systems, and subsystem and component technological accomplishments applicable to future systems are considered. Chapters four and five center on high-powered systems and systems concepts and their applications. Included are contributions on multiple-access, direct broadcasting and TV networking, the national information grid, and communications from deep space. The final chapter provides an international sociological survey of the effects of communication satellite systems.

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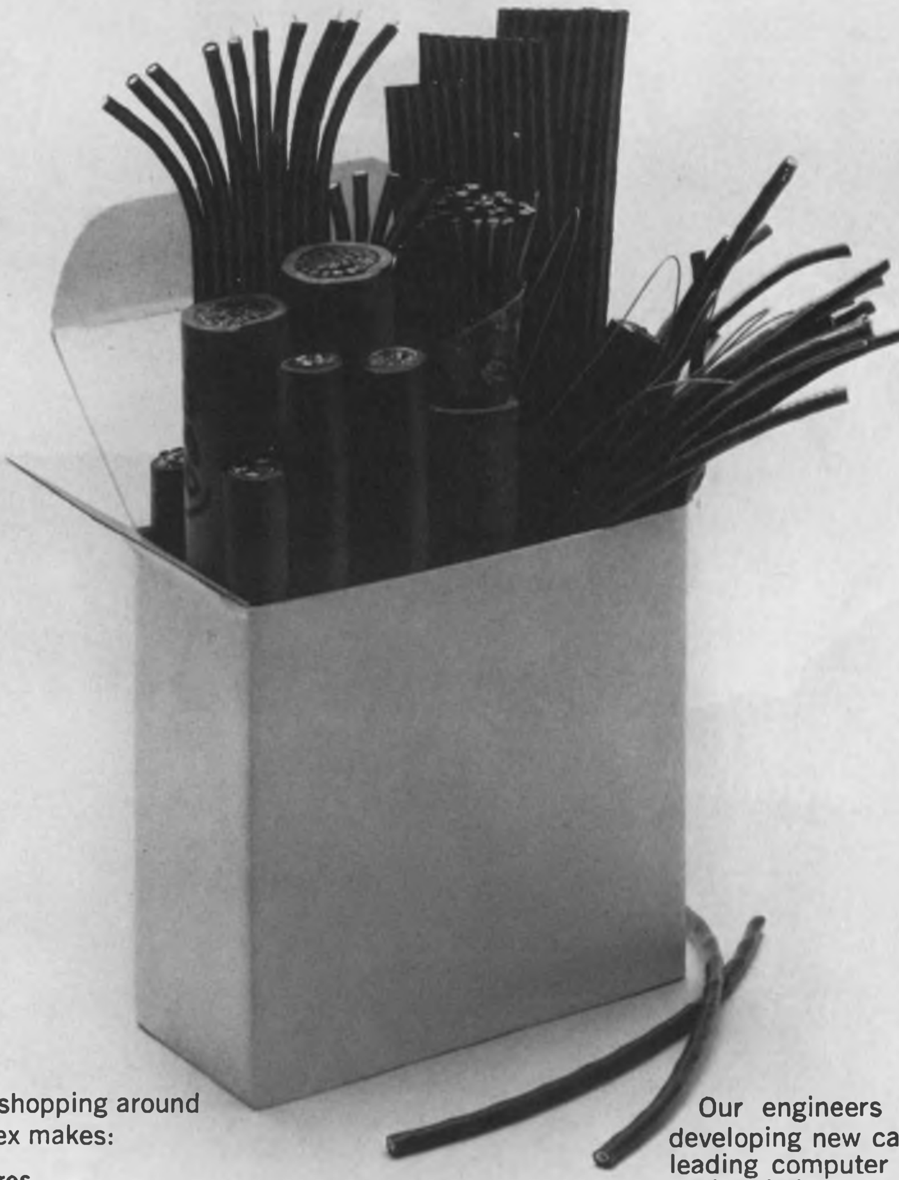

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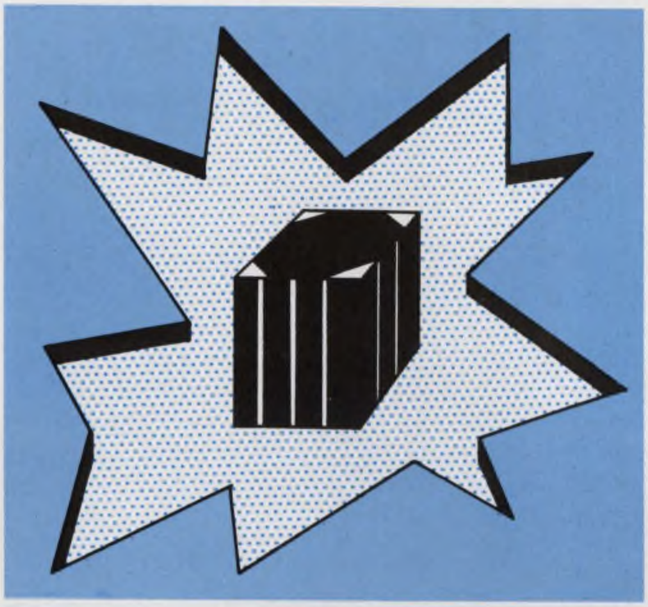
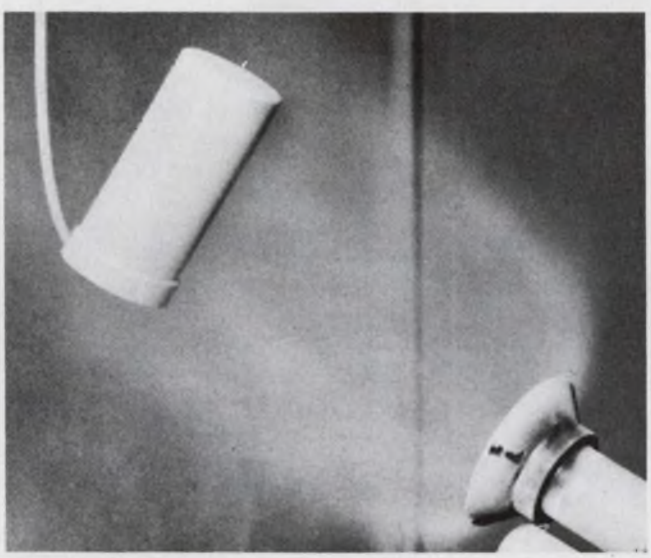
Products



Tiny cubes pack a 100-watt wallop. Five different power circuits are offered. Page 130



Powdered epoxy electrostatically applied to cold or heated parts, then cured. Page 170

Transistors automatically tested from dc to rf, classified and then sorted. Page 176

Also in this section:

Power circuits deliver 30- to 100-watt outputs in half-cubic-inch, three-quarter-ounce package

Powercube Corp., 214 Calvary St., Waltham, Mass. 02154. Phone: (617) 924-1758. P&A: $190 to $275 (1 to 9); 2 to 3 wks.

A new packaging concept puts power-handling capabilities many times that of conventional circuits into a cube a fraction of the size and weight of existing cards, modules, cans and subassemblies. In the same half-cubic-inch, three-quarter-ounce package, Powercube Corp., manufacturer of the devices, offers five different circuits capable of delivering from 30 to 100 watts. The units have integral heat-sinking, termination, interconnection and environmental protection. Modules available are:

- Dc-to-ac inverters delivering 30 W with voltages to 500 Vac.
- Dc-to-dc regulators with closely regulated 4-to-110-Vdc outputs.
- Ac-to-dc converters with outputs up to 500 Vdc and to 6 A.
- Ac-to-dc regulated converters with outputs to 110 Vdc, 2 A.
- Dc-to-dc pulse regulators to regulate wide voltage ranges at 90% efficiency.

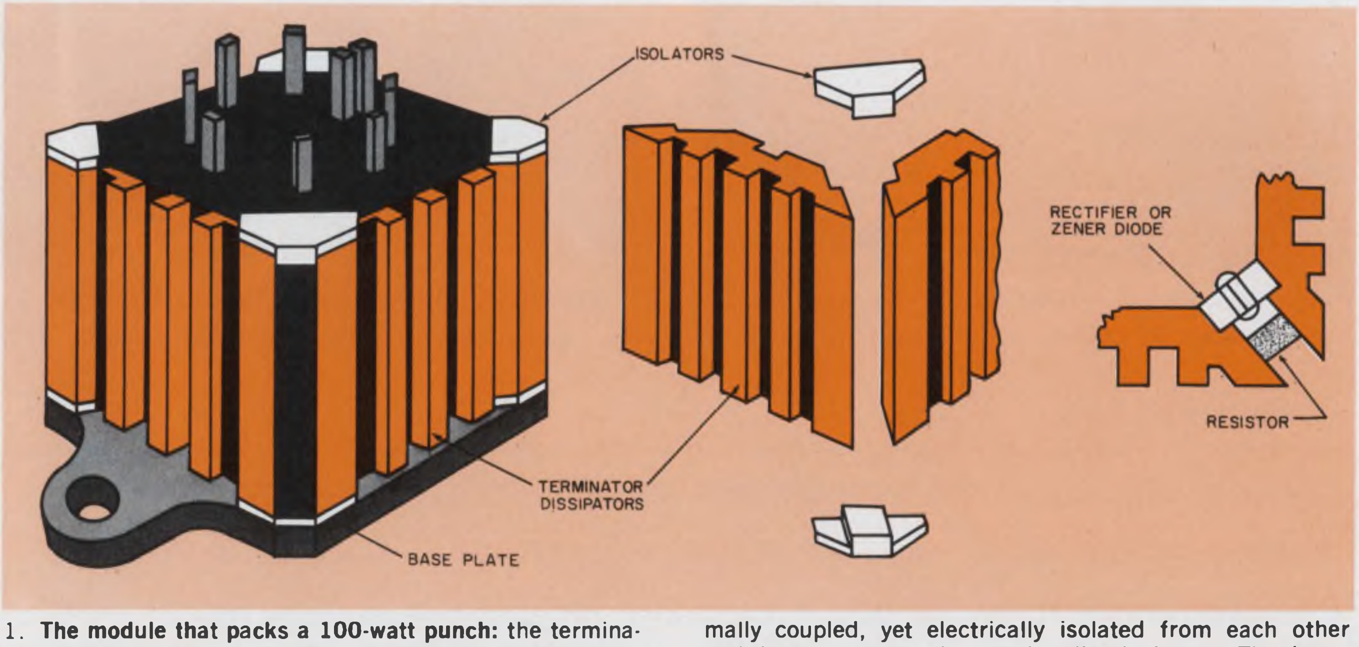
Figure 1 is a cutaway view illustrating the "terminator-dissipator-isolator" concept.

The heat-generating components—rectifiers, Zener diodes and resistors—all terminate in "terminator-dissipators." The walls of the fully brazed package, which are the terminator-dissipators, also act as:

- Electrical terminations for the active elements.
- Electrical interconnections.
- A low-thermal-resistance path for heat dissipation.

The "isolators" provide the mechanical means for joining terminator-dissipators to each other and to the base.

To make maximum use of the package's heat-dissipating capabilities, it is necessary to couple all terminator-dissipators thermally. Electrical isolation, however, must still be maintained for each separate terminator-dissipator since they are at different potentials. These mechanical, elec-



1. **The module that packs a 100-watt punch:** the terminator-dissipators, which are the physical walls of the package, also function as interconnections, heat dissipators, and terminations for the active elements. They are thermally coupled, yet electrically isolated from each other and from the base, by the beryllia isolators. The baseplate, in turn, bridges the thermal path between each terminator-dissipator.

Now—the broadest line of convection-cooled, all silicon, .015% regulated power supplies

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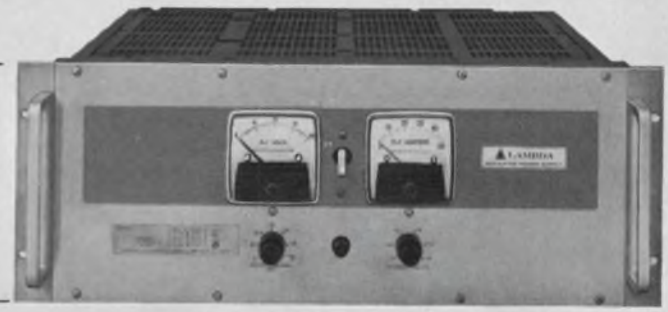
- Ripple—LK models—500 μV RMS LH models—250 μV RMS, 1 MV P-P
- Meet MIL Environment Specs

7"



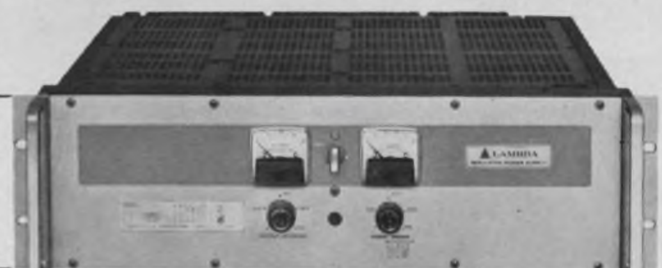
Full Rack 7" LK Series

5¼"

¼ Rack LH Series

5¼"

½ Rack LK Series-LH Series



Full Rack 5¼" LK Series

3 Full-rack Models — Size 7" x 19" x 18½"

Model[2]	Voltage Range	CURRENT RANGE AT AMBIENT OF:[1] 40°C	50°C	60°C	71°C	Price[2]
LK 360 FM	0–20VDC	0–66A	0–59A	0–50A	0–40A	$995
LK 361 FM	0–36VDC	0–48A	0–43A	0–36A	0–30A	950
LK 362 FM	0–60VDC	0–25A	0–24A	0–22A	0–19A	995

3 Full-rack Models — Size 5¼" x 19" x 16½"

Model[2]	Voltage Range	CURRENT RANGE AT AMBIENT OF:[1] 40°C	50°C	60°C	71°C	Price[2]
LK 350	0–20VDC	0–35A	0–31A	0–26A	0–20A	$675
LK 351	0–36VDC	0–25A	0–23A	0–20A	0–15A	640
LK 352	0–60VDC	0–15A	0–14A	0–12.5A	0–10A	650

5 Quarter-rack Models — Size 5³⁄₁₆" x 4³⁄₁₆" x 15½"

Model[2]	Voltage Range	CURRENT RANGE AT AMBIENT OF:[1] 30°C	50°C	60°C	71°C	Price[2]
LH 118	0–10VDC	0–4.0A	0–3.5A	0–2.9A	0–2.3A	$175
LH 121	0–20VDC	0–2.4A	0–2.2A	0–1.8A	0–1.5A	159
LH 124	0–40VDC	0–1.3A	0–1.1A	0–0.9A	0–0.7A	154
LH 127	0–60VDC	0–0.9A	0–0.7A	0–0.6A	0–0.5A	184
LH 130	0–120VDC	0–0.50A	0–0.40A	0–0.35A	0–0.25A	225

11 Half-rack Models — Size 5³⁄₁₆" x 8⅜" x 15⅝"

Model[2]	Voltage Range	CURRENT RANGE AT AMBIENT OF:[1] 40°C	50°C	60°C	71°C	Price[2]
LK 340	0–20VDC	0– 8.0A	0– 7.0A	0– 6.1A	0–4.9A	$330
LK 341	0–20VDC	0–13.5A	0–11.0A	0–10.0A	0–7.7A	385
LK 342	0–36VDC	0– 5.2A	0– 5.0A	0– 4.5A	0–3.7A	335
LK 343	0–36VDC	0– 9.0A	0– 8.5A	0– 7.6A	0–6.1A	395
LK 344	0–60VDC	0– 4.0A	0– 3.5A	0– 3.0A	0–2.5A	340
LK 345	0–60VDC	0– 6.0A	0– 5.2A	0– 4.5A	0–4.0A	395

Model[2]	Voltage Range	CURRENT RANGE AT AMBIENT OF:[1] 30°C	50°C	60°C	71°C	Price[2]
LH 119	0–10VDC	0– 9.0A	0– 8.0A	0– 6.9A	0–5.8A	$289
LH 122	0–20VDC	0– 5.7A	0– 4.7A	0– 4.0A	0–3.3A	260
LH 125	0–40VDC	0– 3.0A	0– 2.7A	0– 2.3A	0–1.9A	269
LH 128	0–60VDC	0– 2.4A	0– 2.1A	0– 1.8A	0–1.5A	315
LH 131	0–120VDC	0– 1.2A	0– 0.9A	0– 0.8A	0–0.6A	320

[1] Current rating applies over entire voltage range.
[2] Prices are for non-metered models (except for models LK360FM thru LK362FM which are not available without meters). For metered models, add suffix (FM) and add $25 to price of LH models; add $30 to price of LK models.
[3] Overvoltage Protection: add suffix (OV) to model number and add $60 to the price of LH models; add $70 to price of half-rack LK models; add $90 to price of 5¼" full-rack LK models; add $120 to price of 7" full-rack LK models.
[4] Chassis Slides for full rack models: Add suffix (CS) to model number and add $60 to the price.

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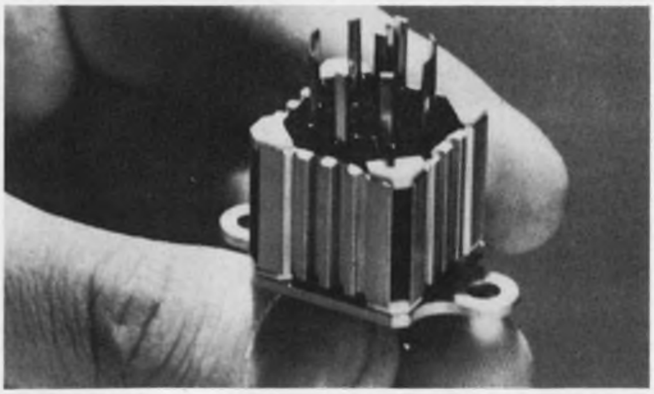
LA-182



2. Power circuits the size of components. The fully brazed, void-free package measures 0.5 cubic inch, weighs 0.75 ounce.

trical, and thermal functions are all performed by the isolators. They are made of beryllia, an excellent electrical insulator with a high thermal conductivity. They are metallized to permit soldering or brazing, if necessary. The thermal and mechanical connection of the terminator-dissipators to the base through the isolators provides a thermally connected, yet electrically isolated base-plate.

The base-plate itself serves three functions:

- It bridges the thermal path between terminator-dissipators, providing for heat passage to all points of the package.
- It forms a mechanical means for mounting the device to an external chassis or heat sink.
- It provides a thermal path for heat transfer to an external heat sink. This allows *full* ratings by conduction alone; extremely desirable in space environments.

The design approach parallels a road recently taken by small-signal monolithic ICs (see "Integrated circuits shed their wires," ED 4, Feb. 15, 1967, p. 17). Just as Bell Laboratories' "beam leads" serve as connectors and heat dissipators, Powercube's "terminator-dissipator-isolators" do the same and more. As a single monolithic assembly performs functions of termination, interconnection, thermal dissipation, environmental protection and circuit operation, so do the new modules. Every material used in the package serves more than one function.

All in all, this technique avoids all of the size, weight and thermal pitfalls which have kept large power circuits bulky. Prepackaged components having active elements much smaller than their finished volume are not used. Separate heat sinks and isolating hardware are not needed. Encapsulation is not used for environmental protection. Terminals serving only as terminals are unnecessary.

CIRCLE NO. 251

Alkaline 1.5-V battery has 20-year shelf life

Mallory Battery Co., S. Broadway, Tarrytown, N. Y. Phone: (914) 591-7000.

A new battery lasts indefinitely—0 years or more—until activated. It is a 1.5-volt alkaline battery easily activated by turning the top terminal cap which releases the liquid electrolyte contained in the battery's structure. Until activated, the battery remains inert and in stand-by condition indefinitely. The battery is manufactured in the D size.

CIRCLE NO. 253

Dc servomotors hit 1200 rpm in 1 ms

Honeywell, Inc., Precision Meter Div., Grenier Field, Manchester, N. H. Phone: (603) 625-6971.

Dc servomotors can reach 1200 rpm in 1 ms from dead stop. Acceleration of the 4.5-lb motor is 278,000 radians/s^2 initial at 2 V. Additional advantages for the 4-inch diameter motor are reported to be the 4200-rpm rated speed and 5.5-A rated current. Torque is 30 ounce-inches. The motor design eliminates all moving iron, leaving a moving-coil shell-type rotor configuration.

CIRCLE NO. 254

Cycle timers control over 100 circuits

Zenith Controls, Inc., 152 W. Walton St., Chicago. Phone: (312) 642-3322.

Multicircuit cycle timers which control 2 to 100 or more circuits operate through adjustable or specially coded cams. Each contact is an spdt snap-action switch rated 15 A, 250 V non-inductive, 350 W tungsten lamp load. Contacts rated at 1000 watts and models offering individually mounted switches are available.

CIRCLE NO. 255

Resistor networks accurate to 0.0005%

Julie Research Labs., Inc., 211 W. 61 St., New York. Phone: (212) 245-2727. P&A: $20 to $200; 1 to 3 wks.

Resistor networks for PC board plug-in cover a range from 10 Ω to 1 MΩ and offer standards lab accuracies. The networks are available in all accuracies ranging from 0.0005% to 0.1% absolute and ±0.0002% to ±0.1% ratio. Stability is ±0.0015% per year absolute and ±0.0002% ratio. The oil-filled units are enclosed in hermetically sealed metal cases which provide electrostatic shielding from environmental stress and change. Temperature coefficients from ±1 to ±5 ppm/°C are standard.

CIRCLE NO. 256

Four-quadrant multiplier spans dc to 10 MHz

Optical Electronics, Inc., P. O. Box 11140, Tucson, Ariz. Phone: (602) 624-3605. P&A: $484; stock.

Four-quadrant analog multiplication from dc to 10 MHz with a 1% full-scale linearity is achieved by this module. Applications include modulation, wideband video and pulse variable gain amplification, high-speed analog computation and data correlation. Features include 10-MΩ input impedance, 100-Ω output impedance and 40-dB useful dynamic range.

CIRCLE NO. 257

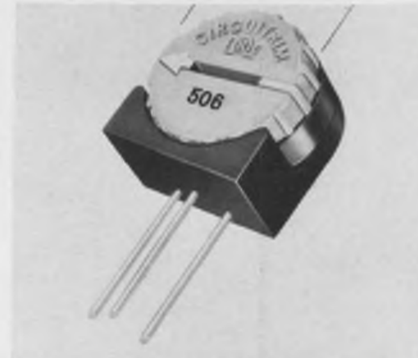
Capacitive transducer measures 3 psi

Lion Research Corp., 60 Bridge St., Newton, Mass. Phone: (617) 864-9313. P&A: $700 and $800; 2 wks.

Pressure transducers for laboratory and space applications are available for the pressure range of 0.05 to 3 psi full scale at an accuracy of better than ±1%. Series 200 is a stretched-diaphragm hysteresis-free design with capacitance sensing of diaphragm position. Power requirement is 1 W (24 ± 4 Vac) and signal output is 0 to 5 Vdc.

CIRCLE NO. 258

Round trimmer pot can mount vertically



IRC, Inc., 401 N. Broad St., Philadelphia. Phone: (215) 922-8900. P&A: $1.70 (500 lots); stock to 30 days.

A vertical mounting fixture transforms IRC's 0.5-inch round wirewound trimmer into a front or side-adjust unit. The resistance element of the single-turn unit offers high resolution over a full 310°. Weldable and solderable PC pins on a 0.1-inch grid are standard. Rated at 0.5 watt at 25°C, the units are available from 10 Ω to 50 kΩ.

CIRCLE NO. 266

Wideband transformers cover video frequencies

North Hills Electronics, Inc., Alexander Place, Glen Cove, N. Y. Phone: (516) 671-5700. P&A: $32.50 (100 lots); stock.

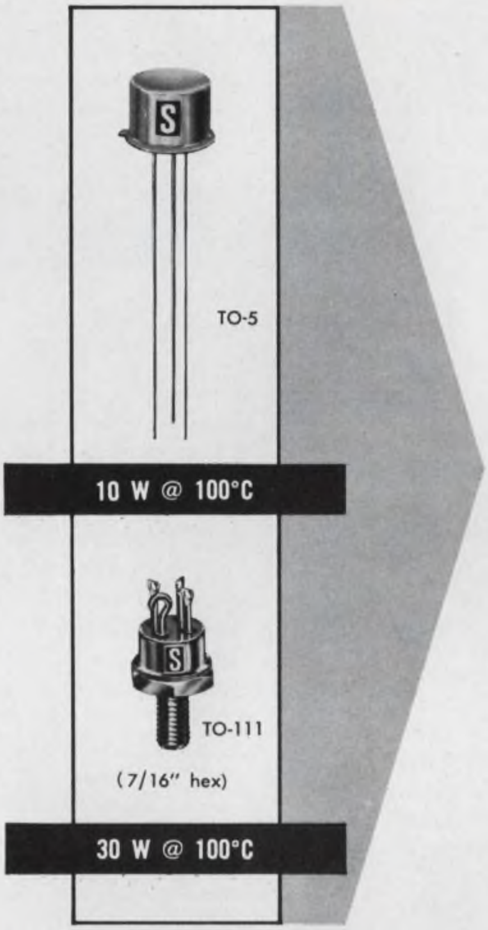
Wideband video frequency transformers for operation from 1 to 20 kHz are available in various impedance ratios. Two groups have primaries unbalanced with the first series having the secondary unbalanced. The second series have the secondary balanced and center tapped. The vswr over the band is generally less than 1.5.

CIRCLE NO. 267

10 Amp *in* ISOLATED Collector Packages

from

Solitron



Solitron's popular 10-amp NPN silicon power transistors are now available in Isolated packages. Designated the SDT 7470 and SDT 7B00 families, these devices offer high performance and reliability, plus small size! The TO-111 is the smallest stud package produced with 10-amp capability. All of the units feature low leakage currents, a uniform gain over wide current ranges and low saturation voltages. Typical characteristic curves are similar to the widely accepted 2N2811-14 Series. These isolated packaged devices may be utilized in many areas where the MHT 7400 Series and MHT 7000 Series are in use.

Type Number TO-111	Type Number TO-5	DESIGN LIMITS			PERFORMANCE SPECIFICATIONS					
		$V_{(BR)CBO}$	$V_{CEO(SUS)}$	$V_{(BR)EBO}$	h_{FE}		V_{CE} (sat)	V_{BE} (sat)	I_{CBO}	f_T
		Volts	Volts	Volts			Volts	Volts	μA	MHz
		$I_C = 10\,\mu A$	$I_C = 0.1A$	$I_E = 10\,\mu A$	$I_C = 5A$,	$V_{CE} = 5V$	$I_C = 5A$,	$I_B = 0.5A$	$V_{CB} = 60V$	
		Min.	Min.	Min.	Min.	Max.	Max.	Max.	Max.	Typ.
SDT 7B01	SDT 7471	80	60	5	40	120	0.6	1.5	1.0	50
SDT 7B02	SDT 7472	100	80	5	40	120	0.6	1.5	1.0	50
SDT 7B03	SDT 7473	120	100	5	40	120	0.6	1.5	1.0	50
SDT 7B04	SDT 7474	140	120	5	40	120	0.6	1.5	1.0	50
SDT 7B05	SDT 7475	80	60	5	20	—	0.6	1.5	1.0	50
SDT 7B06	SDT 7476	100	80	5	20	—	0.6	1.5	1.0	50
SDT 7B07	SDT 7477	120	100	5	20	—	0.6	1.5	1.0	50
SDT 7B08	SDT 7478	140	120	5	20	—	0.6	1.5	1.0	50

DIAL 1- 800-327-3243 FOR A NO CHARGE TELEPHONE CALL AND FURTHER INFORMATION

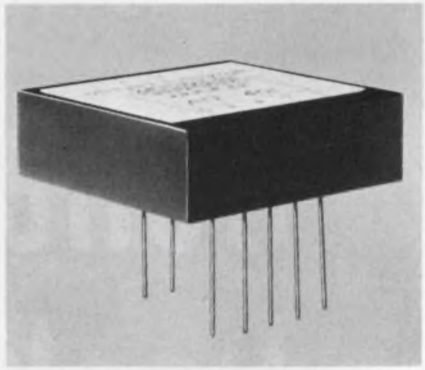
Solitron DEVICES, INC.

1177 BLUE HERON BLVD. / RIVIERA BEACH, FLORIDA / (305) 848-4311 / TWX: (510) 952-6676

Leader in Germanium and Silicon Transistors, Cryogenic Thermometers, High Voltage Rectifiers, Hot Carrier Diodes, Temperature Compensated Zeners, Voltage Variable Capacitors, Random/White Noise Components, Microelectronic Circuits, and Power-Sink Interconnection Systems.

ON READER-SERVICE CARD CIRCLE 65

Hybrid IC op-amps up gain, thermal specs



Amperex Electronic Corp., Semiconductor Div., Slatersville, R. I. Phone: (401) 762-9000. Price: $17, $19, $29 (100 lots).

Hybrid thin-film op-amps are designed with low-noise input stages, internal frequency compensation and good thermal characteristics. The ATF401 has open-loop gain of 100,000, temperature range of −25° to +85°C and noise voltage of 5 μV. The high-gain 402 has open-loop gain of 200,000 and gain-bandwidth product of 2 MHz. Maximum current drift is 1 nA/°C from −25° to +85°C. Initial offset and noise voltage are 5 μV. The 403 is rated with 2 nA/°C current drift from −55° to +125°C. Open-loop gain is 100,000, initial offset is 7.5 mV, gain-bandwidth product is 2 MHz and noise voltage is 5 μV.

CIRCLE NO. 268

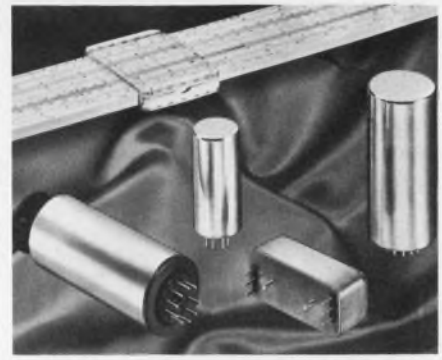
Tiny connectors operable at 500°F

Statham Instruments, Inc., 12401 W. Olympic Blvd., Los Angeles. Phone: (213) 272-0371.

A high-temperature electrical connector weighs 2 grams and is reportedly the smallest hermetically sealed connector available in 1-, 2-, 3- and 4-contact configurations. Body diameter is 0.29 inch with total mated height of less than 0.75 inch. The unit operates in ambients ranging from −100° to +500°F. It can withstand heavy thermal shock from the upper to lower extremes without damage or degradation in performance. Body and pins are made of stainless steel, and each contact pin is individually insulated.

CIRCLE NO. 269

FET switches handle microvolts



James Electronics, Inc., 4050 N. Rockwell St., Chicago. Phone: (312) 463-6500. P&A: $27.43 to $58.41; 6 to 8 wks.

Four double-throw, make-before-break FET switching systems are designed for microvolt-signal service as series shunt instrument choppers, half-wave modems, sampling switches or full-wave modulators. Each micromodulator incorporates a pair of balanced silicon FETs and a compensated magnetic drive system. The driving system operates from a 6.3-V sine or square wave source over a frequency range of 50 to 1000 Hz. The drive system isolates the units from normal transient noise signals and leakage present and permits the units to operate efficiently in the microvolt rather than the millivolt signal range.

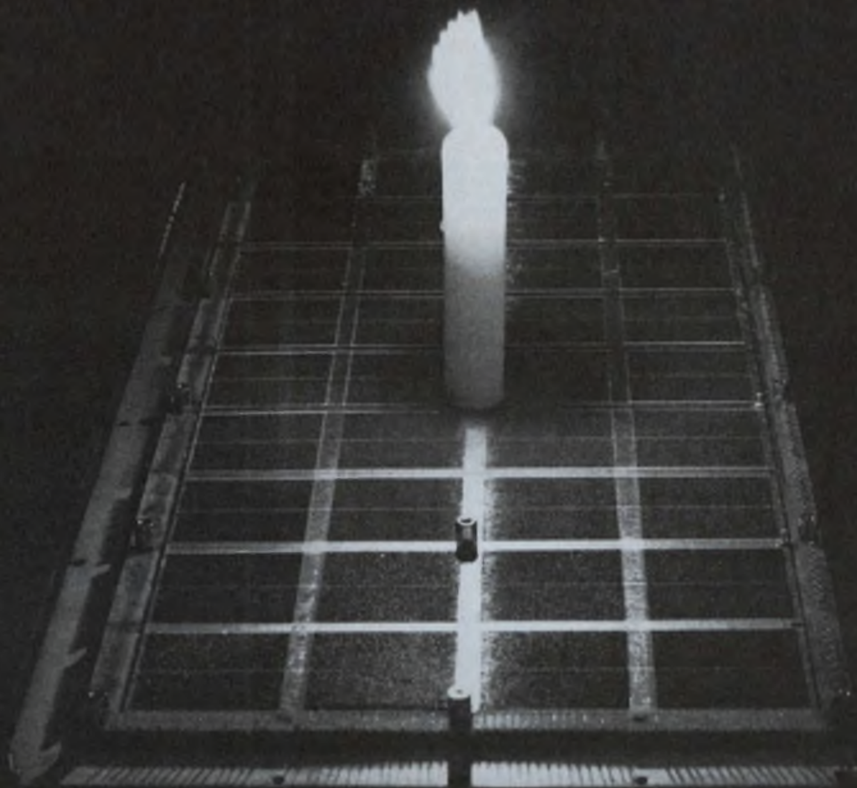
CIRCLE NO. 270

Dc calibration card remotely programable

SRC, 2311 Pontius Ave., Los Angeles. Phone: (213) 477-4573. P&A: $290; 4 wks.

A 6-level remotely programable dc voltage calibration card has application in the testing of amplifiers, VCOs, A-D converters and DVMs or for calibration and signal simulation in data acquisition, telemetry or automatic checkout systems. The dc output voltage may be programed to levels between 0 and 40 V by applying 24 Vdc to the rear connector. The first 5 levels are preselected resistors, and the voltage may be set by actuating the appropriate relay. The sixth level can be remotely programed.

CIRCLE NO. 271



in a memory system somewhere, one of our 2½ D stacks is celebrating its first birthday

After we shipped that one, we started delivering stacks at the rate of nearly one a day. Several hundred to date. Capacities ranged from 4,096 to 16,384 words of 8 to 25 bits. Cycle times went from 900 to 650 nanoseconds. Some were off-the-shelf designs, some slightly modified.

All had wide operating margins and low system noise.

But one of the most important specs was reliability. For example, internal stack connections were reduced by 80%. Drive lines were shortened, and the inhibit winding was eliminated. The result was unsurpassed stack dependability and increased operational speed.

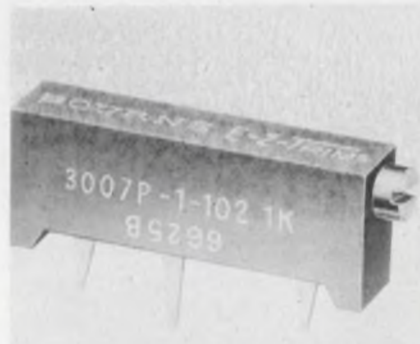
With a brand new design, that first birthday is very very significant. Infant mortality has plagued many an engineer. Now we're confident any one of our stacks could be around for a golden anniversary.

There's a new four-page brochure waiting to be requested. It has all the specs. Write for Litpak 2C.

electronic memories

12621 Chadron Ave., Hawthorne, Calif. 90250, (213) 772-5201

Tiny wirewounds priced under $1

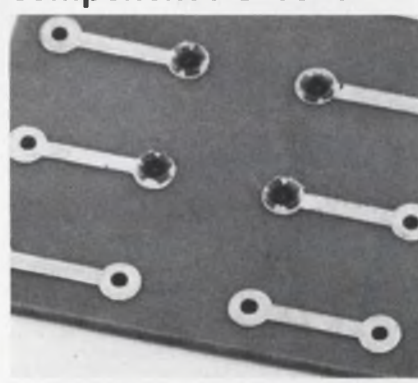


Bourns, Inc., Trimpot Div., 1200 Columbia Ave., Riverside, Calif. Phone: (714) 684-1700. P&A: 99¢ (1000 lots); stock to 3 wks.

Priced at 99¢, this wirewound adjustment pot is available in standard resistances of 10 Ω to 20 kΩ. Power rating is 1 watt at 40°C and operating temperature range is −55° to +125°C. Resistance tolerance is ±10%. The unit has a 20-turn screwdriver adjustment and a self-locking adjustment screw.

CIRCLE NO. 272

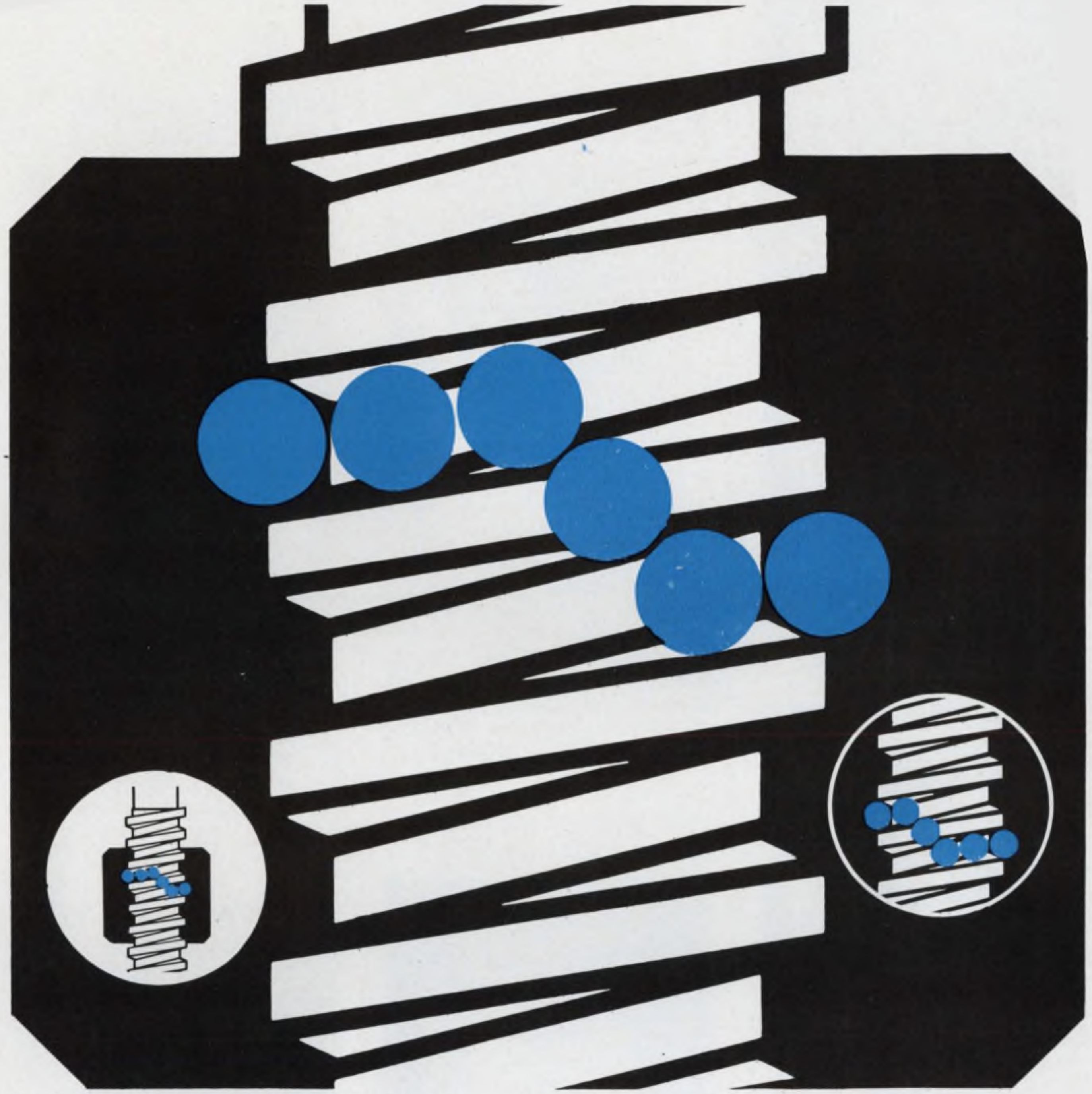
Gripping terminal aids component-PC bond



Berg Electronics, Inc., New Cumberland, Pa. Phone: (717) 938-6711.

Aimed at solving the problem of making reliable joints between circuitry and components mounted in holes on a PC board, this terminal has a gripping feature for mounting leads and components to the board. The Griplet holds leads and hook-up wires securely with "starfish" fingers which permit a standoff if needed. High-reliability solder joints are reported because of metal-to-metal contact between leads and PC conductors.

CIRCLE NO. 273



Kidde Ballscrews

SIZE AND WEIGHT PROBLEM SOLVERS

Kidde Ballscrews do more than solve friction problems of prime movers and drives. They can solve size and weight problems, too—and meet the demands for high efficiency transfer of motion and power. Here's why:

Their compact design results in smaller envelope dimensions. Weight is reduced because external tubes and fittings are eliminated. Kidde designs allow optimum usable power. due to extremely high efficiencies.

To solve these major problems, Kidde has designed a wide range of Ballscrew sizes—from units less than 1" long to 32 foot custom assemblies. From 6" diameters down to 1/8"; sizes 3/16" to 1-1/2" (with various lead) are stocked.

Learn how Kidde Ballscrews can become your problem solver. Write for your free copy of "Standard and Precision Ballscrews." Walter Kidde & Company Inc., 675 Main Street, Belleville, New Jersey 07109.

Kidde

ON READER-SERVICE CARD CIRCLE 127

Line drive amplifier gains 1 to 1000

Bulova Watch Co., Inc., 61-20 Woodside Ave., Woodside, N. Y. Phone: (212) 335-6000. P&A: $175; 8 to 10 wks.

This line drive amplifier has continuously adjustable gain from 1 to 1000 and a frequency response within ±1 dB from 3 Hz to 15 kHz. Input impedance is 500 MΩ. The amplifier operates on a 28-V ±15%, 40-mA supply. Linearity is within 1% and noise is less than 25 μV.

CIRCLE NO. 274

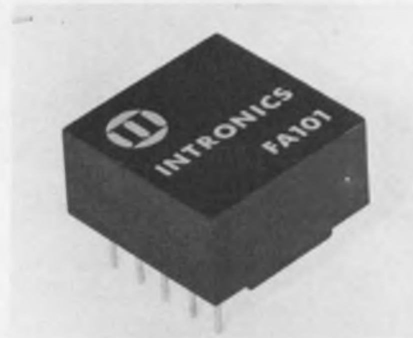
Sine wave modulator phase shifts under 1°

Natel Engineering Co., 7129 Gerald Ave., Van Nuys, Calif. Phone: (213) 782-4161.

A "true," sine wave modulator with less than 1° phase shift from 300 Hz to 5 kHz doesn't use a filter to provide the sine wave output. Null stability is ±2 mV rms from −55° to +71°C. The unit provides a linear rms ac output voltage as a function of dc input. The phase of the ac output is determined by the polarity of the applied dc. Input signal is from 0 to ±100 Vdc and output is from 3.5 to 30 V rms.

CIRCLE NO. 275

Unity gain amplifier has FET input



Intronics, Inc., Chapel Bridge Park, 57 Chapel St., Newton, Mass. Phone: (617) 332-7350. P&A: under $80; stock to 4 wks.

With a FET input stage, this dc-to-200-kHz unity gain amplifier features an input impedance of 10^{10} Ω. Output impedance is 10 mΩ. The module is designed for noninverting unity gain impedance transformation applications. Specifications include 50-pA maximum input offset current, ±10-V, 5-mA output and linearity better than 0.005%. Applications include signal buffering and instrumentation read in and read out.

CIRCLE NO. 276

Multipole transfer switch stacks up small

Pala Switch Co., P. O. Box 2234, Orange, Calif.

A multipole transfer switch for transistor circuitry requires only 0.36 in² of panel space. The new switch is a 10-pole double-throw type. Insulators are diallyl phthalate, blades are beryllium copper, contacts are coin silver and the exterior housing is brass. Current carrying capacity is 2 A resistive at 28 Vdc or 115 Vac.

CIRCLE NO. 277

TAPE WOUND BOBBIN CORES

Standard Cores of 4-79 Mo-Permalloy and Deltamax on Ceramic or Stainless Steel Bobbins . . .

engineered for use in sophisticated data processing systems, high frequency magnetic amplifiers, static inverters, timing circuits, shift registers, ring counters, pulse transformers and as static magnetic memory elements. All tapes are rolled on a beta-ray controlled Sendzimir mill in standard gages of 1, ½, ¼ and ⅛ mil and slit to standard widths of 0.031, 0.0625, 0.125 and 0.250. Cores are wound on semi-automatic machines, then annealed at extremely high temperatures in specially designed dry hydrogen atmosphere furnaces to obtain the final magnetic properties. Arnold maintains complete control over all phases of fabrication. Melting, processing, rolling and slitting of raw materials (nickel iron) to winding annealing and final test are all "in-plant" functions.

Write for Catalog TC-108B.

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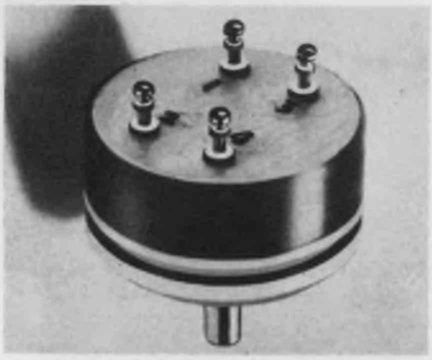
SPECIALISTS In MAGNETIC MATERIALS

THE ARNOLD ENGINEERING COMPANY, Main Office MARENGO, ILL.
BRANCH OFFICES and REPRESENTATIVES in PRINCIPAL CITIES

ON READER-SERVICE CARD CIRCLE 129

Conductive plastic pot linear to 0.05%

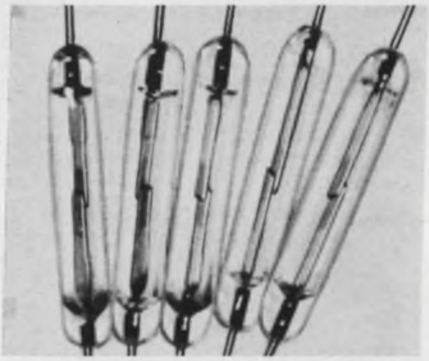


E.W. Bliss Co., Gamewell Div., 1238 Chestnut St., Newton, Mass. Phone: (617) 244-1240.

Linear conductive plastic pots offer highly accurate linearity characteristics: 0.05% absolute linearity in the centers of the operational range, tapering to 0.15% absolute linearity in the end regions. A typical unit has a resistance range of 100 Ω to 20 kΩ ±10%. Power rating is 1.3 watts at 25°C.

CIRCLE NO. 278

Tiny magnetic reed switches 1 kVdc



Hamlin, Inc., Lake & Grove St., Lake Mills, Wis. Phone: (414) 648-2361.

Miniature high-voltage magnetic reed switches are for use in instruments such as oscilloscopes and digital voltmeters requiring switching of low-power, high-voltage circuits. The switch has a uniform glass diameter of 0.125 inch, glass length of 0.805 inch and an over-all length (including leads) of 2.25 inches. Maximum switching voltage rating is 1000 Vdc with maximum breakdown at 2000 Vdc. Maximum current rating is 1 mA and contact resistance is 0.1 Ω.

CIRCLE NO. 279

Hot-carrier diodes useful to X-band

Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000. P&A: $32.40 to $99 (10 to 99); stock.

A series of hot-carrier diodes are packaged to permit use in circuits operating at frequencies up to and including X-band. The 2511 diode is in a miniature, hermetically sealed, metal-ceramic package for stripline and coaxial mixer or detector designs. Package inductance and capacitance are 0.35 nH and 0.21 pF. In conventional mixer applications, the SSB noise figure is less than 6 dB at a carrier frequency of 3 GHz (LO power of 1 mW). The diode can withstand 15 ergs, and peak power dissipation (1-μs pulses with 1% duty factor) is 4 watts. Cw power dissipation is 200 mW. The 2700 series diodes are in a symmetrical, ceramic package useful in waveguide, stripline and coaxial systems. The cylindrical package measures less than 0.06 inch in diameter and 0.05 inch in height. Package inductance and capacitance, typically 0.3 nH and 0.13 pF, make the series diodes useful in broadband mixer and detector applications at frequencies both above and below X-band.

CIRCLE NO. 280

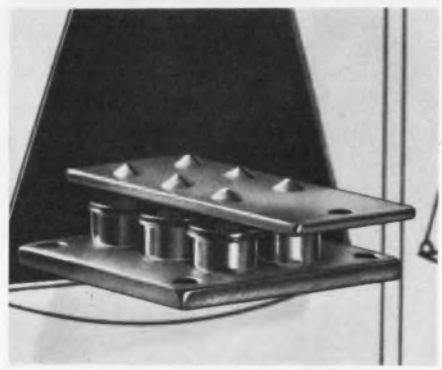
Dual-gate MOSFETs up vhf performance

RCA, Electronic Components and Devices, Harrison, N. J. Phone: (201) 485-3900. Price: $2.50 (vhf TV rf amplifier), $2.25 uhf TV mixer), $2.00 (fm, rf amplifier), $1.75 (fm mixer), $1.50 (color demodulator).

Five new dual insulated-gate MOSFETs are designed for television and a-m and fm receiver entertainment products. They reportedly offer improvement in cross-modulation performance, substantially reduce oscillator radiation through the antenna, and feature as much as 60 dB of agc control utilizing the second gate of a single rf stage. The cross-modulation performance improves as agc causes the device to approach cutoff, with essentially no power being consumed for agc control by the second gate. The devices are n-channel, depletion-type, silicon dual insulated gate MOSFETs. With the exception of the demodulator, they are designed to provide improved performance in the vhf range. They feature low gate leakage currents, feedback capacitances in the order of 0.02 pF, transadmittance of 10,000 μmhos at a drain current of 7 mA and a square-law transfer characteristic.

CIRCLE NO. 281

Devices suppress 12-kW transients

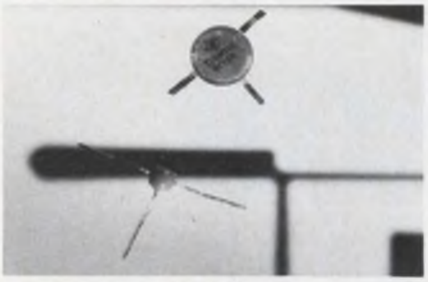


Motorola Semiconductor Products, Inc., P. O. Box 955, Phoenix. Phone: (602) 273-6900. P&A: $30 (100-up); stock.

Solid-state transient suppressors are capable of protecting against power surges up to 12 kW. The devices use matched Zener diodes and are designed to be used individually in dc systems or as back-to-back pairs for applications up to 117 Vac. The suppressors have predictable temperature sensitivity and maintain their breakdown voltage levels relatively constant over an operating range of $-65°$ to $175°C$. Ringing is nonexistent and the large quiescent currents encountered with voltage-dependent resistors are reduced to 50 μA.

CIRCLE NO. 282

Ge planars have 4-dB NF at 2.25 GHz



Texas Instruments, Inc., 13500 N. Central Expressway, Dallas. Phone: (214) 238-3741. P&A: $250 (1 to 99); stock.

Low-noise, high-gain germanium planar transistors have a usable frequency range of 1 to 4 GHz. Designed for use in the 2.25-GHz telemetry band, the devices exhibit a typical noise figure of 4 dB (4.5 dB max) at 2.25 GHz. Typical f_T of the device is 2.6 GHz. The transistors are the TIXM105 in a common-emitter-configuration package for stripline applications, and the TIXM106 in a modified pellet-pack for thick or thin-film hybrid IC applications. Standard impedance is 50 Ω at both input and output leads. Applications include L- and S-band radar preamplifiers, phased-array radars, L- and S-band telemetry, and ECM gear requiring octave-bandwidth amplifiers.

CIRCLE NO. 283

Silicon alloy diodes switch up to 50 W

TRW Semiconductors, 14520 Aviation Blvd., Lawndale, Calif. Phone: (213) 477-6061. P&A: $2.50 (1000 up); stock.

Silicon alloy rf switching diodes provide up to 50-W switching capability at 250 MHz with 800-V breakdown. Maximum forward resistance at 100 mA is 0.7 Ω. Three configurations of the DO-14 package are offered. Type PSV-100L has wire leads, type PSV-100J has a miniature fuse-pin cathode end and wire-lead anode end and type PSV-100D has the miniature fuse-pin on both ends. The diodes are for use in low and medium-power switching, duplexing, phase-shifting and other rf applications now using mechanical coax relays.

CIRCLE NO. 284

Diff-amp transistors in matched pairs

Solitron Devices, Inc., 1177 Blue Heron Blvd., Riviera Beach, Fla. Phone: (305) 848-4311.

Npn and pnp differential amplifier dual transistors are mounted in a six-lead TO-78 or TO-71 package. Since the chips are mounted on the same header, H_{FE} is matched to 0.9, V_{BE} is matched to 3 and 5 mV and V_{BE} tracking is matched to 10 μV/°C. Typical characteristics include h_{FE} of 175 at 10 μA, I_{CBO} of less than 1 nA at 45 V and noise figure of 2 dB at 10 μA.

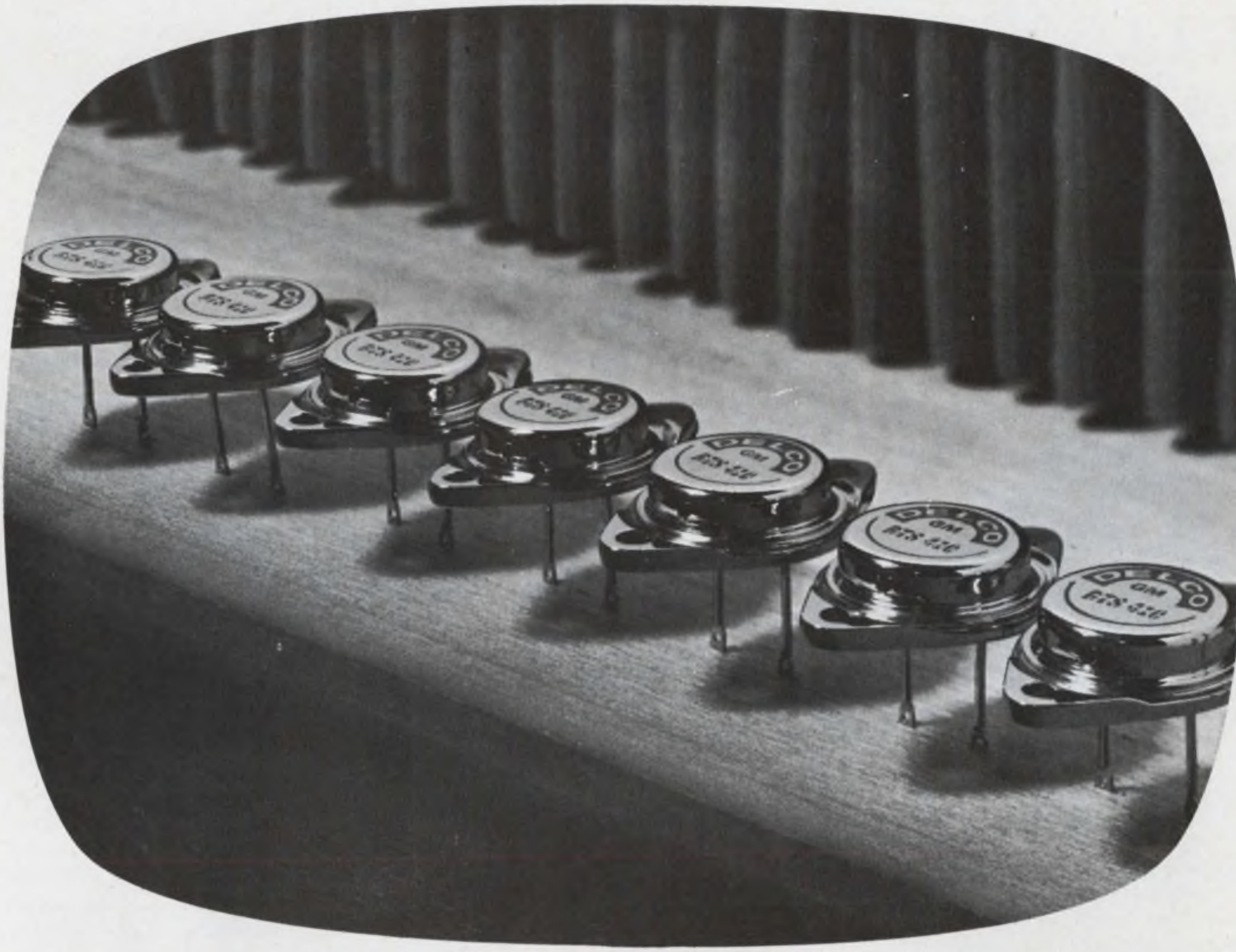
CIRCLE NO. 285

Planar power transistors rated 15 and 20 A

Bendix Corp., Semiconductor Div., Holmdel, N. J. Phone: (201) 946-9400. P&A: $20.50 to $35.50 (100 to 999); stock.

Six 15 and 20-A silicon planar power transistors, the B-148000 series, are designed for high-power nanosecond-switching and amplifier applications. Packaged to the JEDEC TO-61 outline with collector connected to case, the transistors feature V_{CES} from 80 to 120 V and V_{CEO} from 60 to 100 V. $V_{CE\,(SAT)}$ is 1 V at 1 and 10 A.

CIRCLE NO. 286



You should see us in living color

Our transistors have carved quite a career in the entertainment world.

First, in our car radios. (We produce all GM car radios and the power transistors for them.)

Then, in television. (We originated the power sweep transistor—for both horizontal and vertical—which helped to make big screen transistorized TV possible and practical.) Several major TV manufacturers are using them.

Today, we have the experience and the capability to supply these transistors in the volume you need for large scale TV set production. For black-and-white or color.

We welcome your order.

DELCO RADIO Division of General Motors
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Kokomo, Indiana • Phone (317) 459-2175

GM
MARK OF EXCELLENCE

ON READER-SERVICE CARD CIRCLE 133

Ac/dc converter widens dynamic and frequency ranges

Pacific Measurements, Inc., 900 Industrial Ave., Palo Alto, Calif. Phone: (415) 328-0300. P&A: $900; 30 days.

Clever FET switching circuitry has widened the application areas and improved the performance of a new ac-to-dc converter. Key specifications include:

- 70-dB dynamic range
- 10-Hz-to-5-MHz response
- 300-μV sensitivity

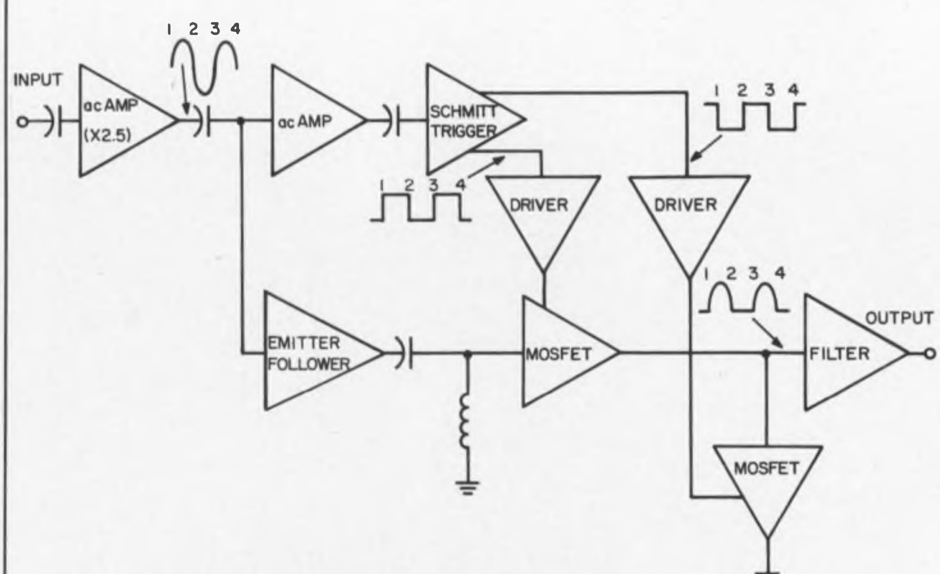
A FET series-shunt electronic switch is the key to the unit's operation. It affords switching at the precise instant of zero crossing of the ac input signal.

A sample of the incoming signal is applied to a high-gain amplifier driving a Schmitt trigger. The output of the Schmitt trigger drives a square-wave generator, which in turn drives the electronic switch. Two outputs, exactly 180° out of phase with each other are provided by the square-wave generator: one to drive the shunt switch, the other to drive the series switch. The series switch passes one-half of the ac cycle, and the shunt switch provides a precise ground clamp during the other half-cycle. Thus the output of the switch is a half-wave rectified signal precisely clamped to ground. This signal is filtered, and the resulting dc voltage is exactly proportional to the magnitude of the input ac signal. Linearity is 1%.

The dynamic signal range, 300 mV rms to 1 volt rms, is not limited in any way by a rectifying semiconductor junction, nor is the speed of response limited by any peak holding capacitor.

The output voltage is unrestricted by any need to operate a rectifier in the current mode, rather than the voltage mode. The linearity does not depend on a large available signal to overcome the nonlinearities of a rectifying junction; the dynamic range is restricted only by noise and mixer unbalance at the low end, and by semiconductor device breakdown at the high end. The speed of response is determined by the capabilities of an output low-pass filter, which rejects signal frequency.

CIRCLE NO. 252



A zero-voltage FET series-shunt switch rectifies incoming ac. A sample of the input ac is amplified to drive the Schmitt trigger, which, in turn, drives the square wave generator. The generator has two outputs: one drives the shunt switch, the other the series switch.

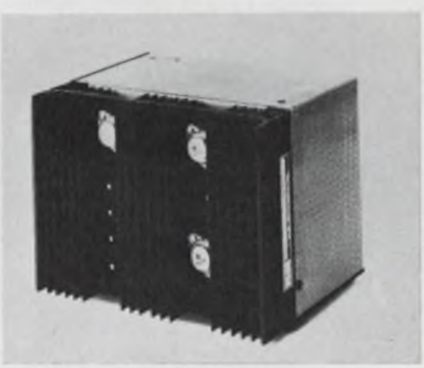
Dc voltmeter offers 10-μV null sensitivity

Precision Standards Corp., 911 Westminster Ave., Alhambra, Calif. Phone: (213) 289-2453.

Featuring 100-μV null sensitivity, this voltmeter has ranges of $\pm$1100 V, $\pm$110 V, $\pm$11 V, 1100 mV and 110 mV. With rated accuracy of $\pm$(0.005% of input +0.0002% of range +5 μV), the instrument features a 6-digit in-line readout with lighted decimal and incorporates a temperature-controlled Zener reference unaffected by shock, vibration or wide temperature excursions.

CIRCLE NO. 287

Dc supply modules rated to 410 V



ACDC Electronics, 2979 N. Ontario St., Burbank, Calif. Phone: (213) 849-2414.

Higher-voltage dc power supply modules, including units to 410 V, extend the company's line from 0 V, 0.1 A to 410 V, 0.6 A. Voltage regulation of 0.01% is provided in the BX series and 0.5% in the BC series. All of the modules feature plug-in PC board construction, automatic overload and short-circuit protection, remote sensing and remote voltage adjustment.

CIRCLE NO. 288

Power sweep generator puts out 100 W

Solar Electronics Co., 901 N. Highland Ave., Hollywood, Calif. Phone: (213) 462-0806.

This power sweep generator produces triangular, square and sine waves at 100-watt levels with selectable sweep rates or manual control for use in performing audio susceptibility tests. It is useful in making transient studies of passive networks, square wave testing of amplifier systems and as a source of 400-Hz or other power frequencies. Frequency range is 15 Hz to 150 kHz. Sweep rates are one per minute, ten per minute or manual dial. The output is adjustable up to 100 watts into a 2-Ω load.

CIRCLE NO. 289

Portable static inverter delivers up to 295 VA

Topaz, Inc., 3802 Houston St., San Diego, Calif. Phone: (714) 297-4815.

Designed for mobile operation of instrument plotters and recording oscillographs, this inverter operates from 12 or 24-Vdc batteries and offers selectable outputs of either 115 or 230 Vac. Output power is 295 VA continuous and 375 VA intermittent. Overload capability of 50% allows the unit to handle normal startup requirements for both the oscillograph drive motor and the recording lamp.

CIRCLE NO. 290

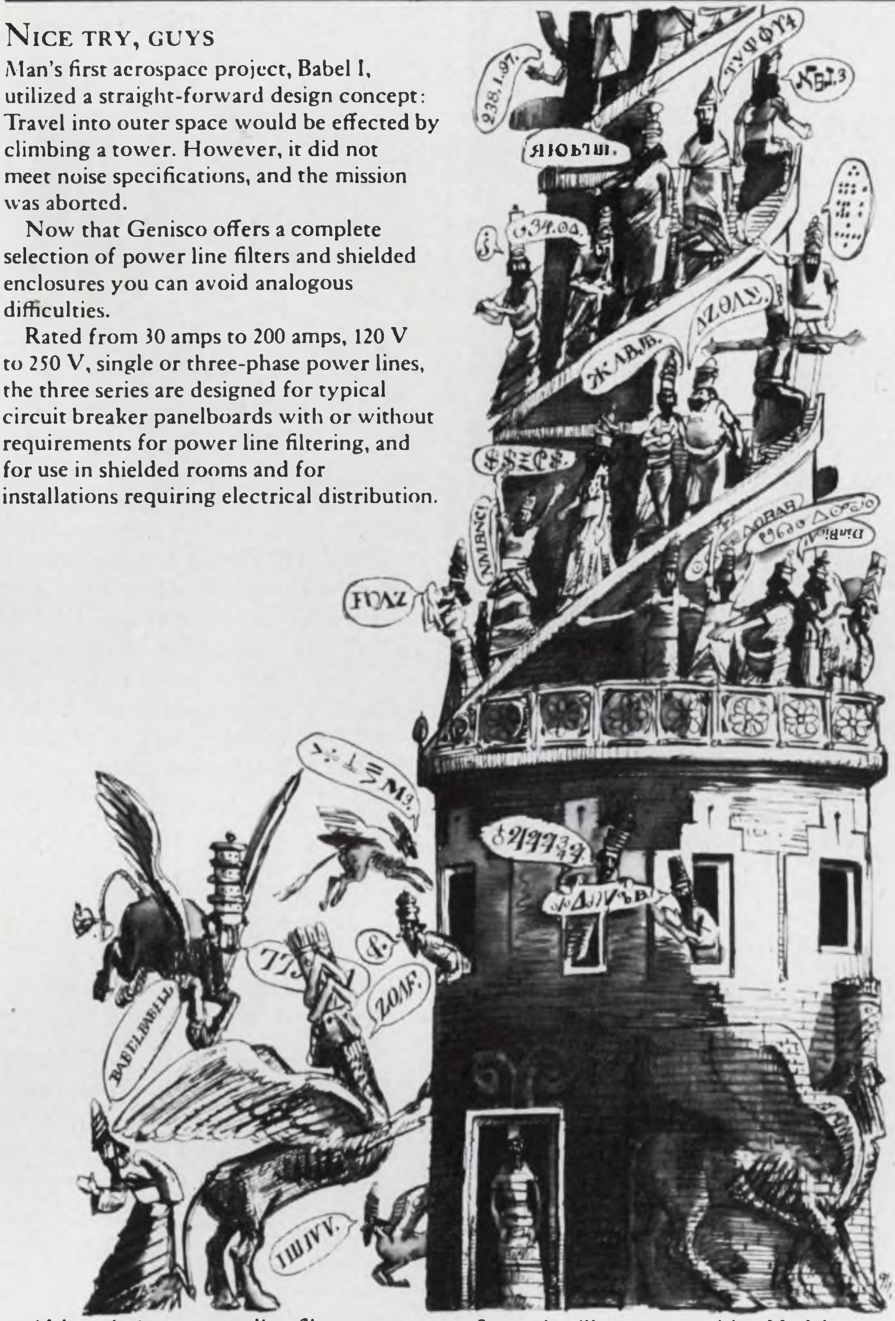
Chapter VI. The Word from GENISCO.

Nice try, guys

Man's first aerospace project, Babel I, utilized a straight-forward design concept: Travel into outer space would be effected by climbing a tower. However, it did not meet noise specifications, and the mission was aborted.

Now that Genisco offers a complete selection of power line filters and shielded enclosures you can avoid analogous difficulties.

Rated from 30 amps to 200 amps, 120 V to 250 V, single or three-phase power lines, the three series are designed for typical circuit breaker panelboards with or without requirements for power line filtering, and for use in shielded rooms and for installations requiring electrical distribution.



Although these power line filter assemblies meet MIL-F-15733, we do not recommend their use in towers extending beyond terrestrial limits. This application is not approved by The Chief Design Engineer.

ON READER-SERVICE CARD CIRCLE 121

Didja hear the one about the bi-planar NAB 14" reels?

Seems like there's this Model 10-276 magnetic tape recorder for aircraft, shipboard, or field portable use. Now, it has this low inertia capstan drive motor, and 6 speed selectable servo to eliminate belts, pulleys, and like that. And get this: no pinch rollers and solenoids to create flutter and skew! Well, these Genisco guys are making a mint on the thing, but they figure they'll come out with a Model 10-286 with 14" instead of 8.5" reels for customers who need longer record time! Then they go and stack the reels in a bi-planar configuration to save space. The funny thing is it works great. Not much of a story maybe, but they sure are nice tape recorders.

ON READER-SERVICE CARD CIRCLE 122

Earn Big $$$$ as a Telemetry Person!!!

Now you can learn telemetry in the privacy of your own home! Take this free aptitude test NOW!

1. (T) (F) A telemeter is what they put on the back of the TV to find out what you watch.

2. (T) (F) A telemetering checkout station is where you sign out for a telemetering.

Congratulations! You've just won our free correspondence course! Naturally you'll now want a Model A-180 or A-186 completely portable ground station. The A-180 completely de-multiplexes any standard FM/FM Signal. Ideal for checkout of airborne or sledborne applications. The A-186 has fourteen stunning channels. Its receiver is continuously tunable over the 215MC to 260MC band. So get on the road to success! Buy some of our telemetry stuff.

ON READER-SERVICE CARD CIRCLE 123

Wheep! Wheep! Wheep!

As your missile speeds downrange you are secure in the knowledge that its electro-explosive device can be armed only by the precise signal you alone can send.

Or, horror of horrors, by an unfiltered random burst of identical frequency and duration.

As perspiration beads your brow you feel a sudden fondness for Genisco, renowned experts in RF hazard testing. How nice of them, you think, to have in stock or to design just the filters for the RFI and EMI protection my firing circuits need.

By golly, you conclude, next one of their ads I see I think I'll just

ON READER-SERVICE CARD CIRCLE 124

It just keeps rollin', keeps on rollin' around.

Going round and round is our new Model 1147 rate-of-turn table's main trick. It keeps at it no matter how much you abuse it.

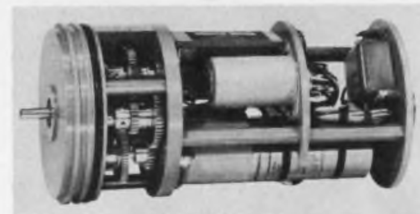
Hydrostatic bearings give precise dimensional stability, excellent alignment, low runout and eccentricity, low mechanical noise, and long happy life. It rotates smoothly at less than sidereal rates (0.004°/sec.). And it's just as smooth up to 1500°/sec. Which is why particularly brilliant (and handsome) engineers picked it as the AGE gyro test table for the F-111 Aircraft System.

Great for the lab or just to tote around de field.

ON READER-SERVICE CARD CIRCLE 125

GENISCO TECHNOLOGY CORPORATION
18435 SUSANA ROAD
COMPTON, CALIFORNIA 90221

Servo device positions, actuates loads



Control Technology Co., Inc., 41-16 29 St., Long Island City, N. Y. Phone: (212) 361-2133.

This "plug-in" servo device positions and actuates a variety of loads as part of an automatic control system. The 0.18-inch diameter output shaft is positioned in response to a dc command signal applied to the unit. Torque produced is 250 inch-ounces and the following speed is 36°/s. Accuracy of positioning is 0.1%. The unit contains a servo motor-generator, clutch-protected multiturn feedback pot, silicon transistor amplifier and gearing.

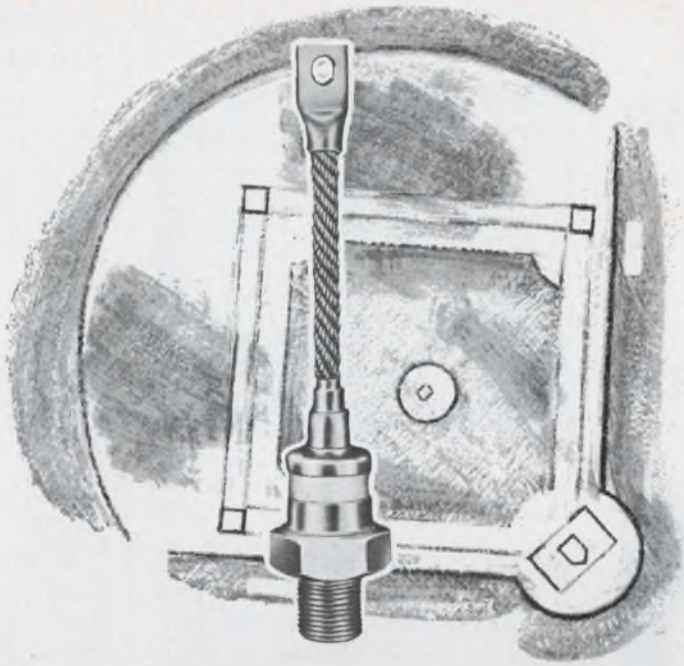
CIRCLE NO. 291

Optical pot is high-speed sweeper

Industrial Control Co., Central Ave. at Pinelawn, Farmingdale, N. Y. Phone: (516) 694-3000. P&A: $150; 4 to 6 wks.

This high-speed potentiometer and sweep or function generator generates a voltage proportional to shaft angle over one revolution by means of a simple optical assembly. Conventional brush or contact noise is absent from dc to the top rotating shaft speed of 12,000 rpm or 200 Hz. The shaft rotates a glass drum around a light source. A mask on the drum surface modulates the light flux, which falls on a photocell and develops a voltage. The mask pattern sets the voltage-shaft-angle relationship. Output waveshape is independent of shaft speed, and contains no noise components. Standard linearity is 5%. By changing the mask pattern, the unit becomes a function generator, developing a step or sine function or any waveshape that can be translated into proper mask geometry. Also, several outputs from a single device are possible. Housing is a size 15 synchro assembly.

CIRCLE NO. 292



Covers All Bases

IT'S ALL FOUR BASES FOR THE LEAGUE LEADING SCORER IN AVALANCHE DIODES

First Base: $L\frac{di}{dt}$ transient protection

Second Base: Exact control of individual junction parameters

Third Base: To 1,600 PRV

Home: Savings in space and costs. (We have enough left over to circle 'em a couple more times—send the coupon!)

Send catalog data about Syntron avalanche diodes 283

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Company__________

Street__________

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SYNTRON COMPANY

283 LEXINGTON AVE. • HOMER CITY, PA. 15748
TELEPHONE 412—479-8011
Sales Representatives Coast-to-Coast

67R12

ON READER-SERVICE CARD CIRCLE 138

Delay 5-V pulses for 3 s to 50 ns

MCG Electronics, 11-22 Joselson Ave., Bay Shore, N. Y. Phone: (516) 586-5125.

A 2-to-5-V input pulse is delayed from 50 ns to 3 μs by this unit with a delay resolution of less than 1 ns. The delay is calibrated at 100-ns intervals and the fine delay control can be locked to hold any delay. The output pulse is +2.5 V into 250 Ω with rise and fall times of approximately 15 ns. The delayed output exhibits a time delay variation of less than 50 ns at the 3-μs setting from 25° to 75°C.

CIRCLE NO. 293

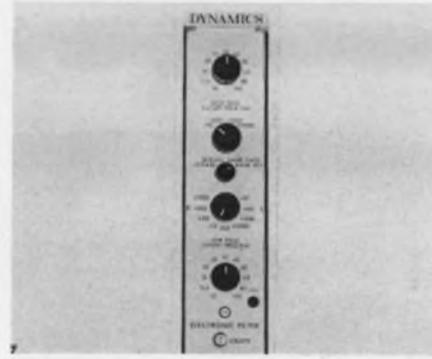
PCM modules use MOS-FETs, DTL logic

Ralph M. Parsons Electronic Co., 151 S. DeLacey Ave., Pasadena, Calif. Phone: (213) 681-0461.

Complete modular PCM systems or individual functional modules are available allowing adaptation to changing data requirements or original system design. DTL integrated circuitry is utilized for all digital circuitry and MOS-FET monolithic arrays are utilized for multiplexing analog signals. Total system sampling rates range up to 50,000/second and bit rates to 500 kHz are available.

CIRCLE NO. 294

Variable filter offers 6th order Butterworth



Dynamics Instrumentation Co., 583 Monterey Pass Rd., Monterey Park, Calif. Phone: (213) 283-7773.

A variable electronic filter offers a sixth-order Butterworth characteristic for high and low-pass band edges. Two frequency ranges are available: 1 Hz to 10 kHz and 100 Hz to 1 MHz. Low-pass or high-pass filtering can be independently switched out. Terminal slope on each skirt is 36 dB per octave. Cutoff frequencies can be selected over four decades.

CIRCLE NO. 295

Triggered pulsers put out kiloamps

Pek, Inc., 825 E. Evelyn Ave., Sunnyvale, Calif. Phone: (408) 245-4111. P&A: $885 to $995; 2 to 4 wks.

Pulse generators incorporating trigger transformers are designed for lab use or applications as flash lamp trigger units, spark gap trigger sources and high-power strobe supplies. The line includes three models offering long-term rms current ratings of 20, 30 and 60 A. Peak secondary ratings are 10, 14 and 12 kiloamperes.

CIRCLE NO. 296

PAM/PDM conditioner computer controllable

Electro-Mechanical Research, Inc., Box 3041, Sarasota, Fla. Phone: (813) 958-0811.

Designed to prepare time-multiplex telemetry signals for computer entry, this unit can accomplish signal conditioning of both pulse amplitude modulation (PAM) and pulse duration modulation (PDM) signals. Signal conditioning may be performed manually or under complete computer control. The unit recovers time-multiplexed serial PAM or PDM pulse trains in the presence of noise, automatically generates pulse and frame synchronization, and converts each incoming data sample to a 12-bit parallel word.

CIRCLE NO. 297

In-line wattmeter spans 30 kHz to 2 MHz

Bayly Engineering Ltd., Hunt St., Ajax, Ontario, Canada. Phone: (416) 942-1020.

This in-line wattmeter reads forward and reflected power in 50- and 75-Ω coaxial systems over a frequency range of 30 kHz to 2 MHz. Two instruments are available with power ranges of 1.5, 15 and 30 watts and 50, 100 and 250 watts. Directivity of the couplers is 25 dB. Connectors are N or UHF female.

CIRCLE NO. 298

DCL®

DESIGNER'S CHOICE LOGIC

Signetics puts IC systems design decisions back in the hands of the systems designer.

Some IC families put severe limits on the decisions the systems designer can make. He's often held back by the speed, power, and noise immunity trade-offs built into the family by the IC manufacturer. Now Signetics Designer's Choice Logic changes all that. Signetics DCL® Series 8000 includes high speed TTL circuits, slower low power TTL circuits that offer high AC noise immunity, and low power DTL circuits that provide high DC noise margins. The series also includes large functional arrays for counting and storage applications. All elements in the 8000-Series are specified compatibly. And we've got a 46-page data handbook — the most complete one of its kind ever offered — to guide you in using these flexible circuits. In designing with DCL® you can optimize your system performance without drawn-out calculations, expensive and time-consuming ground-plane designs, or extensive use of outboard discrete components. The handbook provides special sections directed to systems, evaluation and design engineers. Find out fast what can be done with our DCL® series, and how to loosen constraints on your designs. Write Signetics for your DCL® handbook: 811 East Arques, Sunnyvale, California 94086.

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INTERNATIONAL SALES: France, Germany, Italy, Belgium, Holland, Luxemburg, Spain — **Sovcor Electronique, 11,** Chemin de Ronde, Le Vesinet, (S.-&-O.) France. United Kingdom, Ireland, Sweden, Denmark, Norway, Switzerland, Austria, Portugal — **Electrosil Ltd.,** Lakeside Estate, Colnbrook-By-Pass Slough, Buckinghamshire, Great Britain. Australia — **Corning,** 1202 Plaza Building, Australia Square, Sydney, N.S.W. 27-4318. Canada — **Corning Glass Works of Canada, Ltd.,** Leaside Plant, Ontario, Canada (416) 421-150. Israel—**Optronix,** P.O. Box 195, Ramat-Gan, Israel 724-437. Japan—**ASAHI Glass Co., Ltd.,** Corning Products Sales Dept. No. 2, 3-Chome Marunouchi, Chiyoda-ku, Tokyo, Japan.

ON READER-SERVICE CARD CIRCLE 143

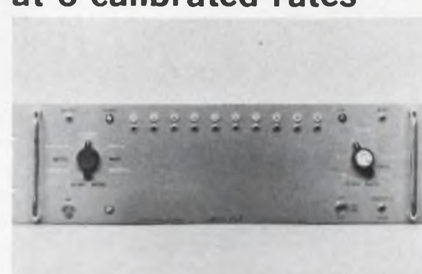
Dc microvolt-ammeter battery-operated

Millivac Instruments, Inc., 2818 Curry Rd. Ext., Schenectady, N. Y. Phone: (518) 355-8300. P&A: $695, $625 (ac only); 4 to 6 wks.

A dc microvolt-ammeter can be operated on either 115/230 Vac or on its own self-contained rechargeable NiCad batteries. Measuring ranges are from 10 μV to 1 kV and from 10 pA to 10 mA. Basic accuracy on voltage is 1% and on current 2%. The input can be isolated from ground.

CIRCLE NO. 299

Multichannel scanning at 6 calibrated rates



Astro Lab, 9371 Kramer Ave., Westminster, Calif. Phone: (714) 839-0741. P&A: from $500; stock to 8 wks.

For automatic multipoint test and recording systems, this scanner contains all necessary control functions, including a trigger generator. Automatic sequential scanning is possible at calibrated rates of 60, 10, 1, 0.1, 0.01 and 0.002 seconds per step with a vernier control provided. Channel switching is optional with a choice of 1, 2 or 3-pole single-throw NO isolated reed relay contacts. The basic unit is available with 10, 20, 30, 40 or 50 channels in a 5-1/4-by-19-inch rack panel.

CIRCLE NO. 311

Ac/dc multimeter is four-in-one

Honeywell, Inc., 4800 E. Dry Creek Rd., Denver, Colo. Phone: (303) 771-4700. P&A: $1350; 30 to 60 days.

Designed to meet ac and dc measuring requirements, this multimeter also can be used as a voltage reference source, a ratiometer, a decade voltage divider and a null detector. Both rms and dc voltages can be measured up to 1100 V in four ranges, and ac/dc ratios using external reference voltages up to ±100 V. Full-scale measurement ranges for both modes are given at 1, 10, 100 and 1000 V with 10% overranging for each range. The frequency range extends from 20 Hz to 20 kHz. Three basic elements make up the units. These are a Zener-regulated, ±11-V reference supply, an electronic null detector and a 6-decade Kelvin-Varley voltage divider with numerical readout.

CIRCLE NO. 312

High line rejection in μ V-ammeter

Keithley Instruments, Inc., 28775 Aurora Rd., Cleveland. Phone: (216) 248-0400. Price: $825.

Line frequency rejection of 75 dB over full scale for a 2% change in meter reading is featured in this 14-range microvolt-ammeter. The 3-μV-to-1-V instrument also offers 180-dB common-mode rejection, 5-nV rms input noise, 2-nV resolution and 1- to -100-MΩ input resistance. The 14 current ranges run from 3 x 10^{-10} to 10^{-3} A full-scale. Because of the high line frequency rejection, low noise and high common-mode rejection, the unit can be used as a microvoltmeter or null detector. The line rejection also allows the unit to detect dc signals in the presence of large ac voltages.

CIRCLE NO. 313

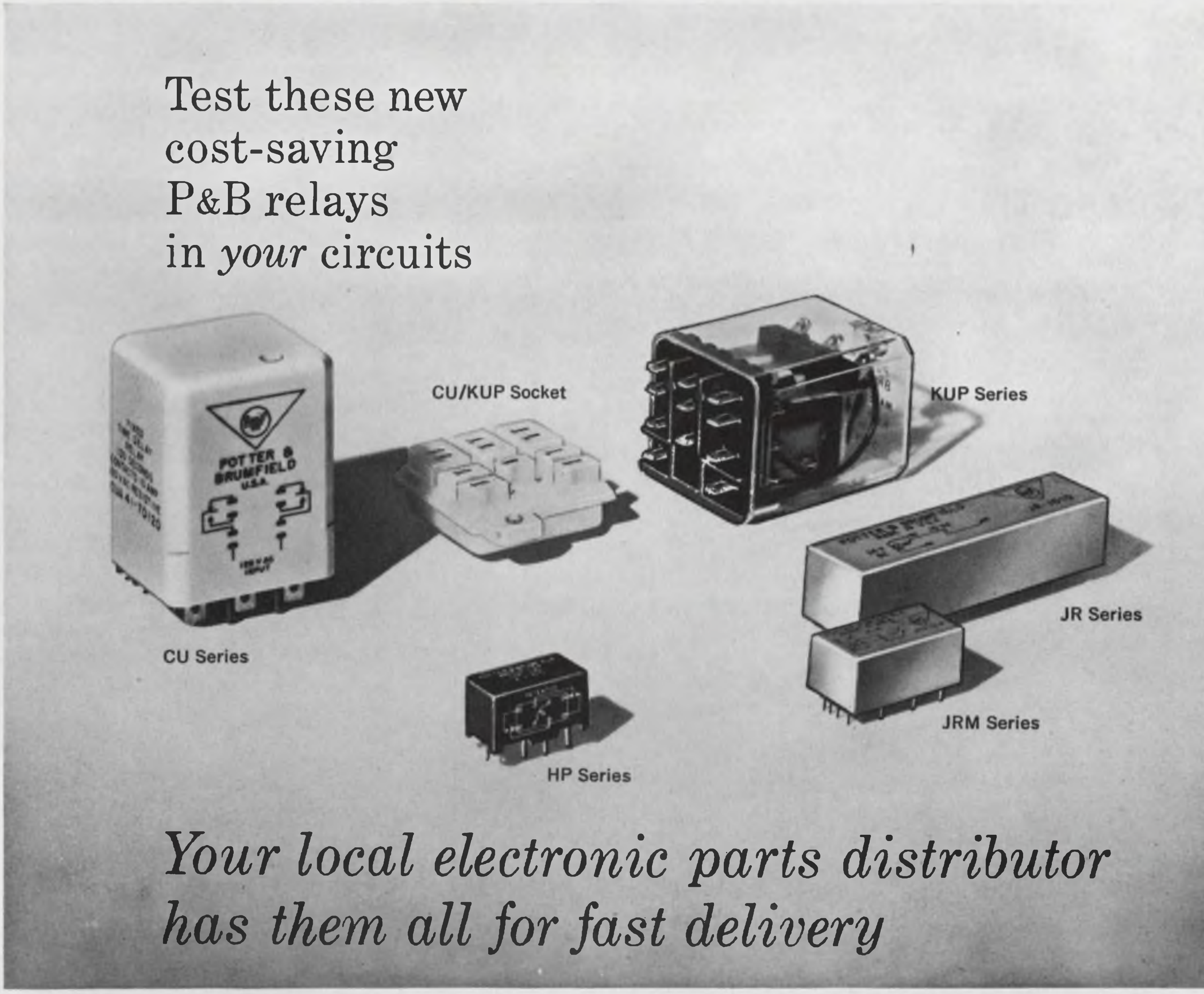
Compact IC counters count at 10 MHz

Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000. P&A: $350 (4-digit), $425 (5-digit), $475 (6-digit); stock.

Integrated circuit counters have a maximum counting rate of 10 MHz in a case one-third of a standard 19-inch rack in width. The counters have a 4-digit readout (5 and 6 are optional) using miniature side-viewing Nixies. The readout retains the most recent count until a new count is completed, for a continuous, non-blinking display.

Frequency and rate measurements are made with either of two count times: 0.1 and 1 s. The time between counts is adjustable between 50 ms and 5 s by a front-panel control, or a count may be retained indefinitely with the control in a hold position. Input impedance is 1 MΩ shunted by 30 pF. Input sensitivity is 0.1 V rms between 5 Hz and 10 MHz. An internal control allows either positive or negative pulses to be counted. The time base is derived from the power line, typically accurate within 0.1%.

CIRCLE NO. 314



RELIABLE SOLID STATE TIME DELAY RELAY FOR ONLY $12.50

This new solid state time delay relay (CU Series) could be the biggest $12.50 relay value you've ever seen. Timing tolerance is ±5%. Internal DPDT relay is rated at 10 amperes. Fixed timing ranges: 10 and 120 seconds. Resistor adjustable ranges are 1 to 10 and 1 to 120 seconds.

Both AC and DC models are available. Standard .187″ quick-connect terminals are pierced for solder connections. A special socket permits plug-in convenience.

FOR LOW COST, HIGH DENSITY PACKAGING

High density relay packaging becomes a reality with the low profile, 1/5 cubic inch HP Series. Height above terminals is only 0.49″. Mechanical life is 10 million operations minimum.

The DPDT contacts are rated from low level to 2 amperes at 30V DC resistive or 0.5 ampere maximum at 120V AC. Coil voltages range from 6V to 48V DC . . . with 12- and 24-volt models standard.

COST-SAVINGS UP TO $2.40 PER PLUG-IN RELAY

This versatile KUP relay can be a cost-saving answer to your plug-in relay problem. Save up to $2.40 each over similar relays with octal-type plugs. Get greater reliability, too. Relay has quick connect/solder terminals. Nylon socket (sold separately) rated for 10 amperes. One to three poles. Cover is heat and shock resistant Lexan. For DC or AC operation.

REED RELAYS MAY REPLACE EXPENSIVE SOLID STATE DEVICES

For applications where fast operate time, low power, high sensitivity, compact size and long life are required.

Both JR standard size and JRM miniature reed relays are available in assemblies of 1 to 4 switches. In a standard range of coil voltages and various combinations of Forms A, B and C contact arrangements.

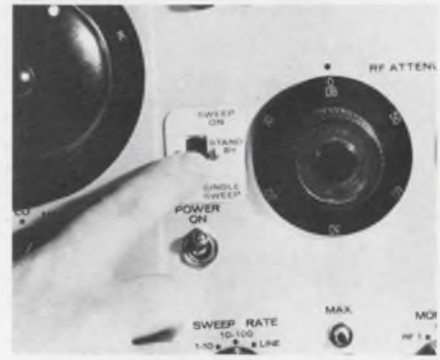
These and 62 other basic relays are listed in Stock Catalog 100. Ask your distributor for your copy.

POTTER & BRUMFIELD

Division of American Machine & Foundry Co., Princeton, Ind. 47570
Export: AMF International, 261 Madison Ave., New York, N.Y. 10016

ON READER-SERVICE CARD CIRCLE 147

Sweepers adapted for X-Y recording



Telonic Instruments, 60 N. First Ave., Beech Grove, Ind. Phone: (317) 787-3231. P&A: $75; stock.

An accessory switching circuit enables a sweep generator to scan a single trace. The use of the single-sweep accessory allows recording the output of the sweep generator on an X-Y recorder or a photographic film. Consisting of a 3-position switch circuit and a BNC output jack, the unit is designed for use with the Telonic SM-2000.

CIRCLE NO. 315

Low-cost log amps centered at 60 MHz

RHG Electronics Lab., Inc., 94 Milbar Blvd., Farmingdale, N. Y. Phone: (516) 694-3100. P&A: $325; stock to 30 days.

Logarithmic amplifiers priced at approximately one-half of comparable units use PC construction. The units have a broadband untuned design and selective input filter to establish the operating frequency. Improved transient response is provided by a turn-off technique in the summing stages. Log accuracy is ±2 dB, center frequency is 30 and 60 MHz, bandwidth is 2, 4 or 10 MHz and dynamic range is 60 dB.

CIRCLE NO. 316

circuit problems?

Signalite Glow Lamps have solved problems in these areas:

• Voltage Regulation & References • Photo-Cell Drivers • SCR Triggering • Timing • Photo Choppers • Oscillators • Indicator Lights • Counters • Voltage Dividers • Surge Protectors • Logic Circuits • Flip-Flops • Memory • Switching • Digital Readouts

Signalite glow lamps combine long life, close tolerance and economy, and are manufactured with a broad range of characteristics to meet individual application requirements. For a creative approach to your design problem . . . contact Signalite's Application Engineering Department.

VOLTAGE REGULATORS BETTER THAN 1% ACCURACY These subminiature voltage regulators are used in regulated power supplies, as reference sources, photomultiplier regulators, oscilloscope calibrators, etc. They are available in voltages from 82 to 143 V. They are used in multiples as regulators in KV ranges.

SEE Signalite Application News Vol. 3 No. 2 for TYPICAL APPLICATIONS.

NEON LAMPS WITH TRANSISTORS The A079 is recommended as an indicator light for transistor circuits, transistorized flip-flops, and other general low voltage operations. The advantages result from the low current and low voltage requirements, the absence of heat generated and extremely long life.

SEE Signalite Application News Vol. 2 No. 5 for TYPICAL APPLICATIONS.

SIGNALITE APPLICATION NEWS

is used to communicate new and proven techniques and applications of Signalite's neon lamps and gas discharge tubes. Signalite Application News provides a forum for an exchange of ideas to keep the design engineer aware of the versatility of neon lamps and their many applications. Copies are available from your Signalite representative or by contacting Signalite.

Reader Service No. 193

TRIGGER LAMPS FOR OPERATION OF SCR'S AND TRIACS The A057B lamp is recommended for use as a triggering device for both SCR'S and TRIACS in motor speed controls and light dimmer circuits. Its properties of stable operation and high current capabilities qualify it for this application.

See Signalite Application News Vol. 2 No. 4 for TYPICAL APPLICATIONS.

MEMORY SWITCHES Neon lamps have proven to be an excellent memory switch since they store information and provide visual indication. The properties of neon lamps provide a large differential between breakdown and maintaining voltages, stable electrical characteristics and high "off" resistance (20,000 meg ohms). Other applications include switching, information storage, timing circuitry, etc.

SEE Signalite Application News Vol. 4 No. 3 for TYPICAL APPLICATIONS.

Signalite

INCORPORATED
NEPTUNE, NEW JERSEY 07753
(201) 775-2490

SUBSIDARY OF GENERAL INSTRUMENT

ON READER-SERVICE CARD CIRCLE 194

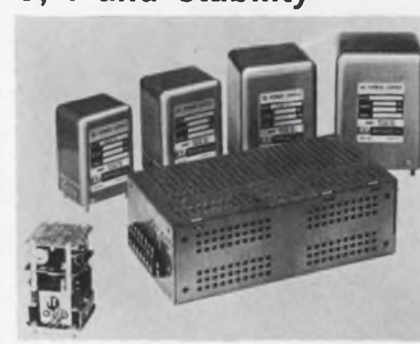
Dual dc supplies track to 6 V

Cal-power Corp., 140 Kansas St., El Segundo, Calif. Phone: (213) 322-5320.

Dual-output, regulated dc power supplies provide outputs of +29 V at 6 A and −29 V at 3 A. Designed for 150-G shock application, the supply operates from a 115-Vac, 400-Hz, 3-phase input and provides ±0.05% regulation with ripple less than 10 mV rms. Tracking of the outputs maintains a maximum differential voltage of 6 V including turn-on or a short circuit.

CIRCLE NO. 317

Dc supplies up in V, I and stability

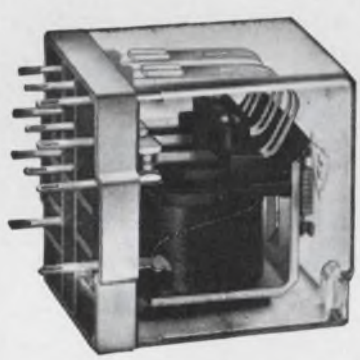


Dynage, Inc., 390 Capitol Ave., Hartford, Conn. Phone: (203) 249-5654. P&A: $56 to $210; 72 hours.

Modular and rack power supplies are available with increased voltage and current ratings with high stability as an option. The series offers a selection of power supplies from 0.5 to 252 Vdc and 0.025 to 6.4 A. Stability runs to ±0.001% or ±120 μV/8 hrs short-term, and ±0.005% or ±600 μV/month long-term. Regulation for line and load combined is ±0.01% and temperature coefficient is ±0.001%/°C.

CIRCLE NO. 318

why should you buy a relay that promises less?



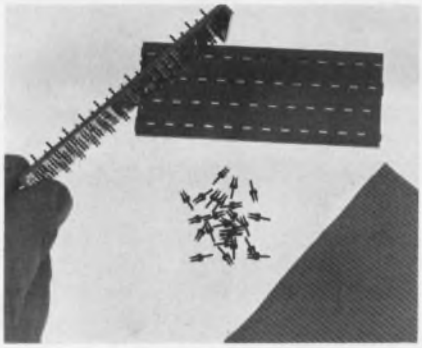
Because this one—the Guardian 1220—promises less of the things you *don't* want. Like wasted space, breakdowns, and high cost. The 1220 is an extremely compact relay. It has a new "Uni-Guard" one-piece switch that eliminates many internal solder connections. The terminal panel is used as the male plug, dispensing with radio-type plug, extra wiring, and sub-assembly. This advanced design boosts dependability, because with fewer parts, there are fewer reasons for breakdown. The U.L. recognized, 10 amp. DPDT or 3PDT 1220 is tightly enclosed (so, no problems from dust or moisture), and it's available from stock. Price? Only $1.85 in quantities. Write today for our free Bulletin B4—it includes full technical specs, dimensions, mounting variations.

GUARDIAN ELECTRIC

1550 West Carroll Avenue, Chicago, Illinois 60607

ON READER-SERVICE CARD CIRCLE 152

Multiconductor flat cable easy to connect



3M Company, 2501 Hudson Rd., St. Paul. Phone: (612) 733-4962.

A systems approach to multiconductor flat cable construction is designed for low-voltage application. Heart of the system is the flat cable, used as a multiconductive constant-impedance jumper for back wiring and interconnection of peripheral equipment.

Depending on application requirements, the cable's design can be varied to match most required impedance characteristics, with wire spacing available down to 0.0125 inch. Wire gauges range from AWG #33 to #24 and can be mixed in a given cable web. Most film insulations are available. Maximum width is 12 inches with a minimum width of 0.04 inch.

With PVC insulation, the cable has a temperature rating of 80°C. Close tolerances are possible in balanced impedance systems from 50 to 300 Ω. "U-type" connecting elements are used throughout the system to make speedy connections. These elements are self-stripping, constant-pressure contacts. Contacts are made by forcing the element points through the cable's insulation, and driving the legs down over the conductor. A base member supports the conductor and cable, providing narrow clearance wells to channel the legs of the elements as they pass through the cable.

CIRCLE NO. 319

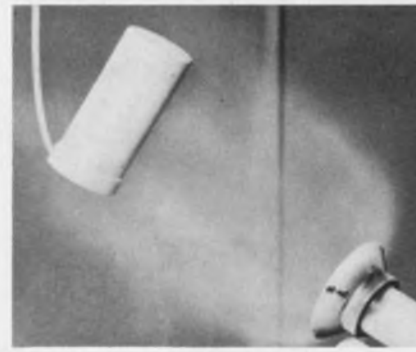
Weldless Dumet in continuous lengths

General Electric Co., Lamp Metals Dept., 21800 Tungsten Rd., Cleveland. Phone: (216) 266-2970.

A new type of Dumet wire is available in continuous lengths without welds in the standard Dumet sizes from 0.008 to 0.1 inch. Improvements result from a continuous production technique called dip forming, in which a small-diameter rod of nickel-iron alloy is passed through a bath of molten copper. A copper coating adheres to the rod as it leaves the bath and forms a sheath with a 100% metallurgical bond. The composite is then drawn to size. The process permits closer tolerances in the thickness of the copper coating, which comprises 22% of the wire by weight. Low-oxygen, high-purity copper is used for the sheath; the core is 42% nickel-iron.

CIRCLE NO. 320

Powdered epoxy resin applied electrostatically

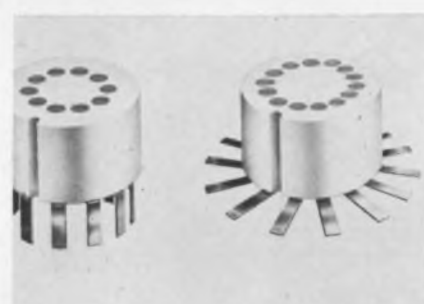


3M Company, St. Paul, Minn., Phone: (612) 733-4033. P&A: $1.79 to $3.40/lb; stock.

A powdered epoxy resin can be applied electrostatically to cold or heated parts and then heat-cured. The powder is specifically designed to accept an electrostatic charge. It may also be applied to heated parts by the conventional methods of fluid bed, spraying, vibrating bed or cascading. Curing may be accomplished at temperatures ranging from 300° to 450°F. Electrical strength is 500 V/mil, dielectric constant is 6.5 and dissipation factor is 0.028.

CIRCLE NO. 321

Sockets hold leads with 3-leaf contacts



Chemelec Products, Inc., 8 Fellowship Rd., Cherry Hill, N. J. Phone: (609) 424-1470.

TFE fluorocarbon sockets for mounting transistors and ICs on PC boards use a 3-leaf design for reliability. In each pin hole are three beryllium copper leaves that bow in toward the center. When a lead is inserted, the leaves deflect to let it slide in, but press against it to assure good contact. A built-in barb prevents accidental pull-out. Contact resistance is 0.01 Ω.

CIRCLE NO. 322

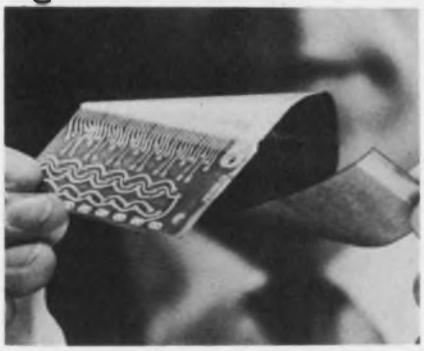
We produce the world's broadest line of tubes for electronic countermeasures.

They include CW magnetrons, TWT's, M-type BWO's, crossed-field amplifiers and BARRATRON® transmitting tubes. We make tubes for both active and passive applications — with versatility to match any system requirement. Come to Litton for your ECM tubes — you'll find we've got plenty to crow about. Electron Tube Division, 960 Industrial Road, San Carlos, California.

LITTON INDUSTRIES
ELECTRON TUBE DIVISION

ON READER-SERVICE CARD CIRCLE 157

'Hybrid' PC systems rigid and flexible



Rogers Corp., Rogers, Conn. Phone: (203) 774-9605.

"Hybrid" rigid-and-flexible printed circuits consist of a rigid laminate on which components can be mounted, combined with a flexible circuit, eliminating the need for external connections. Termination of the flexible lead-offs can be accomplished by all standard methods. A single hardboard connector with the rest of the circuit remaining flexible can be used for part of a system.

CIRCLE NO. 323

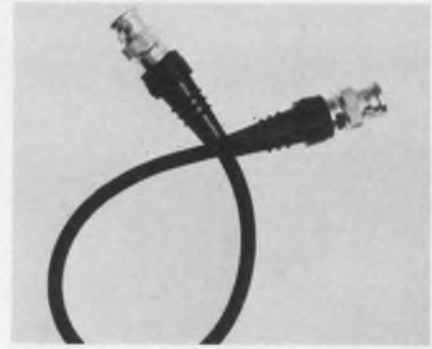
Panel fastener aids rapid assembly

Dzus Fastener Co., Inc., 425 Union Blvd., West Islip, N. Y. Phone: (516) 669-0494.

To facilitate quick and easy installation of various required lengths of console and rack panels, a panel fastener has been designed as a complete assembly for one-step mounting. It is made of cadmium-plated steel. All components are precision fitted into one assembled fastener and packaged for simple, single-motion handling by hand, power or automated installation.

CIRCLE NO. 324

Cable assemblies have low vswr



Stanford Applied Engineering, 340 Martin Ave., Santa Clara, Calif. Phone: (408) 243-9200.

These cable assemblies are designed for long life and good electrical characteristics. Vswr at 2.85 GHz is claimed to be as low as 1.01 to 1.04 within the mismatch range from 1 to 1.5%. A molded grip provides a safeguard against damage to the connector pin when making a quick disconnect. The assemblies are available in standard lengths and colors.

CIRCLE NO. 325

Production line IC testers: lightning strikes twice

Users of integrated circuits should find incoming inspection a lot quicker, easier and cheaper, thanks to two new instruments. For instant go-no go decisions on digital ICs, Teradyne, Inc. is offering its ACT I. For a bit more analysis, Redcor Corp. has the series 990. Both handle up to 16-pin devices, and, both are priced in the $5000 range.

ACT I bows

Teradyne, Inc., 183 Essex St., Boston. Phone: (617) 426-6560. Price: $4850 (basic), $100 to $500 (cards.)

Dubbed ACT I (Analogical Circuit Technique), Teradyne's new tester performs both functional tests and parameter measurements simultaneously. Operating features include:

- Voltage range of 0 to 8 Vdc.
- Current range of 0 to 50 mA.
- Over-all accuracy of 3 to 5%.

ACT I can do up to 10,000 parameter measurements in 1000 steps in 10 ms. Up to fifteen simultaneous analog measurements can be made at a 10-μs logical step.

Programing is done by two 5 x 6-inch cards; one covering all devices within a particular family and grade, the other the individual model. To further simplify programing, Teradyne offers a unique mail-order service: programed cards are available for most popular ICs, or blank cards are offered with instructions. A pair of DTL cards (Series 846) are included with the basic unit.

The instrument handles circuits comprising up to 10 inputs, up to four outputs, one supply and one ground lead in TO-5, dual-in-line and flat packs.

Testing is completely automatic. No switches, dials, matrices, cross-points, or start buttons exist. Test sequencing occurs continuously. When a circuit is inserted in the test, the reject lamp goes out if the device passes, stays on if it fails. Operators can test at about 400 circuits per hour. A bowl-fed automatic handler will increase the rate to over 7000 per hour. Causes of rejects are displayed on front-panel lamps. Any rejected circuit is stepped through each failed test as the lamps display input and output logical conditions and show whether defects occur at the input, output or supply.

The cards are programed to detect:

- Shorts, opens or one-way shorts.
- Invalid logical outputs, high or low.
- Unacceptable fan-in or out, threshold level and output voltage level.
- Excessive supply current.

CIRCLE NO. 326

Low-cost accuracy

Redcor Corp., 7800 Deering Ave., Canoga Park, Calif. Phone: (213) 348-5892. P&A: $4950, (taut-band meter), $900 extra (DVM); Aug.

Like Teradyne's, Redcor's tester can handle all digital ICs. With the same 0.1% power supply accuracy and regulation claimed for it as for $50,000 systems, the unit includes a pulse generator, constant voltage supplies, constant current supply, a swept constant voltage supply and resistive and capacitive loads.

Unlike the Teradyne tester, the 990 is programed manually with a combination of pushbuttons and digital dial settings.

Its features include:

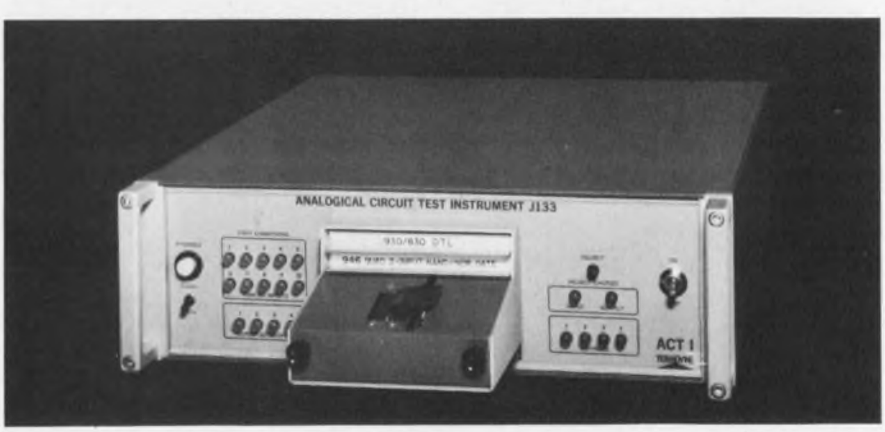
- A 0-to-100-V voltage range at any one of 4 selectable frequencies.
- A constant 100-mA supply.
- Power supply accuracy of 0.1% ±1 mV.

The 100-mA supplies can either sink or source current, thus maintaining regulation even when terminated through a resistance to a higher potential. With one of the constant voltage supplies used as the 0-to-100-V swept supply, frequencies of 0.5, 5, 50 or 500 Hz can be selected.

The pulse generator allows functional testing over a range of 1 Hz to 10 MHz. Redcor feels that this speed is sufficient for 95% of today's ICs. Pulse amplitude is continuously variable from 0 to 3 V on one range, 0 to 10 V on another. Repetition rates are selectable: 1, 10 or 100 Hz; 1, 10 or 100 kHz; or 1 or 10 MHz.

Selectable resistive loads vary in four decades from 10 Ω to 100 MΩ, capacitive loads in three decades.

CIRCLE NO. 327



A potent pair of testers. Teradyne (left) and Redcor units both handle up to 16-pin digital ICs. Both are priced just under $5000. Teradyne unit is programed with PC cards, Redcor's model uses a combination of pushbuttons and digital dial settings. Teradyne's ACT I gives an accept/reject decision; Redcor's unit, a direct readout.

PRODUCTION EQUIPMENT

Test transistors quickly from dc to rf

Kulicke & Soffa, 135 Commerce, Fort Washington, Pa. Phone: (215) 646-5800. P&A: $40,000 to $65,000; 120 days.

Series 2000 testers automatically handle and check transistors at rf frequencies up to 200 MHz, at a rate of 2000 transistors per hour. The unit performs a go/no-go test sequence of dc, pulsed dc, ac, and high-frequency tests. Parameters tested include I_E, H_{FE}, power gain matching, F_T, h_{FE}, $V_{CE\,(sat)}$ and $V_{BE\,(sat)}$. Fully automatic handling is provided for TO-3, TO-5, TO-18 and various plastic types.

CIRCLE NO. 328

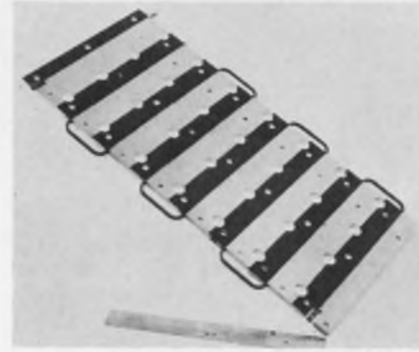
Adjustable assembly aids soldering

Siks Manufacturing, Inc., 501 E. 185 St., New York. Phone: (212) 892-8566. Price: $29.95.

An adjustable soldering and assembly aid adapts to a variety of connector shapes, pc boards, switches and terminal boards. The device can be varied to allow different types of electrical and mechanical assembly operations. It is adjustable in height and width. The tool also provides support for loose wires during assembly or soldering and it prevents wire holder damage.

CIRCLE NO. 329

Aluminum plates cool high-density gear



Lytron, Inc., 71 Pine St., Woburn, Mass. Phone: (617) 933-7300.

Precision cold plates for removing heat from high watt-density equipment are fabricated of aluminum with copper tubing. Typical specifications call for flatness within 0.0005 inches, including the dielectric segments. Dielectric strength of 300 to 500 MΩ at 500 Vdc is maintained and dielectric deposition is held to within 0.005 inches between segments.

CIRCLE NO. 330

Flat packs, dual-in-lines tested in carriers

Barnes Development Co., Lansdowne, Pa. Phone: (215) 622-1525. P&A: $2395; 4 to 6 wks.

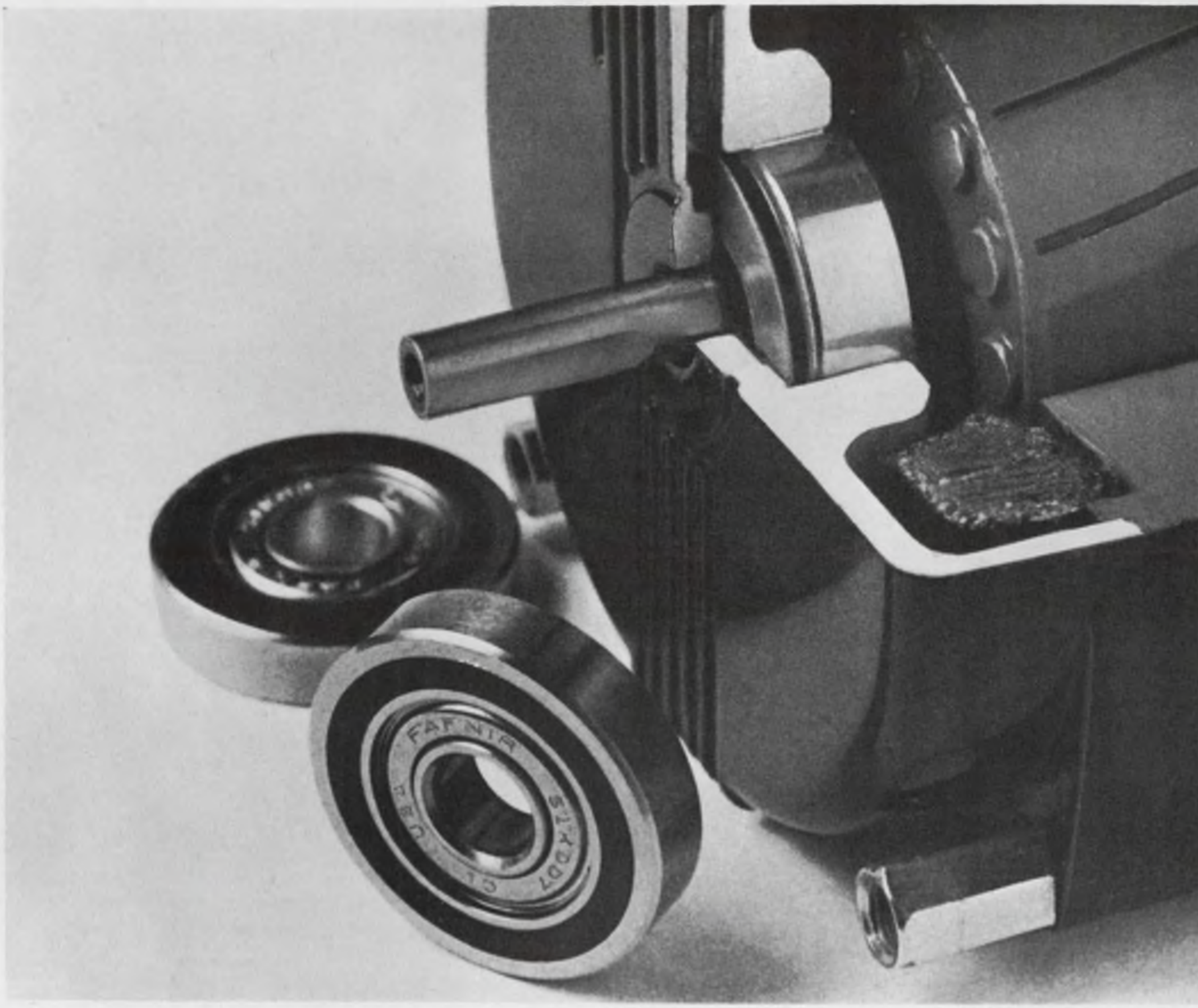
For high-speed testing, this test handler accepts flat-pack and dual-in-line ICs in carriers. Accepting carriers manually loaded or from magazines (up to 150 units per 20-inch magazine), the handler will accommodate flat-pack devices with up to 14 leads, in sizes ranging from 1/8 x 1/4 to 3/8 inch and standard 14 or 16-lead dual-in-line packages. Typical test rates are up to 6000 devices per hour.

CIRCLE NO. 331

Shhh!

Bodine has made a quiet motor... quieter

with noise-damped ball bearings... the next best thing to dead silence.



Bodine's K-2 fractional horsepower motor is now available with a special noise-damped ball bearing for equipment where extra-quiet operation is a must . . . equipment like medical instruments or sound recorders—where sound levels are especially critical.

Super-silent is the word for this new, noise-damped bearing. It's made with a unique combination of rubber and steel rings. A 1/16" thick rubber ring is bonded to the outside of the bearing—then a steel ring is bonded to the outside of the rubber ring. It is lubricated with low-torque-loss grease.

Result: What little sound there is in standard K-2 motors is reduced to a new low level.

Bodine K-2 motors and reducer motors are available from 1/2000 to 1/270 hp, synchronous or non-synchronous—and with spur or helical reduction gearing. Write for data sheet on this modification . . . and for bulletin S which describes over 275 stock types and sizes of Bodine motors—from 1/2000 to 1/6 hp.

Bodine Electric Company, 2528 West Bradley Place, Chicago, Illinois 60618.

Bodine motors wear out–it just takes longer

BODINE
fractional/horsepower
MOTORS
...the power behind the leading products

ON READER-SERVICE CARD CIRCLE 169

Second-generation IC op-amp: compensation in 30 puffs

National Semiconductor Corp., Microcircuits Div., 2950 San Ysidro Way, Santa Clara, Calif. Phone: (408) 245-4320. P&A: $40 (MIL), $8.80 (commercial), (100-up); stock.

Significant improvements over the industry-standard 709 monolithic operational amplifier have been made. National Semiconductor Corp., manufacturer of the new operational amplifier, reports the following advantages for its LM101 over the 709:

- Simplified frequency compensation (only a 30-pF capacitor is used).
- Wider (±5-to-±20-V) supply voltage range.
- Higher (80,000 to 200,000) open-loop gain.
- Halved power consumption.
- Doubled input impedance.

Worst-case specifications for the two units at 25°C ambient and a 15-volt supply voltage are compared in the table. The new unit is available in MIL (−55° to +125°C) or commercial (0° to 75°C) types.

One frequent objection to monolithic operational amplifiers is the complexity of the frequency-compensation networks. Often these external networks physically dwarf the amplifier and double the number of interconnections needed. The LM101 overcomes this. It needs only a single 30-pF capacitor and a feedback resistor. Collector load resistors have also been designed out, so that the input stage can be operated at low currents. The LM101 simplifies compensation circuitry since it is a 2-stage, rather than a 3-stage circuit. It develops its high gain by using current sources, rather than resistors, as collector loads. Substituting transistors for resistors removes limitations on operation at low current levels. Also, transistors occupy far less chip surface area than large-value resistors (the 45-by-45-mil LM101 chip is about 20% smaller than the 709). The circuit can then be compensated with the simple RC network. The location of the compensation network and the fact that the input stage is run at low currents account for the puny 30-pF compensation capacitor. The amplifier is stable for all feedback configurations, even capacitive loads.

The voltage-follower and the inverting amplifier shown below illustrate the simplicity of LM101 circuit designs. Even though fewer compensation components are used, the device has the same pin-for-pin configuration as the 709.

Other advantages are inherent in the new design. Unpredictable operation, which can occur with some amplifiers when they are driven outside their common-mode range, is eliminated. More controlled short-circuit protection is provided and the slewing rate has been improved.

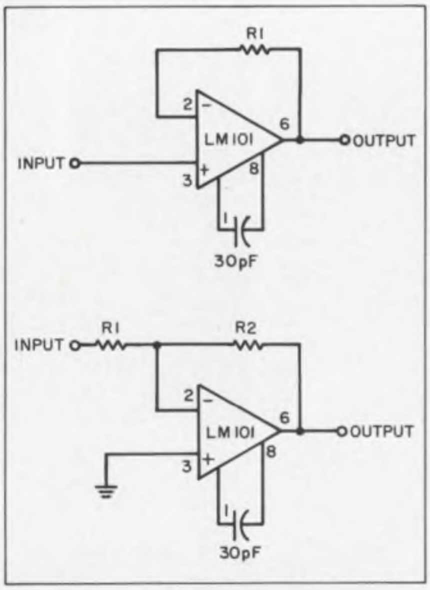
The ±30-V differential input voltage range along with the ability to clamp the output at any desired level makes the amplifier useful as a voltage comparator.

The class-B output—with continuous short-circuit protection—provides at least a ±10-V output swing with a 2-kΩ load. And, the ±30-V differential input range reduces the chance of burnout from overloads.

It is no mere chance that makes the LM101 a pin-for-pin replacement for the 709. The designer responsible for the LM101 has some background in linear ICs. In fact, it was Bob Widlar who evolved the 709, while with Fairchild Semiconductor two years ago.

What's next? Widlar might even put the capacitor right on the chip!

CIRCLE NO. 332



A resistor and 30-pF capacitor are all the compensation needed. Circuits are voltage-follower above and inverting amplifier below. R1 above is zero or equal to source resistance.

Worst-case LM101 and 709 specs compared

Specification	709	LM101
Input offset voltage	5 mV	same
Input offset current	200 nA	same
Input bias current	500 nA	same
Input impedance	150 kΩ	300 kΩ
Input common-mode range	±8 V	±12 V
Common-mode rejection	90 dB	same
Voltage gain	25,000	same
Output voltage swing		
R_L = 10 kΩ	±12 V	same
R_L = 2 kΩ	±10 V	same
Power consumption (±15 V)	165 mW	75 mW
Power supply rejection	150 μV/V	same
Unity-gain bandwidth	500 kHz	same
Slewing rate	0.25 V/μs	0.5 V/μs
Temperature drift	3 μV/°C	3 μV/°C
Supply voltage range	±9 to ±15 V	±5 to ±20 V

Thin-film thermistors compatible with ICs

Victory Engineering Corp., Springfield Ave., Springfield, N. J. Phone: (201) 379-5900.

The Å-thinistor, a deposited oxide thin-film thermistor, makes possible the production of temperature-compensated integrated circuitry without the use of discrete components. The thin-film thermistors are completely compatible with all types of integrated circuits. The deposited oxide unit is made by low-energy sputtering a bulk multiple oxide thermistor directly onto any one of a variety of substrates. The film properties very closely approximate the properties of a bulk thermistor. Satisfactory results are obtained with film thicknesses ranging from a few hundred to a few thousand angstroms. With the aid of suitable masks, the zero power resistance at 25°C may be adjusted to fall in the range of 1 kΩ to 5 MΩ.

Units have been sputtered successfully on substrates of beryllium oxide, aluminum oxide, quartz, aluminum foil and nickel foil. By proper adjustment of the sputtering parameters, as well as location in the bell jar, it is possible to maintain a substrate temperature of 70° to 80°C. Thus, the monolithic integrated circuit can be temperature-compensated as a last step without affecting the other components during the process.

Major fields of application are integrated circuit temperature compensation, measurement and control, surface temperature measurement and IR bolometry.

It is impossible to heat the film without heating the surface. Thus, there is no measurable lag when the film is used for surface measurement.

CIRCLE NO. 333

Threshold-trigger multi for O-TC timers

Raytheon Co., 350 Ellis St., Mountain View, Calif. Phone: (415) 968-9211.

A threshold-triggered monostable multivibrator is designed for use with zero-temperature-coefficient timing components. The RM 288 has a good pulse-width stability from $-55°$ to $+125°C$. Its temperature coefficient is guaranteed at 0.005 $\mu s/°C$ ($\pm 2\%$) for an output pulse width of 50 μs. The device is available in four package configurations: 10-pin Q, 12-pin T, 14-pin dual-in-line and 14-pin J. It is compatible with 200 and 930 series ICs.

CIRCLE NO. 334

Sense amplifier is monolithic, thin-film

Halex, Inc., 139 Maryland St., El Segundo, Calif. Phone: (213) 772-2545.

Thin-film and monolithic technologies have been combined to produce high-density packaging and improved performance in a new sense amplifier. The sense amplifier consists of an integrated circuit (μA711), a thin-film input threshold circuit and a thin-film transistor output stage to improve over-all characteristics. Three sense amplifier circuits are contained in a single 3/8 x 3/8-inch 14-lead flat pack.

CIRCLE NO. 335

Dipped mica caps operable to 125°C

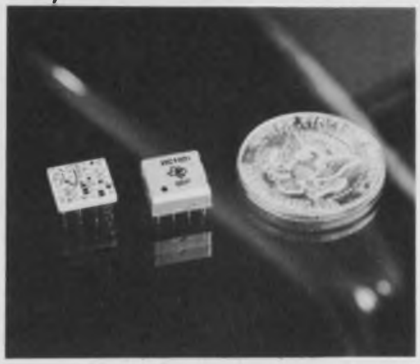
Aerovox Corp., 742 Belleville, New Bedford, Mass. Phone: (617) 994-9661.

Designed for printed wiring and general-purpose applications, plastic-coated, dipped mica capacitors are available with radial leads. The units are available in five different models and 63 different types with capacitances ranging from 150 to 15,000 pF. Temperature range is $-55°$ to $125°C$ and tolerances are ± 20, ± 10, ± 5, ± 3, ± 2 and $\pm 1\%$.

CIRCLE NO. 336

MICROELECTRONICS

Hybrid ICs for TV, audio use



Texas Instruments, Inc., P. O. Box 5012, Dallas. Phone: (214) 238-3741.

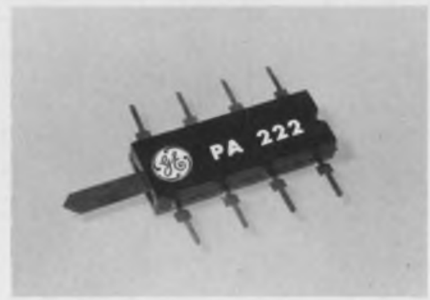
Five hybrid integrated circuits are aimed at TV, radio and phonograph applications. One of the new units, reportedly the first for TV, is an fm sound system module, combining the functional equivalent of 30 components. The other units are four audio-output devices for radios and phonographs requiring 300 mW to 1 W. All combine individual inverted silicon transistor, diode and capacitor chips with thick-film resistors.

The fm module, designated HC1001, combines a wideband i-f amplifier, an fm detector, and an audio preamplifier in a 0.5-by-0.5-by-0.2-inch package. It is designed to accept 4.5-MHz TV i-f signals. Both a high-impedance output (35 V p-p) to drive standard vacuum-tube audio power stages and a low-impedance output (0.3 V rms) to drive transistorized audio outputs are included in the single unit. Audio from the IC's two-stage amplifier needs no preamplification for driving high-power transistor or tube outputs. The circuit's output stage can serve either as an emitter-follower for driving an external bipolar output, or as a common-emitter for driving a vacuum-tube output. A-m rejection is 35 dB, so that electrolytic capacitors usually found in detector circuits are not needed. Limiting sensitivity is 300 μV, about half that of comparable circuitry.

The series of audio ICs includes low-input-impedance (1 kΩ) circuits for a-m radios, and high-input-impedance (1 MΩ) units for fm radios and phonographs. They deliver a minimum of 300 mW of audio power, operating from a 9-to-12-V supply. A 40-Vdc supply can power these units as direct coupled amplifiers. For 1-watt systems, either the HC1004 low-input-impedance module, or the HC1006 high-input-impedance unit can be used. They differ only in input circuitry; the HC1004 uses an npn and the HC1006 a FET.

CIRCLE NO. 337

Monolithic audio amp puts out 2 watts



General Electric Co., Semiconductor Products Dept., Electronics Park, Syracuse, N. Y. Phone: (313) 574-2211.

General Electric has again taken the lead in the monolithic audio amplifier power race. One of three new dual-in-line linear ICs from GE, the PA237, has power output capability of 2 watts. It is a high-performance circuit that can be operated from 12 to 26-V power supplies. The device requires fewer stabilization and frequency-shaping components than competitive audio amplifiers.

The PA230 low-level amplifier can be used as either an audio preamp or an operational amplifier. It provides excellent sensitivity, and high open-loop voltage gain. Typical applications include tape cartridge recorders, players, hi-fi equipment, dictating equipment or any audio product that requires low input sensitivity. For higher power output, the PA230 can be used in conjunction with the PA222 (1-watt) or the PA237 (2-watt) audio amplifier. The PA189 i-f amplifier discriminator is designed for operation at 4.5 or 10.7 MHz. Application is primarily within the fm and TV markets. Specific uses include chroma-phase detector, chroma-reference oscillator, chroma-burst gate, quadrature detector, i-f and high-gain amplifiers.

CIRCLE NO. 338

Resolve to get it.

Most of the synchros and resolvers described in this new 32-page brochure are standard only in the sense that they are readily available at competitive prices. Any of the "standard" units can be quickly modified to suit your particular needs, providing thousands of opportunities for *you* to resolve *your* problems.

These components reflect the highest order of precision in design, construction and performance and are backed by twenty years of Kearfott engineering and production experience.

We don't think you'll find anyone that offers a wider variety than we do. To emphasize the point, our catalog covers: Synchros, sizes 5 to 25; resolvers, sizes 5 to 28; winding compensated resolvers; resolver-amplifier combinations; multispeed units; transolvers; tandem synchros; custom-engineered units such as geared and gearhead synchros; rotary transformers; goniometers; phase shifters; etc.

Order the catalog. It's loaded with diagrams, dimensional data, electrical characteristics and application data. There's even a section on design basics.

ON READER-SERVICE CARD CIRCLE 188

Write today to: Kearfott Products Division, General Precision, Inc., Aerospace Group, 1150 McBride Ave., Dept. 1450, Little Falls, New Jersey 07424.

KEARFOTT PRODUCTS DIVISION

GENERAL PRECISION INC.

AEROSPACE GROUP

LITTLE FALLS NEW JERSEY

A SUBSIDIARY OF GENERAL PRECISION EQUIPMENT CORPORATION.

MICROWAVES

VTM oscillators deliver 500 mW

Varian, Bomac Div., 8 Salem Rd., Beverly, Mass. Phone: (617) 922-6000.

Voltage-tunable magnetron oscillators deliver at least 500 mW over 1.5 to 3 GHz. Power output is flat to ± 1 dB. Linear voltage tuning is accomplished by changing the potential of the anode, which has an FM sensitivity of 1.2 MHz/V. The magnetic circuit used results in a negligible external magnetic field, permitting the tube to contact ferromagnetic materials with no degradation in performance.

CIRCLE NO. 339

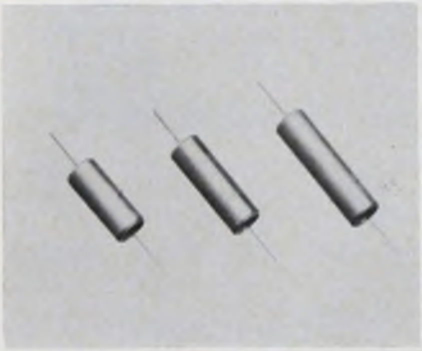
Double balanced mixer weighs 0.2 ounces

Relcom, 2164 E. Middlefield Rd., Mountain View, Calif. Phone: (415) 961-6265. P&A: $50; stock.

In an 0.2-oz package, this double balanced mixer has a frequency range from 50 kHz to 200 MHz, with one port extending to dc. Minimum isolation is 45 dB at 30 MHz. Maximum conversion loss is 6.5 dB ssb at 50 MHz. Maximum noise figure is 6.5 dB at 50 MHz and switching time is less than 2 ns. Hermetically sealed and RFI shielded, the entire package occupies 1/16 in^3.

CIRCLE NO. 340

Step-recovery source is X-band LO



Edwin Industries Corp., Pickard Bldgs., 5828 E. Molloy Rd., Syracuse, N. Y. Phone: (315) 454-4407.

A step-recovery source designed for use as an X-band local oscillator in high-performance receivers has a maximum output of 10 mW at X-band frequencies for a 22-Vdc input. The bandwidth for a minimum of 7 mW is 400 MHz. Spectral purity is better than 60 dB, and noise is of the same order as that produced by a klystron. Varactor tuning is applied over the entire frequency band, and tuning voltage is ±10 Vdc. Input is 17.5 to 28 Vdc, depending on required output power.

CIRCLE NO. 341

Microwave switches insert in coax lines

Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000. P&A: $100 to $175 (1 to 9); stock.

Broadband solid-state switching modules are packaged as coaxial sections that can be inserted as part of a coax line. The structure ensures broad bandwidth (dc to 18 GHz), low insertion loss (0.5 to 2.2 dB) and low vswr (1.5 to 2.3). The hermetically-sealed switching modules can be brazed into coaxial structures or clamped or pressed into place. They match semi-rigid coax lines with 0.141- and 0.188-inch ODs and are adaptable to lines with an 0.276-inch OD. The 50-Ω modules consist of two or more silicon pin diodes shunting the transmission line in a structure that functionally integrates the diodes and matching network into the line.

CIRCLE NO. 342

Microwave signal source based on Gunn diode

Flann Microwave Instruments, Ltd., Old Bridge St., Kingston-upon-Thames, Surrey, England. Phone: 01-546-7217. Price: about $2800.

A solid-state signal generator for frequencies from 8 to 16 GHz is claimed to be the first commercially available unit to use a Gunn-effect diode as the signal source. Spectral purity is reportedly similar to that obtained with a klystron source on continuous wave. The Gunn oscillator is connected into a broadband high-Q coaxial resonator. A mechanically-driven tuning piston, actuated by a frequency-linearizing cam mechanism, is coupled to a digital counter and the front-panel frequency control. Output power is coupled to the RF connector through a matched piston attenuator. Modulation facilities include cw, square wave, frequency deviation and pulse. Delayed sync signals and an ability to synchronize with external signals of either polarity are built in. Typical cw spectral width is 15 kHz with power output of −3 dBm. The range of output level is −3 to −130 dBm.

CIRCLE NO. 343

Three-watt oscillator varactor-tuned

Applied Microwave Lab, Inc., Andover St., Andover, Mass. Phone: (617) 475-6100.

A 3-watt varactor-tuned cw oscillator is designated model 6300-385. Within the bandwidth of 1300 to 1500 MHz at 20 volts positive or negative bias, the oscillator permits 0.5% tuning. The unit requires an input power of 6 watts.

CIRCLE NO. 344

Signal monitor levels sweep generators

Texscan Corp., 51 S. Koweba Lane, Indianapolis. Phone: (317) 632-7351. P&A: $55; stock.

This external monitor is a dual-purpose device designed to externally level sweep signal generators, as well as serving as a signal-monitoring device. The unit makes it possible to ensure a flat input to remotely located test positions. It is provided with a 50-Ω source resistor to set the impedance level at the input of the unit being tested. Frequency range is 500 kHz to 1200 MHz. Impedance is 50Ω with a 3-dB insertion loss.

CIRCLE NO. 345

Solid-state counter measures to 15 GHz

American Electronic Labs., Inc., P.O. Box 552, Lansdale, Pa. Phone: (215) 822-2929. P&A: $4350; late fall.

Measuring directly to 100 MHz, this counter's frequency capability can be extended to 500 MHz to 3 GHz, and to 15 GHz with plug-in converters. The counter measures and displays frequency, period, multiple period average, frequency ratio, frequency ratio average and time interval with internal and external clock.

CIRCLE NO. 346

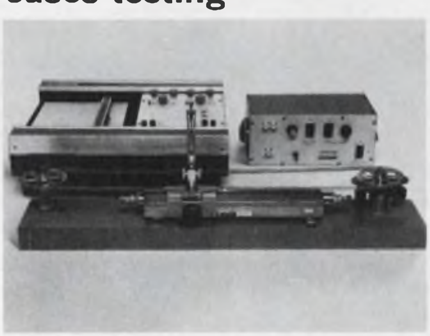
Q-switched lasers deliver 50,000 MW

Cogenel, Inc., 50 Rockefeller Plaza, N. Y. Phone: (212) 757-9130.

Two neodymium-doped glass laser systems are said to produce the highest power and the highest brightness of any commercially available lasers. The laser delivers up to 50,000 MW with 250 joules in pulses with a duration of less than 5 ns. The high-intensity laser produces a coherent beam of brightness greater than 4 x 10^{16} W/cm^2/steradian with 500 joules in pulses with a duration of some 30 ns and peak power of 17,000 MW.

CIRCLE NO. 347

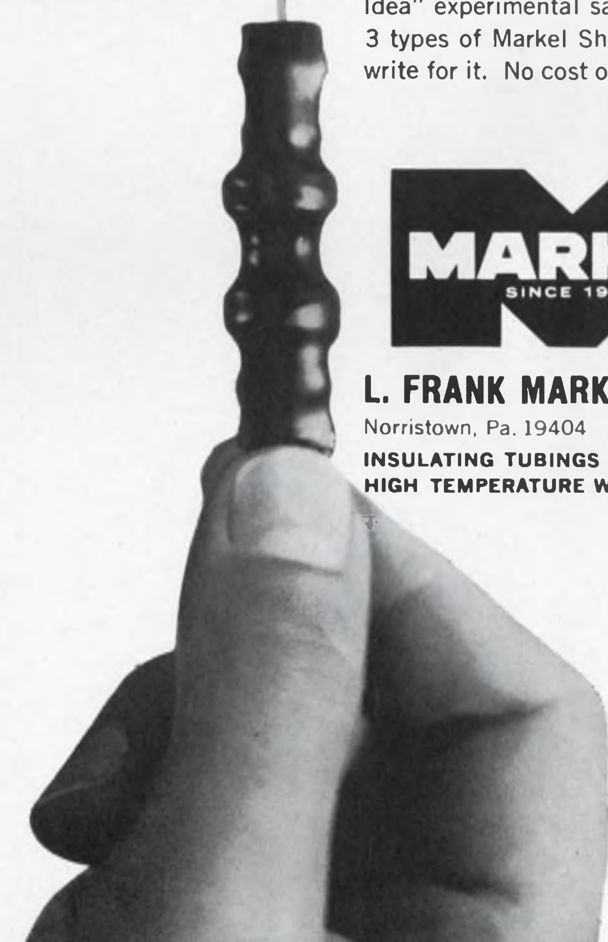
Slotted line system eases testing



Alford Manufacturing Co., 120 Cross St., Winchester, Mass. Phone: (617) 426-2150.

This recording system produces a high-resolution recording of the slotted line output as a function of probe position. The system facilitates production testing by relaxing the requirement for setting the swr indicator, by eliminating the requirement for accurate meter readings and by eliminating the manual recording of data. It operates with any swr indicator and recorder.

CIRCLE NO. 348



Resolver amplifiers range 0.5 to 60 MHz

Merrimac Research and Development, Inc., 41 Fairfield Pl., Caldwell, N. J. Phone: (201) 371-1616. Price: $950 and $825.

A series of phase-shifters (resolver amplifiers) are available for i-f measurement and control applications in the 0.5-to-60-MHz range. They are continuously variable devices employing electromechanical phase-shifters and phase-stabilized solid-state amplifiers. They are available in standard 10- and 22-MHz versions, and a 30-MHz unit.

CIRCLE NO. 349

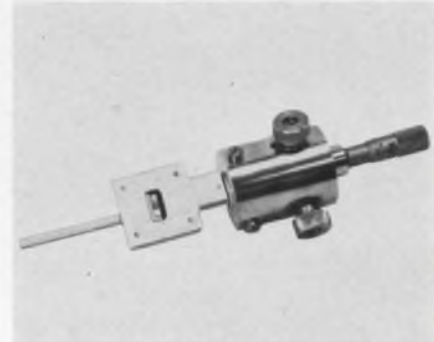
Dc feed units handle 2.5 A

Rohde & Schwarz Sales Co., Inc., 111 Lexington, Ave., Passaic, N. J. Phone: (201) 773-8010. P&A: $188 and $198; stock.

Two 50-ohm dc feed units for microwave measurements provide a means of separating the dc bias circuit from the rf measuring circuit. Maximum bias current is 2.5 A with a maximum voltage across the capacitor limited to 150 Vdc. One model covers 30 to 100 MHz, with typical vswr of 1.04; the second covers 300 to 300 MHz.

CIRCLE NO. 350

Afc/monitor cavity stable to 1 MHz



Microlab/FXR, 10 Microlab Rd., Livingston, N. J. Phone: (201) 992-7700.

Frequency stability of 1 MHz over a temperature range of −30° to 75°C is offered by this afc and monitor cavity. It can be used to stabilize klystrons in any microwave discriminator circuit. The unit is hermetically sealed and filled with dry nitrogen. It offers a tuning resolution of ±0.5 MHz and operates over a frequency range of 5.9 to 7.4 GHz.

CIRCLE NO. 351

Vswr system tops slotted line accuracy

Telonic Engineering Co., Box 277, Laguna Beach, Calif. Phone: (714) 494-7581.

With accuracy specifications claimed to be equal to or better than slotted line methods, this vswr test system spans 500 kHz to 1 GHz. The system makes direct-reading vswr measurements in the range of 1.02 to 3.00 with an extended range capability over any 17-dB return loss range. Typical worst-case system error is less than 4.1% and 1.77% accuracy is typical.

CIRCLE NO. 352

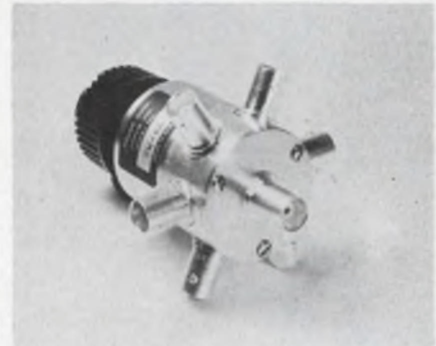
Double-balanced mixer mounts PC boards

Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000. P&A: $75 to $150; stock.

Broadband double-balanced mixers are housed in a compact (1.63 x 0.7 x 0.43 inch) package for mounting directly on PC boards or in stripline circuits. A third mixer is in a metal case with BNC connectors. Frequency range of the 10514B is 0.2 to 300 MHz at the LO and signal ports; the third port is decoupled. The 15034A spans 50 Hz to 150 MHz.

CIRCLE NO. 353

Coax switches span dc to 2 GHz

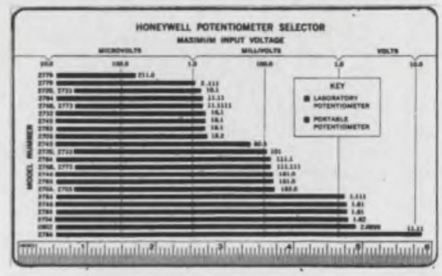


Texscan Corp., 51 S. Koweba Lane, Indianapolis. Phone: (317) 632-7351. P&A: $85; 3 to 4 wks.

Single-pole, six-position manually operated coax switches cover dc to 2000 MHz. Characteristic impedance is 50 Ω, insertion loss is less than 0.15 dB at 1000 MHz, vswr is less than 1.1 and isolation is greater than 70 dB at 1000 MHz. Wafers can be added for switching dc voltages. The unit can be supplied in single-pole, up to 6-position combinations.

CIRCLE NO. 354

Design Aids



Pot selection guide

A convenient reference guide for selecting lab or portable potentiometers to meet specific voltage-measuring requirements is in the form of a pocket-sized plastic card. The card lists ranges, accuracies, resolutions and thermal characteristics. Pots covering full-scale ranges from 211 μV to 11.11 V can be immediately identified from a two-color bar graph on one side of the card. The other side lists operational specifications of each instrument. Honeywell, Test Instruments Div.

CIRCLE NO. 355

Transformer insulation

A sample packet of flexible coated and mica-based insulation materials for transformer construction is offered by 3M. It contains flexible coated non-woven fabrics for class B and F application and corona-resistant flexible mica insulation for class F and H applications. Also included are materials descriptions and listings of typical properties as well as a handy applications chart for determining the proper material to use in a number of different transformer construction techniques. 3M Co.

CIRCLE NO. 356

Motor torque chart

Arranged in tabular form, this chart gives motor torque ratings simply by referring to the hp and rpm ratings of a given motor. Or, from a known torque and rpm, the hp requirement may be obtained. Listings cover motors from 850 to 10,000 rpm, 1/75 to 1-1/2 hp and up to 1776 inch-ounces torque. The reverse side shows dimensional diagrams and performance curves for motors and gearmotors. Carter Motor Co.

CIRCLE NO. 357

Can This Motor Run 5000 Hours ?

No, we can't guarantee it; but it may run longer! For example, a customer used a Clifton motor almost continuously for a year (8760 hrs.) and it still ran, though not up to specification.

Industry standard for servo motors is 1000 hours and all Clifton motors meet it. In addition, we are delivering motors to a 2000 hour life specification. Trade off on some parameters, and Clifton can develop a motor for you which will exceed by far normal life expectancy. Incidentally, when a guaranteed 5000 hour life motor *is* built, we feel Clifton "state-of-the-art" engineers will build it.

Why not have CLIFTON quality for your motor, generator, tachometer needs! Gearheads available also. Call your local Clifton Sales Office or 215-622-1000; TWX 510 669-8217.

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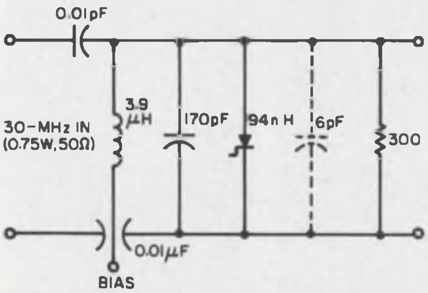
ON READER-SERVICE CARD CIRCLE 204

Application Notes



Frequency multiplier design

A 24-page application note presents theory and practice of efficient frequency multiplier design using step-recovery diodes in the shunt mode. The note gives step-by-step procedures for designing an impulse generator and related circuits that convert an input sinusoidal rf drive waveform into a sinusoid at microwave frequencies. The 30-MHz impulse generator above is one example. Its efficiency of impulse generation exceeds 80%. Other examples include design procedures for a X10 multiplier with an output of 2 watts at 2 GHz and a X5 multiplier with a 5-watt output at 2 GHz.

Design aids in the form of full-page graphs can be used to find optimum circuit components. Methods of matching the multiplier input and output impedances to source and load are described and techniques for compensating the circuit for temperature changes are also discussed. The basic theory of the step-recovery diode and the theory of efficient impulse generator design are presented. Hewlett-Packard.

CIRCLE NO. 358

Diff-amp applications

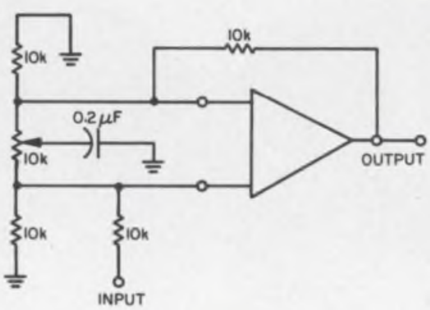
Signetics' SE505 is a general purpose, high gain differential amplifier with differential gain provided at each of the two outputs. Use of feedback techniques, as in operational amplifier circuits, makes this a versatile device. Circuits may be constructed to perform a great variety of functions with few external components. This 8-page note presents applications, including video, sense, logarithmic and band reject amplification. Signetics, Inc.

CIRCLE NO. 359

Bandpass amplifier uses

Philco's PA 7601 is a bandpass amplifier for i-f and rf service in the frequency range of 40 to 150 MHz. It features a gain-control circuit which has a negligible effect on bandwidth and terminal impedances. Its terminal impedances remain relatively constant over the full frequency and temperature range, thus simplifying matching problems. The frequency response is determined to a large extent by external components, thereby giving application utility. Several different bandpass characteristics are discussed in this 8-page note. Philco/Ford Microelectronics.

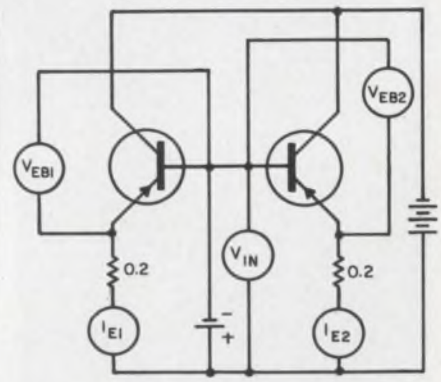
CIRCLE NO. 360



Treble, bass control circuits

A variable frequency response can be realized for treble control by using the appropriate feedback elements in conjunction with the Westinghouse WC 161 operational amplifier. The circuit is shown above with a gain of two set by the 10-kΩ resistors in the feedback loop. A voltage divider is used at the input to bring the over-all gain to unity. The potentiometer is connected between pins 2 and 5 with a capacitor from the wiper to ground. Varying the potentiometer toward pin 2 causes the higher frequency feedback to be shunted to ground and increases the effective gain of the amplifier at these frequencies. Design procedures, performance characteristics and descriptions are given in this folder for the treble and a bass control circuit. Westinghouse, Molecular Electronics Div.

CIRCLE NO. 361



Parallel power transistors

In the design of circuits which must handle extremely high power, designers look toward parallel operation of power transistors. Unfortunately, transistors of the same type do not always have identical characteristics. Unless proper precautions are taken, transistors in parallel will not accept equal portions of the load. One solution to the problem is to use emitter resistors. This application note consists of a graphical calculation with confirming experimental data. It shows to what extent collector currents can be equalized by means of 0.2-Ω emitter resistors at the 5-A level. Calculations and experiments are made on the circuit above and results given. Delco Semiconductor.

CIRCLE NO. 362

Fm measurements

The use of a frequency meter or any other wideband fm discriminator for fm measurements is described in this 17-page note. Two techniques for measuring fm on signal carriers greater than 10 MHz are described, one of these being applicable to signals up to 12.4 GHz. Also described are techniques for measuring small values of fm, such as in measurements of wow and flutter on tape recorders or in evaluating incidental and residual fm in signal generators, and for measuring rf bursts or "chirp" signals. The note also presents procedures for calculating phase deviation from measurements of frequency deviations. Hewlett-Packard.

CIRCLE NO. 363

Who says you need to clutter your system...

...to measure automatically 0.3 to 12.4 GHz?

He's wrong. Hewlett-Packard can supply an automatic, systems-oriented, single-package instrument to measure the widest microwave frequency range at the lowest price—$4750.

The HP 5240A Digital Frequency Meter offers completely automatic tuning and direct readout from 0.3 to 12.4 GHz. No adjustments or calculations are necessary—just select the range desired (0.3 to 1.2 GHz or 1.0 to 12.4 GHz), connect the input signal, and read. Readout is inhibited until automatic phase lock is achieved. Therefore, the first reading made is automatically correct—no need to clutter your system with error-checking circuits. For extra usefulness, the internal counter input is brought out so you can measure from 5 Hz to 12.5 MHz, too. This wide-range versatility makes it perfect for systems work and for rapid, error-free measurement for production and maintenance.

The 5240A uses special sampling techniques to maintain a low input VSWR (typically 1.2:1 to 1.8:1). The operator or system can measure from 0.3 to 12.4 GHz without adjusting for input sensitivity changes. More technical details are in the HP Journal, April, 1967.

Call your local HP field engineer for details on the 5240A. Or write Hewlett-Packard, Palo Alto, Calif. 94304; Europe: 54 Route des Acacias, Geneva.

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ON READER-SERVICE CARD CIRCLE 205

New Literature

Microwave mixer topics

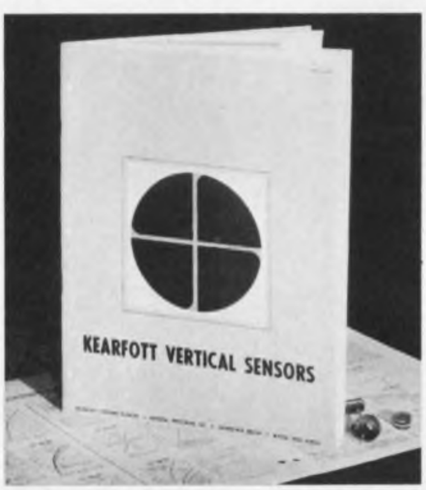
A 36-page discussion focuses on mixers utilizing the point contact resistive microwave diode as the nonlinear element. The brochure begins with an explanation of the general considerations for mixers. Examples and explanations of designs include single-diode mixers, balanced mixers, diodes and diode holders. Sage Laboratories, Inc.

CIRCLE NO. 364

Quick-snap switches

A catalog describing 400 switches in four sizes, for loads from 3 to 200 amperes ac or dc; single-pole to 12-pole single-throw and to 8-pole 4-throw is available. Contained in the catalog are dimensions, mountings, terminal arrangements, weights, torques, handle-positions, accessories and optional features. Electro Switch Corp.

CIRCLE NO. 365



Vertical and tilt sensors

A 12-page catalog describing a variety of pendulous and bubble-type vertical and tilt angle sensors is illustrated with performance curves, schematics, dimensional drawings and pictures. The brochure details high-accuracy and moderate-accuracy electrolytic and electromagnetic pendulous two-axis vertical sensors used in vertical gyros, antenna or camera stabilization systems, and in other missile, aircraft, ground vehicle, and shipboard gyro reference systems. General Precision, Kearfott Products Div.

CIRCLE NO. 366

Electronic taping tips

Included in this 32-page, illustrated booklet are such taping topics as how to protect power input connections, wiring harnessing, circuit isolation protection and antenna and lead-in protection. Photos and instructions demonstrate how to take advantage of electrical tapes in a variety of servicing situations. Additional sections in the catalog tell how to avoid cold-weather difficulties and how to achieve high temperature stability even in areas of atmospheric or chemical contamination. 3M Company.

CIRCLE NO. 367

Thermoelectric catalog

A catalog illustrating the manufacturer's types of plastics processing thermocouples and accessories contains descriptions on spring-loaded and leak-proof plastic melt thermocouples. Five types of melt thermocouples are described for various application requirements. Flush, 1/2- and 1-inch immersion lengths are offered. To complete the presentation, data are given on miniature protected thermocouples which measure liquid and gas temperatures. Thermo Electric.

CIRCLE NO. 368

Frequency control data

A 20-page, 2-color catalog contains information on hermetically sealed low- and high-frequency resonators, crystals, ovens, packaged oscillators and associated components. Schematics and graphs are included in the presentation. Northern Engineering Laboratories.

CIRCLE NO. 369

Stainless steel data

A 10-page booklet includes information on Uniloy stainless. Data are presented on hot working, heat treatment, cold working, welding, machining, corrosion resistance, oxidation resistance, physical constants, typical mechanical properties and chemical analysis of these steels. Universal-Cyclops Specialty Steel Div.

CIRCLE NO. 370

Variable inductors handbook

A 16-page engineering handbook describes communications-grade variable inductors. The components are designed for circuit board mounting, and have a recommended frequency range of 800 Hz to 100 kHz. Listings give nominal inductance value, tuning ranges and dc resistances. Performance curves depict Q vs frequency, tuning range, inductance vs temperature, and self-resonant frequency vs true inductance. Sangamo Electric Co.

CIRCLE NO. 371

Coaxial connectors

A 16-page technical bulletin describes the manufacturer's line of coaxial connectors, including captivated collet and Wirelok designs. An identification and dimension chart relates individual connector catalog numbers to the type of coaxial cable for which they were designed. Pages dealing with individual connector types such as "N" male, EIA, splice and TNC are contained in the catalog. Phelps Dodge Electronic Products Corp.

CIRCLE NO. 372

Readout catalog

A brochure on single-plane rear-projection readouts contains 44 pages, detailing principles of operation for a complete line of readouts. Catalog photos and specifications on units, assemblies, accessories, lamps and prices are included. Industrial Electronic Engineers, Inc.

CIRCLE NO. 373

Components reference

An 84-page catalog covers the field of components and is geared particularly to the needs of engineers and purchasing agents. The volume is a comprehensive reference work which contains dimensional drawings and technical data on standard plugs, jacks, connectors, clips, prods, terminals and associated electronic hardware in use today.

Available on company letterhead from Herman H. Smith, Inc., 812 Snediker Ave., Brooklyn, N. Y.

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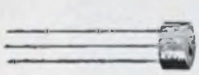

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11/32" dia.
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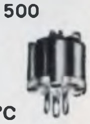

Series 600PC
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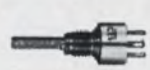
3/4 watt @85°C
For P.C. applications



Series 660
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ON READER-SERVICE CARD CIRCLE 206

Computer techniques

A 32-page, two-color brochure entitled "Computers in the Life Sciences" describes computer techniques that can be performed with a general purpose laboratory computer while the experiment is taking place. Application examples are given for the behavioral sciences, cardiology, and neurology. A bibliography of articles on the use of computers in biomedicine is contained. Digital Equipment Corp.

CIRCLE NO. 374

Superconductive magnets

A 12-page capabilities brochure describes the production of superconducting magnet systems. The catalog outlines design and fabrication techniques used in manufacturing magnets with field strengths of 50 kilogauss and upward. The brochure also lists specifications of standard superconducting magnets and custom-designed magnets including split pairs. Gardner Cryogenics Corp.

CIRCLE NO. 375

TV tube reference

A 42-page illustrated reference book contains key characteristics and data on black-and-white and color TV picture tubes. The booklet provides a reference guide to picture tubes and TV receiver test tubes and contains illustrated comparisons of picture tube protection systems, basing diagrams and interchangeability data. Sylvania, Electronic Tube Div.

CIRCLE NO. 376

Precious metal cladding

A 24-page, three-color booklet discusses the concept of the use of clad precious metals to replace solid precious metals in electronic applications. Examples are furnished and descriptions on how clad precious metals are made, showing the various forms of cladding available, are given. A chart details the dollars-and-cents savings made possible through changeover from solid to clad precious metals. Also furnished are guidelines for evaluating the economics of the composites. Handy & Harman.

CIRCLE NO. 377

Micrologic registration

EIA's Microelectronics Engineering Panel has issued the third in a series of formats for data for registration of semiconductor devices. The format provides for registration of semiconductor integrated bistable logic circuits including monolithic, multichip, film and hybrid bistable logic circuits.

Available for 50¢ from the Engineering Dept., EIA, 2001 Eye St., N.W., Washington, D. C. 20006.

Microwave products catalog

A 12-page brochure covering microwave products details information on crystal video detectors, antennas, microwave components, filters, semiconductor diodes, infrared devices and testers and instruments. Also dealt with in the presentation are the areas of biophysical and electro-medical instrumentation, broadcast equipment and CATV. American Electronic Labs.

CIRCLE NO. 378

Optical engineering brochure

An 8-page catalog on optical engineering entitled "Progress in Optics," describes and illustrates GE's capabilities, facilities and experience in optics. It includes its current activity in automatic design. General Electric Co., Electronics Labs.

CIRCLE NO. 379

Silicone guide

Product information and data on silicones are given in this 8-page, 2-color catalog. Also included are data on sealants, anti-foam agents, additives, textile finishes, paper release coatings and chemicals. General Electric, Silicone Products Dept.

CIRCLE NO. 380

Alumina and beryllia

An eight-page booklet describing the physical, electrical, chemical and thermal properties of alumina and beryllia ceramics contains applications for alumina and beryllia ceramic parts and assemblies. Components and assemblies are illustrated. Frenchtown/CFI, Inc.

CIRCLE NO. 381

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Introduction to Digital Electronics

Engineers in digital systems, solid-state electronics. and computer science: Here is the first reference text to treat digital operations of various types of devices and circuits as a unified subject.
Written by Arthur W. Lo, Princeton University, the book covers: operation modes of switching elements (transistors, cryoelectric and optoelectric devices, maganetic and negative-resistance devices); major circuit configurations; random access memories. Ample references enhance the book's value. 223 pp, 207 illus. (1967) $10.75. Send for your free 10-day examination copy by circling number.

Addison-Wesley

Publishing Company, Inc.
Reading, Mass. 01867

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Solids Go Established Reliability

Users of solid tantalum capacitors who wish to take the road to Established Reliability can now obtain a conversion chart MIL-C-26655B to MIL-C-39003A. Clarification of differences between the requirements of the two specs are included as well as comparison and cross reference charts of superseded parts. Since the new mil spec numbers are non-descriptive, this 8-page chart will enable you to check capacity and voltage when working from MIL-C-39003A numbers and vice versa.

Schweber Electronics
Westbury, New York 11591
516-334-7474

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Electronic Design

ELECTRONIC DESIGN's aim is fourfold. It aids progress in the electronics manufacturing industry by promoting good design. It gives the electronic design engineer concepts and ideas that will make his job easier and more productive. The magazine serves as a central source of timely, up-to-the-minute electronics information. And finally it seeks to encourage two-way communication between manufacturer and engineer.

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We strive for accuracy. We take the utmost pains to ensure the highest standard of accuracy throughout the magazine. A single mistake in practical design information can have serious consequences. But to err is human, and for all the care we take, an occasional error slips through. Whenever this occurs, we publish a correction at the earliest opportunity. You will find these corrections printed at the end of the Letters column. If you should spot an error, be sure to let us know. You may save your colleagues heartaches.

Microfilm copies are available of complete issues of ELECTRONIC DESIGN that have been published since the beginning of 1961, and of single articles. Complete issues cost 4¢ a page, individual pages cost 50¢ each; shipping and handling charges are extra. The minimum charge is $3; delivery time runs from 10 days for single pages to five weeks for complete issues. For further details and to place orders, get in touch directly with University Microfilms, Inc., 300 N. Zeeb Road, Ann Arbor, Mich. 48106; telephone (313) 761-4700.

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Terminal Block Selector

A new 24-page, completely illustrated catalog contains photos, descriptions, ratings, engineering drawings, and prices of the complete line of Curtis terminal blocks. Included are printed circuit, insulated feed-thru, quick disconnect, track type, and high current terminal blocks. Handy selection chart quickly locates the perfect block for your particular requirements. Send today for your free copy. **See us at WESCON, Booth 1013**

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

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Quality Fasteners For All Design Applications

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 Catalog No. S-2 or comprehensive Catalog No. D-3 are available on request.

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Designer's Datebook

JULY

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
23/30	24/31	25	26	27	28	29

AUGUST

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 Reader Service card.

July 18-20
Electromagnetic Compatibility Symposium (Washington, D. C.) Sponsor: IEEE; J. S. Hill, Genisco Technology Corp., 10774 Tucker St., Beltsville, Md. 20705

CIRCLE NO. 469

July 24-28
Design Course on Automatic Electronic Test Equipment (New York City) Sponsor: New York University; D. M. Goodman, N.Y.U. School of Engineering and Science, 401 W. 205 St., New York, N. Y. 10034.

CIRCLE NO. 470

July 31-August 4
Research Conference on Instrumentation Science (Geneva, N. Y.) Sponsor: ISA; Instrument Society of America, 530 William Penn Place, Pittsburgh, Pa. 15219

CIRCLE NO. 471

Aug. 13-17
Intersociety Energy Conversion Engineering Conference (Miami Beach) Sponsor: ASME, IEEE *et al.*; A. Merrick Taylor, Douglas Aircraft Corp., Inc., Santa Monica, Calif. 90406

CIRCLE NO. 472

Aug. 22-25
Western Electronic Show and Convention (San Francisco) Sponsor: WEMA; Ted Shields, WESCON, 3600 Wilshire Blvd., Los Angeles, Calif. 90005

CIRCLE NO. 473

Aug. 29-31
Conference on Engineering Applications of Electronic Phenomena (Ithaca, N. Y.) Sponsor: Cornell University, IEEE, ONR; Conference Committee, School of Electrical Engineering, Philips Hall, Cornell University, Ithaca, N. Y. 14850

CIRCLE NO. 474

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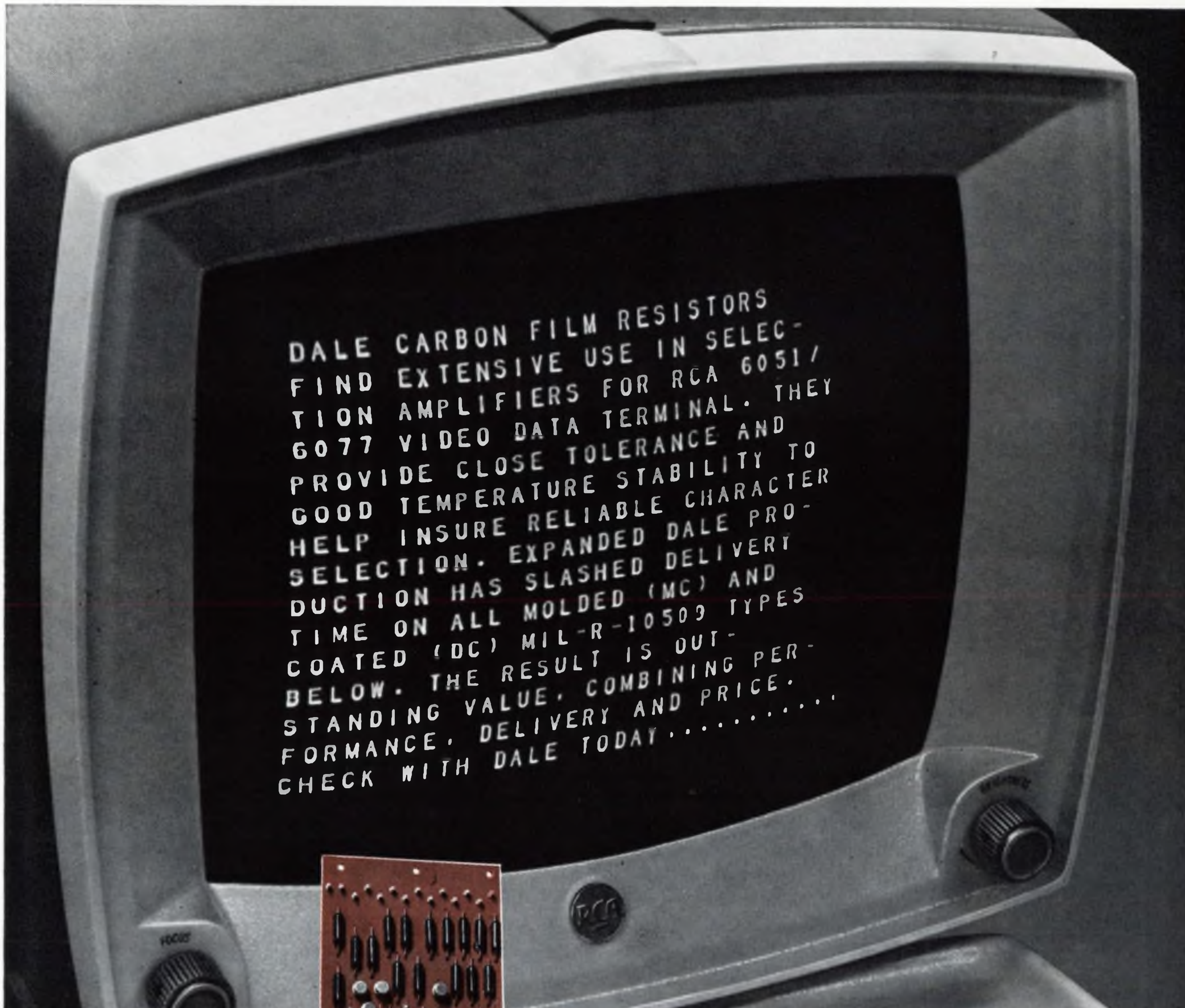

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DALE TYPE	MIL. TYPE	POWER RATING (WATTS) B*	POWER RATING (WATTS) D	MINIMUM RESISTANCE (OHMS)	MAXIMUM 1% RESISTANCE (OHMS)	MAXIMUM 2% RESISTANCE (OHMS)
DC-1/10 MC-1/10	— RN-55	1/10 1/10	— 1/8	2	400K	400K
DC-1/8 MC-1/8	— RN-60	1/8 1/8	— 1/4	1	3 MΩ	5 MΩ
DC-1/4 MC-1/4	RN-10 RN-65	1/4 1/4	— 1/2	1	5 MΩ	6 MΩ
DCS-1/2 MCS-1/2	RN-20 RN-70	1/2 1/2	— 3/4	1	10 MΩ	15 MΩ
DC-1 MC-1	RN-25 RN-75	1 1	— —	1	15 MΩ	30 MΩ
DC-2 MC-2	RN-30 RN-80	2 2	— —	2	100 MΩ	125 MΩ
DC-5	—	5	—	5	150 MΩ	300 MΩ

Tolerance: .5%, 1%, 2%

*DC resistors meet Char. B, MIL-R-10509D requirements, but are dimensionally smaller.

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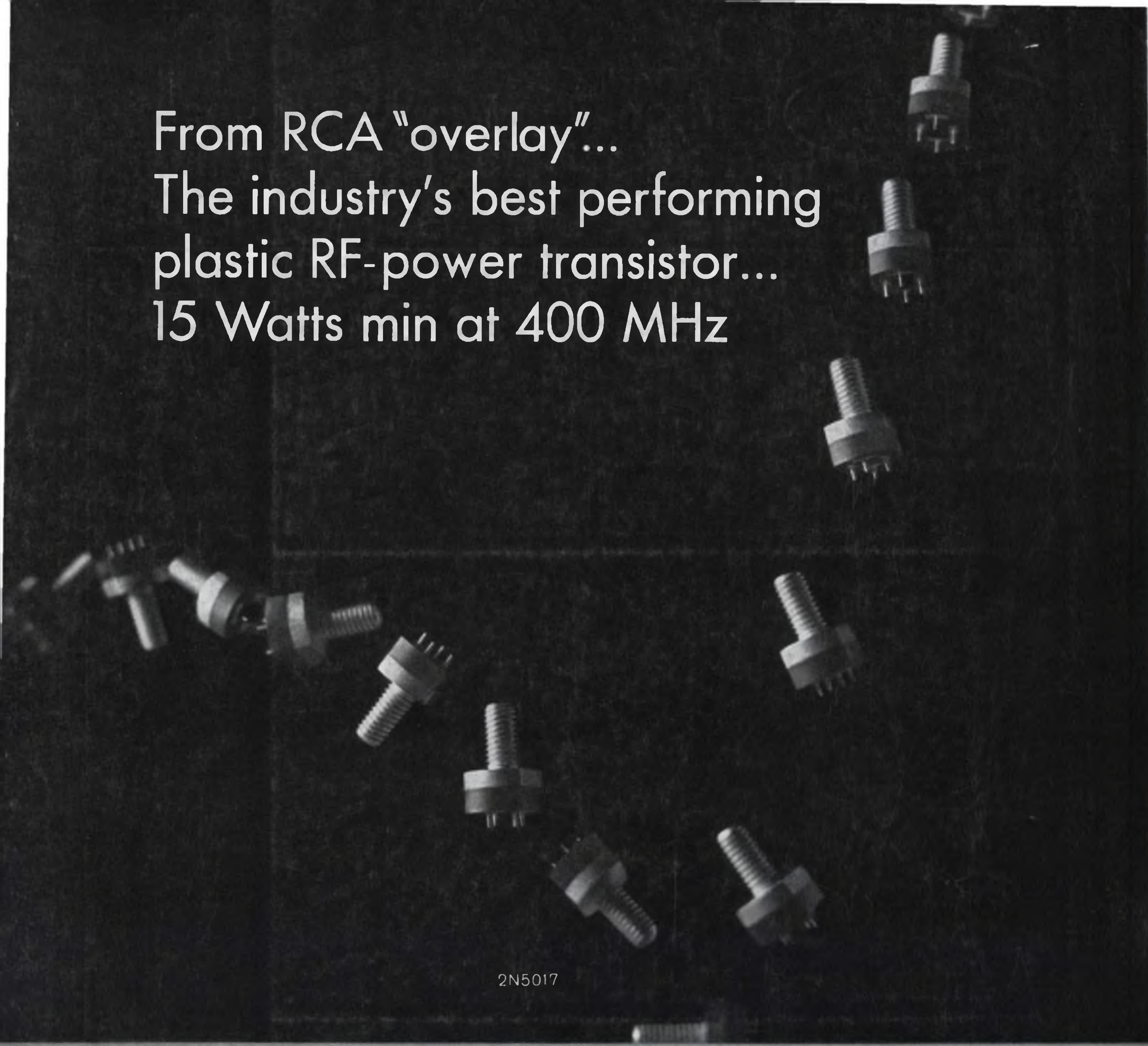

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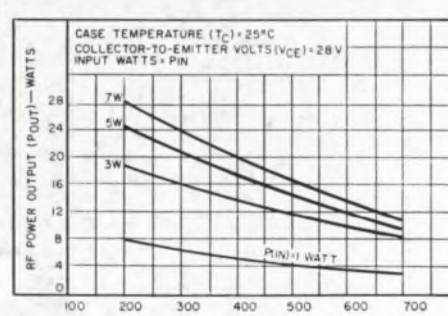

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