Electronic Design

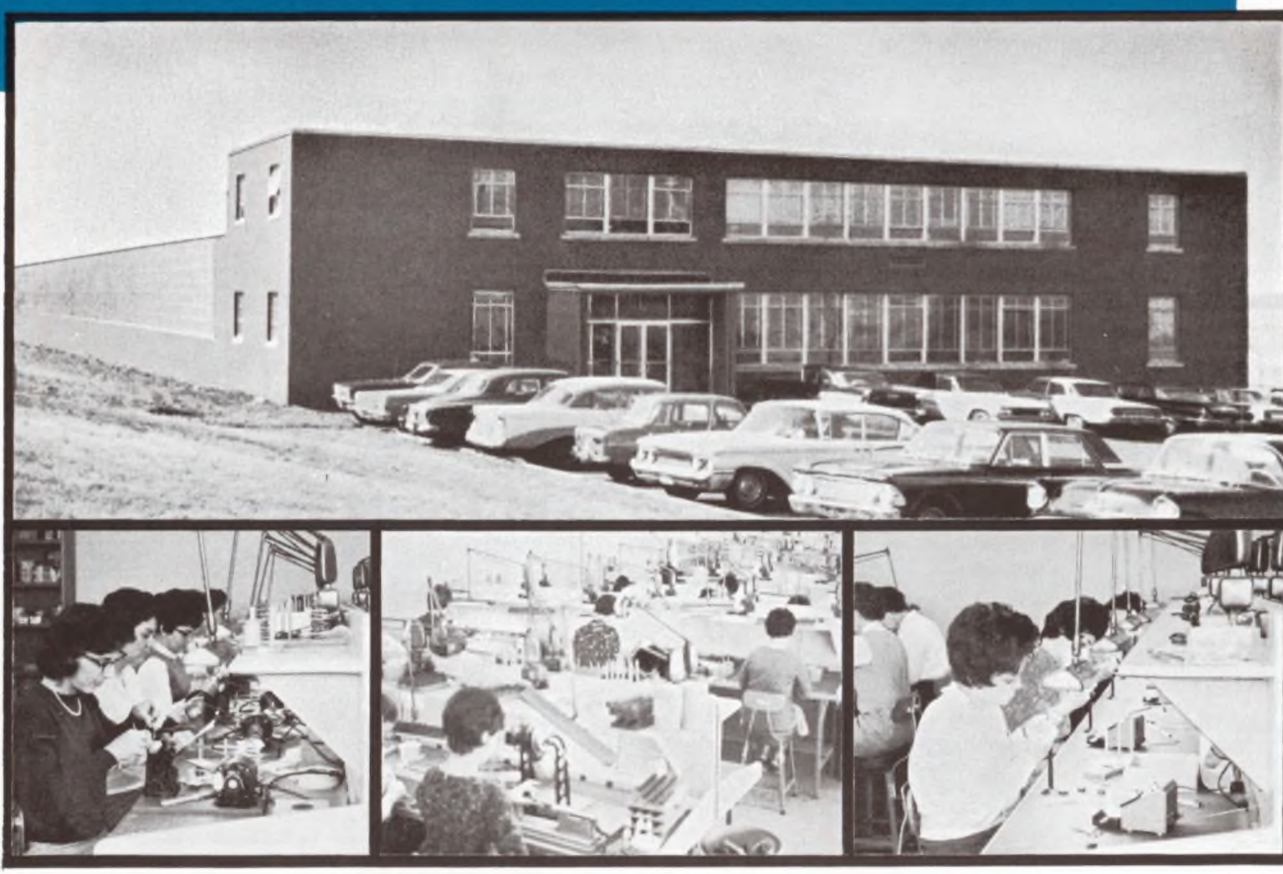
VOL. 14, NO. 11

THE MAGAZINE OF ESSENTIAL NEWS, PRODUCTS AND TECHNOLOGY

MAY 10, 1966

SCRs control motor complex. Semiconductor power converters improve speed regulation in dc motor-control applications. Led by the SCR, their operating capabilities range from fractional hp loads to this multi-megawatt mill-drive system. To learn how and why to apply SCRs in dc motor-control designs, see page 38

Where is this plant?



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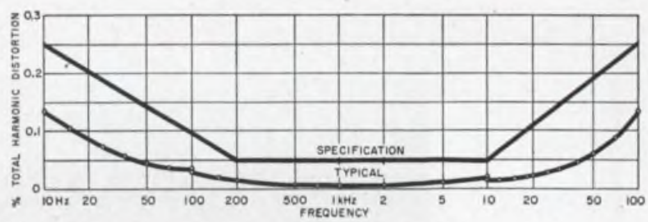

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Excellent Output Characteristics: Waveform purity is unmatched by that of any other oscillator in this price class. Hum is only 0.001% of full output. Open-circuit output is 5 V and is typically constant to 0.5%; guaranteed to be constant within ±2% over the entire frequency range. Amplitude stability is ±0.2% per hour, typically.

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ON READER-SERVICE CARD CIRCLE 214

VOL. 14, NO.

Electronic Design 11

THE MAGAZINE OF ESSENTIAL NEWS, PRODUCTS AND TECHNOLOGY

MAY 10, 1966

NEWS

TECHNOLOGY

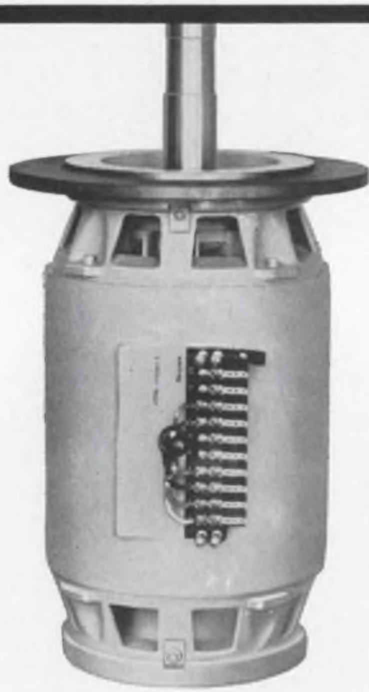
PRODUCTS

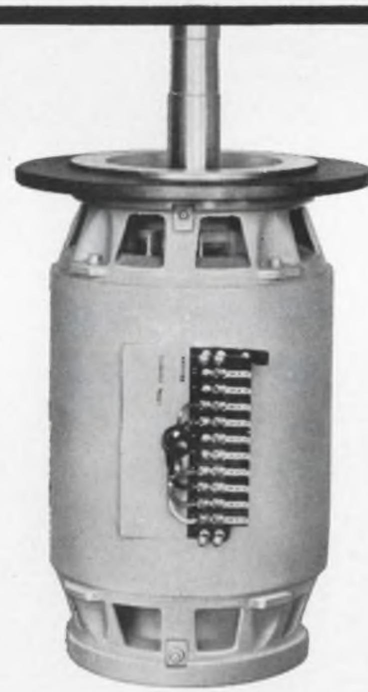
Departments

ELECTRONIC DESIGN is published bi-weekly 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. 61,114 copies this issue.

When ITT Federal Laboratories Division needed a tough, reliable power servomotor that would function unattended for months at a time at isolated VORTAC stations and provide precision at temperatures from –40° to +60°C...

Whom did they turn to ?





They turned to the Diehl Division of the Singer Company, leading suppliers of tough-job power servomotors, resolvers, instrument servos, amplifiers and blowers. For technical data, specifications and other details on these and other Diehl products, contact:

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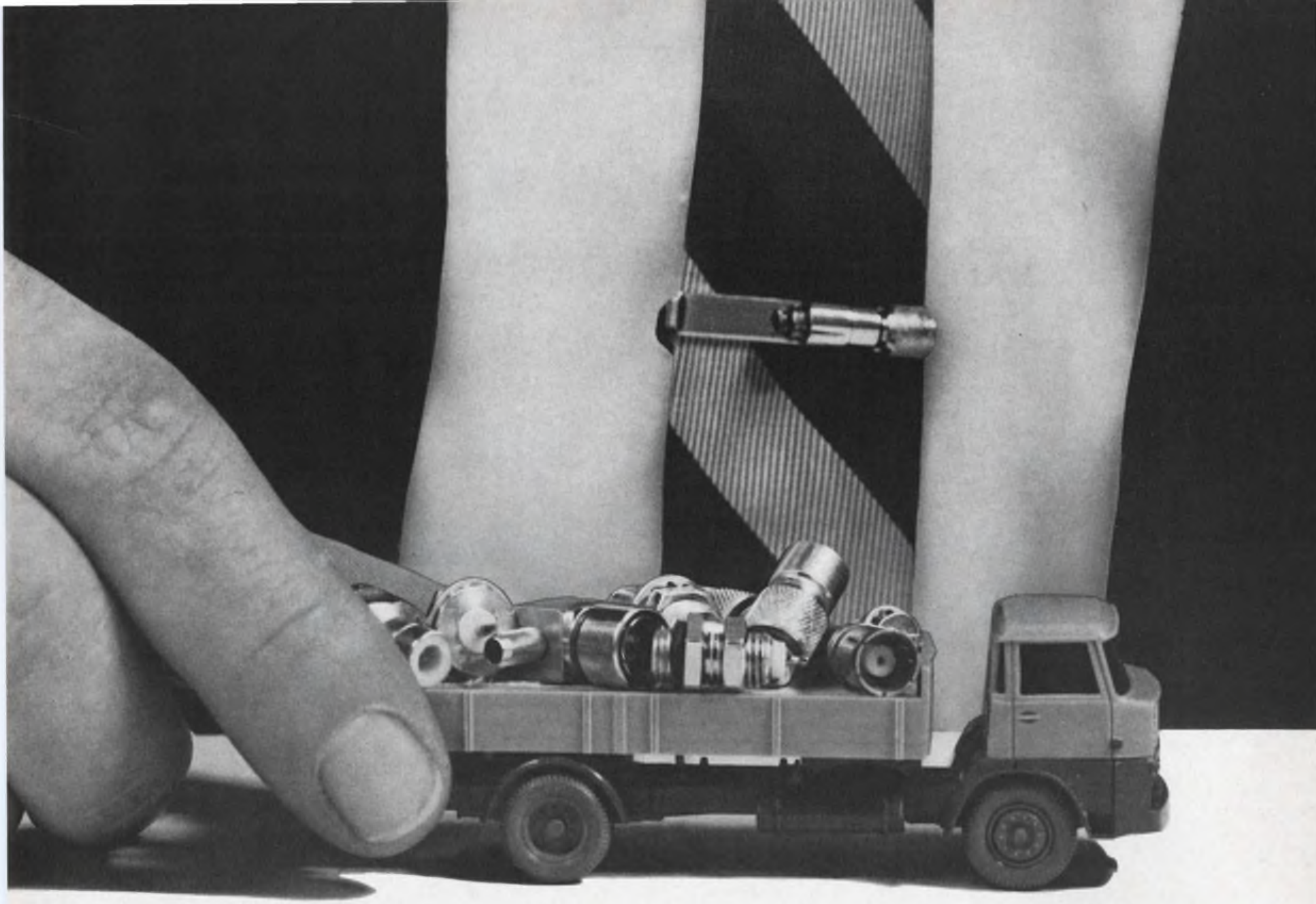
ON READER-SERVICE CARD CIRCLE 3



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COMPLETE SELECTION. Amphenol can fill your order for any one of 130 subminiature coaxial connectors. All give you superior electrical performance.

MEET MIL-C-22557A. Subminax 27 Series connectors have VSWR values below 1.2:1 to 6 GHz. New field-serviceable UG additions to the 27 Series include 50-ohm screw-on plugs, jacks, bulkhead jacks and bulkhead receptacles.

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Incidentally . . . note the attractive tie-bar pictured above. If you'd care to have one, call your Amphenol Sales Engineer or write us, ATTN: Dept. 103. We'll be happy to send you one while the supply lasts.

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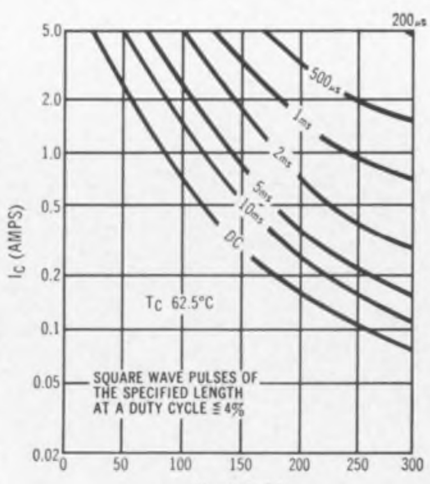
◀ ON READER-SERVICE CARD CIRCLE 215

Who could build a better silicon power transistor than our DTS-423?

We could. Meet DTS-431.

PARAMETER	MAXIMUM	TYPICAL	MINIMUM
V_{CEO}	400V		
V_{CBO}	400V		
V_{CEO} (sus)		370	325
I_C	5A		
I_B	2.0A		
Junction Temperature	150° C		−65° C
h_{FE} (I_C=2.5A V_{CE}=5V)	35		15
h_{FE} (I_C=3.5A V_{CE}=5V)			10

TYPICAL SWITCHING TIMES:
Rise time —0.40 Microseconds
Storage time—0.45 Microseconds
Fall time —0.35 Microseconds



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Introducing the DTS-431, the newest addition to Delco Radio's line of high voltage silicon power transistors. It offers you a number of distinct design advantages over the DTS-423, including an even higher current capability.

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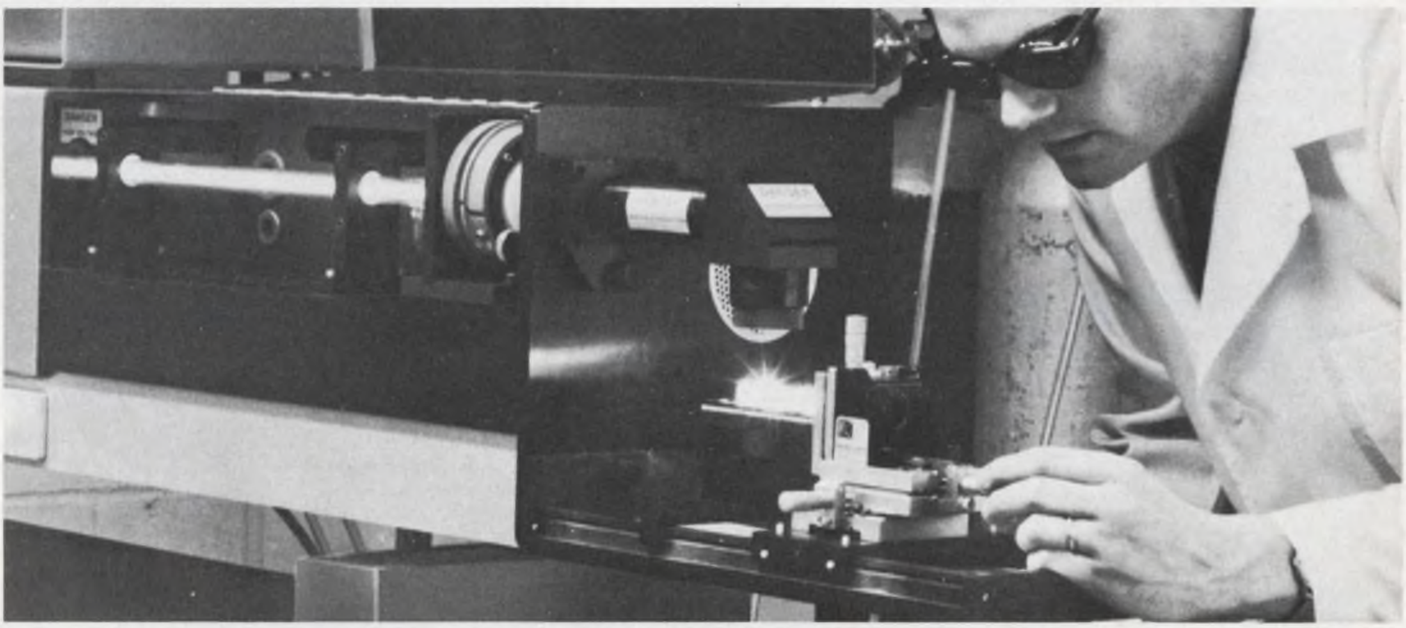
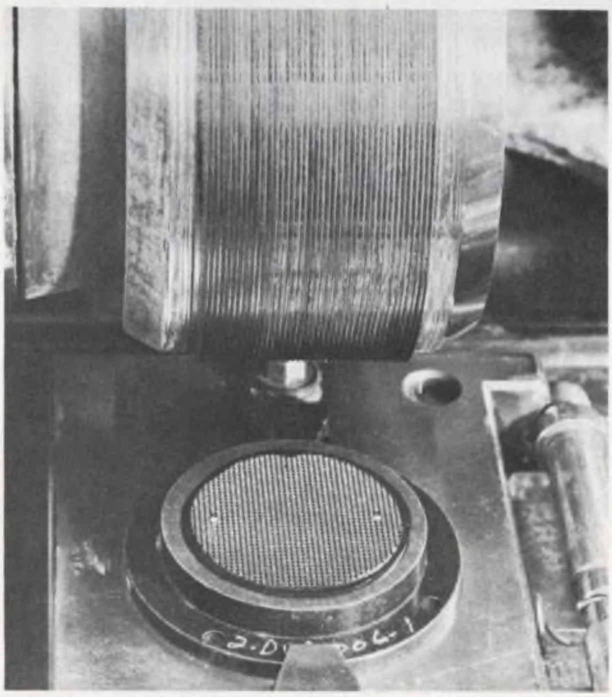
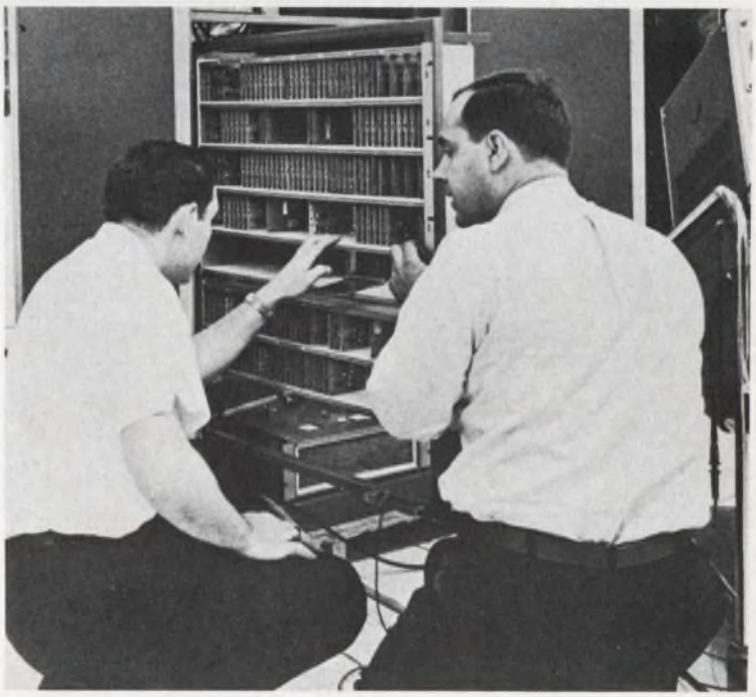
ED News



Is there a laser in your future 21



Cut, but don't touch 26



Tailor-made systems 26

Will Nike X catch ICBM?

News Report

Senate OKs $168 million for Nike X

Over the opposition of Defense Secretary McNamara, the Senate has approved a $167.9-million appropriation for "radars and other hardware" for the Nike X anti-missile missile.

President Johnson pointedly omitted a specific request for the program from his budget message, limiting himself to vague support for the "continued development" of Nike X (see ED Vol. 3, Feb. 1, p. 13). This sort of treatment usually spells trouble for a program, Washington observers note, and the Senate's present action is still no guarantee of ultimate approval.

The Nike-X money was contained in a total of $17.2 billion approved for the procurement portion of the $59-billion defense budget. The Senate also earmarked just under $7 billion for R&D and $75 million for a nuclear-powered frigate. Senator Richard Russell (D-Ga.), Armed Services Committee chairman, said that these funds would provide a long lead time for Nike X. He added that by next year the U.S. would have 1000 intercontinental missiles plus 656 more aboard 41 Polaris submarines.

The appropriation was said to have been voted by the full Senate and the House Armed Services Committee largely as a result of reports of Communist China's nuclear and ballistic-missile activity. McNamara, however, has often stated that no anti-ballistic-missile system can be wholly effective, and that he'd rather have a powerful offensive armory than a questionable defense system.

Sperry delivers attache-case size gyro

A ring laser gyroscope about the size of an ordinary attaché case is en route to the United States Air Force. Using a continuous wave helium-neon gas laser, the gyroscope warms up instantly, and indicates angular rotation rates on a digital readout.

The gyro's sensitivity to angular rotation rates is comparable to that of missile guidance and space navigation gyros, according to Thomas C. Hutchinson, head of electro-optics engineering at the Sperry Gyroscope Div., of Sperry Rand Corp., Great Neck, N. Y. He says the gyro has withstood accelerations of more than 100G in a centrifuge.

The heart of the gyro is a pair of light beams that are reflected around a rectangular path in opposite directions. As the gyro starts to rotate, the wavelength of one beam increases and the wavelength of the beam traveling in an opposite direction decreases.

This is because light has a constant velocity in an inertial system. The wavelength shift is accompanied by a corresponding frequency shift. The frequency shift, a quantity that is proportional to the rotation rate, is read out on a digital display.

The gyro has no moving parts. Sperry engineers indicate that laser gyros, because of their simplicity, can be made for a small fraction of the cost of comparable mechanical gyros.

210-ft Goldstone dish dedicated

A 210-ft-diameter automatic space tracking and telemetry antenna—one of the world's largest—has been dedicated at Goldstone, California. The fully steerable, parabolic aluminum dish will give two-and-one-half times the range of the 85-ft-diameter antennas now used in NASA's Deep Space Network (DSN).

Operated by NASA's Jet Propulsion Lab at the California Institute of Technology, the $14-million Goldstone facility is expected to be able to track spacecraft to the edges of the solar system, as far as Pluto and beyond. While there are larger antennas in service, notably the 250-ft dish at Jodrell Bank, England, they do not have the 210's extreme range and sensitivity.

As an example of the performance of the new dish, NASA said it plans to track the Pioneer VI spacecraft, now in orbit around the sun, for as long as 14 months—even though by then the signal strength will be only a billionth of a billionth of a watt when received on earth. With the 85-ft antennas, Pioneer's ever-weakening signal could have been picked up for only six months. —(over)

Like other DSN facilities operating at S-band (2110-2120 MHz transmitting and 2290-2300 MHz receiving), the 210-ft dish incorporates a Cassegrainian cone feed mounted at the center of the reflector. Signals collected in the main dish bounce up and hit a sub-reflector which focuses the signal into the feed horn of the Cassegrainian cone where there is a maser amplifier. The deep-space signal is usually maser-amplified about 40,000 times before it is fed into the rest of the receiver system for further amplification.

NASA is planning to build additional antennas the size of the Goldstone facility at other DSN sites around the world.

Semiconductor sales rose sharply last year

Last year was a banner year for semiconductor manufacturers, with factory sales up 20 per cent over the 1964 figures. Another 19-per-cent increase is expected this this year, according to Electronic Industries Association estimates.

Germanium transistors led the field in total numbers sold with over 333 million units worth $166.5 million. In dollar value, silicon transistors were top, with 272 million units sold for over $213 million. Sales of FETs were over 610,000 units, a whopping 265-per-cent increase over 1964. IC sales were up 93 per cent over 1964 for a total of $79 million.

SECAM "oui" PAL "nyet"

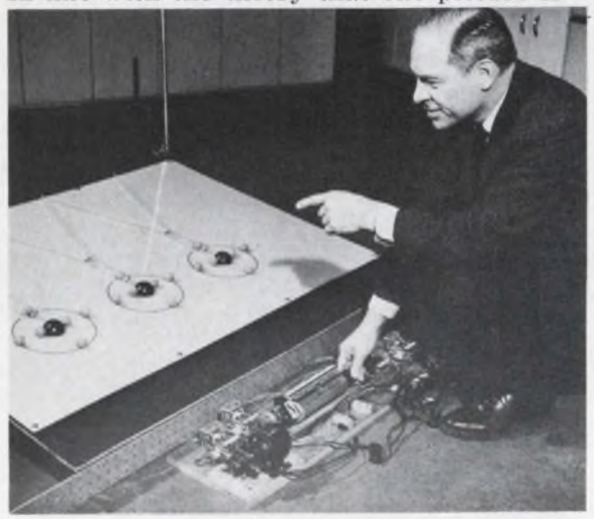
French and Russian endorsement of the SECAM-3 color-television system has scuttled hope for a compatible Pan-European system. On agreeing to SECAM-3, the Soviets shelved their proposals to adapt the SECAM system in such a way as would have made it a variation of the German PAL system. To date all other major European countries have indicated preference for the amplitude-modulated PAL system. The French-Soviet action spells trouble for international exchange of programs. It also complicates the manufacture of TV sets for the European market.

Educational TV to beam laser theory

This fall selected scientific subjects, including the theory and operation of the laser, will be aired during "prime" time for adult TV viewers. The program, to be called "Experiment," will be carried by the 104 stations of the National Educational Television Network.

The new science show will be hosted by Don Herbert, who for 14 years made "Mr. Wizard" famous explaining science to children. Now Herbert will turn his talents to the grown-ups.

In line with the theory that one picture is



worth a thousand words, animated displays will have a major role in the show. Typical of these is the set-up that will be used to explain laser action (see illustration). Electrons are represented by cork balls and photons by an array of 324 lamps. An Actan rotating-drum memory switch, made by the Sealectro Corp. of Mamaroneck, N.Y., controls the symbolic interaction of the electrons and photons by programing the lamps and balls.

Overseas computer market booming

The digital computer market outside of the U.S. is expanding at a much greater rate than the domestic market, according to a recent study conducted by International Data Corp. of Newtonville, Mass. The study reported that the number of digital computers installed outside the U.S. increased 28 per cent during 1965.

Feasibility of satellite communications in South America will be studied by Page Communications Engineers, Inc., of Washington, D.C. The study will be conducted under a $250,000 contract with the Inter-American Development Bank.

Exhibit space for the 1966 WESCON show has just been sold out. Over 1100 of the available 1150 exhibit booths have already been contracted for by more than 600 companies. The WESCON show and convention will be held August 23-26 in Los Angeles.

NEW MICROTRANSFORMERS AND MICRO-INDUCTORS

MIL-Spec Reliability, Laminated-Core Efficiency in a ¼-inch Cube!

Now — microtransformers and micro-inductors created especially for tight, hi-rel military / aerospace environments. The new Bourns Models 4210 and 4220 exceed the environmental requirements of MIL-T-27B and the transformer-reliability specifications of MIL-T-39013!

In performance, too, these models hit new highs. They are the only units to give you the efficiency of laminated-core construction. At 1000 cps the insertion loss is less than 3db. In high-frequency operation, the model 4210 is dramatically superior to the smallest solid-core units available. In square-wave operation, droop is as low as 5%, overshoot as low as 10% and rise time as little as 100 nanoseconds. In every performance category, Models 4210 and 4220 give you the industry's highest ratio of performance to size.

Like Bourns potentiometers, the 4210 and 4220 are subjected to the intensive testing of the exclusive Bourns Reliability Assurance Program. The big "B" on the cover means there's a full measure of reliability in the package.

We specialize in winding custom microtransformers and micro-inductors to meet your exact requirements, and we substantiate performance in our qualified test laboratory.

Write today for complete technical data!

Standard Specifications, Model 4210 and 4220

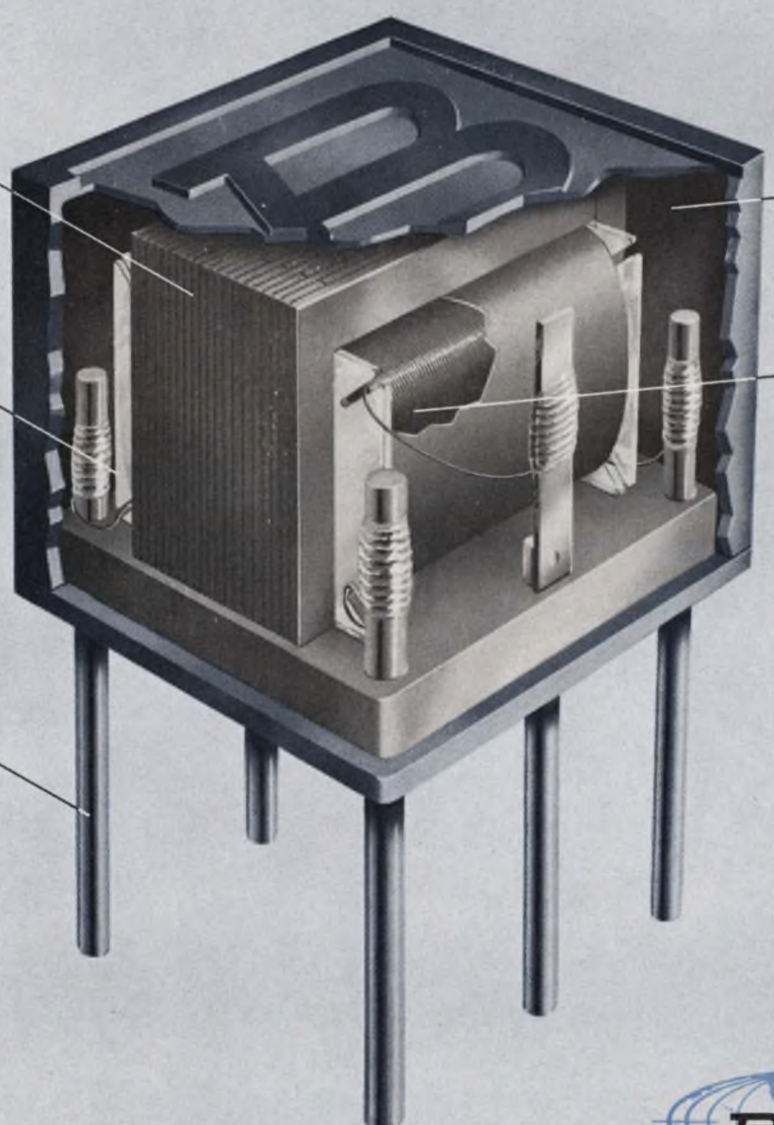
Size: .25" x .25" x .25"
Maximum operating temp.: +130°C
Frequency response: —2db, 400 cps to 250 kcps (Model 4210)
Power rating: 1 watt at 10KC (Model 4210)
Insertion loss: 3db max. (Model 4210)
Primary impedance range: 100Ω to 200KΩ } (Model 4210)
Secondary impedance range: 3.2Ω to 10KΩ } (Model 4210)
Turns ratios: to 15:1 (Model 4210)
Inductance range: .08 to 66 Hy (Model 4220)
MIL-Specs: designed to exceed MIL-T-27B and MIL-T-39013

Units shown actual size

Bourns Model 4210
Microtransformer

Bourns Model 4220
Micro-inductor

Standard Models available from stock!



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ELECTRICAL SPECIFICATIONS

Model	Output Voltage Vac	Regulation Line & Load Combined	Distortion w/10% Input Harmonics	Response Time μs	Input Frequency c/s	Isolation In/Out db	Price
FR1000	115	± 0.05%	< 0.25%	50	57-63	100	$1425
FR1010	230	± 0.05%	< 0.25%	50	47-53	100	$1650
FR1020	115	± 0.05%	< 1.0%	50	380-420	100	$1525
FR1030	230	± 0.5%	< 0.25%	50	57-63	100	$1650

RAYTHEON

ON READER-SERVICE CARD CIRCLE 200

Crisis in standards: new survey pinpoints needs

NBS services falling short of industry needs; diagnosis—acute budgetary malnutrition

Peer Fossen West Coast Editor
Robert Haavind Managing Editor

First the "missile gap," now the "standards gap."

The latter refers to the subject of a new survey being reported today (May 10) at a meeting of the National Conference of Standards Laboratories (NCSL) in Gaithersburg, Md. This survey pinpoints areas where industry needs basic standards or calibrations services; but can't get them. The survey was conducted by an NCSL committee headed by Charles Johnson of Boeing Co., Seattle, who is making the report.

According to Johnson, the most critical areas of need revealed by the survey of 118 member-laboratories were:

- High-frequency attenuation.
- Spectral transmission.
- Vacuum measurements and leak-rate measurements under vacuum conditions.
- High-frequency reflection coefficient.
- Impulse spectral density.

A majority of the requests for new standards, according to Johnson, come from NASA or from manufacturers in space work. Very few relate to the civilian economy.

Spokesmen for both industry and the National Bureau of Standards agree that NBS has failed to meet national needs for several years. Rapid changes in technology have entailed new standards or greater accuracy in existing ones. NBS has been unable to keep pace. This situation was recognized in the late 1950s. Industry and NBS launched a massive cooperative effort at that time on the basis of an Aerospace Industries Association study (ED, Dec. 9, 1959, p. 27). The results of that study had such impact that for the first time in history, the Government granted a supplemental appropriation—$1.5 million—for standards work.

But, despite the greatly increased efforts of the last few years, the standards gap still exists. What is the cause of this? The diagnosis of metrology specialists is unanimous: acute budgetary malnutrition.

The Bureau's annual operating budget has remained fairly constant at the $28-$31 million level through the past three years (see table, p. 18). Although the cost of the Central Radio Propagation Laboratory at Boulder, Colo., has been removed from the Bureau's budget, some of the funds that this freed were promptly soaked up by new assignments.

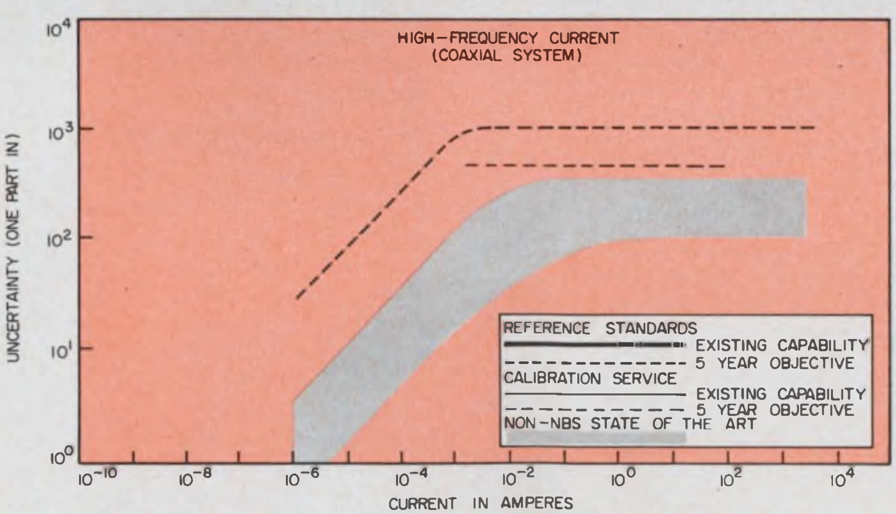
A major new service of the Bureau, for example, is the National Standard Reference Data System. This is a program, started in 1963, to compile and evaluate systematically data in all the physical sciences—a valuable, albeit monumental, task! But at the same time, Bureau officials say, it is a task that has never been funded well enough to accomplish the stated objectives.

Another factor that has helped to deplete the operating budget has been the Bureau's $100-million investment in a new facility in Gaithersburg, Md. Some five years in building and furnishing, this is now almost complete. Part of the new premises houses a nuclear reactor, which will enable the Bureau to offer new standards in such areas as nuclear-monitoring instruments.

A serious problem confronting NBS in discussion of its budget requests with Congress, according to William A. Wildhack, associate director of the Institute for Basic Standards, is how to translate standards inadequacies into dollars lost to the economy. A major contribution of the AIA study was that it did unearth some specific cases of unnecessary costs in the missile industry. Some failures were traced directly to malfunctions stemming from measurement tolerances.

In the case of the Minuteman missile system, for example, underground antennas were being overspecified when each extra dB incurred the expenditure of thousands of dollars. This was an immediate result of the Bureau's lack of a field-strength standard. But the greater part of the cost to the economy is just not traceable.

Sound design proceeds on a worst-case basis, he explained, so that the designer must assume that all values fall at the worst edge of his measurement tolerances. In fact, many of these errors may cancel, so that the equipment is overde-



Existing reference standards and calibration service capability of both NBS and non-NBS sources are given in NBS Technical Note 262, an example of which is shown here. For high-frequency current (coaxial systems), NBS has no present capability, although one will be available in the future

(standards, ***continued*****)**

signed at the outset. Then an inspector is assigned to test the equipment. Again, he tests on the basis that all values are falling at the worst side of the measurement tolerance band. So, the equipment is overtested. Finally, in the field, the user wants to take no chances, so he operates the system at the lower edge of its rating tolerances.

Thus, because of inaccuracies in standards, the equipment costs and weighs more than it should and performs below its potential.

NBS tied to Commerce Dept

Many in industry ascribe the Bureau's difficulties in part to the fact that it is part of the Commerce Department. Its activities are just as essential to space or military programs as many elements of the NASA and DOD budgets, they say, yet they receive closer scrutiny.

"NBS can't say, 'Without this we can't beat the Russians to the moon' like NASA can," one industry spokesman said, "Although, in fact, something of the sort may be true."

One instance that clearly points up this situation was cited by Charles White, publicity chairman of NCSL and a standards manager at Avco Corp., Wilmington, Mass. West Coast companies were spending millions of dollars making repeated thrust measurements for rocket engines. Because the tests were not very accurate, they had to be duplicated again and again, in order to develop a reasonable degree of repeatability. Finally NBS received authorization to build a million-pound standard dead-weight tester at a cost of $1.5 million—about as much as four inaccurate tests would have cost.

The practice of giving NBS annual allocations, instead of long-term contracts, is another vexing question, according to Bruno Weinschel, president of Weinschel Engineering Co., Gaithersburg, Md. NBS gets military or Advanced Research Projects Agency funds on a year-to-year basis.

"The Bureau cannot attract additional top level men on such a basis. They need five-year funding so that they can plan properly," Weinschel said.

He and other metrologists hope that the new NCSL survey will provide the nudge needed to improve the Bureau's financing.

Most trimming of the NBS budget in the past few years has been done by the House Appropriations Committee. The Subcommittee on State, Justice and Commerce, headed by Rep. John J. Rooney (D-N.Y.) has handled the hearings. The Senate has been more liberal in its treatment, and the final budgets shown in the table were reached generally through House-Senate compromises.

Complaints form pattern

All these factors do not satisfy industry critics. A sampling of opinion at instrument companies and standards laboratories around the country elicited the following comments:

- "NBS is not calibrating certain instruments we can build. As a result, we are stymied in our development of better instruments."
- "The Bureau does not have the capability to measure instruments to the precision we require."
- "There aren't enough skilled people at the Bureau. NBS can not attract the new, young blood needed for creative, imaginative, dynamic leadership."
- "The Bureau is too much concerned with routine low-level calibration. It competes with, and takes business away from, commercial calibration laboratories. It should direct its activities, instead, toward defining and researching tomorrow's standards, so they can be available when needed."

A definite pattern emerged from ED's survey of the standards field. The loudest and most bitter complaints emanated from instrument manufacturers. The reasons for their strong feelings are fairly obvious: more instruments with higher accuracy claims mean more sales.

In one specific case an instrument maker says he can produce an ac instrument with errors within 0.01% over a wide frequency range. Yet the best certification he can get from NBS is 0.01% up to 20 kHz and 0.05% from there to 1 MHz.

A member of the Bureau's Instrument Calibration Group at Boulder replied to this, explaining NBS' policy on such standards.

"Sure we would like to have better accuracy. But we here at NBS have found absolutely no need for accuracies better than this (what is now available) anywhere in the field. Now, just because one company makes an instrument that has a certain stability, is not a good enough reason to sink a lot of good taxpayer's money into something that will give him better accuracy than is needed by everyone else." If there were a demand for greater accuracies, he added, the Bureau would definitely try to improve its service.

New developments in works

One particular complaint brought to light two new developments, which the Bureau will be announcing shortly. An instrument maker charged that NBS had stymied his development of a low-frequency (up to 100 kHz) differential voltmeter, with specifications of about 0.05%. He said that he felt he could improve on this, but with the Bureau limited to about 0.01% he did not consider that there was enough margin.

It was revealed that the Bureau has developed a ratio transformer, actually a high-frequency inductance

NBS operating budget, 1963-1967

Fiscal year	Budget request (millions of $)	Funds granted (millions of $)
1963	30.8	28.3
1964	33.2	28.7
1965	35.8	30.8
1966	31.7*	28.7
1967	31.9**	——

* Adjusted to take into account the removal of the Central Radio Propagation Laboratory at Boulder from NBS.
** Budget now under consideration; CRPL again excluded.

in stock...in quantity 6x8 monolithic diode matrices

Exclusive dielectrically isolated circuits and fusing techniques provide unlimited matrix designs

Radiation's highly flexible 6 x 8 matrix is available for immediate shipment in quantity. These circuits contain 48 active devices per chip. A fusible link in series with each diode permits unlimited matrix patterns to be formed. In addition, matrices can be combined to provide an infinite variety of matrix sizes and configurations—6 x 8, 6 x 16, 12 x 8, 12 x 16 . . . $n_1 \times n_2$!

In addition to *flexibility,* Radiation matrices provide other important benefits: *System reliability* is increased by monolithic construction. *Space requirements* and weight are slashed through use of fewer packages. And, assembly of discrete diodes is eliminated.

Only Radiation supplies monolithic diode matrices. Write or phone for our detailed data sheets which include worst-case limits and all information required by design engineers. Radiation Incorporated, Physical Electronics, Department ED-05, Melbourne, Florida 32901. Phone: (305) 723-1511, extension 554.

flexibility, reliability size & weight

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RADIATION INCORPORATED

Radiation RM-30 Diode Matrix*

CHARACTERISTIC	TYP LIMITS	TEST CONDITIONS
Forward drop		($T_A = +25°C$)
$V_F(20)$	1.0 v	$I_F = 20$ ma
$V_F(1)$	0.7 v	$I_F = 1$ ma
Reverse breakdown BV_R	60 v	$I_R = 100\ \mu a$
Reverse current I_R	7 na	$V_R = 25$ v
Reverse recovery t_{rr}	7 nsec	$I_F = 10$ ma to $I_R = 10$ ma Recover to 1 ma
Crosspoint capacitance C_{cp}	1.9 pf	$V_R = 5$ v, f = 1 Mc
Coupling coefficient I_{CL}	20 na	

*Supplied in TO-84 packages.

Sales offices: Suite 622, 650 North Sepulveda Blvd., El Segundo, Calif. (213) 772-6371—Suite 438, 600 Old Country Road, Garden City, N. Y. (516) 747-3730—P.O. Box 37, Melbourne, Florida (305) 723-1511.

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ON READER-SERVICE CARD CIRCLE 9

(standards, ***continued*****)**

voltage divider with a 2:1 ratio, that will cover the range from 10 kHz to more than 1 MHz. Ratio error will be less than one-tenth of 1 ppm —far better than 0.01%. Similarly, below 30 kHz, a new standard will be announced at the Standards Conference in Boulder in June.

Another problem is that many manufacturers do not seem to realize that they can call the Bureau and try to arrange for calibrations not specifically offered, Robert Huntoon, Director of the Bureau's Institute for Basic Standards, explained. Present capabilities are listed in NBS Technical Note 262* but the Bureau can make arrangements for services beyond these.

This publication is part of another important effort made by NBS and industry since publication of the AIA report. The aim is to inform those who need to know of what is actually available.

NBS spokesman gave the bureau's response to two other points of criticism:

- "We are trying to concentrate on laboratory-type standards. But we are not taking the position that we are an ivory tower and that we will not do other things, if the measurements system needs it and it does not have the capability."
- "The decision to move the Boulder wing to Washington was one of pure economics. Nowhere else in our organization do we have duplicate services. We knew we would lose some good people through the move, but we have good people here in Washington too."

The concensus among metrologists seems to be that the ills will not be cured without a good dose of extra funding. Already Johnson of Boeing is considering extending the survey to standards users outside NCSL in order to obtain even better information on which to base NBS budget demands. Of a total of 128 requests for specific services in the present survey, only five included dollar estimates of the cost of being without services currently. The NCSL group will now analyze the data that they have on hand and clarify any questions that arise. ■ ■

*NBS Technical Note 262, is available from the Superintendent of Documents, Government Printing Office, Wash., D.C. at $1.

Fewer dramatics, more uses forecast for lasers

Townes predicts $1-billion laser market by 1970. New scanner for possible TV use described.

Ralph Dobriner
West Coast Editor

Practical applications and new innovations, rather than dramatic breakthroughs, were foreseen for lasers at the recent Quantum Electronics Conference in Phoenix, Ariz.

Dr. Charles Townes, discoverer of the laser phenomenon and provost of Massachusetts Institute of Technology, said: "We can now expect a slowdown in the completely new and very striking laser developments."

The Nobel Prize winner predicted, instead, increased turnout of practical commercial devices during the next five years, along with stepped up efforts to make lasers more economical and competitive. An example, outlined at the conference, was a scheme to use sonic signals for horizontal deflection of a laser-TV beam.

$1-billion market by 1970

In pointing to the laser's already considerable impact on the commercial market, Townes cited a survey which forecasts a $1-billion market by 1970—a not unreasonable estimate, he said.

The report estimated that $150 million would be spent on laser development this year, compared with $100 million spent in 1965.

Townes noted that, as a new tool and technique, the laser is affecting not only the commercial market but also is having a growing impact on more and more scientific fields. "However," he said, "we have nowhere approached the benefits of the laser from a scientific point of view—using it as a powerful and precise experimental technique—but we'll see that developing over the next decade."

To underscore Townes' observations, of the more than 200 technical papers presented at the symposium—covering all facets of the expanding quantum electronics field—none described any striking breakthrough.

Unusual laser applications and new techniques were more plentiful than at recent laser conferences. Papers that evoked considerable interest included:

- A method for producing a scanned beam of light from a laser, bringing closer the day of the laser-TV display.
- A laser Doppler velocimeter for measuring the flow of gases and liquids.
- Experiments on the use of lasers for precise determination of satellite orbits.
- Application of negative feedback in a Q-switched laser to achieve greater power output.
- A current transformer, designed for extremely high-voltage transmission lines, which uses a laser beam as the transmission medium.

Laser TV imminent?

In the design of a laser-TV projection system one of the most difficult problems is the choice of a horizontal scanning device. The requirements are that it produce a linear light source with a small retrace time and that it be capable of operating at 15 kHz with a resolution of about 500 spot diameters.

Several methods have been proposed, such as electro-optic devices, moving mirrors and more recently a fiber optics scan converter.

A technique for producing a scanned beam of light from inside the laser cavity was reported by E. S. Kohn and V. J. Fowler of General Telephone and Electronics Labs, Bayside, N. Y.

In essence, scanning is accomplished by transmitting sonic pulses down an optical delay line situated within a special four-mirror He-Ne laser cavity. The four mirrors are arranged to form a Z-shaped beam.

The components of the system are shown disassembled in Fig. 1, where (1) is the laser-discharge tube covered by a cloth. Light, diffracted by sonic pulses traveling through the quartz delay line (2), is reflected by an oblique apertured mirror (3). This reflected beam strikes a projection mirror (4), and is projected through a polarizer (5) and projection lens (6) on to a photomultiplier (7).

Using a 10-MHz Corning delay line in a one-inch collimated beam, the laboratory system has produced

1. **Laser scanning system** developed at General Telephone and Electronics Corp. uses sonic pulses for scanning.

(laser, ***continued*****)**

about 15 resolvable spot positions so far. The peak power in the scanning beam was 4 mW.

According to the scientists, the speed and linearity of the swept beam obtained from this system makes it very attractive for use as the horizontal scanner in a TV display. In this application, cylindrical optics would be used to collapse the moving line of light to form a scanning spot. The spot could then be scanned in the vertical direction by an electro-optic or vibrating mirror deflector.

Laser measures rate of flow

Development of a laser Doppler velocimeter for measuring localized flow velocities in gases and liquids was reported by J. W. Foreman, et al., of Brown Engineering Research Labs., Huntsville, Ala.

Velocity measurements are made by detection of the Doppler shift in monochromatic laser light which is scattered from small contaminant particles in the fluid. A continuous-wave gas laser serves as the light source, and the Doppler shift is detected by optical heterodyne techniques.

Gas flow velocities from 1 cm/s up to approximately 200 m/s have been measured and, according to the authors, experiments are currently under way to extend the measurements to supersonic velocities.

Advantages of the laser Doppler velocimeter over conventional devices for flow velocity measurement is that it is unnecessary to place any sensors directly in the flow field, since all the required information is transmitted by light beams. The flow pattern is therefore undisturbed by the measurement.

It is also possible to use the velocimeter to measure three non-coplanar components of the velocity vector simultaneously, thereby completely determining the magnitude and direction of the velocity vector at a given point in the flow field.

The authors said that the shape of the scattering volume from which appreciable optical heterodyning is obtained (with their optical arrangement) is roughly cylindrical, with a radius of about 4 μm and a length on the order of 100 μm.

Satellites tracked by laser

Experiments on the use of lasers to supplement the present worldwide camera network in obtaining precise satellite orbits were reported by P. H. Anderson, et al., of the Smithsonian Astrophysical Observatory, Cambridge, Mass., and General Electric Co., King of Prussia, Pa.

A pulsed-ruby laser and photoelectric receiver located at an observing station in Organ Pass, N. M., was used to track three satellites (Explorer XXII, Explorer XXVII and GEOS A) equipped with retroreflectors.

A camera was used to photograph a point image of Explorer XXII when illuminated from earth with a non-Q-switched laser pulse. The photoelectric receiver—consisting of a searchlight reflector and RCA 7265 photomultiplier tube—detected the return pulse when the laser was operated in either the Q-switched or non-Q-switched mode.

Range determinations were made to an accuracy of ± 15 meters. Range accuracy was limited mainly by the counter accuracy. More accurate counters are planned for future systems.

More power through feedback

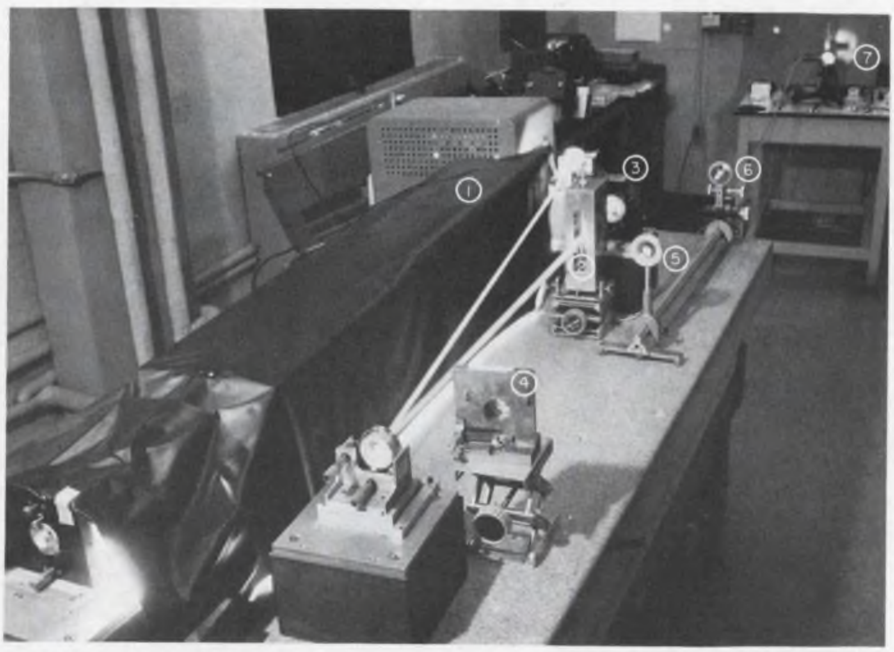
Increased average output power from a laser can be achieved either by increasing the pulse amplitude or by lengthening pulse duration.

Choosing the latter approach, G. Price and C. H. Thomas of Edgerton, Germeshausen and Grier, Inc., Goleta, Calif., reported on a feedback technique in which the time duration of light emission from a Q-switched ruby laser was increased from 30 ns to 5μs, a factor of 1000.

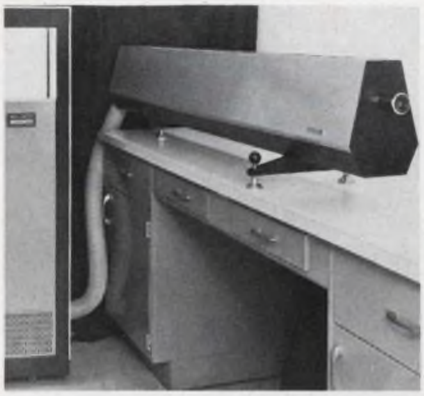
The configuration of the experimental feedback-controlled laser system is similar to a conventional Kerr-cell Q-switched laser normally used to generate giant light pulses. In Q-switching, pulse emission is prevented until a high excitation level is reached in the laser crystal. The main difference in the new configuration is that a beam-splitter is inserted between one end of the ruby rod and a Glan prism. A portion of the laser light within the optical cavity (the space between the end mirrors) is deflected by the beam-splitter into a photodiode.

The photodiode output is fed back to a specially designed low-voltage Kerr cell which also functions as the Q-switch for the laser emission.

The control of the Q-switch action, in proportion to the sampled laser emission, tends to stabilize the emission at some point of equilibrium in a manner analogous to a negative feedback loop. The Kerr cell is biased to an operating point where a relatively small alternating control voltage effects a 100% transmission change.



2. **Molecular laser** displayed by Perkin-Elmer produces a minimum of 10 watts of continuous, coherent infrared light.



3. **Commercially available CO_2 laser system** displayed by Korad Corp. reportedly provides a 75-watt output at 10% efficiency.

The primary goal of developing a laser system capable of emitting a "flat-top" 20-kW pulse for a period of 5 to 10 μs was only partially achieved. Though control has been effected, optimum "flat-top" pulses were not obtained. This was due to AM modulation of the emitted light pulses by a high-frequency (30 MHz) instability.

The scientists reported, however, that by refining the feedback control technique and by use of high-powered laser systems, "flat-topped" output pulses of 10 μs should be possible. Such a device, they said, would be extremely useful for short-time telemetry and plasma diagnostics.

Transformer employs laser

Current transformers used on extremely high voltage (EHV) power-transmission lines are cumbersome and difficult to construct because their primary and secondary windings must be heavily insulated against the EHV.

Development of a current transformer which employs a laser beam to transduce the magnetic field around an EHV transmission line was reported by S. Saito, et al., of the University of Tokyo and the Tokyo Electric Power Co.

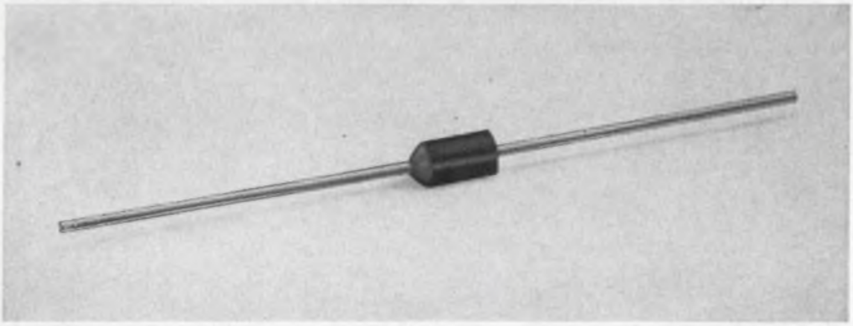
The device, which uses the laser beam as the transmission medium and an optical Faraday rotator of heavy glass flint as the current transducer, has been recently used to transduce the 50- or 60-Hz magnetic field formed around a 1000-amp transmission line.

According to the scientists, the transformer is compact and costs less than conventional types now in use. ■ ■

DESIGNER'S

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

Molded Zener Diodes give high reliability at low prices



The Mallory Type ZA zeners are molded units which give performance and reliability equal to that required by military specifications—at about half the price of hermetically sealed zeners.

One reason for this unusual quality is that Mallory uses the same silicon cell in the Type ZA as in the zener diodes we make for military requirements. Another is the unique Mallory production technique, in which complete classification, screening and pre-testing can be done on silicon cells before packaging. And finally, there's the economy of the molded case—moisture-proof, electrically cold, and so compact that high-density circuit packages are readily accommodated.

The 1-watt Type ZA and 3-watt Type ZAC are available in zener ratings from 6.8 to 200 volts. Hermetically sealed and high wattage ratings are also available.

CIRCLE 240 ON READER SERVICE CARD

Wire-Wound Controls with special Temperature Coefficients

When exceptional stability of resistance is needed over the normal operating temperature range, Mallory can supply custom-made wire-wound controls with special values of temperature coefficient. Selected types of resistance wire are used for the winding.

The minimum TC available is 20 parts per million per degree C . . . also stated as .002% or ±.00002 ohm/ohm/°C. All styles of Mallory wire-wound controls—2, 3, 4, 5, 7 and 12½ watts—can be supplied with special TC.

CIRCLE 241 ON READER SERVICE CARD

New Hermetic Seal Tantalum Capacitors—Style CL55 of MIL-C-3965C

The new Mallory Type TL wet slug tantalum capacitor is a compact rectangular package designed for ability to withstand extreme environmental conditions. It has glass-to-metal terminal seals in a hermetic sealed outer case. Microfarad-volt ratings per unit volume are exceptionally high for this class of construction.

The TL offers the superior performance which is characteristic of Mallory wet slug capacitors. It has exceptional stability of capacitance and power factor, both over a broad temperature range from −55°C to +125°C, and throughout extended operating life and shelf tests. DC leakage is low; maximum values at top mfd-volt ratings are in the order of 10 microamps, with actual test values typically around 1 to 2 microamps.

Ratings available: 2400 mfd, 15 volts to 180 mfd, 150 volts. Temperature rating: −55°C to +125°C. The TL is designed to meet performance criteria of style CL55, per MIL-C-3965C and MIL-C-3965/21B.

CIRCLE 242 ON READER SERVICE CARD

FILE

MALLORY

50th ANNIVERSARY

No voltage de-rating needed on MTP wet slug tantalum capacitors

Many designers add their own "safety factor" by specifying a considerably higher voltage rating than actually needed for surge or steady state conditions in the circuit. With Mallory MTP miniature wet slug tantalum capacitors, you don't need to de-rate. And you can often save space and money by *not* de-rating.

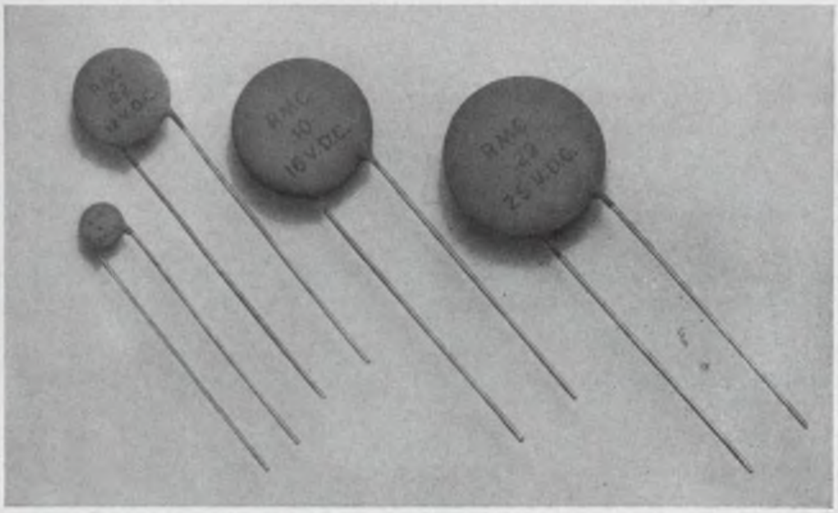
How come? In the first place, we've already built in a generous safety factor in the stated rating on the capacitor. And second, we've found out by tests that operating at reduced voltage neither improves nor impairs performance of the MTP. We have extensive data in a recent engineering report, which we'll be glad to send on request.

As an example of the size savings possible, a 33 mfd, 60 volt MTP measures .225″ in diameter by .775″ long. But the same 33 mfd at *50* volts fits into the next smaller case size: .145″ in diameter by .590″ long. And the cost is about 13% lower.

The MTP, incidentally, has the most capacity per unit size of any tantalum capacitor—up to 178,000 mfd-volts/cubic inch, or about five times what you can get in any solid electrolyte type. And it's made in the same high-reliability facility as similar Mallory capacitors for Minuteman II.

CIRCLE 243 ON READER SERVICE CARD

High capacity ceramic capacitors save space in transistor circuits



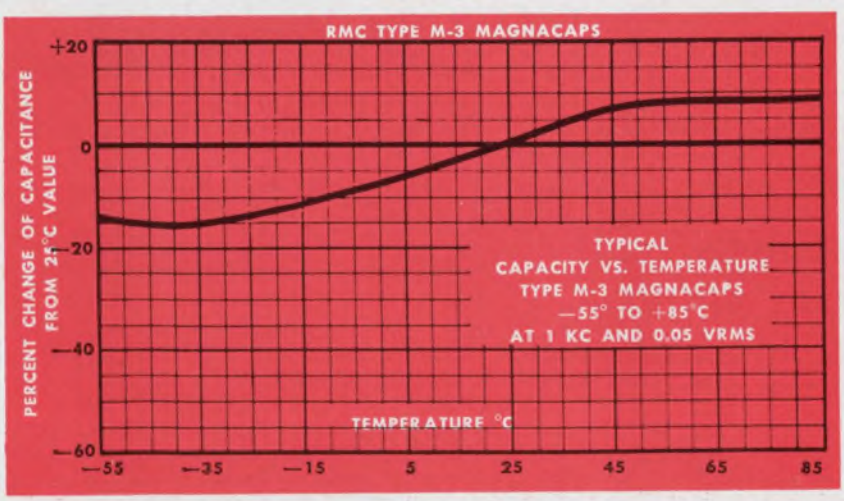
Whenever you need a lot of microfarads in a small space at transistor circuit voltages, use Magnacap® disc ceramic capacitors. Made by Radio Materials Company, a division of Mallory, Magnacaps are particularly applicable to by-pass and coupling in low impedance transistor circuits.

Because they maintain their impedance characteristics well into the radio frequency range, they are especially useful as emitter by-passes. They fill the range of capacitance values between standard RMC Discap® Capacitors and Mallory aluminum or tantalum electrolytics.

Insulation resistance is amply high to assure excellent operation in battery powered equipment. Magnacaps have outstanding stability of capacitance from −55°C to +85°C. They have a proven record of reliability, and are economically priced.

3, 12, 16 and 25 volt ratings are available. Maximum capacities: 2.2 mfd @ 3 volts; 1.0 mfd @ 12 volts; .22 mfd @ 16 volts and 25 volts.

CIRCLE 245 ON READER SERVICE CARD



Saw cuts IC wafers without touching them

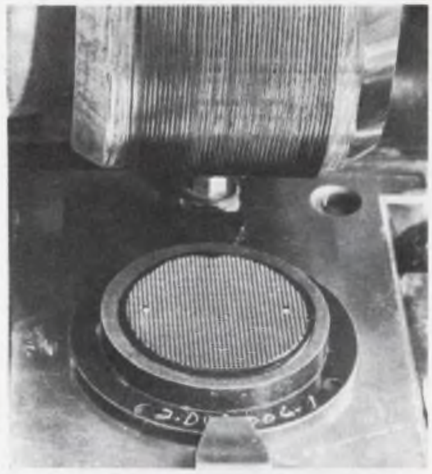
A high-speed dicing saw that cuts semiconductor wafers into over 1000 chips without touching the wafer has been unveiled by IBM.

The circular saw, which contains 40 stainless steel blades that spin at 12,700 rpm, works with an abrasive silicon carbide solution called slurry. The actual cutting is done by the slurry, which is thrown off by the spinning blades. In this way, the saw makes 40 parallel, 0.004-inch-wide cuts on a wafer without ever touching its surface.

For dicing, a wafer is first aligned in the saw housing, then locked into place. After being cut in one direction, it is automatically rotated 90 degrees and cut perpendicularly. The result of dicing, which takes 90 seconds for each wafer, is more than 1000 individual chips.

During dicing, the wafer is held in place on a phenolic base by a soluble glue. After cutting, the glue is dissolved and the chips are cleaned.

The saw is presently being used in the manufacture of Solid Logic Technology (SLT) modules for IBM's System/360 computers. In January IBM announced that production of the SLT modules had reached the 54-million mark, with 10 million produced in December, 1965, alone. ■ ■



High-speed rotary saw dices wafers into over 1000 chips in 90 seconds.

Computers tailored to individual needs

Like a hi-fi enthusiast, who shops around for different components and then blends them all into one superior system, a laboratory in Fairlawn, N. J., will build you a custom computer system by using off-the-shelf units.

The work is being done by specialists at Western Union's Information Systems Computer Laboratory.

The laboratory is equipped to link computers made by various manufacturers with peripheral equipment and communications circuits, and then provide full programing and evaluation testing prior to their delivery to customers.

Programing work is now under way on computerized information systems for such customers as the 3M Company, Blue Cross Association, U.S. Department of Defense and the National Aeronautics and Space Administration. A major project recently completed was the design and implementation of an electronic, computer-operated communications system for Dun & Bradstreet.

Nine computer systems are presently being programed and tested at Western Union's laboratory: five Univac 418's, two CDC 8090's, one Honeywell H-200 and one SDS 930. ■ ■

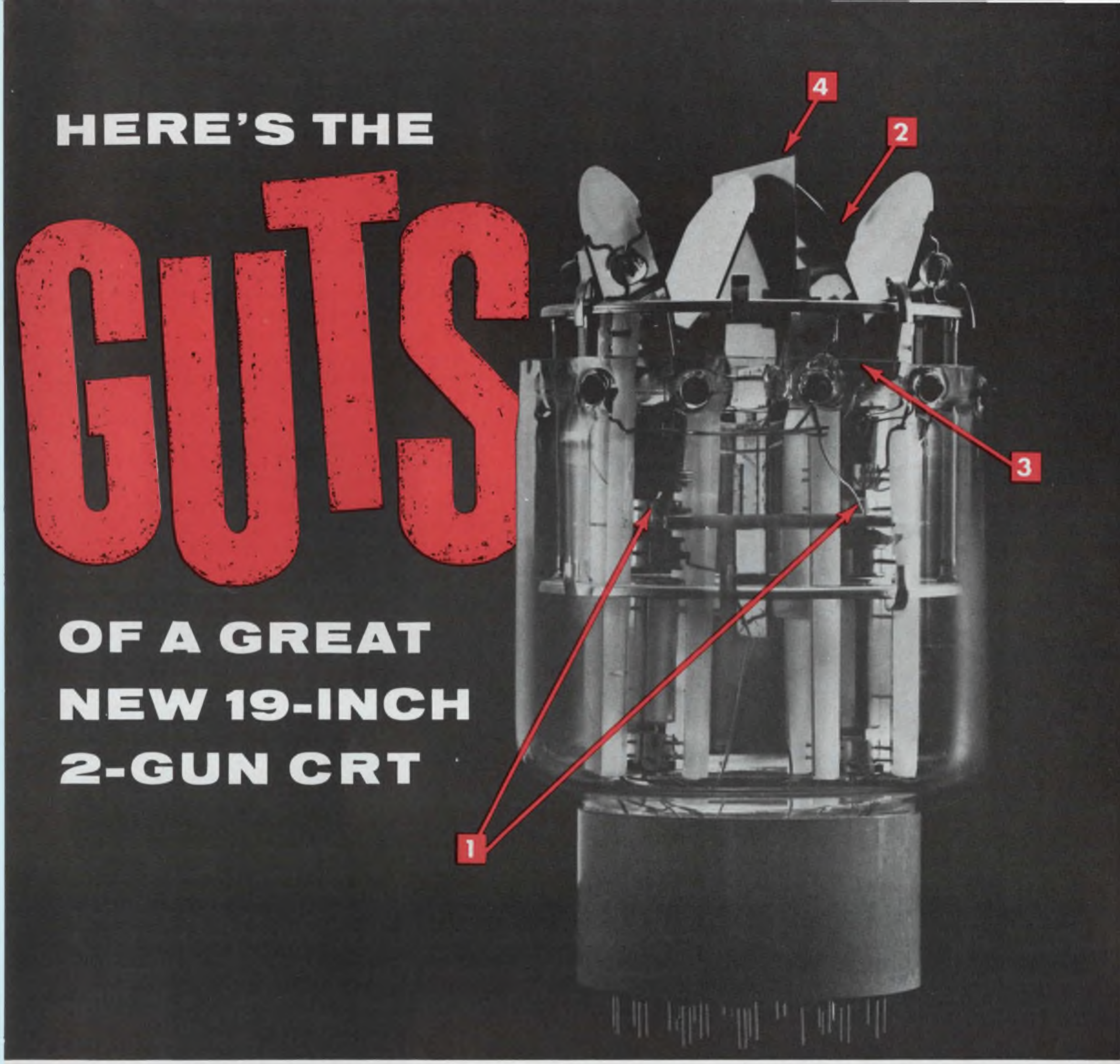
Engineers debugging a component of an on-line computer system under actual operating conditions at Western Union's computer research laboratory.

Strain-gauge used in phono cartridge

The piezoresistance principle has been applied to phonograph cartridges of a type designed to compete with ceramic types.

The units, developed by Sonotone Corp., which also produces ceramic types, uses a silicon-chip piezoresistive element. Fed with a bias current of 15 mA, the cartridge will reportedly deliver 300 mV rms. Frequency response is concentrated toward the low frequencies, as would be expected with a strain gauge. Typical power output approaches 1 mW, which would require about 30 dB power gain to deliver 1 watt peak audio power.

The company expects to offer considerable circuit economies and competitive pricing to potential users of the units, which will be available in both stereo and monaural models. ■ ■



(only DuMont would have the intestinal fortitude to build it!)

This is the electromechanics of DuMont's new Type KC2572, dual-gun CRT.

Instead of showing a dramatic trace, we're showing what's *responsible* for the dramatic trace.

The KC2572 has two guns **1** It can be used as a ground-radar display to track two targets, or as an information display where one gun makes a video presentation and the other writes alpha numerics, or special symbols.

The electrostatic deflection structure **2** employs a new and improved construction (proprietary with us) which maintains pattern geometry and high tracking accuracy—*simultaneously*. The spot from one gun may be registered over the other *anywhere* on the 17-inch useful screen diameter with the distance between the two spots *never exceeding 0.125 inches!*

The guns, the deflection structure and internal feedback electrodes **3** are designed to operate together to correct both focus and astigmatism. No external stabilization or guidance are required!

The specially-designed shield between the two deflection structures **4** controls field configuration and helps keep interstructure interaction to a minimum—the spot of one gun may be varied 17 inches in either direction, and the movement of the other spot will not exceed 0.019 inches!

The KC2572 also employs electrostatic focusing, has a spot size of 0.12 inches, and resolution is maintained over the entire face of the tube. An aluminized screen for greater light output and to stabilize screen potential is supplied, and the tube is ruggedized for severe environmental operation.

Like the 4000 other *standard* tubes in the DuMont line, the KC2572 represents a *courageous*, knowledgeable solution to a special display problem.

Chances are, one of them will solve yours. Just ask.

WORLD'S LEADING MANUFACTURER OF DISPLAY TUBES

FAIRCHILD

DUMONT ELECTRON TUBES

A DIVISION OF FAIRCHILD CAMERA AND INSTRUMENT CORPORATION

CLIFTON, N.J.

Jets power portable ground station

Gas-turbine jet engines will power a transportable U.S.-built ground station for communications satellites to be erected in Australia, where 50-Hz power is preferred to 60 Hz. Sylvania Electronic Systems was responsible for development of the station, which will be shipped "down-under" in mid-May. It will be the principal western terminal for NASA's Application Technology Satellite (ATS) program.

Jet engines are very sensitive to changes in load and, therefore, are excellent regulators, according to Tully Gibbon, ATS site supervisor.

Sylvania was directly responsible for the antenna and feed, the tracking receiver, the master control console, and the integration and testing of the complete station. "We have become night owls—most of the tests must be done at night to avoid interruption," said Windsor D. Wright, senior engineering specialist responsible for program management and performance evaluation.

The preamplifier was subcontracted to Airborne Instruments Laboratory. NASA supplied the transmitters.

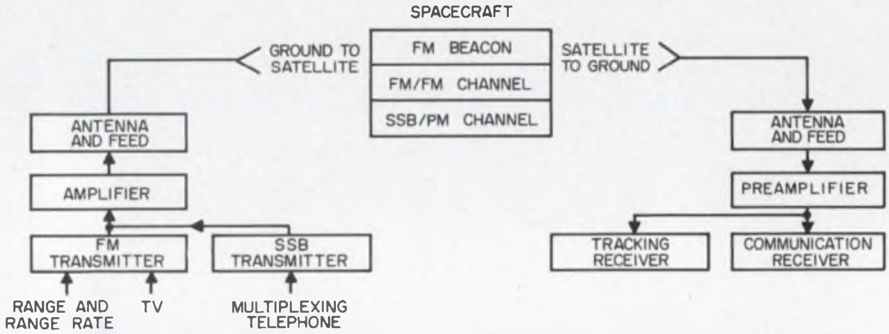
The high-power dual-frequency feed built by Sylvania is a low-noise, high-gain monopole type, capable of working with single-channel or three-channel receivers. The central element (see photo) is the receiver. It tracks the polarization of the received signal at 4.15 GHz. The four symmetrical elements transmit at 6.2 GHz. Because these Teflon parts must withstand power levels up to 20 kW cw, a cooling system is essential, Wright explained. Cool air from the cryogenically cooled preamplifier is blown at the Teflon elements through openings in the wave-guides leading up to the feed. A small "feed-dome" over this recirculates the air and protects the feed from adverse weather.

The 40-foot-diameter antenna dish, which has a beam width of 0.5°, needs no radome. It is designed to resist all weather conditions encountered in Australia.

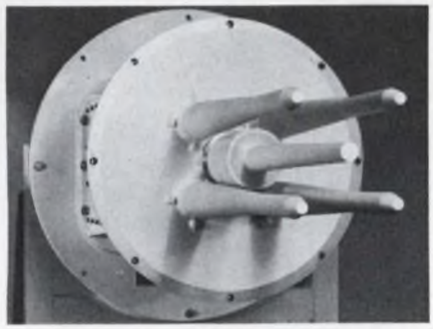
Both a traveling-wave maser and two parametric amplifiers are included in the cooled portion of the preamplifier package. The maser operates at 4.2°K, the parametric amplifiers at 10°K.

The design makes it possible to compare the performances of the maser and the parametric amplifiers by allowing either to be used as the low-noise element in the receiver.

In either mode the bandwidth of operation is around 150 MHz at 4.12 GHz. The gain is about 30 dB. The noise temperature with the maser is about 10°K; with the parametric amplifiers, about 28°K. ■ ■



1. **It takes three months** to set up this transportable ground station for communication satellites. Under the aegis of Sylvania, the system should be operational by mid-December, the launching time for NASA's ATS/B, in Australia.



2. **Dual-frequency Teflon feed** receives at 4.12 GHz with the center element and transmits at 6.2 GHz with the four symmetrical elements.

3-D TV? Wait 50 years, says expert

Formidable technical obstacles make three-dimensional television "something for the next century," says the father of basic holography. He is Dr. Dennis Gabor, the British physicist who worked out his holographic principles more than 20 years ago.

Dr. Gabor made his gloomy prediction for 3-D TV on the grounds that present RF bands simply cannot carry enough information. His remarks were contained in a recent lecture at NASA's Electronic Research Center in Cambridge, Mass.

NASA wants to photograph the moon and planets by holographic methods to increase its knowledge of the topography and minimize risks to astronauts. Dr. Winston Kock, director of the Research Center, would like to exploit the properties of the hologram in space photogrammetry. While he conceded that no definite method for accomplishing this had yet been elaborated, he pointed out the value of lunar or planetary photographs that would permit the viewer to look around and beyond objects. But the present impracticality of televising three-dimensional signals back to earth from space rules out serious consideration of the uses of remote TV holography.

In discussing the center's plans, Dr. Kock said that if he were able—"and that's a big if"—to get a hologram picture of the moon or Mars, he could obtain much more data about surface conditions than is afforded by ordinary photography. ■ ■

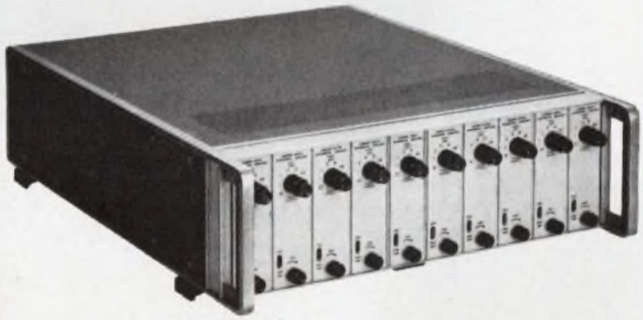
NEW wideband DC data amplifier for $495

including integral power supply

★ SOLID-STATE ★ DC — 75 KC
★ GAIN OF 1000 ★ NO CHOPPER

Precisely measure thermocouple, strain gage and similar low level dc outputs with this high performance new Model 8875A Data Amplifier. Use it with modern data acquisition systems employing analog-to-digital converters, digital printers, magnetic data recorders, oscillographs, digital voltmeters, and other readout instrumentation. The new 8875A is a solid-state wideband dc amplifier with an output of ±10 v, 100 ma and features dc — 75 kc bandwidth, 1000x amplification, ± 0.1% gain accuracy, ± 0.01% gain stability, and 120 db common mode rejection — *at $495 including power supply.*

This new Sanborn amplifier measures just 4-3/4" high by 1-9/16" wide by 15" deep, weighs 3.5 lbs., including integral power supply. For multi-channel use, ten units can be mounted in a 5" x 19" modular cabinet which contains input and output connections, power cable, on-off switch, cooling, fuse, and mating connectors for ten amplifiers. These modules can be stacked, or equipped with tilt stands for bench-top use. When used individually, the completely enclosed amplifier requires no cooling.



SPECIFICATIONS

Bandwidth:	dc to 75 kc within 3 db.
Gain:	from 1 to 1000 in seven fixed steps
Gain Accuracy:	±0.1%.
Gain Stability:	±0.01%.
Vernier Gain:	continuously adjustable between fixed steps.
Gain Trim:	±3% with sufficient resolution for setting any one gain to ±0.01%.
Common Mode Rejection:	120 db from dc to 60 cps, 40v p-p tolerance.
Output Circuit:	±10 volts across 100 ohms and 0.2 ohms max. output impedance at dc.
Drift:	±3 μv referred to input, ±0.2 mv referred to output.
Non-Linearity:	Less than 0.01% full scale value, 10 volts.
Overload Recovery Time:	recovers to within 10 μv R.T.I. +10 mv R.T.O. in 10 msec. for 10 v overload.
Power:	115/230 volts ±10%, 50-400 cps, 6 watts.
Available options:	Switch-selected filtering, dual output (±10v, ±10ma; ±10v, ±100ma; a short on one output has negligible effect on the other output).

For complete specifications and application assistance, call your local HP/Sanborn field engineering office, or write: Sanborn Division, Hewlett-Packard Company, 175 Wyman Street, Waltham, Mass. 02154.

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ONLY 3C OFFERS . . .

NEW MODULES, HARDWARE, ACCESSORIES ADDED TO THE EXTENSIVE I/C μ-PAC DIGITAL LOGIC MODULE LINE

New Model BT-332 TILT DRAWER BLOC houses 240 μ-PACS™ in only 5½" of rack panel height — pulls out, tilts down for PAC access, up to expose wire wrap terminals. Detents hold the BT-332 in any position from . . . horizontal to full vertical for convenient PAC replacement, testing, wiring, or system assembly. To further facilitate system fabrication, new mounting panels are available to adapt standard μ-PAC hardware for 19" . . . rack installation. In addition, 3C offers custom system assembly and wiring capability for the special purpose system builder or volume manufacturer using μ-PACS.

LD-331 HIGH-DRIVE LAMP DRIVER PAC contains 8 independent microelectronic lamp-driver circuits with discrete output transistors. Each driver is capable of switching up to 300 ma at 35 volts from standard μ-PAC signals.

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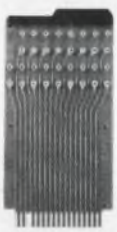
PN-335 NON-INVERTING POWER AMPLIFIER PAC contains 6 three-input AND gates. Each gate contains two inverting amplifiers in series which provide the non-inverted output. Electrically common outputs and built in short circuit protection are standard features.

SR-335 SHIFT REGISTER PAC contains 8 prewired integrated circuit shift register stages. Up to 16 custom assembled stages can be supplied to meet customer design requirements.



TP-330 TEST POINT PAC provides convenient system trouble shooting capability without wire side probing for observation of waveform characteristics. Isolated test points for 34 PAC fingers are furnished.

AS-330 COPPER CLAD BLANK PAC kit provides a basic μ-PAC card with 5.5 sq. in of copper plate on each side for custom etching of interconnections. PAC handle and fastener are included.

μ-PACS feature 5 mc operation, high packaging density, low cost per logic function, inherent reliability, low power consumption, and noise protection in excess of one volt utilizing NAND logic with DC coupled circuitry.

Write for complete catalog of μ-PAC monolithic integrated circuit digital logic modules, power supplies, hardware, and system design and fabrication accessories.

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ON READER-SERVICE CARD CIRCLE 11

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World Wide Photo

Washington Report

S. DAVID PURSGLOVE,
WASHNGTION EDITOR

Electronics has major role in auto safety

Commerce Department officials take it for granted that a "tough" automobile-safety law will soon be in force and are now laying the groundwork for enforcement of several provisions that will heavily involve electronics. Sen. Warren G. Magnuson, the Washington Democrat who heads the Senate Commerce Committee, completed hearings on the traffic safety act in April and has been holding executive sessions to draft the committee bill, which he says, may "be expected any day." Magnuson and many committee members did not like the Administration bill, which would have merely permitted the Secretary of Commerce to act on its provisions as he sees fit. The Senate is expected to put more teeth in the bill by making its provisions mandatory.

In anticipation of this strong bill, the Department has already spelled out an order of priorities for tackling the auto-safety problem. First priority will be to set standards. A start in this direction has been made under a 1965 Law that encourages each state to set up a highway safety program based on uniform standards approved by the Secretary. Standards that the new Law is expected to make compulsory will cover vehicle equipment and performance, and the method of registering and inspecting them; traffic engineering; traffic control; surveillance to detect and correct potentially hazardous traffic conditions; highway design and maintenance; accident records systems; driver education, examining and licensing; emergency communications and medical services; laws, courts and police.

A Department spokesman said first action would be taken to obtain uniformity of traffic control devices and road rules, signs and markings.

The electronic industry has watched the progress of the new legislation closely for nearly a year (ED, Dec. 20, 1965, p. 23 and Feb. 15, 1966, p. 32). It is already playing a growing role in systems for intersection-signal and freeway-access control, city-wide traffic monitoring, police communications, driver teaching and testing. In the longer term, electronics should be the backbone of possible roadside and car-mounted warning systems, speed governors, fore and aft scanners, automatic steering and distress signals.

Lowell K. Bridwell, Deputy Undersecretary of Commerce for Transportation, says there is an important role in auto safety for R&D, largely conducted by private industry, perhaps with Federal funds. He pointed out that, although the Government is deeply involved in safety R&D and likely to remain so, "we have no intention of usurping this task from private industry." He observed that many firms associated with transportation are small business that cannot pay for the kind of talent and "sophisticated equipment required for this kind of analysis and exploration."

He sees the Commerce Department—or a new Department of Transportation, in which he would probably be Number Two man—as a distributor of data to these firms. The companies should flourish since, in Bridwell's words, "The Commerce Department has stated repeatedly that a greatly expanded program of research and development will be required, and the ultimate refinement of these standards may have to wait for these research findings."

P.O. may have more to spend on electronics

Talk of a $100 million-a-year Post Office research and engineering budget for automation and computerization sounds more plausible in the wake of the opening round of Congressional hearings aimed, in part, at making that budget a reality. The Fiscal 1967 Post Office research and engineering budget is $16 million; last year it was $12 million. Observers have talked of its hitting an annual $100 million in about five years. Chairman Arnold Olsen (D-Mont.) of the House Subcommittee on Postal Facilities and Modernization believes this will be necessary if the Post Office is not to lose the battle of the "mail explosion." The Post Office handled 72 billion pieces of mail last year, will handle 76 billion next year (double what it was handling at the end of World War II), and expects to handle 90 billion pieces in 1970.

Olsen has called the hearings ostensibly to consider his bill (H.R. 13822) to create an additional Assistant Postmaster General to head up a new Bureau of Research, Development and Engineering. But by Olsen's own admission, the hearings are primarily, in fact, a review of what the P.O. has done—and has not done—in R&D and engineering. Olsen and most other Congressmen with authority over Postal operations have been trying to have the P.O. request more money to beef up its largely electronic R&D efforts. The new Postmaster General, Lawrence F. O'Brien, has been receptive to Olsen's ideas and has privately indicated that "some old-fashioned skulls around this place" might be knocked together to make them more cooperative.

Olsen has pointed out that the Agriculture Department research allocation of $224.9 million is 3.2 per cent of the Department's total $6.99-billion budget, that R&D at the Commerce Department amounts to 6.4 per cent of its budget, that the Office of Economic Opportunity plans to devote 3.2 per cent of its budget to R&D, and that Pentagon R&D is 11.5 per cent of the total Defense-Department budget. The Post Office R&D budget of $16.1 million is less than 1/3 of one percent of the total P.O. budget. Should the P.O. increase its R&D budget to a sum comparable to that of other departments, it would be well over $100 million.

Most of such a budget would go into electronics, if past and present spending can be taken as a guide. It would pay for a gigantic centralized computer system, ZIP-code readers, letter sorters, stamp readers, a yet-to-be-designed automatic parcel-sorting and facing system, electronic address directory system (for which P.O. has just requested proposals from R&D firms), systems for mating electronic presorters with electronic cancelers, electronic mail-counting devices, and a new information-cataloging, storage and retrieval system for research and engineering data used in the proposed new Assistant PMG's department.

Sun sets on desalting

With the comment, "there is little opportunity to apply solar energy in the U.S.," a Government spokesman announced that the Office of Saline Water will phase out its solar power programs. "We are not disenchanted with solar devices or with the concept of solar distillation," he said, "it's just that we have completed our R&D programs on solar-still designs and don't see in the offing any good ideas that look like they would improve on present designs."

OSW has received many ideas for using solar energy for water desalination, but usually they involve investing even more capital to better utilize the heat. OSW's attitude is that they do not pay off for the few Btus' increase they achieve. But "'we have not closed the door on solar ideas," the spokesman said. OSW would give a sympathetic hearing to "a really new idea with potential for major improvement." However, there would have to be "substantial" saving over present costs.

Unsolicited research proposals from small R&D firms do get consideration by the Air Force. The Air Force reports that its Systems Command accepted and funded at a cost of $18.5 million almost 27 per cent of the 1189 technical proposals deemed worthy of technical evaluation that were received during the second half of 1965. AFSC states: "Many new firms, particularly small ones who would never have an opportunity to prove their worth otherwise, are able to establish their capabilities and qualifications through unsolicited proposals." An Air Force spokesman points out: "We don't care about the size of a firm; it's the competence of its people that interests us."

Comprehensive study of the lf component of the Fleet Broadcast System is being carried out for the Navy by Deco Electronics, Washington, D. C. At the same time, Deco will conduct a Navy investigation of propagation of extremely low-frequency waves.

Navy is seeking improved radar safety goggles to protect the wearer's eyes from microwave radiation in the 3-to-10-GHz spectrum. Negotiations with a company that has experience in the field are believed under way.

A new air-droppable electronic homing and command device is being sought by the Air Force Aeronautical Systems Division. It will have to be a highly portable receiver-decoder weighing less than 25 pounds and completely self-contained. Contract negotiations are said to be in progress.

Army Electronic Proving Ground is preparing a "Human Factors Checklist and Guidebook" for use by test engineers in planning engineering and service tests.

Army Engineers at Ft. Belvoir, Va., have asked selected R&D firms to carry out exploratory design study on electron optical systems that are either transparent or reflective, or both. The goal is to turn up completely new concepts in electron optics.

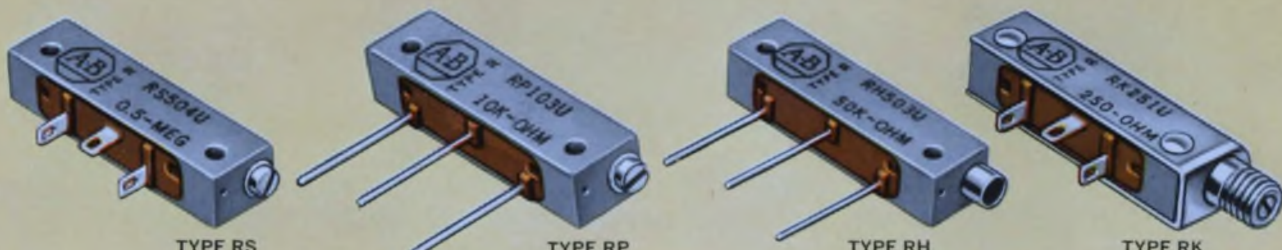
Here's your answer to shock and vibration problems

■ Allen-Bradley Type R adjustable fixed resistors are unexcelled for holding precise settings through extreme conditions of shock and vibration. This unusual ruggedness is the result of a manufacturing process—perfected and used only by Allen-Bradley—which hot molds the resistance and collector elements, terminals, and insulating material into an almost indestructible component. Thus, the controls can be mounted by their own rugged terminals *without* additional support.

The solid resistance track assures such smooth control that it approaches infinite resolution. Its smoothness cannot be compared with the abrupt wire-wound turn-to-turn resistance changes which may cause circuit transients. Since Type R controls are essentially non-inductive and have low distributed capacity, they can be applied in high frequency circuits where wire-wound controls are impractical. The Type R molded enclosures are both dustproof and watertight, permitting encapsulation after adjustment.

Allen-Bradley Type R controls are suitable for use from −55°C to +125°C and are rated ¼ watt at 70°C, 300 volts max. RMS. Available as standard in total resistance values from 100 ohms to 2.5 megohms with tolerances of ±10% or ±20%. As special, can be furnished down to 50 ohms. Technical Bulletin B5205 contains complete specifications. Please send for your copy today: Allen-Bradley Co., 222 W. Greenfield Ave., Milwaukee, Wisconsin 53204. In Canada: Allen-Bradley Canada Limited. Export Office: 630 Third Ave., New York, New York, U.S.A. 10017.

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



TYPE RS TYPE RP TYPE RH TYPE RK

ALLEN-BRADLEY
QUALITY ELECTRONIC COMPONENTS

"We have learned through bitter experience that **Allen-Bradley resistors are unmatched for reliability**"

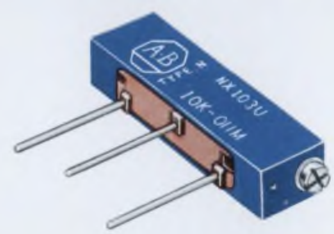
Philbrick Researches

Typical Philbrick solid state operational amplifiers. The Model P65A differential operational amplifier with cover removed shows the use of Allen-Bradley hot molded fixed resistors and an Allen-Bradley Type N adjustable fixed resistor for zero balance adjustment.

TYPE BB 1/8 WATT	MIL TYPE RC 05
TYPE CB 1/4 WATT	MIL TYPE RC 07
TYPE EB 1/2 WATT	MIL TYPE RC 20
TYPE GB 1 WATT	MIL TYPE RC 32
TYPE HB 2 WATTS	MIL TYPE RC 42

HOT MOLDED FIXED RESISTORS are available in all standard EIA and MIL-R-11 resistance values and tolerances, plus values above and below standard limits. Shown actual size.

The need for a yearly production capacity of well over a billion units is a testimonial to the uniformity and reliability of all Allen-Bradley hot molded resistors.



Type N hot molded adjustable fixed resistor rated ⅓ watt at 50°C ambient. Available with nominal resistance values from 100 ohms to 2.5 megohms with tolerances of ±10% and ±20%.

"Why have Allen-Bradley hot molded resistors been our first choice since the late 1940's? In a word: Reliability!" states Philbrick—the leading manufacturer of operational amplifiers. There's nothing accidental about this superiority of A-B resistors. A unique hot molding process using completely automatic machines, eliminates the "human element" and produces such uniformity from one resistor to the next—year in and year out—that long resistor performance can be accurately predicted. No instance of "catastrophic failures" has ever come to our attention.

Allen-Bradley Type N adjustable fixed resistors likewise use a solid hot molded resistance track. Adjustment is so smooth, it approaches infinite resolution—and settings remain fixed. Being noninductive, Type N controls can be used at high frequency, where wire-wound units would be completely unsatisfactory.

For more details on the full line of Allen-Bradley quality electronic components, please write for Publication 6024: Allen-Bradley Co., 222 W. Greenfield Ave., Milwaukee, Wis. 53204. Export Office: 630 Third Ave., New York, N.Y., U.S.A. 10017.

A-B QUALITY

ALLEN-BRADLEY

QUALITY ELECTRONIC COMPONENTS

63-05-6E

LETTERS

Holiday death tolls are not exaggerated

Sir:

A recent letter from one of your readers [John Darrow, ED 5, March 1, p. 32] questioned the National Safety Council's "sincerity" in our "misleading emphasis of the danger of holiday driving." To prove his case, the reader unfortunately made the same statistical error made by so many others: He divided total traffic deaths for the year by 365 to arrive at a per-day figure, then multiplied this by the number of days in the holiday weekend and discovered the result to be not too different from the number of persons killed in traffic accidents over the holiday period.

Here is why such reasoning is wrong. The only deaths included in the holiday figures supplied to the Council by the Associated Press and United Press International are those of persons who have accidents and die during the holiday period. Thus, the 575 persons who died over the last Labor Day weekend, for example, were in accidents that occurred during those 78 hours, and they died during those 78 hours. The actual number of deaths caused by traffic accidents *during* that holiday weekend amounts to about 765. Almost 200 of these deaths occurred after the weekend was over, in some cases considerably later. This 765 figure is the only one that can validly be compared with the figure obtained in the manner of your letter writer. The 575 figure can be compared only with the number of persons who might have died during those 78 hours if it hadn't been a holiday period; our estimate of that was 440.

It is interesting to note that the Associated Press runs an actual count of traffic deaths a weekend or so before such a holiday period to determine a "normal" figure; their figure on this runs amazingly close to our statisticians' estimate of what might be expected during such a non-holiday period. In our contacts with the media during the holiday period, we try to stress the difference between the "immediate" deaths during the period and the "complete" total to result from accidents during the period, but we are at the media's mercy in trying to get our message across, of course.

Wayne Willie
Asst. Director, Public Information
National Safety Council
Chicago

Received signal cannot be found

Sir:

The Feburary 15th issue of ELECTRONIC DESIGN carries a brief note and nomograph on p. 84 under the title, "Find the received signal." After a very careful reading of this article by R. A. Hunting and E. J. Salley, I have come to the conclusion that the reader will have to search for a mighty long time to "find the received signal."

Either the blue pencil of an editor cut some essential information or the authors ignored things like transmitting antenna form, efficiency, gain, polarization, seasonal and diurnal variation in the ionosphere, the possibility of skip distance, height of the reflection coefficient, ground wave, etc.

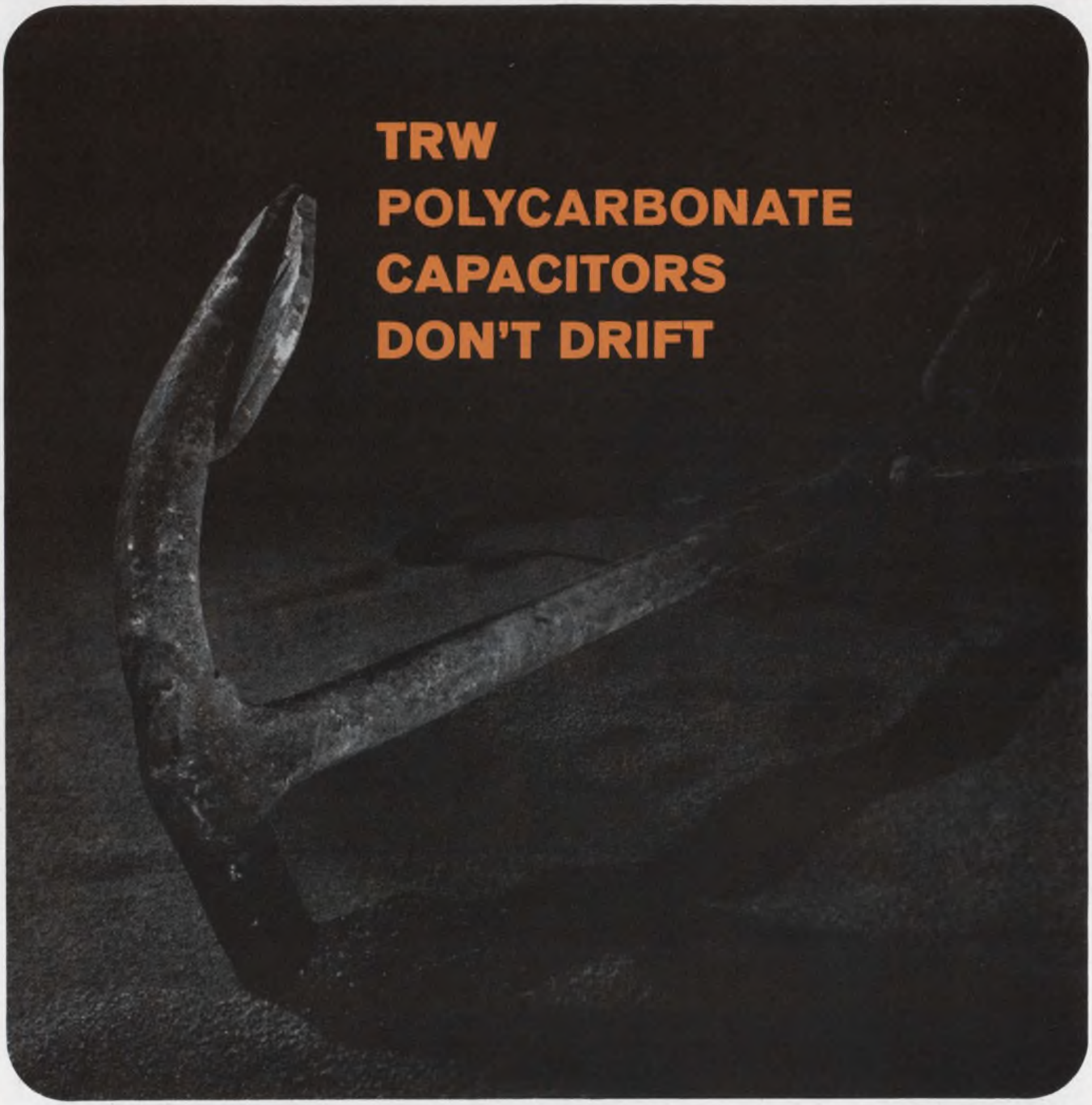
In short, this attempt to boil volumes of information on propagation theory and data down to one page is of dubious value and may mislead engineers by giving them incorrect field strength values.

G. H. Keitel
Acting Chairman
Dept. of Electrical Engineering
San Jose State College
San Jose, Calif.

Accuracy is our policy

On page U142 of ED 6, Mar. 15, 1966, Radio Frequency Lab's thermometer bridge is incorrectly shown as Julie Research Lab's potentiometer, and Julie's pot as RFL's bridge.

Scientific Data Systems points out that in ED 8, Apr. 12, 1966, p. 18, the Sigma 7 computer is erroneously stated to have an 8-bit word size. It in fact has a 32-bit word size.



Less than .01% T.C. from 0°C to +125°C

TRW—acknowledged leader in film capacitors—continues its leadership with advanced polycarbonate types providing *mica-like stability* through 125°C.

This is a complete new line of low-TC devices designed for no-drift performance at elevated temperatures.

TRW polycarbonates are offered in a variety of styles to meet all design needs for operation from −55°C to 125°C.

- **WIDE-RANGE TEMPERATURE STABILITY**—< 1% capacitance change from 0°C to 125°C (positive or negative TC available).
- **LONG STABLE LIFE**—less than .1% drift after 10,000 hours.
- **CLOSE TOLERANCE**—available in capacity tolerances to ±.5%.
- **SMALL SIZE**—up to 90% less volume than paper dielectrics.
- **QUICK DELIVERY**—widely used styles available from stock.
- **MIL-C-19978 and MIL-C-27287** performance and ruggedness.

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TRW CAPACITORS

ON READER-SERVICE CARD CIRCLE 13

Making the proper first impression . . .

Cap-and-gown time is approaching at engineering college campuses throughout the country, and industry recruiters are now in the last throes of their preparations. Professional interviewers are busily arranging trip schedules, and agencies are putting last-minute touches to company brochures and personnel managers are setting up plant tours for interested students. Competition for outstanding '66 graduates is keen.

The company that hopes to attract its share of talent is wise to make a sound first impression. How? Recruitment specialists in recently published advice* say use the company brochure and follow these steps:

1. Resist the urge to go all-out on an elaborate brochure. Presentations combining brevity and simplicity are preferable.
2. Be up-to-date. Use descriptions of current job openings. If company statistics or product innovations are presented, ensure they are recent.
3. Clearly state educational requirements for each position, opportunities for advancement, and minimum standards expected of a new employee.
4. Outline basic salary structure; specific salary figures are unnecessary. Include, however, salary review procedure and approximate salary ranges after set service periods.
5. Detail what the new employee will be doing, indicating when he can expect to assume a superior position.
6. Describe the major points of the company's training program.
7. If jobs are offered in different areas of the country, include brief descriptions of the cultural and leisure opportunities as well as educational and residential information.
8. Define company policy on relocation and travel, especially when transfers during the first few years are to be expected.
9. List key fringe benefits, including medical and health coverage, policy on graduate-level courses, disability plan, etc.
10. Tell the candidate how to make arrangements for an interview. Once the candidate becomes interested in your company, don't force him to write for an application blank. Include the necessary forms and indicate clearly the name, address and telephone number of the personnel contact.

A sure way to be ineffective, according to the recruitment experts, is to concentrate on the following:

1. A series of ethereal illustrations, depicting a modern plant nestled serenely in a valley, with just a few overstated captions.
2. A flowing account of a proud company's rise from obscurity to prominence.
3. A passionate promise by a company president of a glowing future for new employees, devoid of details on how really to succeed.
4. A number of detailed balance sheets starkly charting a company's financial pattern and growth.

In short, recruitment advisers regard the '66 graduate as sophisticated, intensely concerned with long-range career plans. He's asking how hard he'll have to work to achieve a particular goal, not where to find a soft job. As one university placement direct put it: "You can't get away with giving him a glittering generality and a snow job."

HOWARD BIERMAN

*"College Recruiting," *Business Management*, Dec., 1965, p. 50.

Wired with RCA wide-temperature-range cores, your stacks can meet many MIL Specs...and you get the economy of molded plastic frames

Specifically designed to cut the cost of memory stacks for the commercial market, these new high-impact plastic frames are so rugged that they meet many MIL-Spec requirements. And they offer these important advantages:

Rugged Construction. Individual plane frames are molded of tough, rigid high-impact plastic. Wiring terminals are molded into the material and jig-soldered for maximum uniformity from plane to plane.

Compact Design. The new design features reduced space between cores, reduced space between planes, shortened wiring to reduce length of current paths, and also eliminates complex printed-circuit input/output connections.

Three Basic Plane Sizes. Planes are available with 4096 cores (64 x 64), with 8192 cores (64 x 128) or with 16,384 cores (128 x 128)...with diagonal or rectangular sense-line wiring.

High-Operating Speeds. For 1 μsec memories...with high-speed RCA 20- or 30-mil coincident-current ferrite cores.

Adaptable to Special Packaging. Densities to 12,000 bits per cu. in. have been attained.

Economy. These new plastic frames and the new manufacturing techniques mean new low prices... let us quote on your design requirements.

For complete information on how to design Memory Stacks with RCA's molded-plastic frames, ask for Application Note AN203.

Call your local RCA field office today...or call, write or wire RCA Electronic Components and Devices, Memory Products Operation, Section FG5-2, 64 "A" Street, Needham Heights 94, Mass. 617-444-7200.

RCA ELECTRONIC COMPONENTS AND DEVICES, HARRISON, N.J.

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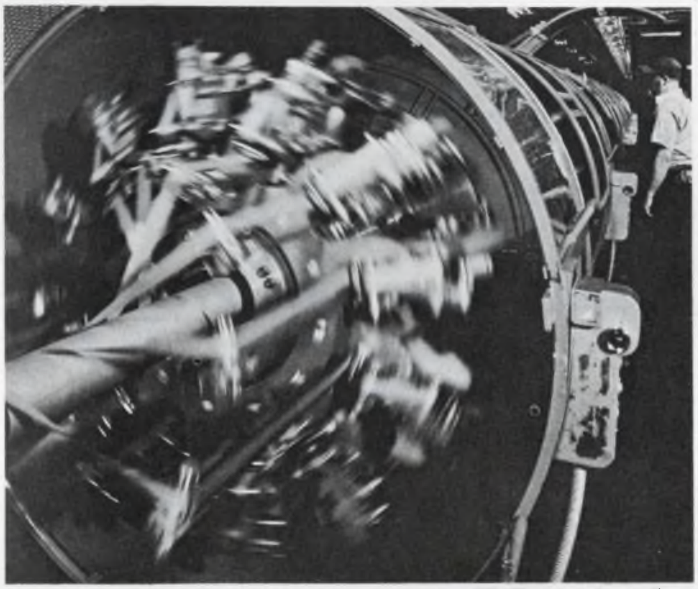
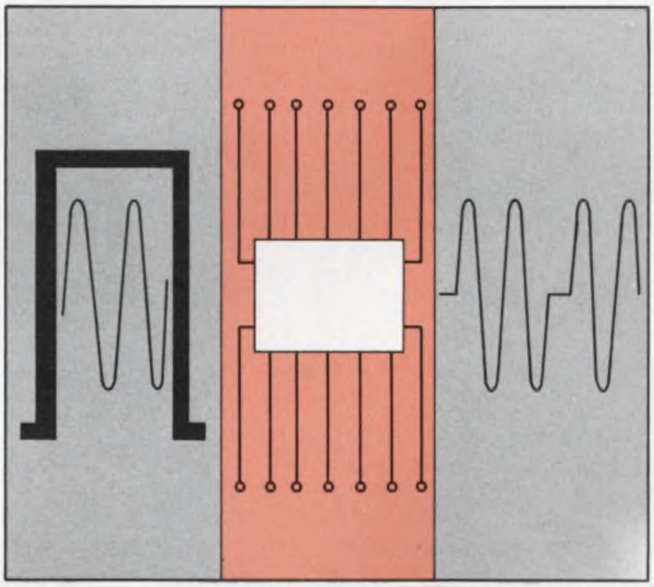
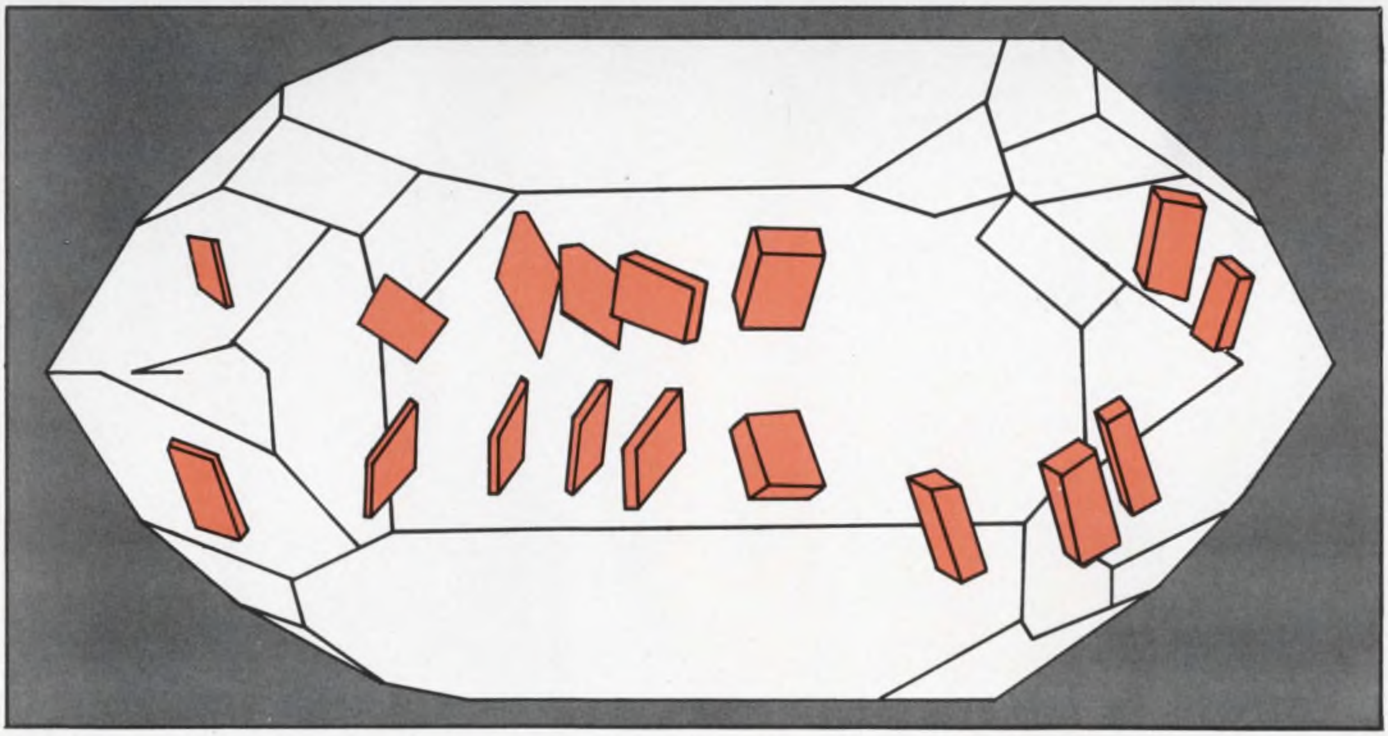


Turn to SCR control . . . **38**

LTV Electrosystems, Inc.



Off-the-shelf IC chops signals . . . **54**



Slicing a quartz crystal . . . **48**

Device-hunting for motor speed control?

Look to the source as a guide—it shows when, where and why the SCR usually outlaps competing units.

An increasing number of motor speed-control systems now rely on a semiconductor power switch or regulator to govern the drive power furnished to the load. In a number of cases the engineer must choose between the SCR and power-transistor devices for this role. Not many designers realize, however, that the nature of the power source will usually dictate which semiconductor is best to use.

When this is taken into consideration, the SCR qualifies as a near-universal device for dc-motor speed control. Of course, such traditional factors as cost, complexity, size, speed of commutation and efficiency must also be considered. But even with all of these criteria, the SCR invariably fills the bill, regardless of the type of motor—series, shunt, compound or permanent-magnet—involved.

This SCR dominance is due to these properties:

- Unlike the transistor, it naturally accommodates ac power sources. It can also be used with dc supplies, requiring a minimum of commutating circuitry in those applications.
- It has both higher and broader power-handling capabilities, extending from fractional horsepower loads to hundreds of kilowatts.
- It now has excellent speed and conducting characteristics. Some can switch at rates of 25,000 Hz, and its forward voltage drop is nearly as small—1 V typically—as that of the transistor. (Transistors are faster switches; but their power-handling capability is lower than the SCRs.)
- It possesses a built-in latching action that ensures high power gain and automatic commutation at zero current conditions.

Let's see how these attributes are put to work. By examining the salient characteristics of the major dc motors, we will develop the design criteria for speed regulation peculiar to each. Then, using the power source as our litmus, we will analyze a number of typical SCR speed-control systems.

A look at three dc-motor types

Dc motors take three general forms: series, shunt and compound wound. Fig. 1 shows the field-armature relationships and torque speed curves for these three types. In general, the torque, speed and power relationships of dc machines apply and are given by

$$T = K_1 \Phi I_a, \tag{1}$$

$$s = \frac{K_2}{\Phi}(V_{IN} - I_a R_a), \tag{2}$$

and

$$hp = KTs. \tag{3}$$

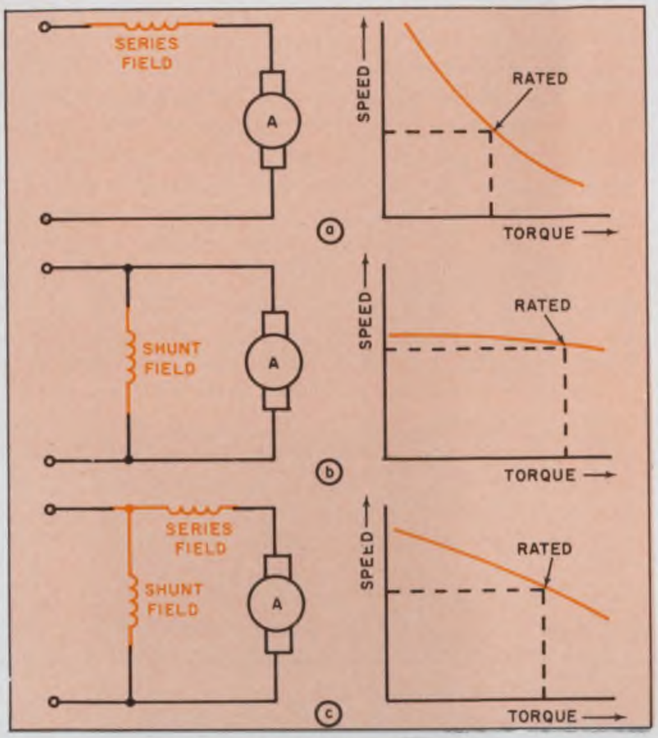
In Eqs. 1 to 3, T is the motor torque, Φ is the flux per pole, I_a is the armature current, s the motor speed and V_{IN} the input voltage. R_a is the armature resistance, K_1 and K_2 are motor constants, K is a dimensional constant equal to 1/5250 and hp is the output horsepower.

Note from the speed relationship (Eq. 2) that there are two parameters that can be varied to change motor speed. These are the input voltage and the field flux. As input voltage is decreased, speed decreases. Conversely, as flux is decreased (field weakening), speed increases. Note that the resistive voltage drop in the armature is ignored here, inasmuch as it is small compared with V_{IN}.

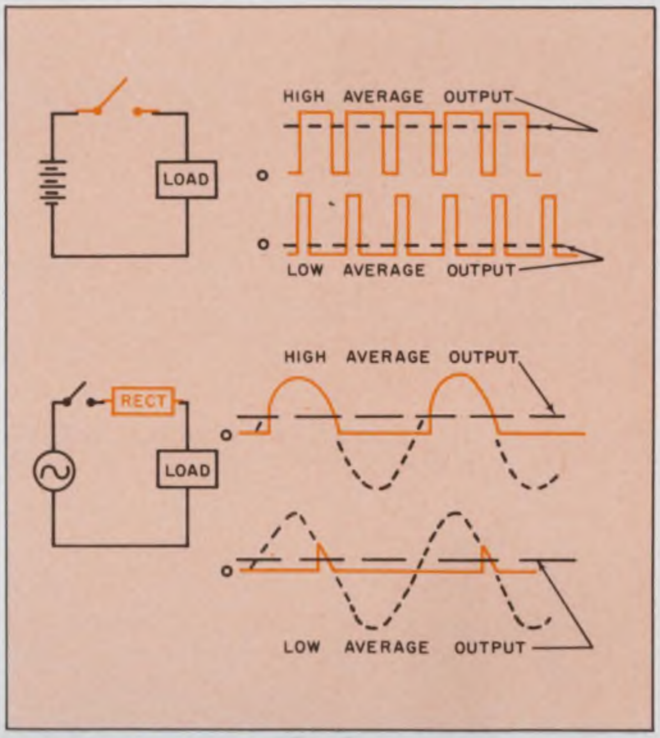
With a shunt motor one usually has both the armature and the field available for control purposes. By holding the field voltage constant and varying the armature input voltage, we obtain speed variation while delivering essentially constant torque to the load. This type of control is especially desirable in such applications as machine tools and conveyer drives. If the field excitation is varied, torque is increased as speed decreases, and essentially constant horsepower is delivered to the load. Although field control is not

Don't get your wires crossed. Author Hey hooks up his SCR motor speed control unit for a test run.

John C. Hey, Applications Engineer, General Electric Co., Auburn, N. Y.



1. **The speed of any dc motor is controlled** by regulating either its input voltage or its field flux. Shown are the simplified armature-field relationships and the associated torque-speed curves for series (a), shunt (b) and compound (c) motor types.



2. **A varying voltage is used** to effect a change in motor speed. If the power source is dc, it must be chopped, and duty cycle levels establish the amount of power furnished to the load (a). If the source is ac (b), phase-control is used to govern the amount of load power.

as widely employed as armature control, the former's constant hp output is ideal for such applications as winder drives or fan controls.

In a series-wound machine, armature current and field current are the same. Observe that field flux is proportional to field current. We thus have a slightly more complicated situation than with the shunt motor, because of this interdependence of armature and field. Since the field must carry the armature current, its impedance must be very small. As such, most of the input voltage is applied to the armature. This dependency is expressed by

$$T \propto \left(\frac{V_{IN}^2}{s}\right). \tag{4}$$

Torque may turn tables

For a constant torque load, the speed of the machine varies in proportion to the input voltage. As torque requirements increase, additional input voltage is required to maintain a given speed, and even more voltage is needed to increase the speed.

Torque may also, by itself, determine the application. One important characteristic of the series-wound dc motor is its high-starting torque. Torque, being proportional to field flux and armature current, is therefore proportional to the square of armature current (neglecting saturation effects). The high-starting current provides comparably high-starting torque, which makes this machine ideal for vehicle drives, including railway service, and crane and hoist drives. The universal motor, which is a small form of the series motor, has found wide application in small shop and portable hand tools because of its torque property.

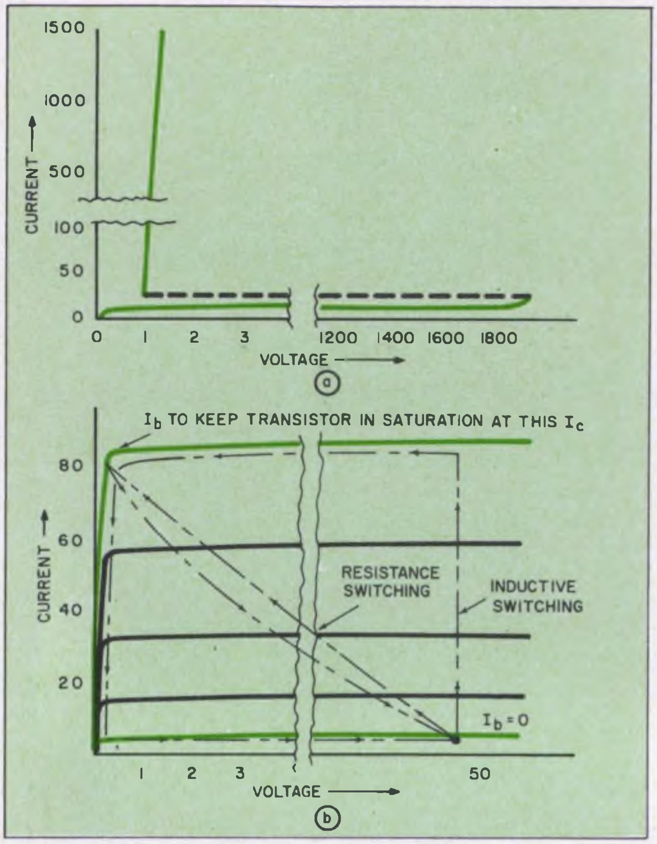
The compound motor has both a series and a shunt field. It exhibits characteristics that lie between the extremes defined by the series and shunt motors. The speed of a compound motor is varied either by field or armature control, as is the case with the shunt motor. Although the series motor has the highest starting torque of the dc motor family, its no-load speed can climb to dangerous levels. The compound motor is thus used to give higher starting torque than the shunt motor, while providing a safe, finite, no-load speed.

Another type of dc motor that is gaining in popularity is the permanent-magnet (PM). Its characteristics are somewhat similar to the shunt-wound motor. The PM motor, however, is more efficient, because external field excitation is not required. Only armature control (for speed regulation) is possible, and therefore constant-torque applications are a natural for the PM motor.

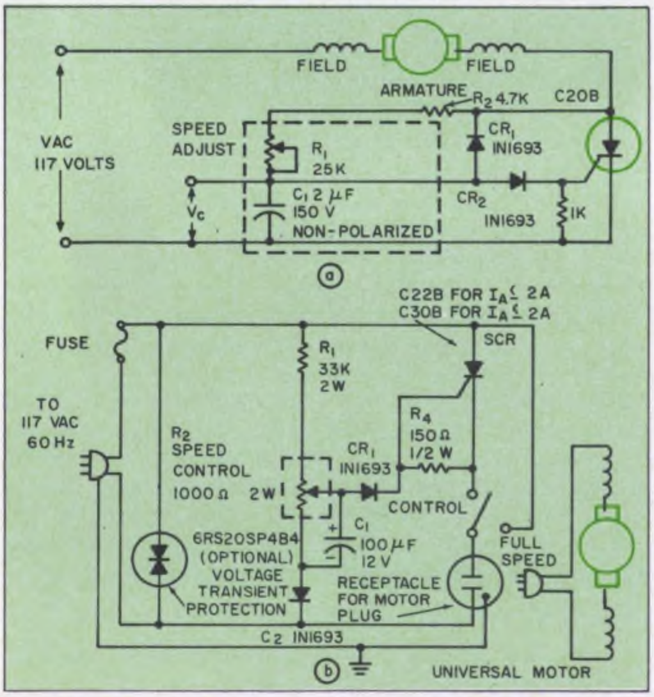
So far we have considered ways to vary the input voltage to the machine to change its speed. Let's see now how solid-state components achieve this function.

Power switch needed for chopping

An adjustable dc voltage can be produced efficiently by chopping the source voltage at variable duty cycles. This delivers a varying average dc voltage to the load. The chopping is done either directly from a dc source (by means of a chopper) or from an ac source (by employing phase control) as illustrated in Fig. 2.



3. **A comparison of the switching characteristics** of the SCR (a) and the power transistor (b) shows that commutation with the former device is automatic. This is because the transistor is basically a dc device, does not exhibit a latching characteristic and has only two junctions.



4. **When an SCR is used to control the speed** of a dc series or universal motor, it performs two functions: rectification and phase control (a). The R_1 C_1 network establishes the triggering point of the SCR. To compensate for torque drops with decreasing input voltage, a more complex feedback arrangement is used (b). Here the voltage on the arm of potentiometer R_2 is compared with the counter emf of the motor.

The switch used to perform the chopping function is all-important. It must be highly efficient, very fast, have long life and be capable of handling high current or high voltage, or both. In the light of these requirements, power semiconductors have been widely accepted. The two major types of power devices are the three-junction thyristor (SCR) and the two-junction power transistor. One excellent way to determine which to use is to compare a typical germanium power transistor and a standard high-voltage SCR. The table shows the prime differences in properties between these types. Fig. 3 contrasts their switching characteristics.

In general, the power transistor offers distinct advantages over the SCR in motor-control applications that are marked by the following:

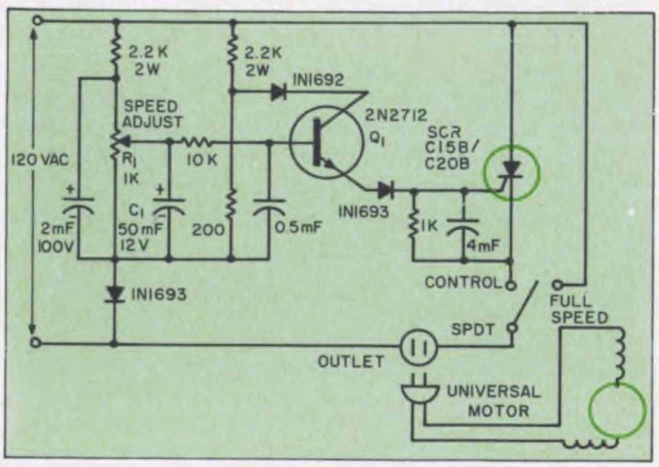
- Supply levels $\leq$24 volts, where the supply itself is dc.
- Power figures in the low regions (up to a few tens of watts). Higher power loads, where paralleling of the transistors is not a major obstacle, are also accommodated.
- Very fast switching speeds (in excess of 2000 Hz).
- Extremely high efficiency (low ON-voltage requirements).

The SCR is usually superior in situations where these criteria do not exist. And, as technological advances are made (faster speeds, for example), it continues to nibble away at these remaining

Power transistor vs SCR

Characteristic	Power transistors	SCRs
Blocking voltage & forward current capability	700 V at 3 A 400 V at 10 A 200 V at 30 A 150 V at 65 A	Up to 1800 V at 550 A*
Latching	no	yes
"ON" or saturation voltage	very low	low

*Average current, single phase, 180° conduction angle.



5. **For wide-range, very smooth speed control** a transistor is placed in the feedback path between the SCR gate and the reference adjust. Higher gain and stability result.

bastions of transistor supremacy.

Note also that because of its nonlatching property, the power transistor is basically a dc device. Commutation is accomplished in a dc circuit by simply removing its base drive. On the other hand, the latching characteristic of the SCR makes it basically an ac switch, where the commutation is automatic whenever current through the SCR tries to reverse.

This is not to imply that dc operation of SCR's is impractical. On the contrary, dc applications are many and are growing. They include inverters, choppers, pulse modulators and dc static switches.

Observe that the SCR has higher voltage and current capabilities, while the transistor has a lower forward drop in the ON state and is slightly faster. In an ac circuit the transistor loses its forward-drop advantage, inasmuch as a diode must be added in series with its collector to provide for a reverse-blocking capability. In effect, three junctions are required here. The SCR has all the necessary junctions, and each is optimized for the job at hand.

The basic differences in properties point to source voltage as the prime consideration in device selection.

Phase control used for ac sources

Fig. 4a shows the simplest of approaches to the speed control of a dc-series, or universal, motor. The SCR here provides two functions: It changes ac to dc (half-wave) and then varies the resulting dc voltage to the motor by means of phase control. The R_1C_1 phase-shift circuit varies the point in the positive half cycle at which the SCR triggers.

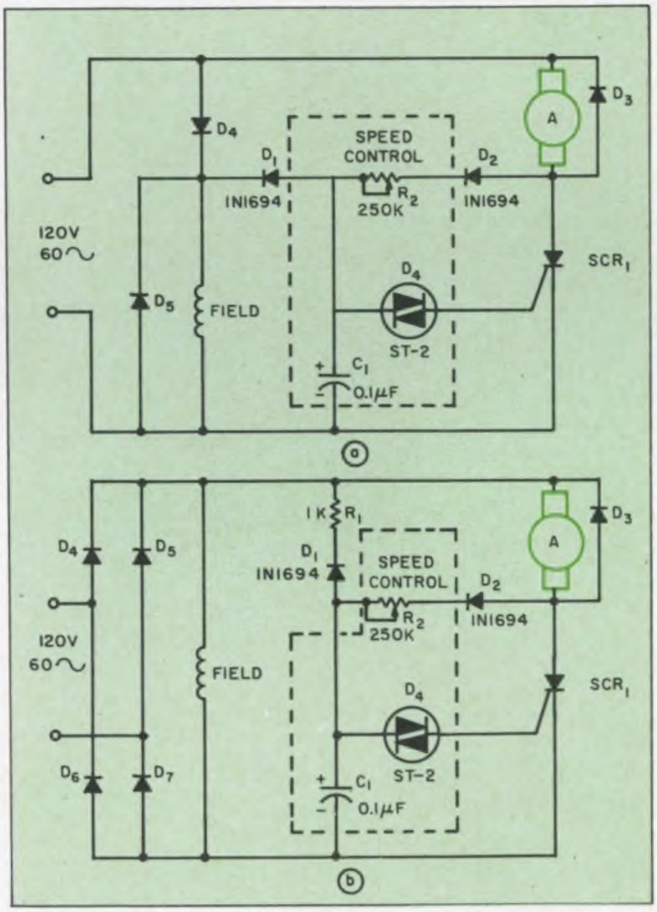
As we have already seen, the series motor loses torque as the input voltage is decreased. This can be a serious handicap in such applications as hand tools, where low speed and high torque are required. A circuit that automatically adjusts the input voltage to the motor so as to compensate for the load-induced speed reduction appears in Fig. 4b. During positive half cycles of supply voltage, a reference voltage is established on the arm of potentiometer R_2. This voltage is then compared with the counter emf of the motor through the gate of the SCR. When the potentiometer voltage rises above the counter emf, current flows through CR_1 into the gate of the SCR. This triggers the SCR and thus applies the remainder of that half cycle of supply voltage to the motor.

If load is applied to the motor, its speed tends to decrease, and this decreases the counter emf proportionally. The reference voltage then causes current to flow into the SCR gate earlier in the cycle. The SCR triggers sooner than before, and additional voltage is applied to the armature to compensate for the increased load and to maintain the preset speed.

The particular speed at which the motor operates is selected by R_2. With this arrangement, stable operation is provided over a speed range of approximately 10 to 1. Stability at very low speeds can be improved by reducing the value of C_1 at the expense of feedback gain. Note that there will be some variation in the effectiveness of speed control from one motor to another, depending upon the magnitude of the residual field for each motor.

Before we consider the control needs of more complex motors, observe the over-all simplicity of the circuits in the dc-series motor (Figs. 4a and 4b). This is one reason why SCR universal-motor controls are widely used, even in applications where low cost is paramount, such as hand tools.

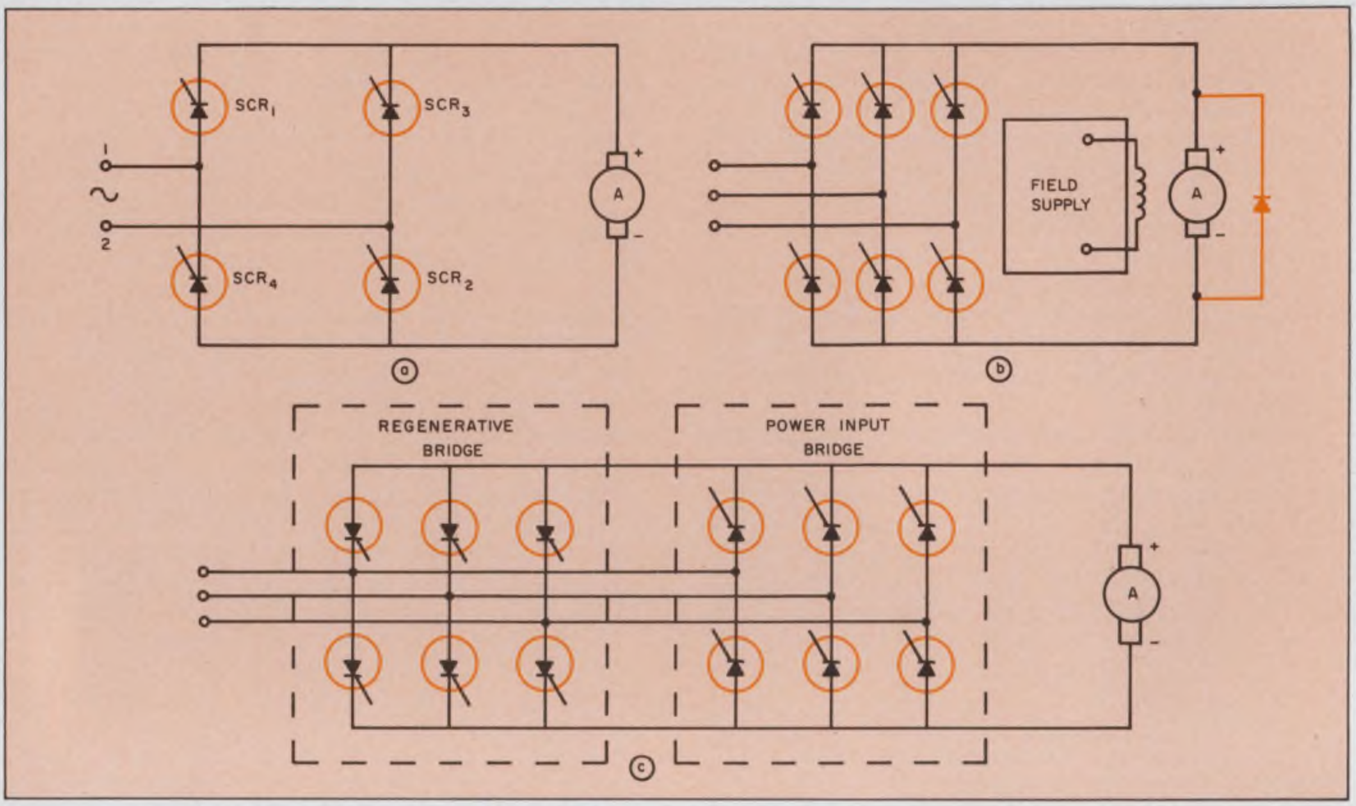
For more elaborate motor speed-control needs, higher performance is achieved by a "plush" version of the dc-series, or universal, motor speed control (Fig. 5). The principle of operation is the same as previously described, except that a transistor is used to provide current gain from the reference voltage to the SCR gate circuitry. The superior feedback characteristic of this circuit yields smooth operation, with feedback providing stability throughout the range, including the very low speed portion.



6. **With shunt motors, speed control is effected** by using the motor voltage to drive the SCR's phase-shift network. Shown are half-wave (a) and full-wave (b) control.

Drive shifted for shunt motors

Speed control of shunt motors is accomplished in a manner similar to that employed with the series motor. Fig. 6 illustrates a simple approach for both half-wave and full-wave control. In both cases the voltage across the motor, as determined



7. **For large dc shunt motors,** use a polyphase supply for speed control. More power is required than is usually available from single-phase sources (a), where four SCRs are needed. Only three SCRs, three diodes and a coasting rectifier are needed (b) with a three-phase source. A three-phase regenerative system employing twelve SCRs (c) has the advantage of dual behavior—that is, it acts as a motor-generator set.

by speed and load, is used as the driving function for the R_2C_1 phase-shift network.

If the motor speed tends to slow down, the SCR voltage is higher (there is less back emf), causing earlier breakover of D_4. This in turn triggers SCR_1 earlier in the cycle, thus bringing the motor back to speed. Conversely, if the motor tries to speed up due to a lighter load, the SCR is made to trigger later in the cycle. In the half-wave case, C_1 is discharged via the field winding because of the conduction of D_5 during negative half cycles. In the full wave case the phase-shift network is reset via R_1 and D_1 at the end of each half cycle.

For larger dc shunt motors it is desirable to operate from a polyphase supply, because the power available from a single-phase source is usually limited. Fig. 7a shows a dc motor driven from a three-phase supply by way of a full-wave bridge. A coasting rectifier is required across the load to free-wheel the inductive load current during the SCR OFF periods.

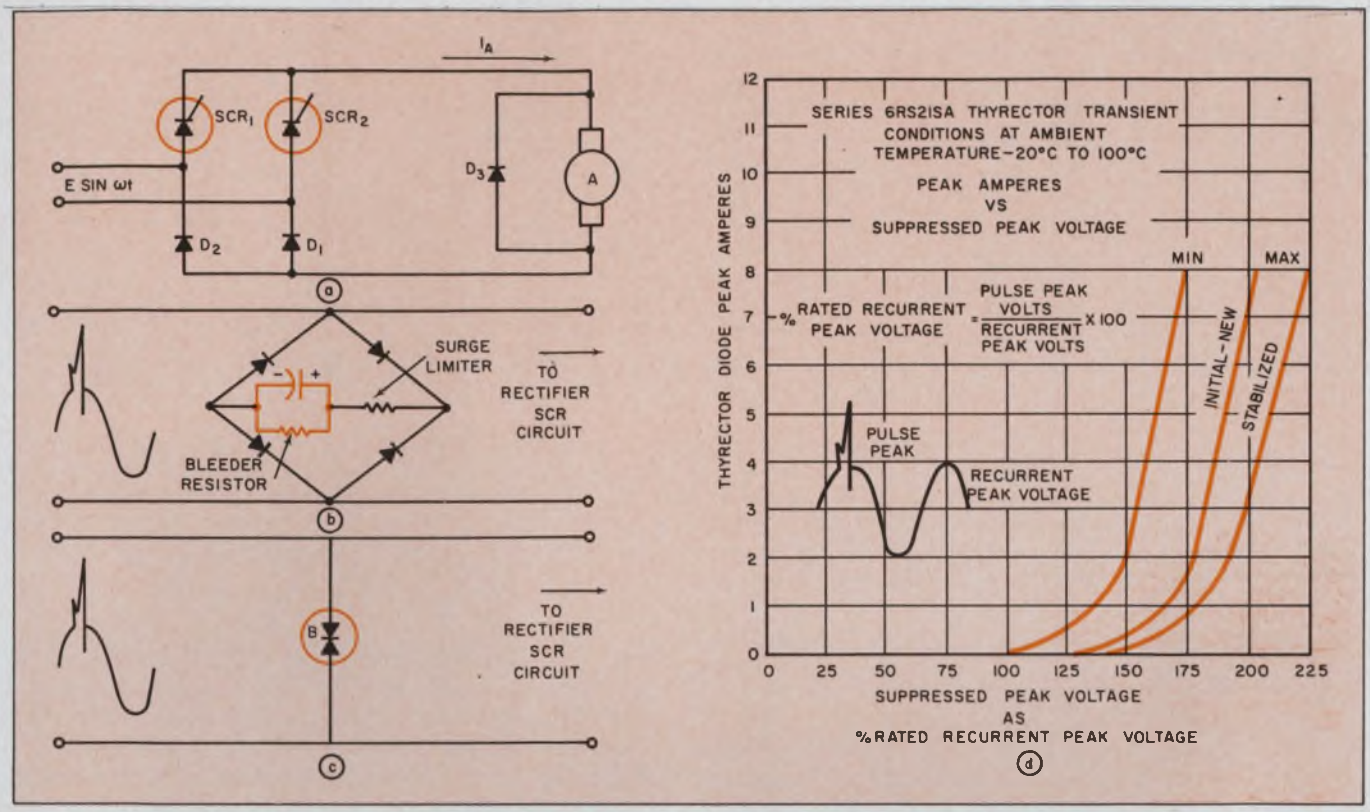
Instead of using a coasting diode, one may use an inverting bridge—that is, a bridge capable of returning the inductive load energy to the ac source. This is a particularly useful approach for fast field-control situations. For a single-phase, full-controlled bridge, four SCRs are used, and for three-phase operations, six rectifierss are required (Fig. 7b). Assume (in Fig. 7a) that the input line one is positive with respect to line two. At some delay angle (after one has gone positive), SCR_1 and SCR_2 are triggered, and power is delivered to the load. As the source voltage is reversed, inductive load current is free-wheeled back to the source, until the load current goes to zero or until SCR_3 and SCR_4 are triggered.

There are two distinct modes of operation: continuous and noncontinuous, as applied to the flow of load current. A high-inertia load may draw discontinuous current as the motor starts, go to continuous current operation at rated speed and rated torque, and then return to a discontinuous current flow when the motor is idle. Each case must be evaluated separately, inasmuch as voltage, current and dynamic stresses to the SCRs are different.

By using two full-control bridges, one can build a regenerative system. This type returns power to the source over periods that are larger than a portion of a cycle, as was the case with a single, full-controlled bridge. A typical application for this type of system (Fig. 7c) is an elevator drive, where power is delivered to a dc machine to lift the cab. Then, as the cab descends, the machine becomes a generator, delivering energy back to the supply.

Voltage determines choice of SCR

Let's see how to choose an SCR for a typical motor-control application. Assume we have a controlled bridge feeding an inductive load with a free-wheeling rectifier arrangement (Fig. 8a). E is both the peak repetitive forward and reverse voltage encountered by the power semiconductors in this circuit. For inputs of 120, 240 and 480 volts



8. **In a typical speed-control system** (a), some provision must be made for protecting the SCR against voltage peaks and transients. Capacitor surge suppresors (b) and thyrector selenium suppressors (c) are commonly used. The former stores excess energy; the latter device dissipates it. The thyrector volt-ampere characteristic (d) is used to establish its blocking role. Note that it must conduct heavily to suppress excess energy levels effectively.

rms, the peak values are 170, 340 and 680, respectively. With a 10% high-line situation, the peaks become 187, 374 and 750 volts. Stiff power sources can deliver energetic transient voltages. For these reasons, some form of voltage suppression is desirable.

This is particularly true in high-power systems, where the investment in power semiconductors and the probability of high-energy transients warrant voltage protection. Even though the SCR's ability to withstand surges of current and voltage is superior to that of power transistors, the investment is worth the insurance against costly down time. Of the numerous devices available for this protection, the cheapest and most widely used combination is the simple capacitor and the selenium surge suppressor. Capacitors are effective against low-energy transients, where the energy-storage capability is sufficient to limit the voltage to the capability of the power semiconductor.

Fig. 8b shows a typical capacitive voltage suppressor. It is obvious that an additional voltage capability is required of the power semiconductor, above that demanded by the recurrent peak of the input voltage. The selenium surge suppressor differs from the capacitive approach in that it dissipates transient energy (as opposed to storing it). The selenium suppressor is applied directly across the ac input (Fig. 8c). A typical volt-ampere characteristics for a Thyrector surge suppressor appears in Fig. 8d.

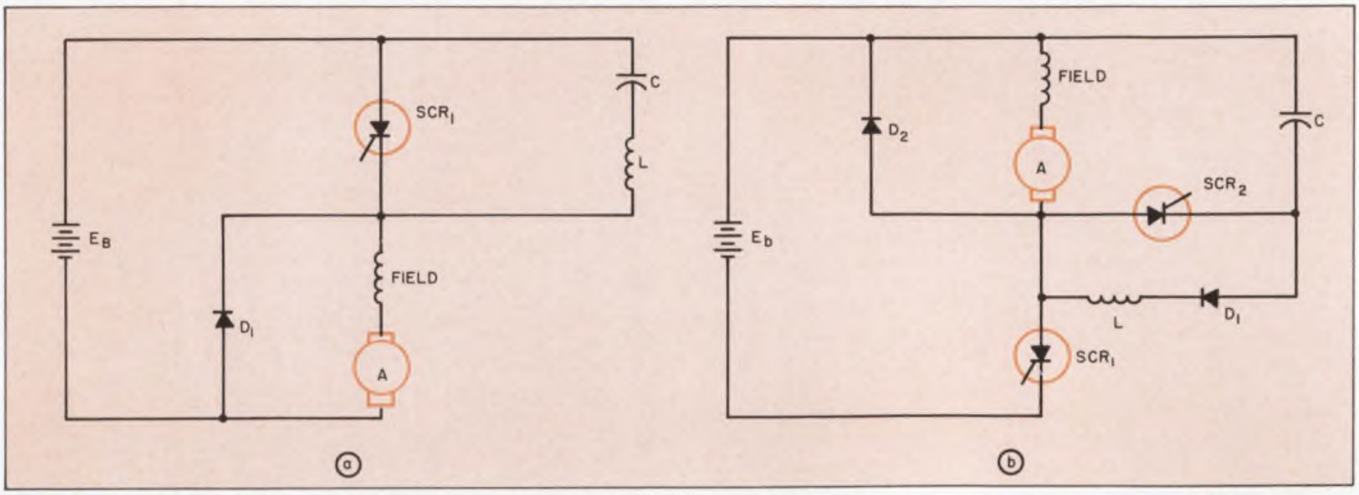
Note that the voltage across the Thyrector must go to 1.75—two times the rated blocking voltage—before the Thyrector is in heavy conduction. Voltage clamping is needed to handle the transient energy. In designing high-power semiconductors into equipment, the designer must predict the maximum transient energy available, so the suppressor can accommodate that energy without danger of semiconductor damage or malfunction. He then chooses his surge suppressor so that voltage is limited to the transient, or peak, voltage rating of the semiconductors while that maximum energy is either stored or displayed.

Surge-current protection is handled in a similar fashion. The time-current capability of the semiconductor (i^2t) is coordinated with that of a fuse, so that the fuse is limiting. The maximum average current per semiconductor in the circuit of Fig. 8a is $I_A/2$ at all conduction angles.[1]

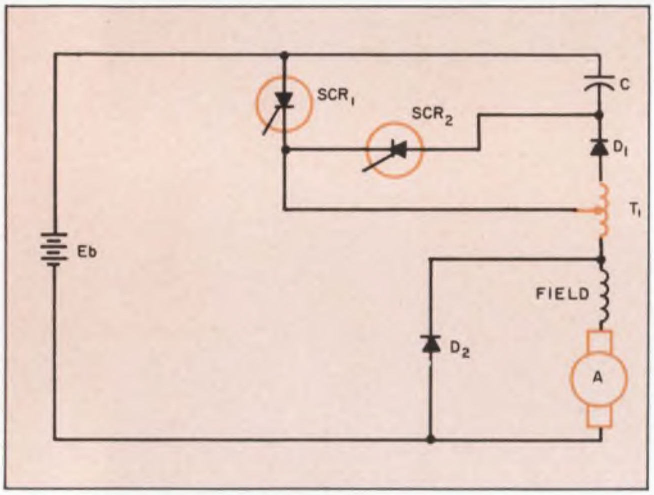
Dc sources require extra commutation

Referring to Fig. 2 again, we recall that when a motor is controlled from a dc source (by chopping the voltage with a rapid-acting switch that uses an SCR as the power device), some form of auxiliary commutation is required. In the simplest of SCR choppers, the turn-on action of the SCR resonates a series LC circuit (connected across the SCR) as shown in Fig. 9a. The time required to charge the capacitor is the duration of power delivery, via the SCR, to the load.

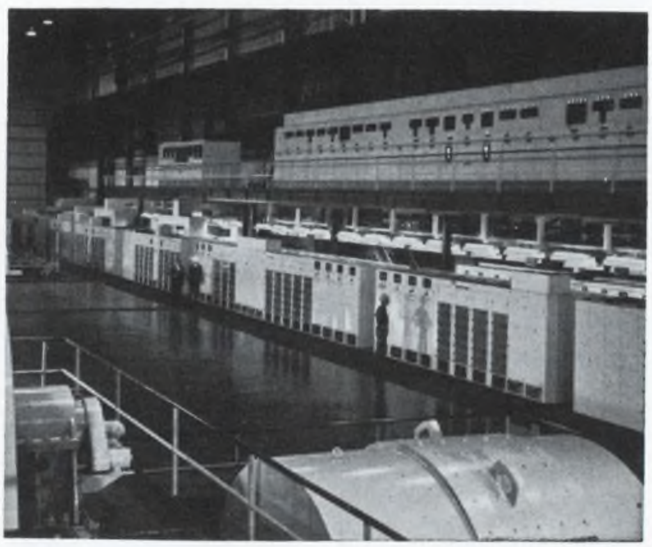
As the capacitor voltage begins to ring back, the discharge current extinguishes the SCR. The



9. **With dc power sources,** SCR chopping is used to frequency-modulate the power supplied to the armature (a). When an extra SCR is used for pulse-width modulation (b) (in addition to the FM action of the other SCR), a smoother commutation results. This obviates stalled armature or plugged motor conditions.



10. **Reduction of the capacitor used** in the chopper circuit is achieved by using an autotransformer. Here the capacitor is charged to higher voltages (than in Fig. 9b), to handle the same amount of joules (1/2 CV^2).



Motors rely on SCRs. Banks of SCR power converters control giant GE motors in this mill-drive system. More than 15,000 kW is being handled here (Bethlehem Steel's Burns Harbor [Ind.] plant).

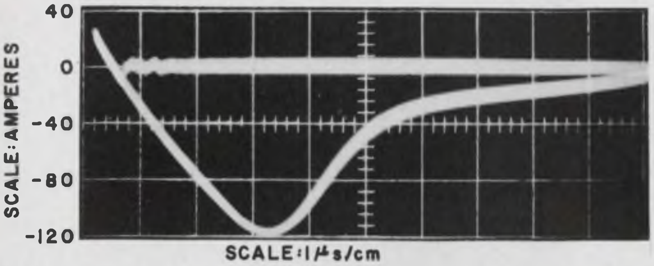
capacitor further discharges into the load, until its voltage equals that of the supply. SCRs not only require reverse voltage for commutation, but they also require that this voltage be applied for a minimum period of time: the turn-off time. In the circuit the length of time that the capacitor retains its reverse voltage is dependent upon how quickly the load allows it to discharge. In other words, the circuit turn-off time (that presented to the SCR) is dependent upon load impedance. It is for this reason that an SCR chopper must be designed for the condition of lowest load impedance, or, more appropriately, highest load current.

In the case of motor loads this corresponds to a stalled armature condition, or, even worse, plugging. For the configuration in Fig. 9a, when the circuit is operating into a stalled motor, the turn-off time is 0.7 $R_{SA}C$, where R_{SA} is the motor-stalled armature resistance. This circuit provides a constant pulsewidth to the load, and modulation is obtained by altering the triggering frequency of the SCR.

Fig. 9b outlines an approach whereby the addition of an auxiliary SCR provides pulsewidth modulation in addition to frequency modulation. As the main SCR is triggered, the commutating capacitor rings up to twice the supply voltage via L and D_1. The diode prevents the capacitor from discharging. When SCR_2 is triggered, reverse voltage is applied to SCR_1, and commutation proceeds as previously described.

Turn-off time is a cost factor

We see that for a given load circuit, turn-off time is dependent on the capacitance of the commutating capacitor. Obviously the shorter the turn-off time required by the SCR, the smaller the commutating capacitor need be. Since the total of microfarads can be roughly equated to the total of dollars spent for capacitors, SCR manufacturers have made great efforts to provide devices with short turn-off times. To date, 10 μs is the practical lower limit on this parameter.



11. **With high-duty cycles, diode recovery problems** can interrupt the speed control, particularly when power transistors are used. Fast-recovery rectifiers should be used instead of conventional types. Note that the transient duration with the former (top trace) is only a small fraction of the latter (lower trace) and that the attendant current levels are much lower.

Another way to look at the turn-off time factor is from the standpoint of energy storage. An auxiliary energy-storage circuit or component is always required in SCR dc control circuits, and it generally is a capacitor. Since energy storage is proportional to the square of the voltage, one can reduce the number of microfarads required by charging the capacitor to a higher voltage. Figure 10 shows an extension of the dual-modulation circuit (Fig. 9b), where the commutating capacitor is charged to a reverse voltage considerably higher than the supply voltage. Rather than ringing the commutating capacitor to twice the supply voltage with an inductor, we insert the primary of an autotransformer in series with the load. The secondary of the autotransformer can then be charged to many times the magnitude of the supply voltage.

Note that a free-wheeling rectifier is used with the dc motor load. At high duty-cycles, with continuous-flow situations, the recovery of the free-wheeling rectifier diode can be quite important. For a short period of time (usually a few microseconds) after turn-on of the main power switch, the diode is a short-circuit. In general, this presents no problem for the SCR in low-voltage circuits.

On the other hand, the period of diode recovery presents a very real problem with respect to the power transistor. The power transistor, not being a latching device, can come out of saturation under the high collector currents demanded by this short-circuit condition (or any surge condition for that matter). An additional aggravating factor is that, in general, the transistor's current gain decreases with increasing collector current.

The cure for these problems is to use a fast recovery rectifier in the free-wheeling socket. Fig. 11 shows a comparison of reverse current during the recovery interval for a conventional and a fast-recovery, high-current rectifier diode. The commutating conditions in this contrast are typical of those seen by a free-wheeling rectifier used in the circuit. ■ ■

Reference:

Semiconductor Controlled Rectifiers: Principles and Applications of pnpn Devices; Gentry, Gutzwiller, Holonyak, Von Zastrow, Prentice-Hall, 1964.

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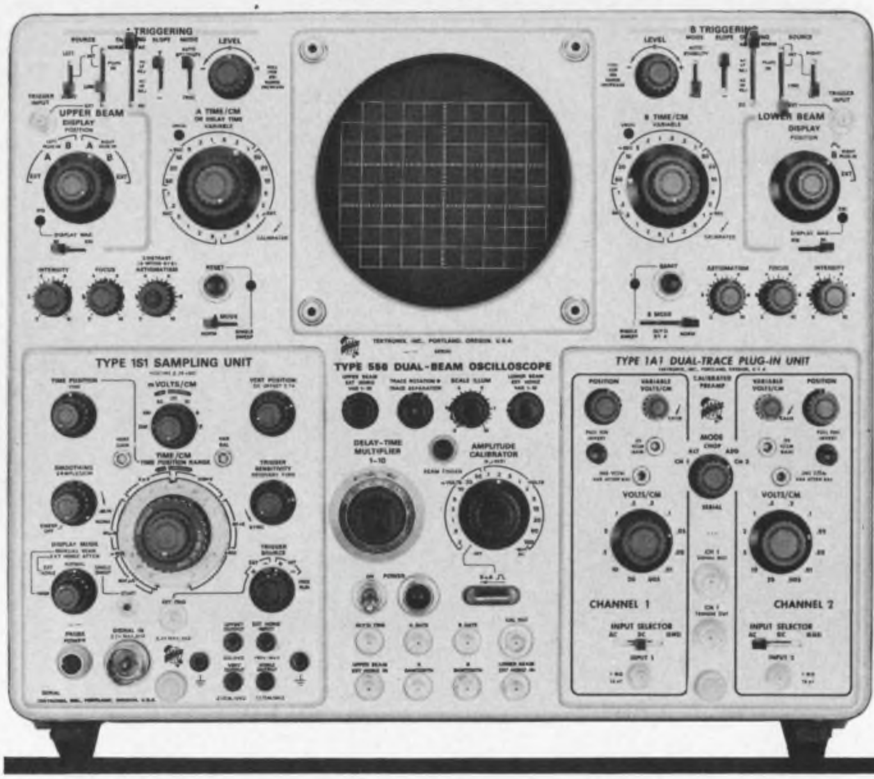

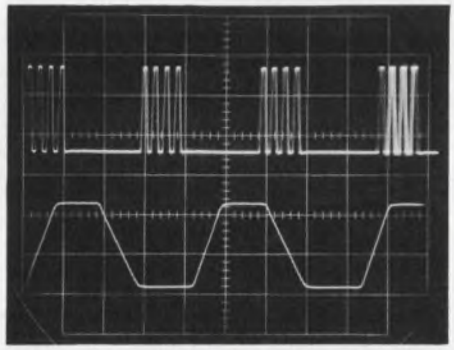

Single-Input Dual-Beam Displays. The upper beam shows **bursts of 2.5 MHz pulses** on Time Base A with time variation between bursts. This shows up as increasing time-jitter between the first and successive bursts. The lower beam shows B Sweep (0.1 μs/cm) delayed by A Sweep and triggered on the second pulse of the last burst to provide a jitter-free expanded display of the A Sweep intensified zone. The use of only one probe and one plug-in input simplifies signal connection and provides minimum loading on the source.

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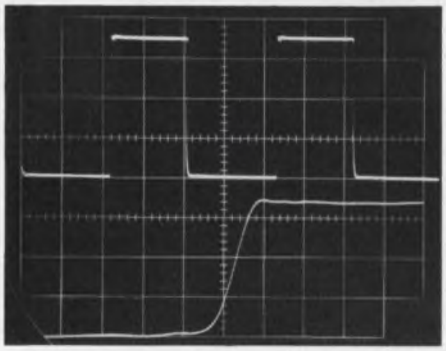
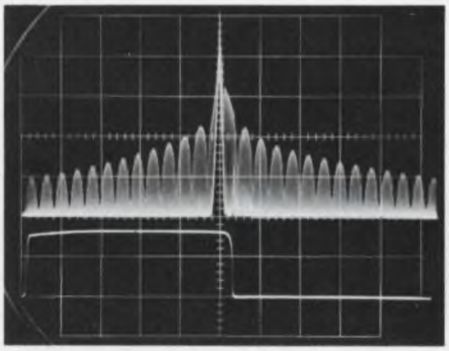
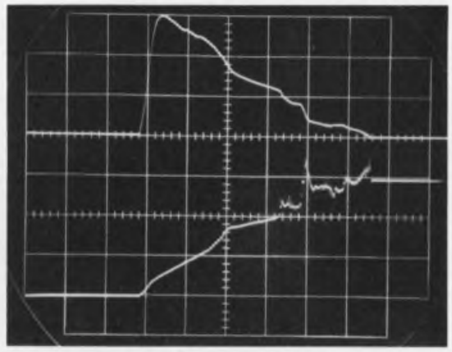
The LOWER BEAM can display a signal from the *right* plug-in; with either Time Base B or external signals; triggered from a composite vertical signal, plug-in single channel signal (with 1A1 or 1A2), external, or line.



Sampling and Real-Time Displays. Upper beam shows a square wave at 1 μs/cm as applied to a Type 1A2 Plug-In. The lower beam shows the risetime of the same pulse at 1 ns/cm as provided by a Type 1S1 Sampling Plug-in.



Time and Frequency Displays. The upper beam shows the spectral output of a 200 MHz gated oscillator applied as IF feedthrough to a Type 1L20 Spectrum Analyzer; the calibrated dispersion is 1 MHz/cm. The lower beam shows a real time display of the 10 kHz gating pulse; sweep rate is 0.5 μs/cm.



Simultaneous Single-Shot Displays. Current versus voltage display of a .75 ampere, fast-blow fuse during destructive overload. Both beams are driven by B Time-Base at 50 μs/cm which is delayed by pre-triggered A Time-Base to provide base reference lines before and after the event. The upper beam shows the current waveform at 30 A/cm while the lower beam shows the corresponding voltage across the fuse at 100 V/cm.

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Plug-ins illustrated

Type 1A1 Dual-Trace Unit $600
(Dual-Trace: 50 mV/cm at DC-to-50 MHz, 5 mV/cm at DC-to-28 MHz. Single-Trace: 500 μV/cm at 2 Hz-to-15 MHz. 5 Display Modes: Channel 1, Channel 2, Alternate, Chopped, Added Algebraically. Front-panel signal output.)

Type 1S1 Sampling Unit $1100
(DC-to-1 GHz, internal triggering, built-in delay line. Sweep Rates: 100 ps/cm to 50 μs/cm, with ±3% accuracy, normal or magnified (up to X100). DC Offset Range: greater than ±1 V. 4 Display Modes: repetitive, single sweep, manual scan, or external scan.)

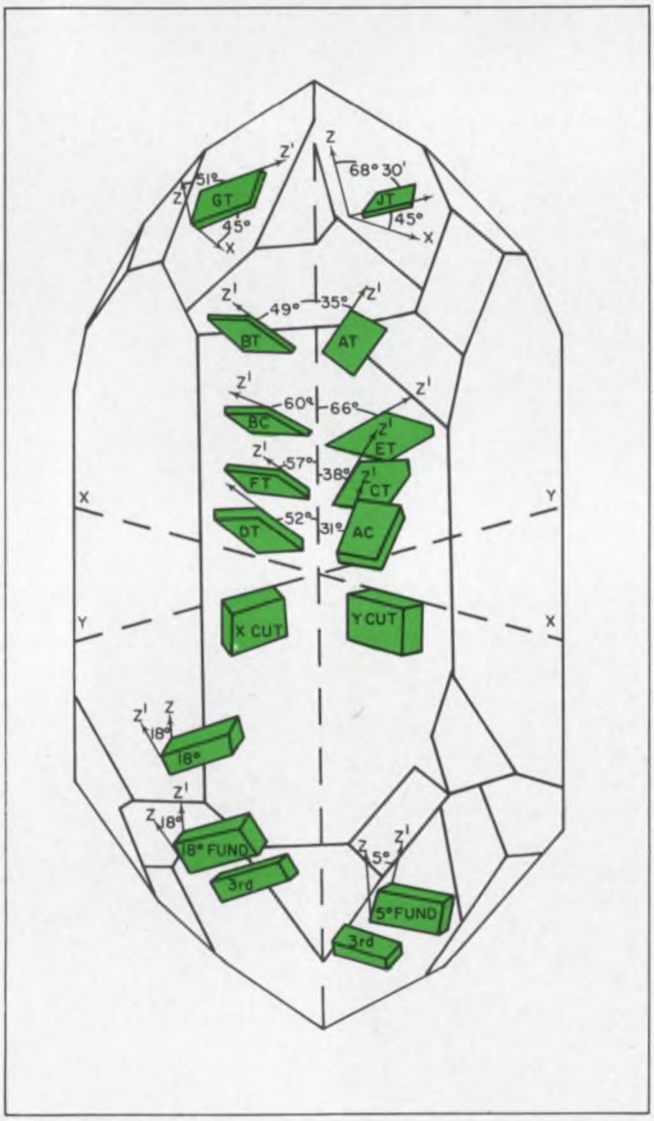
If you've been waiting for an oscilloscope that will handle your present requirements and that has the versatility to take care of future needs, investigate the new Type 556. Call your nearby Tektronix field engineer for complete information, or write Tektronix, Inc., P.O. Box 500, Beaverton, Oregon 97005.

Tektronix, Inc.

ON READER-SERVICE CARD CIRCLE 15

A guide to crystal selection, this handy table can help you get better acquainted with the wide variety of crystals on the market.

Where should a $+5°$X crystal cut be used? Does it need temperature compensation and are there any fabrication difficulties? If these questions make you pause and think, the following table may prove very handy. It lists the popular crystals and some special cuts too. It also includes a practical discussion of each type: The advantages and disadvantages and the important operating parameters are explained, along with the areas of application. (The drive level is expressed in milliwatts.)



1. **The orientation of the better known crystal cuts** shows the difference among the types.

Peter J. Ottowitz, Program Manager, Texas Instruments Inc., Attleboro, Mass.

The equivalent circuit of a crystal, shown in Fig. 2, is useful to explain the basic concepts governing the crystal's performance. C_0 represents the static capacitance and is the sum of the capacitance between the electrodes and capacitances added by the wire leads and holder. The R_1, L_1, C_1 branch is known as the motional arm. C_1 represents the mechanical elasticity of the quartz, L_1 is a function of the mass and R_1 is the sum of the losses (acoustic loading, molecular friction, and power transmitted to the mounting).

The impedance of the crystal is close to zero at the series resonant frequency, f_s, and rises to a peak at the parallel anti-resonant frequency, f_a (Fig. 3).

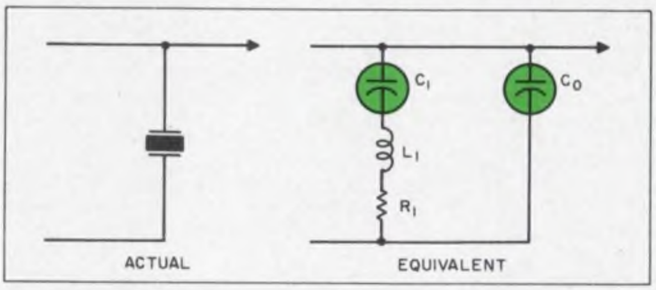
The practical parallel-resonant operating frequency ranges between f_s and f_a, and may include these two limiting values. The operating frequency is expressed as:

$$f_p = f_s \sqrt{1 + \frac{C_1}{C_0}}$$

The steep slope of the curve and the corresponding large differential between the impedances at f_s and f_p indicate that the Q of the crystal is high. Also, the frequency separation between f_s and f_p is determined by the capacitance ratio, C_0/C_1. For example, the 45° cut is a favorite choice in crystal filters because of its low C_0/C_1 ratio. Therefore a large filter bandwidth can be attained with fewer crystals.

The ratio of stored mechanical energy to stored electrical energy is a measure of the activity of the crystal. The greater the activity, the less its resistance and therefore the less the power required to drive the crystal.

The mounting and holder provide the electrical



2. **Equivalent circuit of a crystal** includes the capacitances contributed by the wire leads and the holder in C_0. The ratio of C_0 and C_1 indicates the frequency separation between the resonant and anti-resonant frequencies of the crystal.

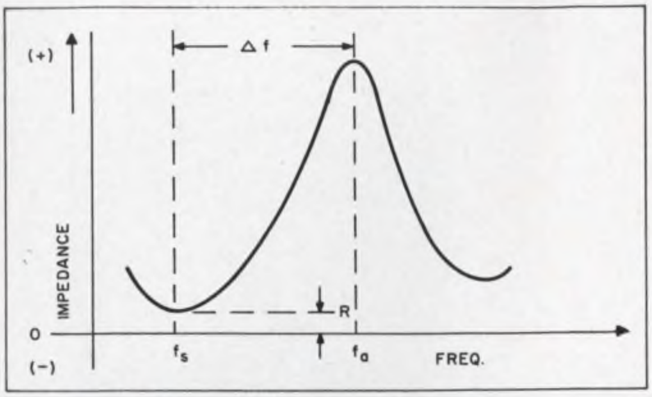
A list of crystals, important parameters and best applications.

Cut	Designation	Mode of vibration	Frequency range in kHz	C_0/C_1	Max. drive level	Remarks
Duplex 5°X	J	Length,	0.800-10	190-250	0.20	Used in frequency and oscillator applications. Zero-temperature coefficient occurs at approximately room temperature; therefore the crystal is limited to oven operation and to rigid temperature-control conditions.
XY	Custom-made	Length, width	3-50	600-900	0.1	Suited for oven-control applications, especially in its optimum frequency range.
NT	N	Length,	4-150	800-1500	0.1	Preferred in low-frequency oscillators and filters. It operates over large temperature ranges. Stability of ±5 ppm can be obtained over ±5°C, if oven-controlled in the frequency range. Rugged, if properly mounted. Can obtain frequency stability within ±0.0025% over the normal room-temperature range, without temperature control.
+5°X	H	Flexure	5-140	225	0.1	A relatively large frequency deviation over temperature range restricts filter applications to controlled environments. Low temperature coefficient and large ratio of stored mechanical energy to electrical energy are the characteristic features. Used in wideband filters, below the range of practical size E plates, and in transistor oscillators, where LC circuits are not stable enough, or where there is a space problem. Disadvantages: Fabrication difficulties. The crystal must be made in the form of a long, thin bar to fit in a special holder, to avoid jumping between modes.
BT	B	Thickness	1-75	–	–	Thicker crystal possible at higher frequencies. Disadvantages: Too thick for low frequency. Also, difficult to fabricate and has zero-temperature coefficient over only a very small temperature range. Not as active as the AT.
−18-1/2°X	F	Extensional	50-250	200	–	Used principally in filters where low temperature coefficient is sacrificed for freedom from certain spurious responses. Suitable for multi-electrodes.
+5°X	E	Extensional	50-250	130-160	2.0	Mostly applicable in low-frequency filters, because of low C_0/C_1 and good temperature coefficient.
DT	D	Face shear	80-500	450	2.0	Suitable for oven and non-oven applications. Its low capacity ratio permits many useful filter applications. Used as calibrator crystal and time base for frequency counters. Also used in FM and TV transmitters. Disadvantage: Does not perform well over 500 kHz.

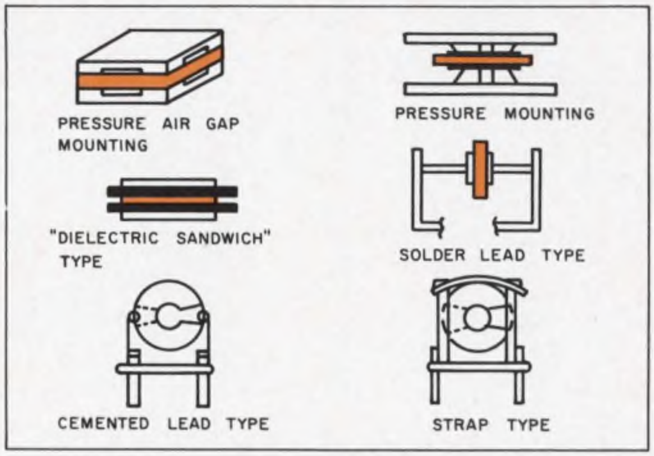
(Continued on p 50)

Crystal list (cont.)

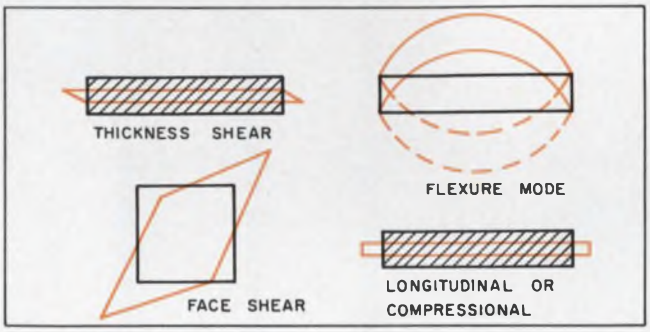
Cut	Designation	Mode of vibration	Frequency range in kHz	C_0/C_1	Max. drive level	Remarks
MT	M	Extensional	50-250	250	2.0	Its low temperature coefficient makes it useful for oscillator control and for filters where low C_0/C_1 ratio is required along with low inductance and good temperature coefficient. However, this crystal is seldom used, because more compact units have replaced it.
GT	G	Extensional	85-400	375	0.1	Has the greatest stability yet attained within a cut. Does not vary more than 1 part per million over a range of 100°C. Offers a low temperature coefficient over a wide frequency range, by coupling any desired mode with another of nearly equal amplitude at a frequency equal to 0.86 times its natural frequency. Used in frequency standards and when stability without temperature control or low impedance is essential. Disadvantages: Most expensive of all types, because of painstaking labor required to obtain exact orientation in dimension.
CT	C	Face shear	300-1100	350-400	2.0	Provides a zero temperature coefficient in the shear mode for low frequencies. Widely used in low-frequency oscillators and filters and does not require constant temperature control over normal operating conditions. Useful in filters because of low C_0/C_1 ratio. Popular in oscillators because of its low series resistance, especially above 400 kHz. Disadvantages: Large face dimensions make it difficult to fabricate for the very low frequencies.
X	Custom-made	Extensional	350-20,000	–	–	Mechanically stable and an economic type of cut. Disadvantages: Large temperature coefficient, with the tendency to jump from one mode to another.
SL	Custom-made	Face shear, coupled to flexure	300-800	450	–	Electrical characteristics similar to DT, but it is larger, has better Q and uniformity of characteristics above 300 kHz. Its various characteristics make it desirable for some filter applications.
Y	Y	Thickness, shear	500-20,000	–	–	Most active. Ratio of stored mechanical to electrical energy is large. Is strong mechanically. Disadvantages: Large temperature coefficient and poor frequency spectrum.
AT	A	Thickness	550-20,000 fundamental 10,000-60,000 (3rd overtone) 100,000 (5th overtone)	10-100,000	1.0-8.0	Excellent temperature and frequency characteristics. Its overtones are used in cases where the frequency should not change with oscillator reactance variations. Designs provide suitable capabilities for satisfying 70-80% of all crystal requirements. Preferred for high-frequency oscillator-control wherever wide variation of temperature is encountered. Because of small size, it can be readily mounted to meet stringent vibration specifications. Disadvantage: Difficult to fabricate for optimum operation without coupling between modes.



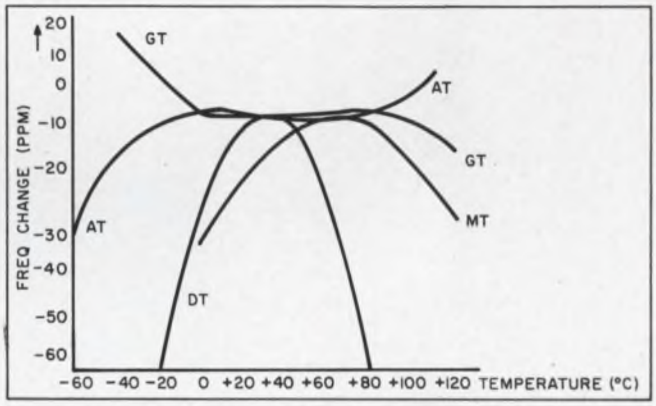
3. **The impedance of a crystal is near zero** at the series resonant frequency, f_s, and reaches its peak at the anti-resonant frequency, f_a. Steep slope between these two frequencies indicates a high Q.



5. **The mounting technique** for crystals depends on the particular application. The most widely used methods are shown above.



4. **Crystals may vibrate in four modes:** flexure, longitudinal (or extensional), face shear and thickness shear. In some cases, coupling is possible among the modes.



6. **Temperature characteristics** of four popular crystal cuts show the extremely stable behavior of the GT cut. Its frequency change is about 1 part per million over a 100°C range.

connection and the mechanical support for the quartz crystal blank. The type of mounting is a factor in determining the maximum size, stability, ruggedness and resistance of the crystal. The type of holder is also influenced by the mode of vibration of the crystal. For example, the X-cut crystal will not oscillate if the edge movement is restricted, because the X-cut mode of vibration is extensional. On the other hand, the AT crystal, which operates in the thickness-shear mode, can operate when the edges of the crystal are clamped.

Mountings are generally not specified but are left up to the manufacturer. The size of the crystal package, type (glass envelope or metal can), lead-type and size are generally specified. The usual mounting types are shown in Fig. 5. Fig. 6 shows the temperature response of four cuts.

In a pressure mount the crystal is held between two flat electrodes under a light spring pressure. This type of mounting is rugged and relatively inexpensive. The spring pressure, however, adds a certain amount of mechanical impedance to the crystal. As a result, crystals in this type of holder exhibit less activity (lower ratio of stored mechanical energy to electrical energy) than those in more critically designed mounts.

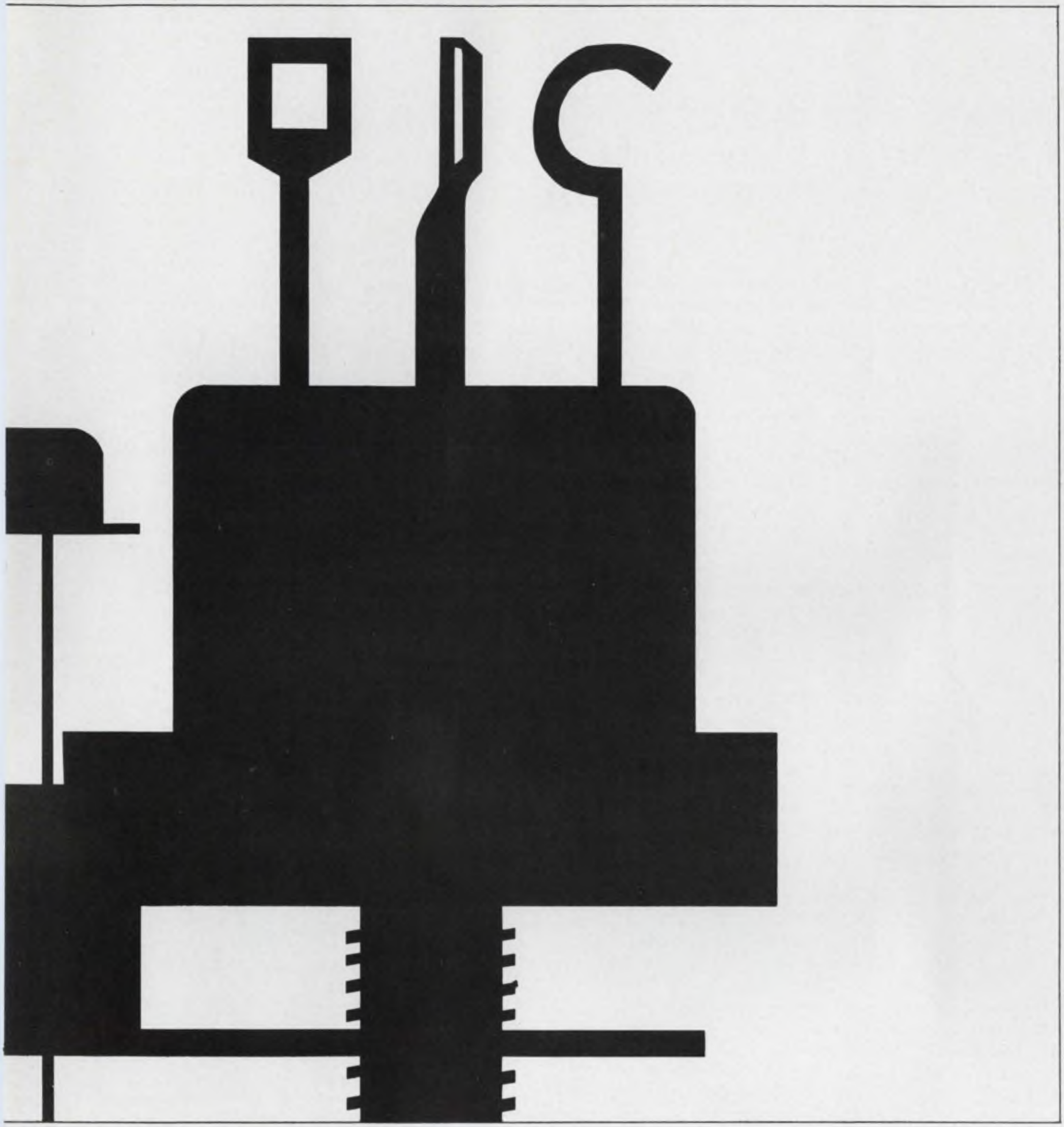
The pressure air-gap-type is less rugged than the standard pressure mount because the crystal is free to move in the space between the electrodes. This mounting technique is generally preferred when extreme frequency stability is required. It is also effective for high-frequency crystals that vibrate in the thickness-shear mode.

A dielectric sandwich minimizes the danger involved in overdriving either the pressure mount or air-gap mount by using thin sheets of materials having high dielectric constants. Overdriving a crystal could result in arcing between the electrodes and the quartz, thus causing the crystal to be punctured or the electrodes to be oxidized.

Solder-lead-type wire mountings have the advantage of being relatively shock-proof as well as reducing the effects of damping due to mounting. This type consists of wires soldered to the electrodes plated on the quartz crystal blank.

Cemented-lead-type is standard for crystals operating in the thickness-shear mode for ordinary specifications down to 1-15 MHz. Here the wire is cemented to the edges of the crystal.

Strap-type is used for very thick crystal plates. The crystal may or may not be bonded to the holder with bonding cement. The strap-type plus bonding cement has superior resistance to vibration. ■ ■



Fairchild is in the power business with more than 25 transistors, diodes, and SCR's, in nine package configurations. These are newly-designed devices, for efficient circuits. They feature integrated nickel-chromium resistors and epitaxial construction where appropriate, and something else: Planar processing that keeps out most of the impurities and keeps in all of the reliability. But Planar processing also means higher yields. And that means that Fairchild power costs less. You can learn to live with that, can't you? We can.

POWER FAIRCHILD SEMICONDUCTOR

ON READER-SERVICE CARD CIRCLE 16

Design a transformerless chopper with "off-the-shelf" integrated circuits. Small size and low cost are the main advantages.

A transformerless chopper circuit useful in many system applications can be built with "off-the-shelf" integrated circuits. Compact and inexpensive, it will get around the usual need to trade off cost and size.

Good matching of active devices on a monolithic chip and a constant-current-source biasing scheme will give a highly effective and readily fabricated integrated chopper characterized by low power consumption, low offset voltages and high-frequency operation.

Conventional drive limitations

Choppers, of either the electro-mechanical or semiconductor types, are used for low-level multiplexing, mode-switching, commutating, and modulating and demodulating. Their function in these applications is to transfer signal information alternately without distorting the original signal content or introducing any level-error information. Since no device functions as a perfect switch, any design will have parameter limitations such as offset voltage, dynamic ON resistance, leakage current, frequency capability or isolation. System requirements determine which specific type of chopper can be used.

Proper isolation of the chopper drive circuit from the signal channel is a major design aim. A widely used arrangement, the basic transformer drive, is shown in Fig. 1, but where size is important, this method is severely limited. Alternate drive circuits using capacitive discharge[1] effects, for example, have been designed particularly for integrated circuit applications. However, these techniques are not only complicated but also often expensive. The use of a standard digital integrated circuit in a common-mode configuration provides an inexpensive chopper which is useful in a variety of systems.

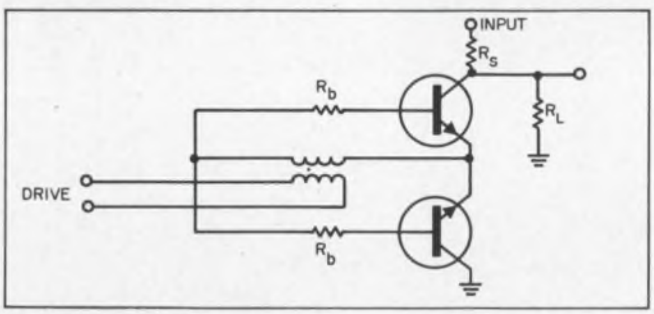
Analyzing the common-mode chopper

The basic configuration associated with this technique[2] is illustrated in Fig. 2. If the components inside the dotted lines are fabricated on a monolithic chip and the input drive current, I_D, and the output emitter current, I_E, of the circuit are equal in magnitude, the base currents of the transistors will be equal. This is due to the matched characteristics of the monolithic components. In conventional dual-transistor chopper designs, matched base currents produce equal and opposite offset voltages in the transistors. These tend to cancel one another and a minimum resultant offset voltage, V_{OS}, appears at the output collector terminal. This is readily seen in the equivalent circuit representation shown in Fig. 3. (The source and load resistances have been deleted in this diagram.) The equivalent circuit includes the emitter and collector bulk resistances, which can affect operation, as well as the offset voltages and dynamic resistances. The compensation current, I_O, is the current supplied by transistor Q_2 to correct any current imbalance in the circuit.

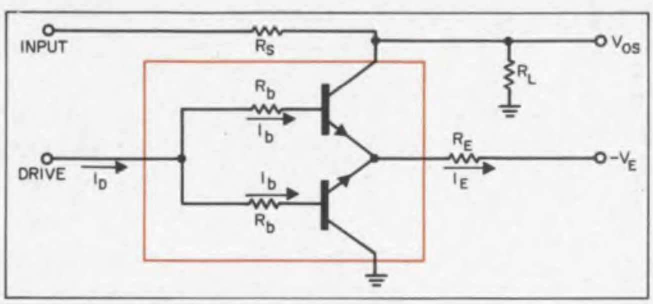
The offset voltage of a single transistor, operated as a saturated switch in the normal common-emitter configuration and with zero signal current,[3,4] can be given as:

$$V_{CE_N} = \phi_{CE} + I_b r_E', \qquad (1)$$

where ϕ_{CE} is the normal offset voltage, r_E' is the emitter bulk resistance measured from the junction to the emitter terminal, and V_{CE_N} is the normal



1. **Conventional chopper circuit** uses a transformer to isolate the drive circuitry from the signal channel.



2. **Common-mode chopper** requires a good device match and a constant-current-source bias scheme. The outlined monolithic block provides an excellent device match.

K. A. Blair, Senior Engineer, Westinghouse Electric Corp., Aerospace Div., Baltimore, Md.

mode collector-to-emitter voltage. The offset voltage is:

$$\phi_{CE} \approx \frac{KT}{q} \ln\left(1 + \frac{1}{h_{FE_I}}\right), \qquad (2)$$

where $KT/q = 26$ mV at room temperature and h_{FE_I} is the inverse large-signal current gain near the saturation region. If a reasonable emitter impurity doping level can be assumed, the emitter bulk resistance will be very small and the voltage drop across the emitter bulk resistance due to base drive current can be neglected. At room temperature, Eq. 1 becomes:

$$V_{CE_N} \approx 26 \text{ mV} \left[\ln\left(1 + \frac{1}{h_{FE_I}}\right)\right]. \qquad (3)$$

The total dynamic ON resistance of a single transistor in the normal mode is:

$$r_{ON_N} = r_s + r_E' + r_c', \qquad (4)$$

or

$$r_{ON_N} \approx \frac{KT}{qI_b} \frac{1 + h_{FE_N} + h_{FE_I}}{h_{FE_N}(1 + h_{FE_I})} + r_E' + r_c' \qquad (5)$$

where r_c' is the collector bulk resistance from the junction to the collector terminal. In monolithic structures this collector resistance can be formidable, since the collector connection is made at the top of the chip rather than at the bottom as with normal transistors, and cannot be neglected in most cases. Assuming $h_{FE_N} >> 1 + h_{FE_I}$, $h_{FE_I} << 1$, and $r_E' << r_c'$, Eq. 5 reduces to:

$$r_{ON_N} \approx \frac{26}{I_b} + r_c' \qquad (6)$$

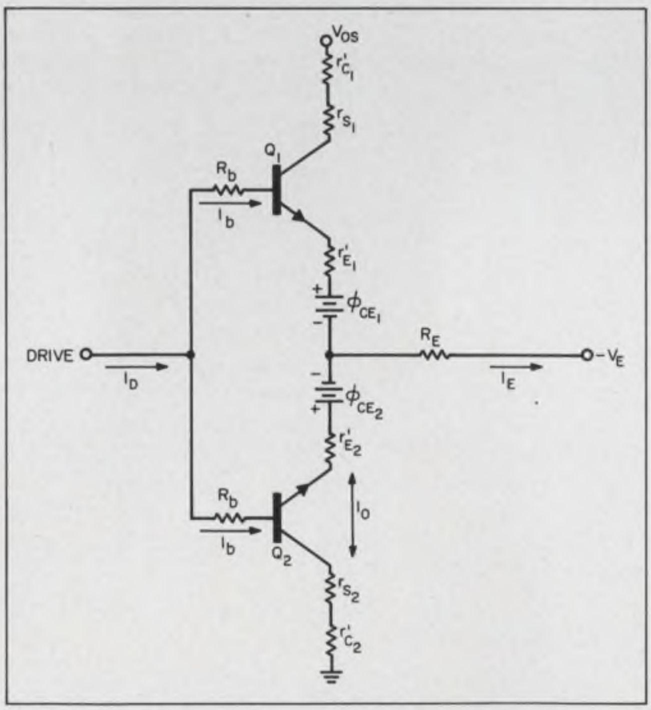
where I_b is in milliamps.

When used at current balance, the resultant chopper unit will exhibit canceling offset voltages and additive dynamic ON resistances. Since the large signal-current gain is a function of current level, there is an optimum drive current to get minimum offset voltages. As the dynamic ON resistance, however, is also a function of the drive currents, trade-offs must be considered, because the ON resistance forms a voltage divider network with the signal-source resistance. The leakage currents encountered in the OFF condition can be ignored; it is primarily the ON condition that is of concern. The leakage currents of monolithic circuits are characteristically quite small but must ultimately be factored into the final design of a high-impedance circuit, as in a conventional transistor chopper.

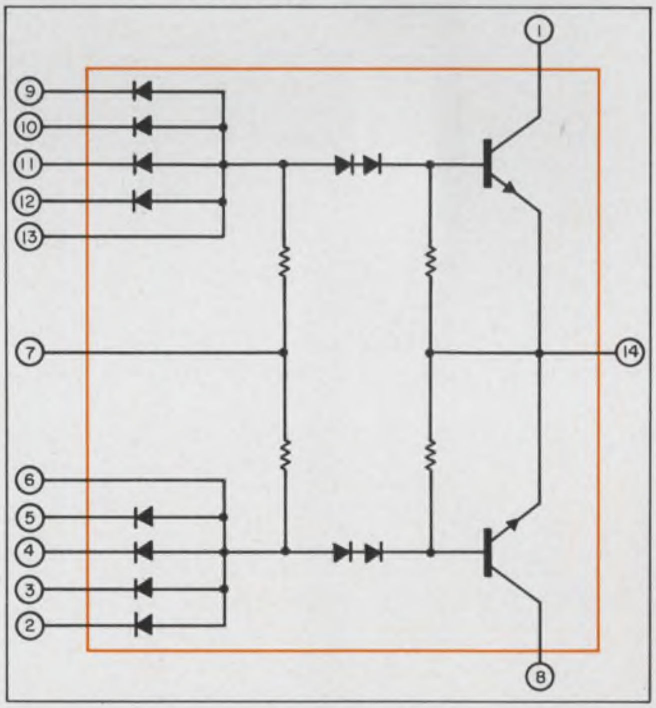
There is another factor that must be taken into account in this chopper technique. When the input drive current is either greater or less than the sink current through the common emitter resistance, transistor Q_2 must supply a compensation current, I_0. It produces a voltage drop across the dynamic ON resistance and the bulk resistances of Q_2, and this voltage drop will either add to, or subtract from, the total offset voltage. This effect will reduce the normal offset voltage of the chopper to very small values.

Testing the "off-the-shelf" IC

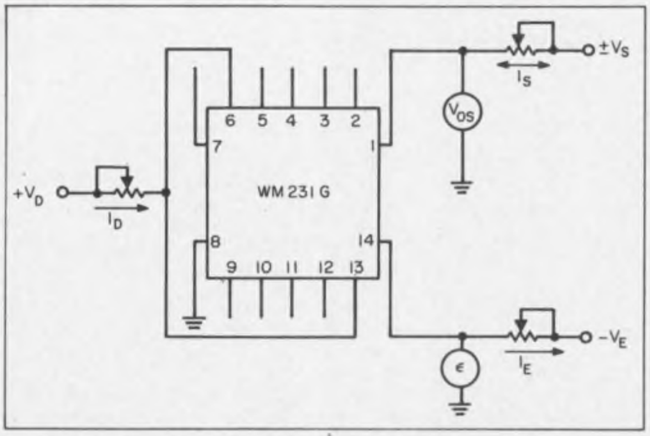
The Westinghouse WM231G NAND Gate, shown in Fig. 4, was used to evaluate this concept. Although this particular device is not specifically tailored for chopper applications, it does have the



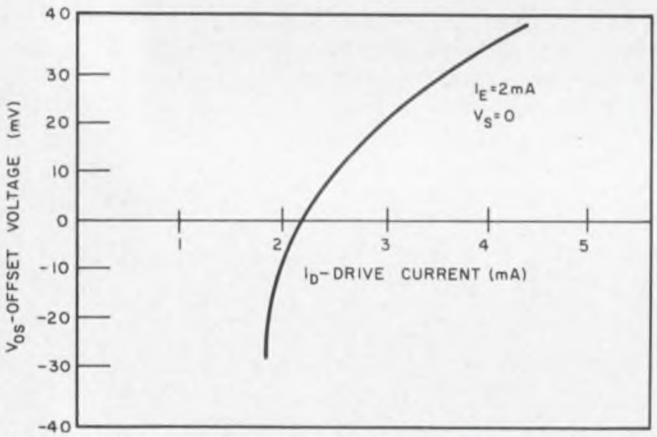
3. **The equivalent circuit of a common-mode chopper** includes the transistor offset voltages (ϕ_{CE1} and ϕ_{CE2}). Being in opposition, these voltages tend to cancel, resulting in a low total offset voltage.



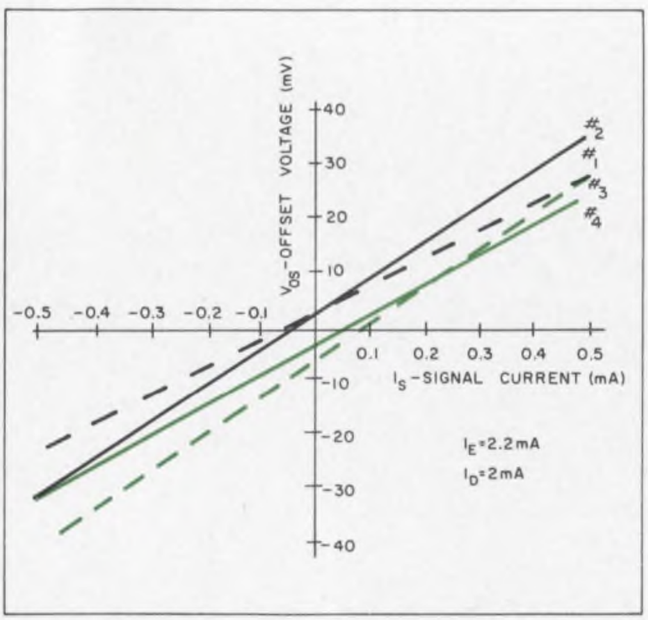
4. **A dual NAND gate,** the WM231G, is available as an off-the-shelf integrated circuit and is well suited for this chopper application. Many other available IC devices could also be used for this application.



5. **Test set-up for measuring the offset voltage** of the WM231G chopper circuit, as a function of the drive, sink and emitter currents.



6. **The offset voltage may be externally adjusted** by changing the chopper drive current. For this test the signal voltage is set at zero volts and the emitter sink current is at 2 mA.



7. **Variations in offset voltage from one unit to another** are relatively small. Where production quantities are involved, this can simplify the external circuit design.

required characteristics, such as device-matching, low saturation voltage and low dynamic resistance. The test setup for measuring the offset voltage of the WM231G as a function of drive, sink and signal currents is shown in Fig. 5.

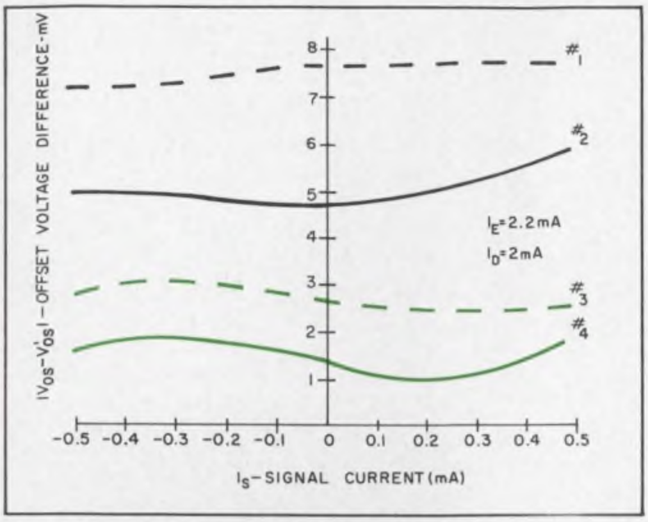
The test results obtained with the WM231G operated as an integrated transformerless chopper are shown graphically in Figs. 6, 7, 8 and 9. Fig. 6 gives the total resultant offset voltage with zero input signal and as a function of input drive current. The emitter sink current is a constant 2 mA. Adjustment of the drive current will increase or decrease the resultant offset voltage. Fig. 7 gives the offset voltage as a function of input signal current for each of four test devices. The drive and sink current are kept constant at 2 mA and 2.2 mA respectively. With the signal current at zero, the total measured offset voltage is approximately equal to the difference of the offset voltages of the two transistors in the chopper. The only deviation is due to the compensating current, I_0, that flows in the circuit. In this case, this effect is relatively slight. As indicated, the resultant offset voltage of the four choppers lies between +3 and −4 mV. In many typical system applications, this is more than adequate. The slope of the curves is an indication of the total dynamic ON resistance of the chopper. These are calculated to be between 49 ohms and 65 ohms.

In order to determine the true symmetry of the WM231G for chopper applications, the test devices were inverted so that the original signal input terminal, pin 1, was grounded and the collector terminal, pin 8, was connected to the signal source. Offset measurements were then taken. The differences in offset-voltage measurements, obtained by alternately grounding each collector, are shown in Fig. 8 for the four devices. The maximum offset-voltage difference encountered was less than 8 mV, indicating a fairly good degree of symmetry. As would be expected, the deviation about the zero level with signal current is small, since the total dynamic ON resistance should remain the same. The deviations that exist can be attributed to measurement errors. Fig. 9 illustrates the variation of offset voltage and dynamic ON resistance for two of the devices as a function of temperature. Though some variation exists, it is not considered excessive.

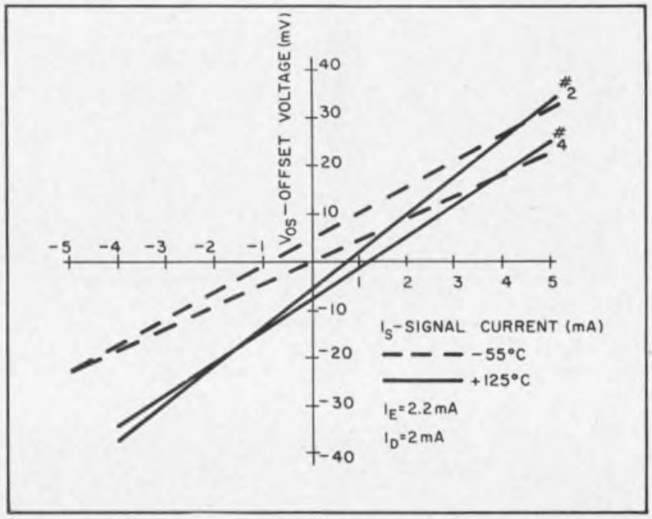
If the device were truly symmetrical, the resultant offset voltage would remain unchanged, but as shown in Fig. 8, this condition of symmetry is not completely met. It would also normally be expected that the ON resistance would increase as a factor of temperature as indicated by Eq. 6. Since it does not, the assumptions made for Eq. 5 may not be completely valid.

Driver also uses IC

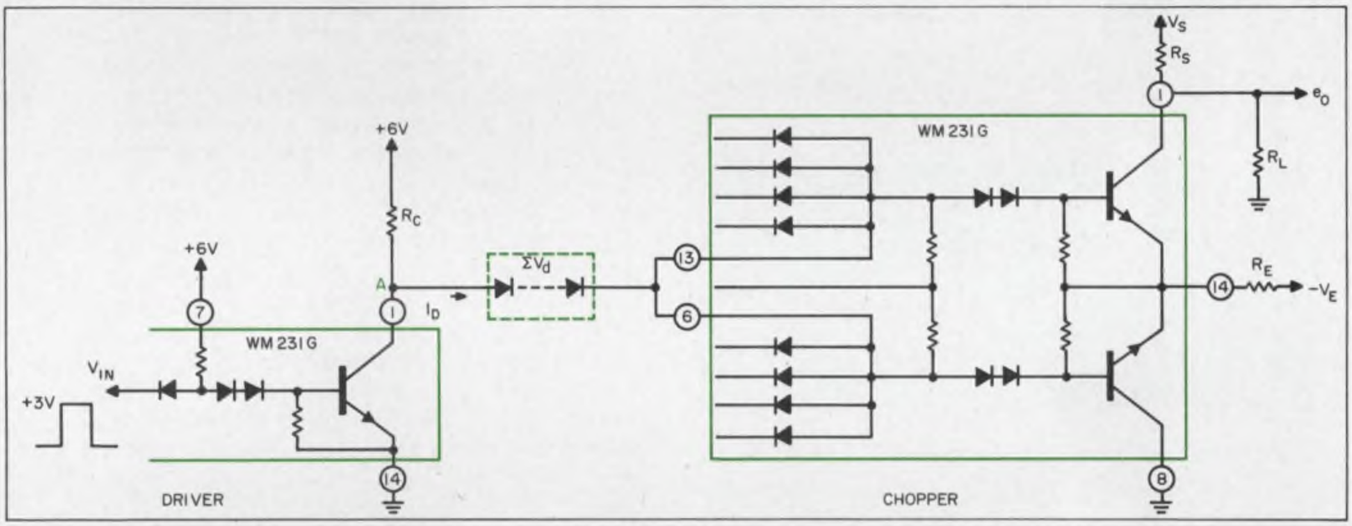
While it is possible to drive the integrated transformerless chopper from another NAND gate, some boundary conditions must be observed to obtain optimum results. If the driver is connected directly into the summing-diodes input of



8. **Symmetry of the WM231G block** can be determined by inverting the test devices and then measuring the offset voltage for the four devices tested, the maximum difference in offset was less than 8 mV.



9. **The temperature dependence of the offset voltage** and dynamic ON resistance is not excessive for most applications. Two temperature extremes are considered, —55°C and +125°C.



10. **Complete driver-chopper circuit** uses two WM231G devices. The series-string of diodes is used to provide a predetermined cut-off voltage and resistor R_C is used to set the input drive current.

the WM231G, and the base drive resistors (Pin 7, Fig. 4) are connected to +6 volts as in the standard configuration, two problems arise:

- The relative magnitudes of the base resistors and the supply voltage severely limit the total available drive current. This does not permit designing for minimum offset-voltage conditions.
- There is no direct means to insure that the chopper will be completely turned off.

Fig. 10 illustrates a driver circuit that can be designed not only for optimum drive currents with respect to offset voltage, but will also ensure an adequate cut-off margin. In this configuration, the driver collector resistor R_c determines the magnitude of the drive current and the series-diode string will provide the required cut-off requirements for the chopper.

In the ON condition the driver current is determined by

$$I_D = \frac{V_c + V_E - \Sigma V_D - 2V_D - V_{be}}{R_C + R_E} \tag{7}$$

The emitter sink current will normally be equal to the drive current or

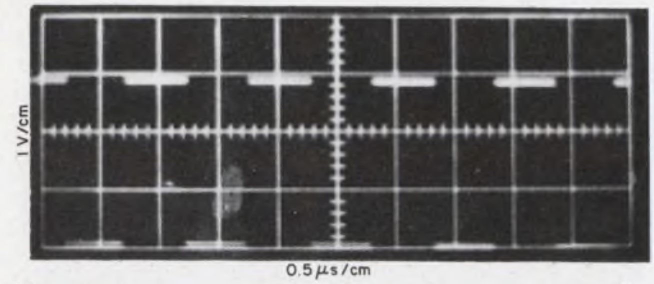
$$I_E = I_D = \frac{V_E - \epsilon}{R_E} \tag{8}$$

where ϵ, the common emitter voltage, is approximately zero.

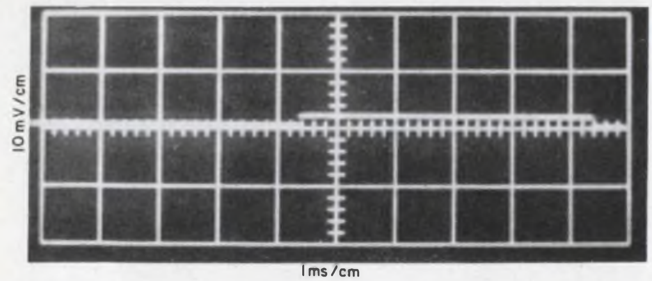
In the OFF condition, two dc paths must be considered. The worst-case condition is used to establish the required magnitude of the series-diode string threshold voltage. One path is through the base offset diodes and the base-emitter diode, the other is through the base offset diodes and the base-emitter resistance. Investigation will show that the worst condition is encountered through the base-emitter pull-down resistor, so that

$$I_D = \frac{V_{sat} + V_E - \Sigma V_D - 2V_D}{R_b + 2R_E}, \tag{9}$$

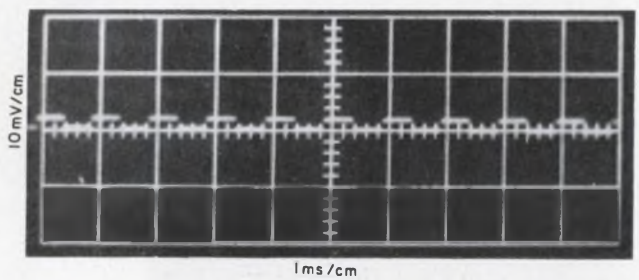
where V_{sat} is the saturated collector-emitter volt-



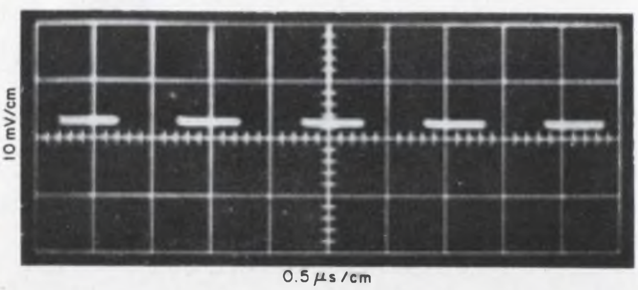
11. **Driver output voltage** as measured at point A in Fig. 10. The bottom line in this photo represents zero volts dc. The prf is 1 kHz.



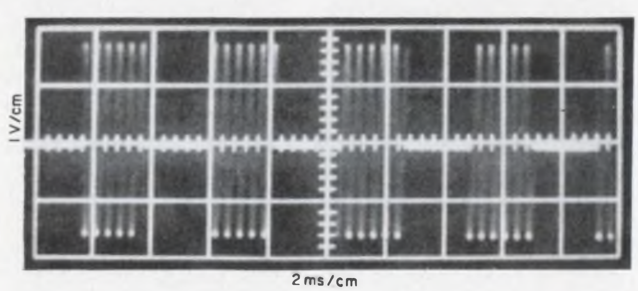
12. **Chopper offset voltage** is measured with zero signal voltage. The driver prf is 100 Hz and R_s is equal to 10 kΩ. The center line is at zero volts.



13. **The offset voltage remains at +2 mV** when the driver prf is increased to one kiloHertz.



14. **Offset voltage remains at +2 mV** as a 2-V dc signal voltage is applied. Only the near-ground portion of the chopped signal is shown.



15. **One-kiloHertz signal** is chopped at 100-Hz rate. Center line is at zero volts dc.

age of the driver transistor. When $I_D=0$, in the cut-off condition,

$$V_{sat}+V_E=\Sigma V_D+2V_D. \qquad (10)$$

The number of series diodes required to insure cut-off can be readily determined.

If necessary, modifying the present circuit design and fabrication technique to obtain a better match of offset voltages and lower ON resistances will lead to even better chopper devices.

Test circuit works well

As shown in Fig. 10, a WM231G NAND gate was used as a driver stage for the transformerless integrated chopper. The component values are:

$R_E=1\ \text{k}\Omega$ $\quad R_C=1.5\ \text{k}\Omega$ $\quad R_L=\infty$
$V_E=-2\ \text{V}$ $\quad V_C=+6\ \text{V}$ $\quad \Sigma V_D=$ two series diodes

In these tests the input signal to the driver stage was a three-volt positive-going square-wave that was operated at a 100-Hz and at a 1-kHz pulse repetition frequency (prf). Time limitations prevented making measurements at other frequencies.

An oscilloscope photograph of the driver stage output voltage, measured at point A, is shown in Fig. 11. Measurements showed that the amplitude was unaffected by prf selection.

The chopper output voltage, e_o, obtained with a signal voltage of zero, is shown in Fig. 12. In actuality, this is the dynamic representation of the static offset voltage measured previously. The offset or error voltage is +2 mV for a driver prf of 100 Hz. This establishes the minimum discernible signal level for the chopper. When signal levels approach this 2-mV level, an error is introduced in the output signal voltage. Fig. 13 shows the same dynamic offset or minimum discernible signal level with a 1-kHz prf.

Fig. 14 is a photograph of the chopper output voltage, e_o, when a dc signal voltage is applied. For clarity, only the lower or ground-level portion of the output signal is shown. When $V_s = +2$ volts, the output voltage is still +2 mV. This shows that the input signal level does not alter the basic chopper characteristics. Fig. 15 shows the chopper output voltage when the signal input is a 1-kHz sine wave and the chopping frequency is 100 Hz. ■ ■

Acknowledgements:

The author wishes to thank E. M. Williams, co-investigator of the integrated transformerless chopper for his significant theory and design assistance. Special thanks is also expressed to G. E. Marx for conducting device measurements and to M. H. White and R. P. Borrello for their valuable suggestions and assistance in preparing this article.

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2. Patent pending.
3. J. J. Ebers and J. L. Moll, "Large Signal Behavior of Junction Transistors," *Proceedings of the IRE*, XLII (December, 1954), 1761-1772.
4. R. L. Bright, "Junction Transistors Used as Switches," *AIEE Transactions (Communications and Electronics)*, LXXIV (March, 1955), 111-121.

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332A	0 to 1111 vdc	0 to 50 ma	±0.0015%	7 digit inline	±0.003%	7" —60 lbs.	$2,490
382A	0 to 50 vdc 0 to 5 vdc	0 to 2 amps	±0.002%	6 digit inline	±0.01%	5¼"—50 lbs.	$1,595
383B*	0 to 50 vdc	0 to 2 amps	±0.005%		±0.025%	5¼"—50 lbs.	$1,950

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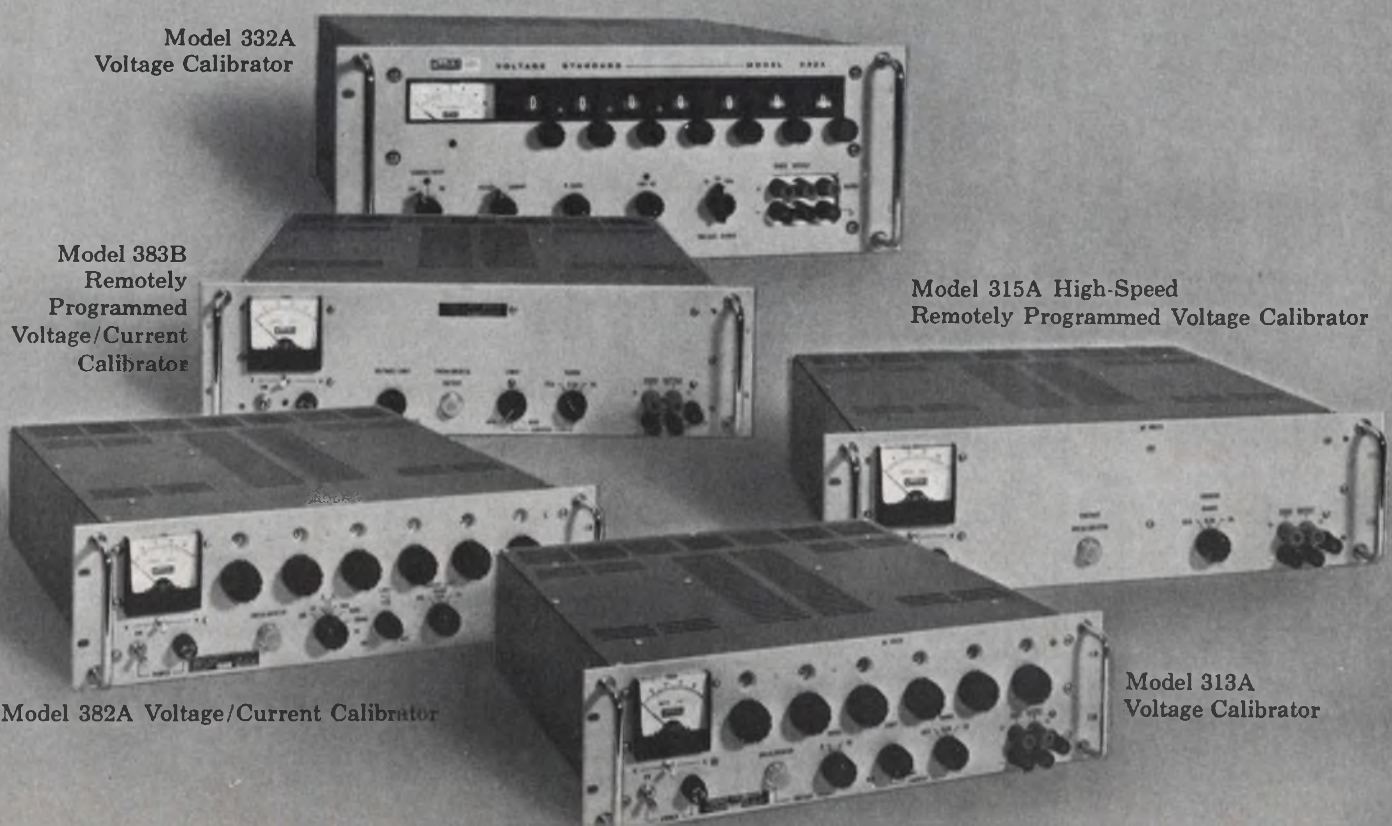

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Model 383B Remotely Programmed Voltage/Current Calibrator

Model 315A High-Speed Remotely Programmed Voltage Calibrator

Model 382A Voltage/Current Calibrator

Model 313A Voltage Calibrator

A silent stepping relay? Yes, it's possible with the use of a combination of reed relays and silicon-controlled rectifiers.

A silent, high-speed stepping relay that is inexpensive and yet reliable may sound like a tall order. But it's possible to design one by combining miniature magnetic reed relays and silicon-controlled-rectifier (SCR) actuating circuitry.

Such a unit is often an excellent compromise between relatively slow and noisy mechanical stepping relays and very-high-speed electronic switches.

Reed relays have many advantages.

The development and production of a wide variety of magnetic reed relays in the last few years has resulted in a whole new family of switching circuitry, with these advantages:

- Silent operation.
- Low power, typically 100 mw.
- Hermetically sealed contacts.
- Fast actuating time, typically 0.5 to 1 msec.
- Extremely long life expectancy.
- Uniformly low contact resistance.
- Low open-circuit capacity.
- High open-circuit resistance.

The basic magnetic reed switch consists of a pair of thin cantilever strips sealed inside of a short glass tube. These cantilever strips (or reeds) are mounted in such a way that the free ends overlap each other slightly and maintain a normally-open spacing of several thousandths of an inch or more. The reed elements are made from a magnetic material; hence, when the reed is aligned with a sufficiently strong magnetic field, the electromagnetic force across the gap causes the reed elements to move together. The normal manner of energizing the magnetic reed switch is to place one or more of these units inside a solenoid coil.

Stepping circuit uses reed-relay stages.

The use of magnetic reed switches in a high-speed stepping-relay circuit is shown in Fig. 1. This particular circuit is designed to sample both X and Y coordinate signals for direct oscilloscope plotting. However, the basic principle is suitable for a wide variety of applications.

The stepping relay circuit is composed of N number of magnetic reed relay stages. Each stage consists of a coil, three magnetic reed units and an SCR energizing circuit. In the normal circuit operating mode, the sequencing, or stepping, of the switches is controlled by a positive trigger-input to the SCR gate circuit. For each stage, the connection to the gate circuit is made through one of the normally-open reed contacts (c) of the preceding stage. Hence, the positive trigger-pulse will be applied only to the gate of the stage immediately following the stage that is energized. The negative anode-to-cathode pulse required to turn the SCRs off is obtained by capacitance coupling between adjacent SCR anodes.

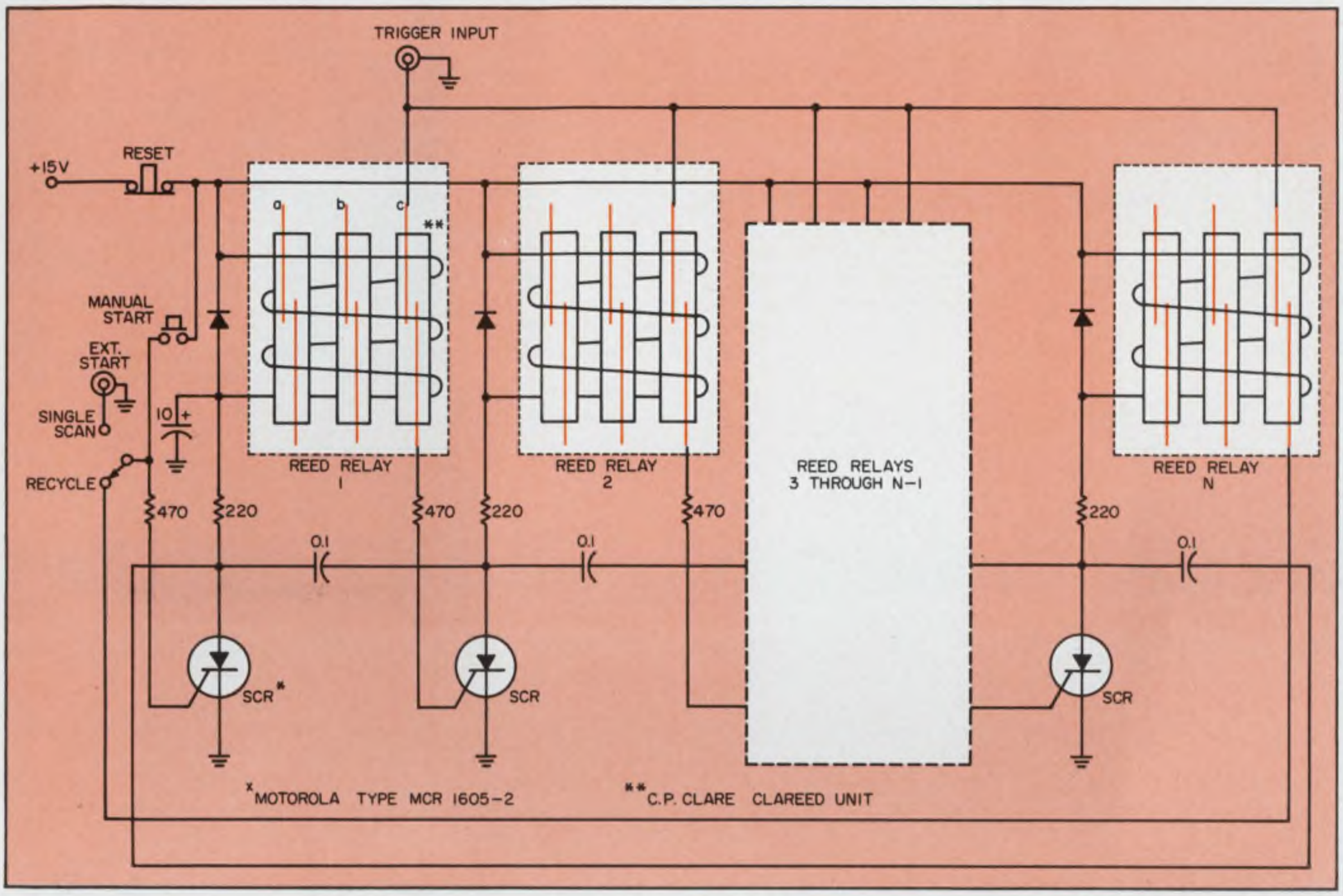
Gate triggering to the initial stage may be switched from either an external input (Single Scan) or from the reed contact of the final stage (Recycle). When the initial stage receives its gate trigger externally, the stepping switch will sequence from position 1 through position N, and hold position N closed until the next gate trigger. When the initial stage is triggered from the final stage, the stepping switch will continually recycle from position 1 through position N. The X and Y signal samples are taken through normally-open reed contacts (a and b) in each stage. RESET and MANUAL START buttons are provided to permit external control of the stepping switch.

Receiver sampling represents typical use

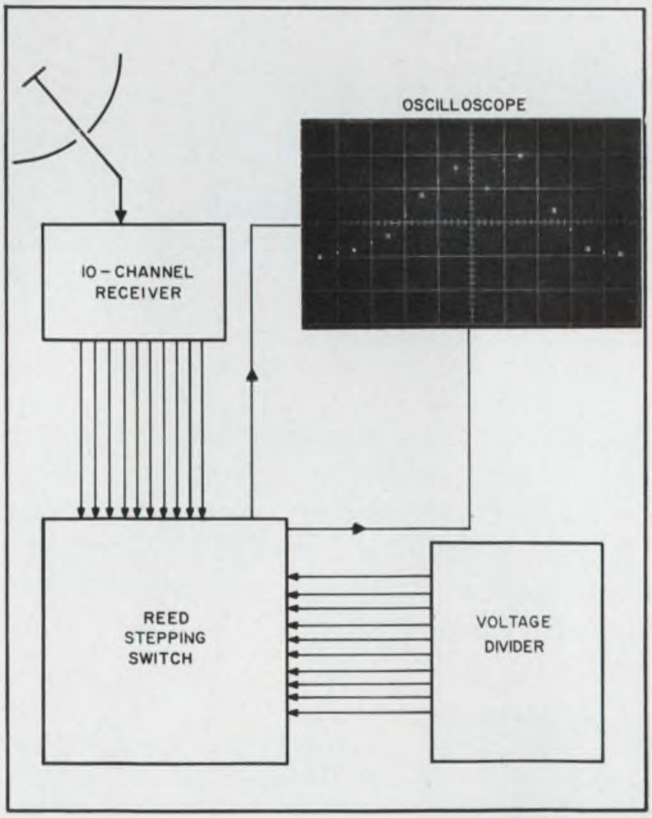
Fig. 2 illustrates the use of the reed stepping switch to sample the output of a 10-channel receiver system. The channels are equally spaced in frequency, with the spacing equal to the channel bandwidth. In this case the X samples are the detected channel output level, and the Y samples are equal dc voltage increments. Hence, the oscilloscope display is a plot of the received spectrum. It should be noted that the stepping action is make-before-break, so intermediate points are visible between the 10 main points on the plot.

Typical waveforms on the gate and anode of successive stages in the stepping switch are shown in Fig. 3. Note the negative spikes that appear on the anode voltage as a result of the capacitive coupling between adjacent anodes. It is this negative spike that provides the convenient turn-off action in the SCR. ■ ■

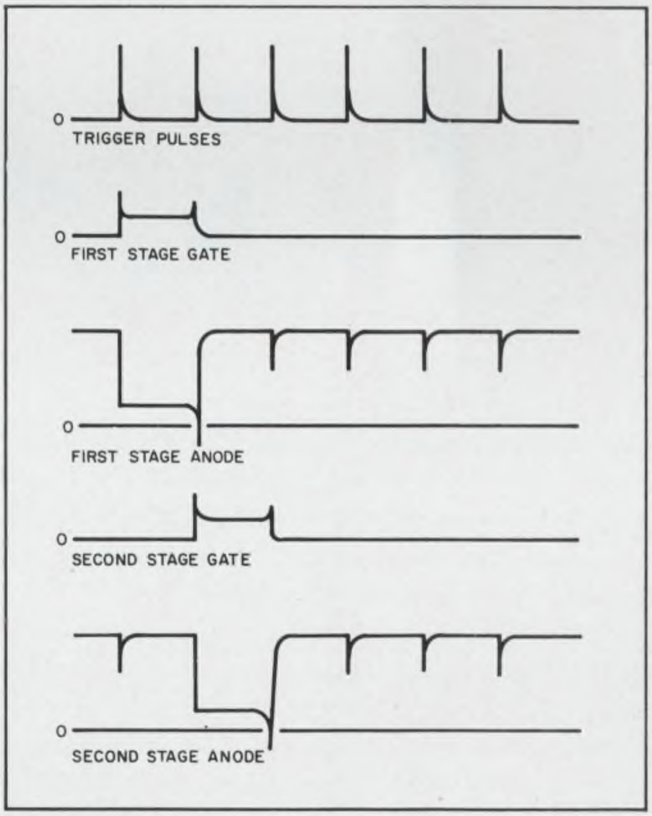
Hays Penfield, Engineer, Concord, Mass.



1. **Stepping-relay circuit** consists of N number of identical reed-relay stages. The circuit steps in sequence when a positive trigger-input is applied. The first stage can be triggered either externally or from the last stage.

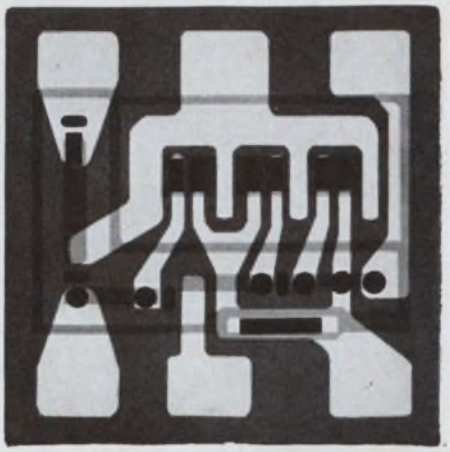


2. **Typical application** of the stepping-relay circuit is demonstrated by this arrangement for sampling the output of a multi-channel receiver.



3. **SCR waveforms** for all stages are identical, except that those of each succeeding stage are displaced in time by the interval between trigger pulses.

for integrated circuits...



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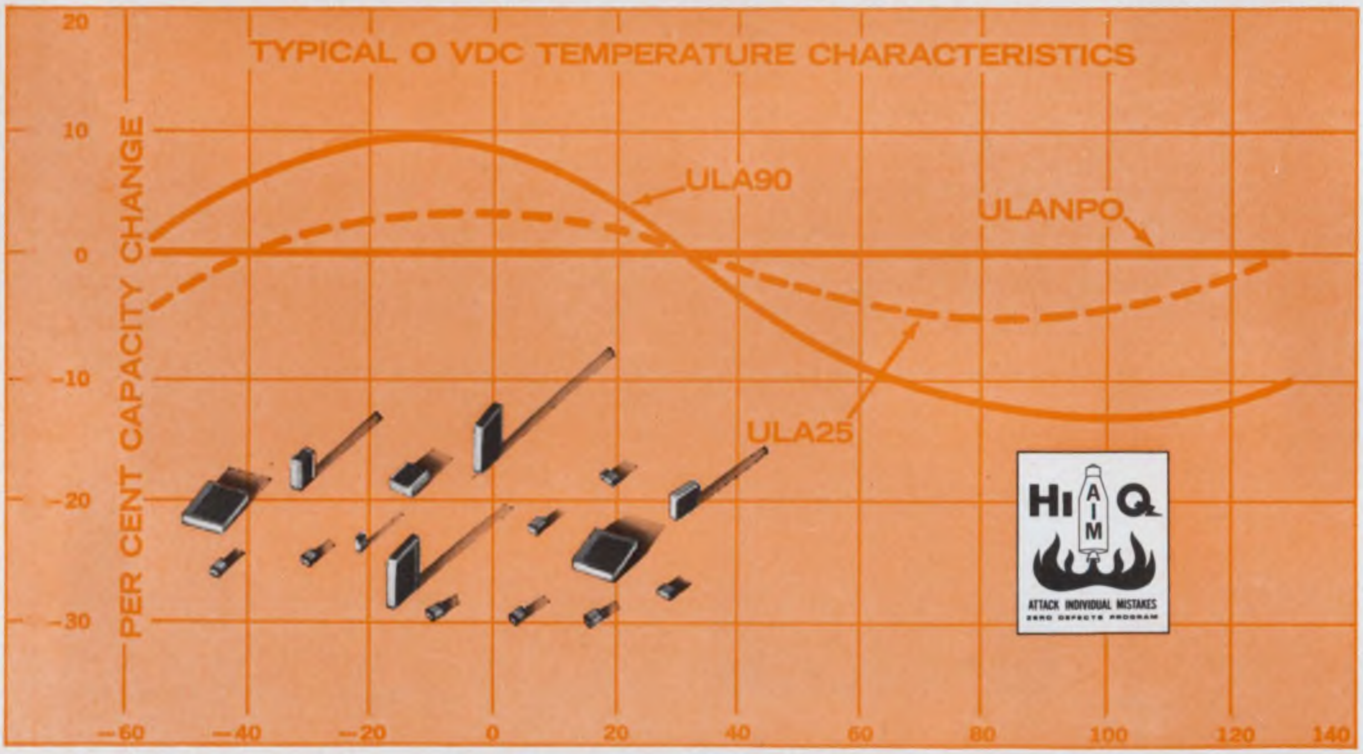

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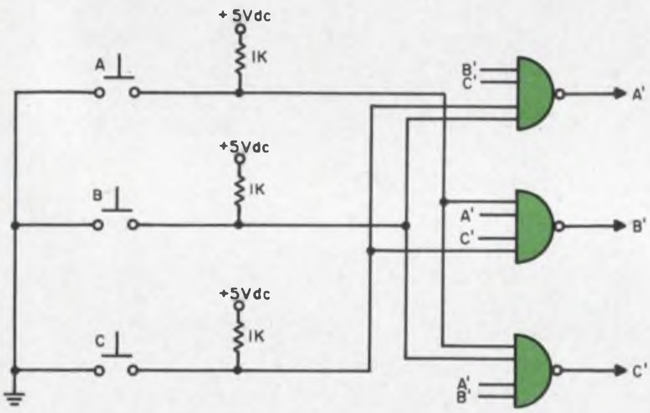
NAND gates form tri-stable flip-flop

Three 4-input NAND gates may be used to form a tri-stable flip-flop. Thus connected, these standard DTL elements provide three clean, unique outputs.

The system was developed to meet a specific need to store the identity of the last operated of three pushbuttons. In addition, the outputs had to switch cleanly as a new pushbutton was operated, with no evident contact-bounce.

The usual approach would use two or three flip-flops and the appropriate gating or decoding. Here (see schematic) three DTL NAND gates were used instead.

The inputs are switch contacts A, B and C; the output logic levels are A', B' and C'. One output, corresponding to the operated input, will be at logic "zero"; the other two will be at logic "one." When a switch is operated, its corresponding output will switch low with no contact bounce, and remain in that state until another switch is operated. Operation of more than one switch causes all outputs to be high. Load resistors of 1.0 kΩ hold the inputs at logic "one" in the absence of the switch contact to ground.



Three standard DTL 4-input NAND gates are connected to form a tri-stable flip-flop.

Robert M. Walker, Project Engineer, Philco Corp., Palo Alto, Calif. VOTE FOR 110

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Low-voltage supply replaces small batteries

Diodes and capacitors can be combined to produce a small, efficient replacement for the battery. Line-operated, the substitute eliminates the need for bulky transformers or resistive dividers.

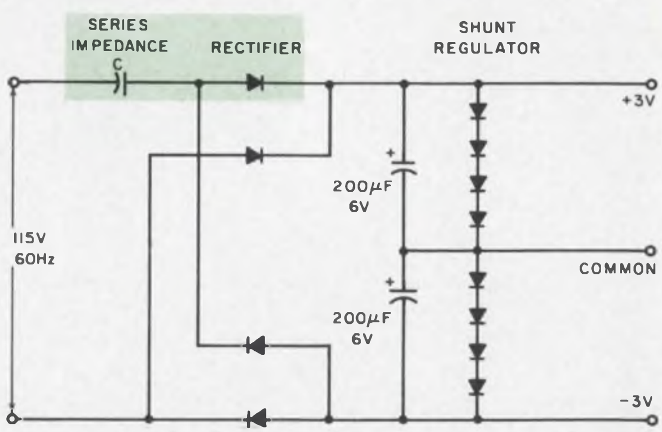
Portable, battery-operated instruments, such as radios or volt-ohm meters, are often used consistently at one site; replacement of batteries can be an expensive, needless nuisance. Moreover space needs are often critical.

At first glance the development of an ac-operated, low-voltage supply suggests stepping the 115-volt line down with a transformer. Even at the low currents involved, however, the transformer is too large to permit the power supply to be fitted into a standard battery compartment.

A second method employs a resistive divider; because the operating current is low (80 mA is typical), this seems attractive. However, approximately 12 watts would be dissipated in the dropping resistor. Such power may heat the instrument excessively.

A better design involves dropping the line voltage with a series reactive impedance (see schematic). A capacitor is preferred, because an inductor would occupy as much space as a transformer. Simple calculations show that approximately 40 mA per μF will flow through a series capacitor.

To illustrate, a particular instrument being converted requires ± 3 volts at 40 mA, with peaks to 50 mA. A 2.0-μF series capacitor is used to provid a total of 80 mA—40 mA each to the load and the shunt regulator.



Low-voltage replacement for batteries is formed by this capacitor-diode arrangement. Line-operated, it is efficient (most of the power is reactive) and compact. **Note the** absence of inductive and resistive elements.

The shunt regulator consists of eight forward-conducting silicon diodes in series. Zener diodes could be used but would give poorer regulation at this low voltage (3 volts). Virtually any type of silicon signal diode may be used in both the regulator and the bridge rectifier. The ac voltage into the bridge is only 7.6 volts. A full-wave rectifier is necessary here, because a bi-directional current flows through the capacitor.

The low-voltage power supply fits on to a 2-by 3-inch plastic card, easily meeting the small space needs of the battery compartment. As most of the power is reactive, the circuit is very efficient.

Howard F. Stearns, Principal Engineer, Fairchild Hiller Corporation, Rockville, Md.

VOTE FOR 111

Low-frequency astable circuit uses three inexpensive relays

One ordinary relay and two thermal-delay relays may be combined to create an inexpensive, low-frequency astable system. Total timing periods of six minutes or higher may thus be achieved.

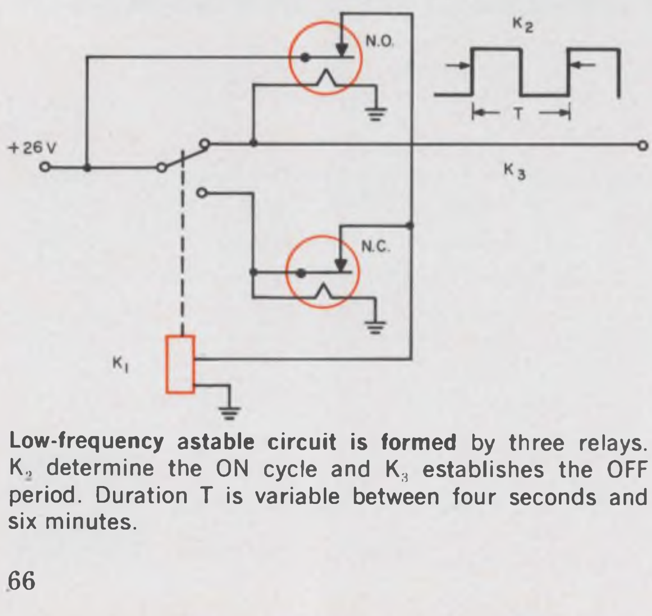
In the circuit, K_1 is a conventional relay and K_2 and K_3 are the thermal types (see schematic). The thermal-delay relays establish the duration of the ON and OFF cycles.

Power is initially applied to the filament of K_2. After a time interval determined by the thermal characteristic of K_2 has elapsed, its NO contacts close and energize relay K_1. Power to K_2 is broken by K_1, but power to the coil of K_1 is maintained through the NC contact of K_3 and the NO contact of K_1. At the same time, power is applied to the filament of K_3.

After a time interval determined by the thermal characteristic of K_3 has occurred, the NC contacts of K_3 will open and cause K_1 to deenergize. The system is now in its original state. The filaments should be permitted to cool off before the start of a new cycle.

G. Richwell, Staff Engineer, Reflective Electronics, Stamford, Conn.

VOTE FOR 112

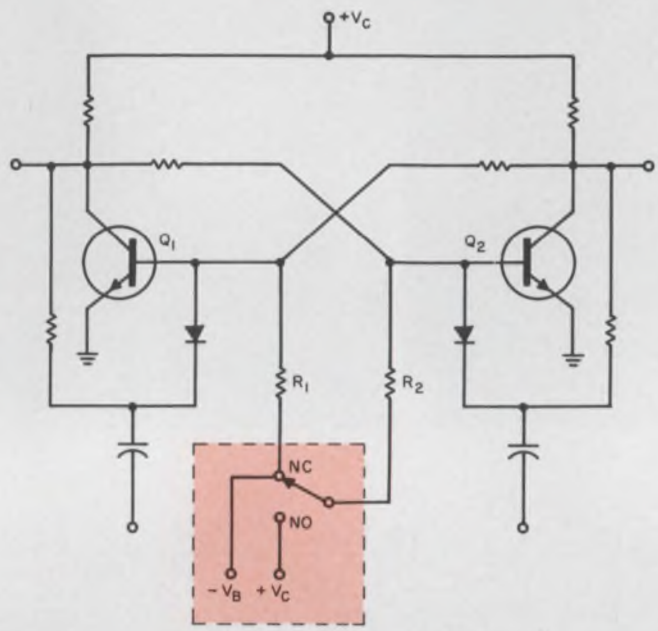


Low-frequency astable circuit is formed by three relays. K_2 determine the ON cycle and K_3 establishes the OFF period. Duration T is variable between four seconds and six minutes.

Flip-flop reset circuit requires no diodes

Digital systems often require a means to reset their flip-flop stages manually. A simple and direct method of achieving this uses one spdt switch and no extra diodes.

In the normal operating mode (see schematic) resistor R_2 is connected through the NC position



Resetting of flip-flop is easily achieved by an spdt switch connected to two power sources. This function does not require switching diodes.

of the reset switch to bias voltage $-V_B$. When the switch is momentarily depressed, R_2 is connected to the $+V_C$ source. This applies a positive bias to transistor Q_2 and resets the flip-flop.

By connecting the bias resistor of each flip-flop to the reset switch, any number of flip-flops can be reset. Moreover, with this method there is no problem of cross-coupling other than that which is normally present on the voltage-bias lines.

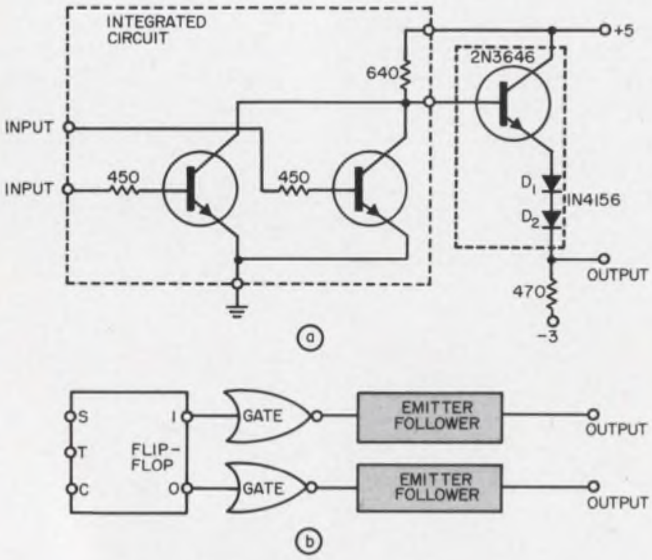
John T. Hannon Jr., Project Engineer, Metric Systems Corp., Fort Walton Beach, Fla.

VOTE FOR 113

Output circuit increases noise immunity of ICs

A simple transistor-diode output configuration, coupled to standard DTL and TTL integrated circuits, increases the noise immunity of the microcircuit logic elements. This emitter-follower output stage requires little power and raises the fan-out figure.

Some low-priced ICs (dual, two-input gates, J-K flip-flop, etc.) exhibit poorer noise immunity than their more expensive counterparts. Noise immunity can often be increased to ±2.0 volts, and the fan-out raised to 20 or more, by the addition of a discrete component output circuit (see schematic "a").



Noise immunity is increased when an emitter-follower diode output stage is connected to an integrated circuit (a). Suitable for DTL, TTL and other logic elements, they are used with buffer-gates when connected to flip-flops (b).

The base-to-emitter diode voltage drop of Q_1 and the voltage drop across D_1 and D_2 cause the output to swing from +2.5 volts to −2.0 volts, instead of the usual swing from +3.5 to ground. When the output is at −2.0 volts, the input transistor in the next stage is back-biased by two volts, thus giving it two volts of noise rejection. When the output is at +2.5 volts, the input threshold of the next stage is exceeded by nearly +2.0 volts, thus providing two volts of noise rejection here.

The low output impedance of the emitter-follower also helps to improve noise immunity. To boot, the fan-out of the gate is increased to 20 or more because of its current gain.

The flip-flop output voltage swing is not as large as the gate output voltage swing, because there are internal feedback connections in the flip-flop. For this reason, the flip-flop must be buffered with gates (schematic "b"). Propagation delay tests were made to ensure that these circuits would work in a system with a 2-MHz clock and a fan-out of 20. Eight gates with emitter followers were connected in series, and each emitter-follower was loaded with 500 pF to ground. In parallel with the 500 pF were 27 ohms in series with a diode. The resistor-diode combination represented approximately 20 gate input loads. The total delay through the eight circuits was 400 ns.

Four flip-flops buffered with gates and emitter-followers were then connected as a binary counter. When each emitter-follower was loaded, total delay through all four elements was also 400 ns. With the lesser capacitive loading typical of actual use, the circuits will be even faster.

The technique of making the output swing negative of the ground reference to increase noise immunity is not limited to a particular logic form. For example, it may be used with DTL or TTL. In line with today's microelectronic trends, the emitter-follower could be placed on the same integrated circuit chip as the gate or the flip-flop.

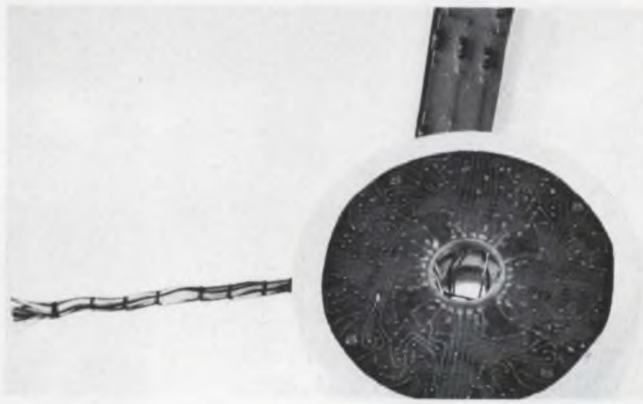
Gary Babcock, Design Engineer, U.S. Naval Ordnance Test Station, China Lake, Calif.

VOTE FOR 114

Package electronic modules with shrinkable tubing

Plastic tubing that shrinks when heated has an unusual application in the packaging of entire electronic assemblies. The round package in the photograph consisted of three circular printed-circuit assemblies, each potted in epoxy. To hold the three assemblies together, tubing slightly larger in diameter than the modules' 5.9 inches was used and shrunk in place.

Since the tubing shrinks to 50% of its original diameter, it folds itself over the ends and provides a very tight, secure package that resists vibration, tensile and shear stresses very well. The other



Shrinkable tubing encapsulates modules of various sizes, providing insulation and environmental protection, and even binding the modules together.

package shows that the technique can be used with other than circular packages, even though the original shape of the tubing is circular.

In addition to providing a simple, effective means of binding the modules together, the material's dielectric properties are used to advantage in insulating the package.

Plastic materials that shrink when heated are extensively used for "spaghetti," cabling jackets, splice insulators, etc. Less familiar to electronic designers is the larger diameter and thicker tubing of the same material that is primarily used in industrial applications, such as the weather-proofing of pipeline weld joints. This material is usually supplied with a coating of tar, but can be purchased untarred in varying diameters (to 18 in.).

Gilbert C. Willems, Research Engineer, U.S. Army Missile Command, Redstone Arsenal, Ala.

VOTE FOR 115

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Dan R. Cole, Skil Corp., Chicago, Ill.

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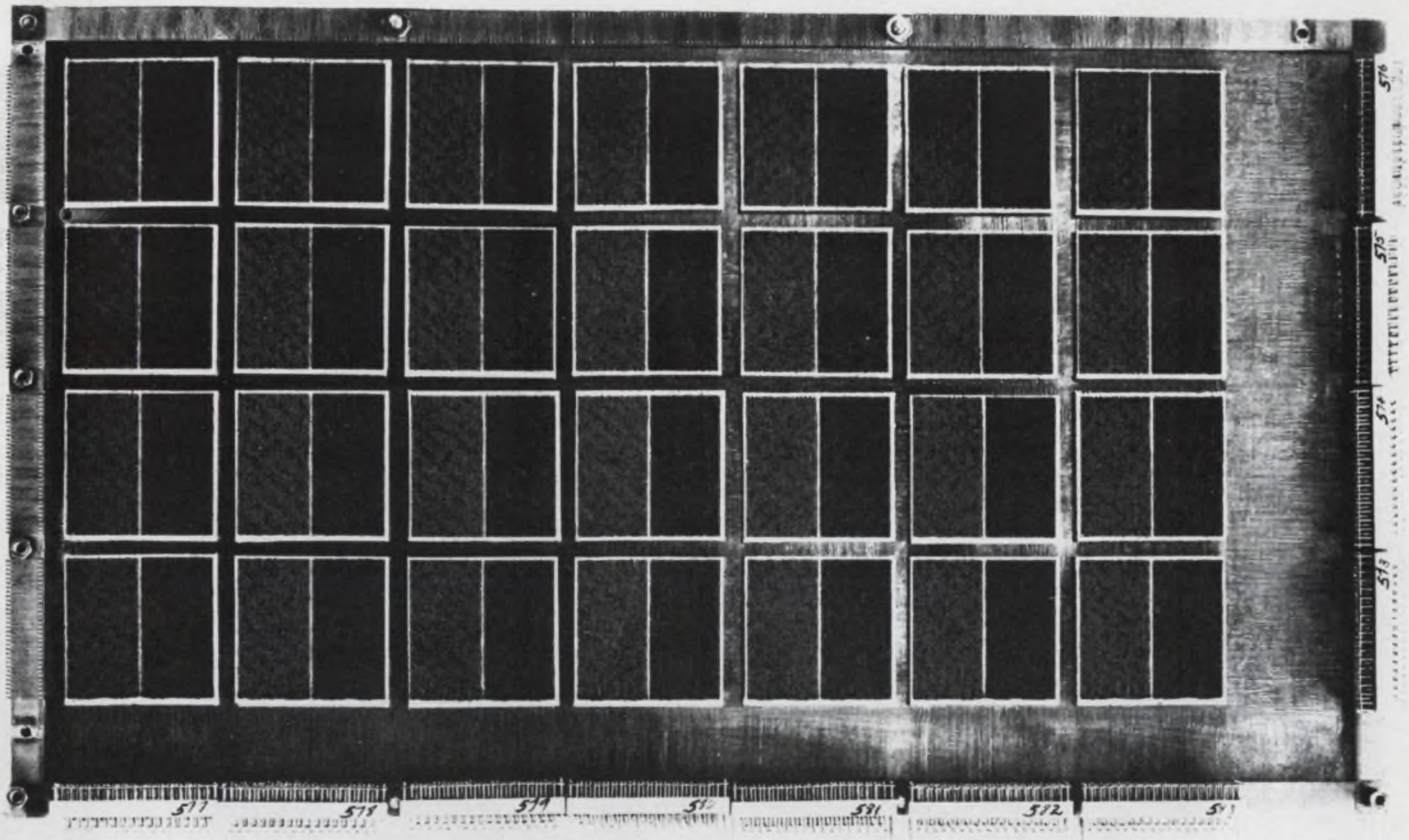
ON READER-SERVICE CARD CIRCLE 224 ➤



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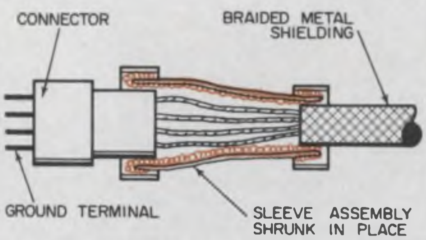
NASA Tech Brief

70 watt-hours/lb from regenerative fuel cell

The problem: To provide an electrical energy-storage medium that is lightweight, efficient, and inexpensive.

The solution: A hydrogen/oxygen regenerative fuel cell that is adapted for a large number of cycles with deep discharge. Its output is up to 70 watt-hours/lbs.

The fuel cell consists of two gas-permeable electrodes separated by a body of electrolyte. The first electrode is of inert platinized nickel, the second electrode is of silver. The electrolyte body is a fine, porous, nonconducting bed of asbestos, partially saturated with an aqueous solution containing 35% potassium hydroxide by weight. When the cell is initially charged with a predetermined



amount of electrical energy, electrolysis occurs in the electrolyte solution, producing hydrogen gas from the first electrode and oxygen gas from the second electrode. Substantially all of the oxygen gas immediately combines with the silver to form silver oxide. The gas pressures are balanced by the expansion of the regular diaphragm.

When a preset amount of electrical energy is discharged from the cell, the silver oxide is reduced to pure silver and the gaseous hydrogen reacts with the hydroxylions, formed at the silver electrode, to produce water which is absorbed into the electrolyte bed. Thus the cell is regenerative.

The voltage efficiency of this cell is about 95.5%, the current efficiency is about 95%, and the power efficiency is about 91.7%.

For further information, contact: Harlan Doyle, Harvey Frank and Charles W. Stephens, Electro-Optical Systems, Inc., 300 N. Halstead St., Pasadena, Calif. 91107.

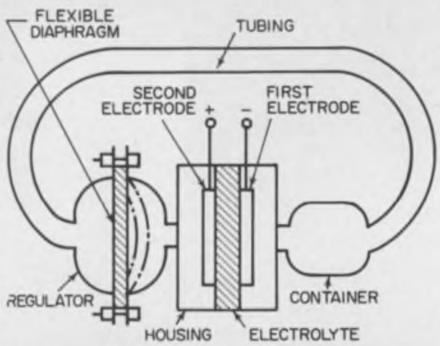
Sleeve for RF cables bridges shielding gap

Problem: Eliminate the RF shielding gap between an RF cable (with braided-metal RF shielding) and a multipin connector.

A grounding jumper across the gap between the terminated portion of the braided metal and connector, which is commonly used, does not provide adequate RF shielding across the gap.

Solution: A sleeve assembly, installed between the connector and the terminated portion of the metal shielding.

The sleeve assembly consists of a short length of braided metal enclosed in a heat-shrinkable



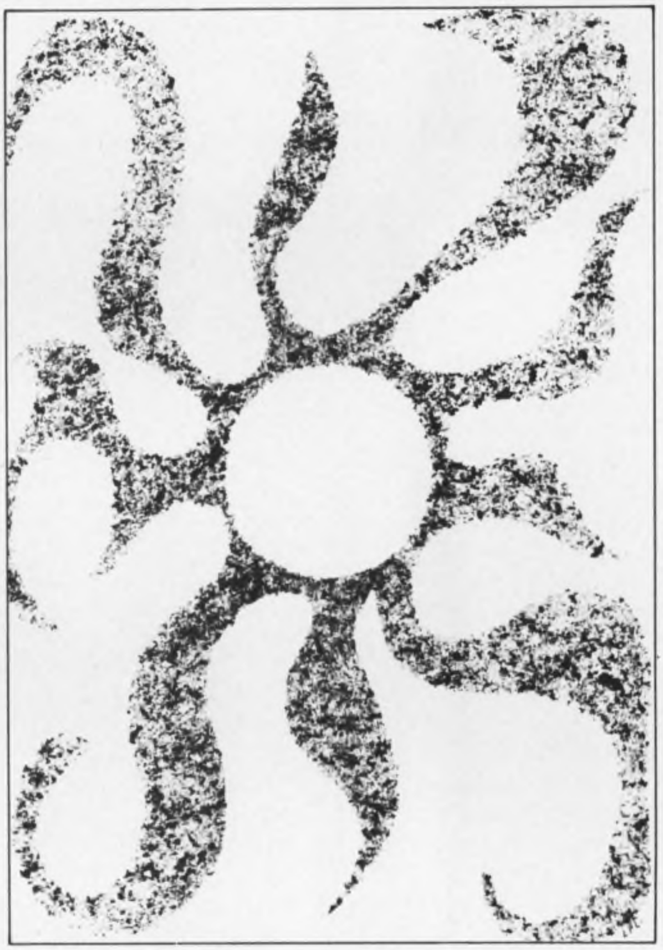
plastic sleeve. The assembly is slipped over the terminated end of the cable and the base of the connector. Heat is then applied to shrink the plastic sleeve and force the inner metal braiding tightly around the mating components, thus forming a continuous RF shield. The sleeve assembly can be easily removed when necessary.

This device may be used at any section of an RF harness where a shielding gap exists.

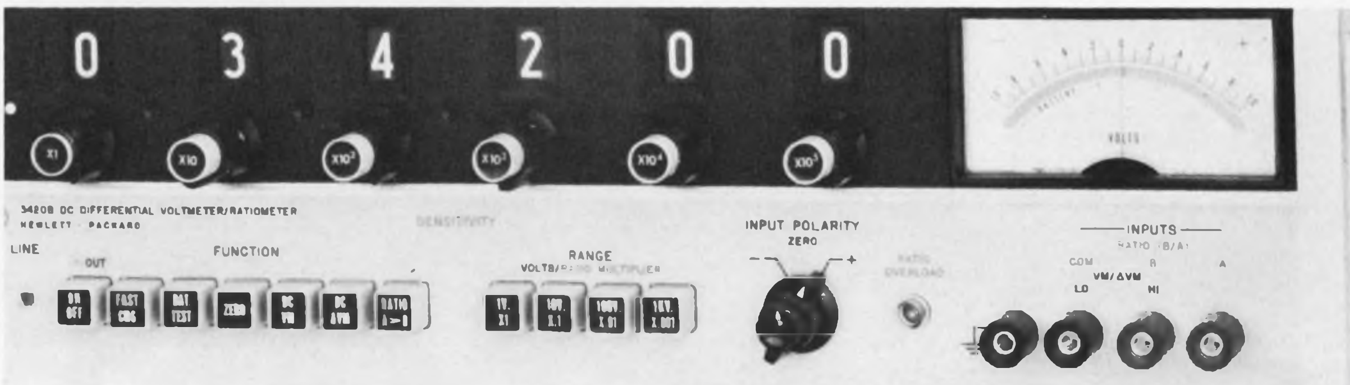
For further information, contact: Technology Utilization Officer, Western Operations Office, 150 Pico Boulevard, Santa Monica, California, 90406 (B65-10387).

ED Products

Miniaturized microwave microfarads . . . 88



Sun keeps op-amp juiced . . . 88



Pushbutton accuracy, stability, resolution . . . 78

Differential volt-and-ratiometer has high accuracy and stability

High accuracy, stability and resolution in a pushbutton differential volt/ratiometer could return many standards lab functions to the engineer. Model 3420 A/B dc differential volt/ratiometers measure dc voltage and voltage and resistance ratios in four ranges. For operation as a differential voltmeter, accuracies of 20 ppm of input plus 1 ppm of range are stated. Stability in both modes is 1 ppm/hour with null meter resolution of 0.2 ppm of range on all ranges.

Six binary coded decade dividers with concentric color-coded null sensitivity pushbuttons offer high resolution and convenience. Null sensitivity from X1 to X10^5 may be selected. Input impedance is infinite at null with at least $10^{11}\Omega$ off null on the 1 and 10 V ranges and 10 MΩ on all other ranges. Model 3420A is designed for 115 or 230 Vac line operation while the 3420B has trickle-charged Ni/Cd batteries for true floating dc measurements.

As a differential voltmeter, the instrument has ranges of 1, 10, 100 and 1000 Vdc with 10% overrange of all ranges. The decade dividers need not be adjusted to zero-set the null meter. The "Zero" pushbutton automatically disconnects the input signal and shorts the inputs. Input is disconnected on all modes until one of the function pushbuttons is depressed.

As a ratiometer, the 3420 covers from 0.000000001:1 to 0.999999:1 in ranges of 1, 0.1, 0.01 and 0.001 full scale with 6-digit resolution. Accuracy is 20 ppm of reading plus 2 ppm of range. Short-term stability is 0.5 ppm/hour and long-term stability exceeds 15 ppm/1000 hours. A modified Wheatstone bridge is formed by the decade divider and the range stick. The test ratio forms the remaining two arms.

The 3420's accuracy and stability derive mainly from the 11 V reference supply which drives the decade dividers. The reference amplifier is a zener diode and a high-gain planar silicon transistor in a TO-5 can. Temperature coefficient is held below 1 ppm/°C without an oven. With line operation, common mode rejection exceeds 140 dB for dc, and 150 dB at 60 Hz on all ranges. The instrument is protected from 1100 V overloads with a recovery time from 10^6 overloads of less than 3 s. A high-contrast 6-digit readout and 1 V dc recorder output are standard.

Applications cited include calibration of digital and potentiometric voltmeters, thermocouple, thermistor and transducer measurement and line and load regulation of dc standards.

P&A: $1175 (3420A), $1300 (B); July. Hewlett-Packard, 815 14th St. S.W., Loveland, Colo. Phone: (303) 667-5026.

Circle No. 277

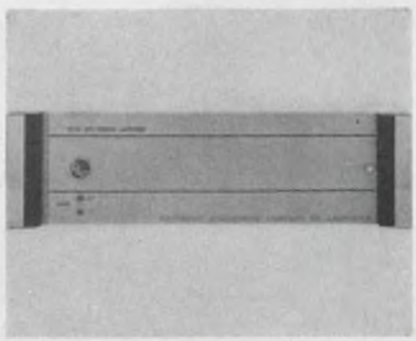
Multichannel scope

The DU-17 is a multichannel, display oscilloscope which can be used with almost any frequency-sweep generator. Two high sensitivity Y-amplifiers and one medium sensitivity Y-amplifier permit simultaneous display of three frequency response curves. The display can be referenced with the aid of two adjustable reference lines.

The horizontal amplifier (frequency axis) accepts sinusoidal, triangular or sawtooth waveforms. Both amplifiers are dc coupled so that narrow band measurements can be carried out at slow sweep speeds. A polarity reversing switch in each channel adapts the instrument to RF probes with positive or negative diode outputs. Input impedance is 1 MΩ and bandwidth is dc to 10 kHz for the Y-amplifiers. The X-amplifier has 100 kΩ impedance and 50 mV/cm deflection factor. An internal frequency marker unit has 10 kΩ impedance. Standard display is a medium-persistance CRT.

Price: $1375. Texscan Corp., 51 S. Koweba Lane, Indianapolis, Ind. Phone: (317) 632-7351.

Circle No. 278



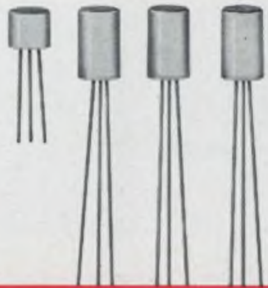
Timing amplifier

Model 872 timing frequency converter and 12-channel amplifier provides 6 square waves for distribution of timing signals. Rates are 1 Hz, 10 Hz, 100 Hz, 1 kHz, 10 kHz and 100 kHz. Rise time is less than 1 μs and output level is adjustable from 0.5 to 10 V with up to 2-kΩ load. Input is 1 MHz or 100 kHz, sinusoidal or square.

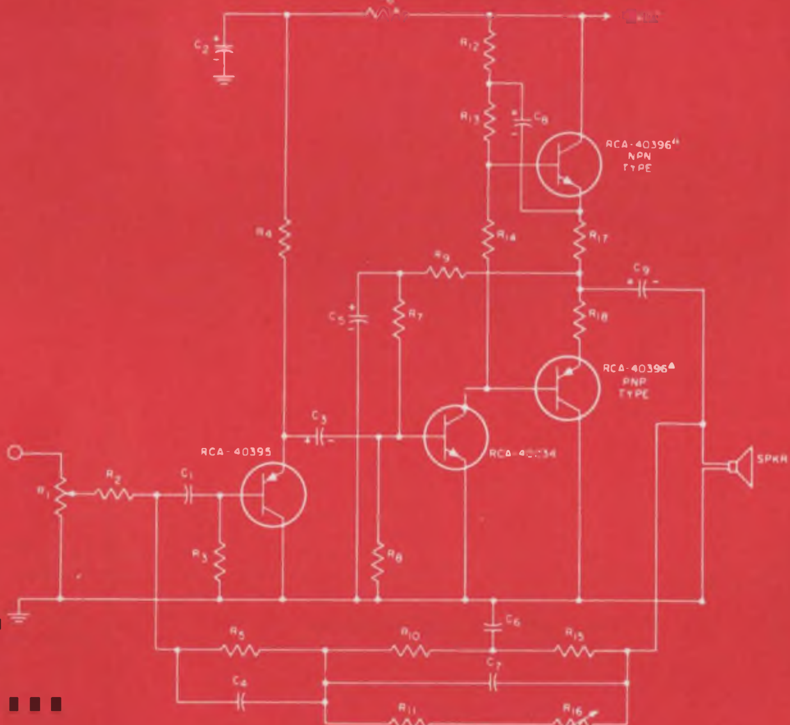
Price: $1250. Electronic Engineering Co., 1601 E. Chestnut Ave., Santa Ana, Calif. Phone: (714) 547-5501.

Circle No. 279

take this RCA 4-transistor 1-watt kit



PUT IT IN THIS TRANSFORMERLESS COMPLEMENTARY SYMMETRY CIRCUIT



PACKAGE IT...

AND YOU'VE GOT A LOW-COST PHONOGRAPH WITH TOP-OF-THE-LINE PERFORMANCE

With this matched complement of four RCA audio transistors in the circuit above, you can build a 3-stage, 1-watt AC-operated audio amplifier that has many "top-of-the-line" features for a "bottom-of-the-line" production cost.

The complementary symmetry push-pull output stage uses an RCA-40396—a matched pair of PNP/NPN transistors—eliminating the need for output and driver transformers.

At 0.5 watt output, total harmonic distortion, hum and noise *combined* do not exceed 2% (10% at one watt).

Frequency response of the amplifier for a constant-voltage input (with tone control in "flat" position) is *substantially flat from 180 to 20,000 c/s*. And the tone control both "boosts" and "cuts".

The 12.6-volt ac input for the power supply is easily obtained *from an auxiliary winding on the phonograph motor.*

The circuit offers an automatically compensated loudness control *without use of a tapped potentiometer.* This provides automatic base boost, minimized midrange distortion . . . . yet saves costs in both parts and labor.

Tight control of the driver and output transistor characteristics provides *excellent thermal stability* and eliminates need for a bias-adjustment potentiometer in typical circuits.

For more information, write for *RCA Technical Bulletin ICE-326* (1-66); it contains performance curves, applications data, and specifications for both the transistors and a typical circuit. Write to: RCA Commercial Engineering, Sec. EG5-2, Harrison, N. J. Or call your RCA Field Representative.

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Dual-beam scope

This dual-beam scope accepts over 25 plug-ins. Dual-trace plug-ins for dc to 50 MHz, dc to 30 MHz or spectrum analyzer units are used. Displays include simultaneous single-shot with each beam at a different sweep rate, 4-trace with 2 traces at different rates and spectrum analyzer displays.

The upper beam displays the signal from either left or right plug-in and can be deflected by either internal or external time base. The lower beam can display the signal from the right and be deflected by one time base or both signals. Passband is dc-to-50 MHz at 50 mV/cm, dc-to-28 MHz at 5 mV/cm and 2 Hz to 15 MHz (single channel) at 500 μV/cm. Sweep rates are from 10 ns/cm to 5 s/cm calibrated, and to approximately 12 s/cm uncalibrated. Precision calibrated sweep delay is from 0.1 μs to 50 s.

P&A: $3150 to $3250; 90 days. Tektronix Inc., P. O. Box 500, Beaverton, Ore. Phone: (503) 644-0161.

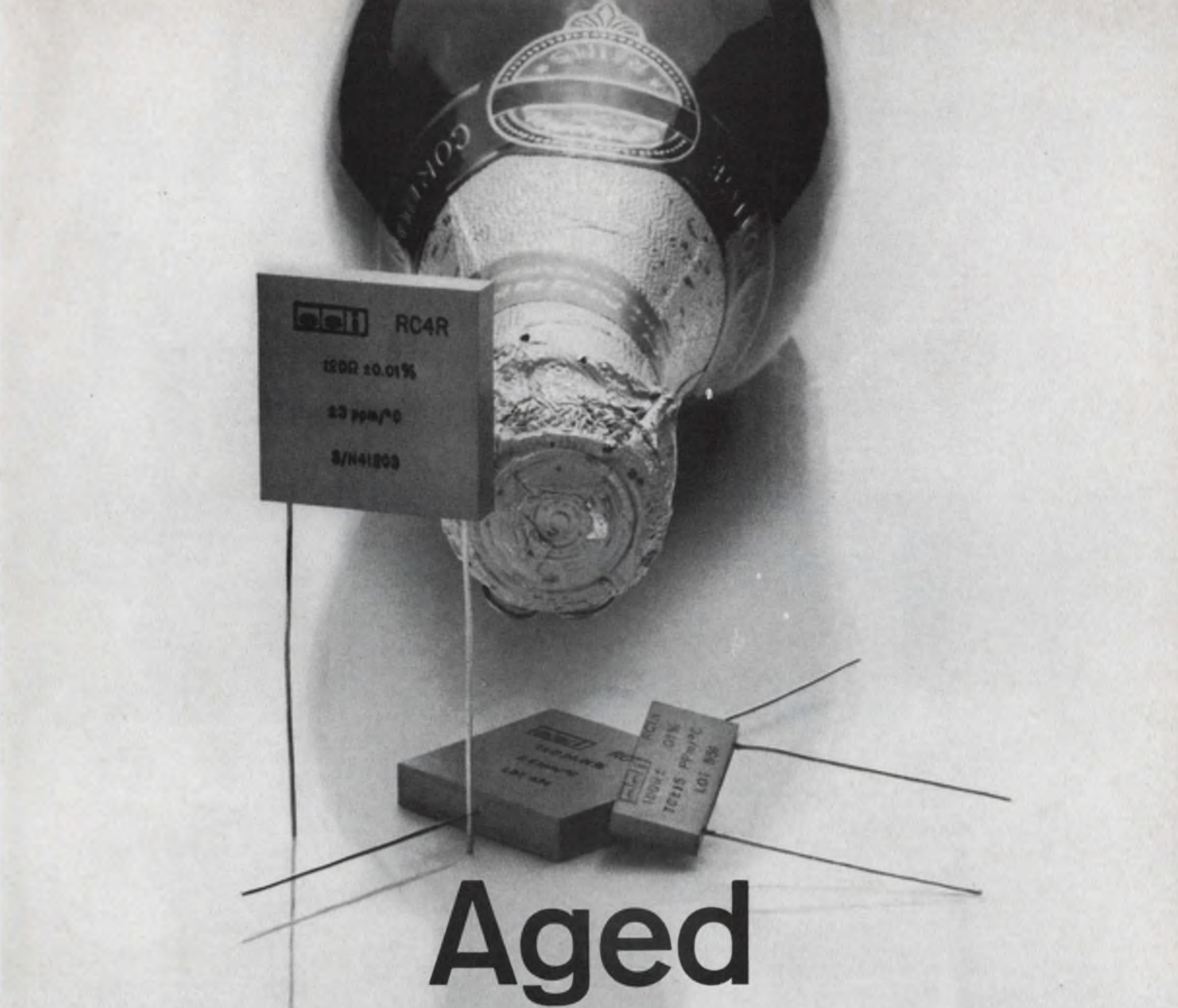
Circle No. 280

Video noise meter

A video noise meter operates in the presence of sync and blanking pulses on TV cameras, film scanners and video tape recorders, radio links, coax lines, and TV transmitters, receivers and transposers. It can be used for both weighted and unweighted noise voltages and as a conventional VTVM. It has a 40-Hz to 5-MHz range with 7 measurement ranges from 1 to 1000 mV p-p. Output impedance is 1 MΩ shunted by 30 pF, or 75 Ω bridging with a scope output.

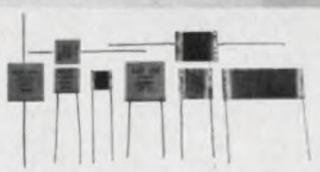
Rohde & Schwarz Sales Co., 111 Lexington Ave., Passaic, N. J. Phone: (201) 773-8010.

Circle No. 281



Aged

Our precision resistors are aged to improve reliability, and we guard the process like a vintage champagne maker. Ageing is one of many extra steps that make our precision components the most reliable you can specify. The four families of ESI components are described briefly below. A detailed catalog can be yours by return mail.



1. Precision Wire-Wound Card Resistors

Whenever small changes in the resistive element can affect the performance of the final assembly, you should consider the wire-wound ESI card resistor. Initial accuracy to ±0.0015%. Yearly stability to ±10 ppm.

2. Dekastat® Decade Resistors

Designed for use with dc and at audio frequencies, these multi-decade resistors make use of a patented ESI circuit giving high accuracy and resolution. Accuracy is ±0.02%. All units carry a two-year guarantee.

3. Dekapot® Resistive Voltage Dividers

Like all ESI decade units, these rapid-setting potentiometers are available with flange for panel mounting. They have terminal linearity up to 0.002%. Kelvin-Varley circuit provides constant input impedance.

4. Dekatran Transformer Voltage Dividers

The patented coaxial dial on these and other ESI decade units is easy to read and adjust. Accuracy of 0.001% and long-term stability are achieved through gapless toroidal cores of very high permeability.

Electro Scientific Industries, Inc., 13900 NW Science Park Drive, Portland, Oregon 97229. esi®

ON READER-SERVICE CARD CIRCLE 226

Tape command

A portable signal source for driving computer tape transports and other peripheral equipment with simulated bi-directional commands is offered. The unit provides commands to simulate operation under computer or remote control for exercising transports during off-line testing. The simulator is a pulse generator consisting of 4 timing generators coupled together in a ring. Both independently and commonly variable, the generators correspond to forward run, forward stop, reverse run and reverse stop. The generators drive two output command lines through a switch-selectable logic network.

P&A: $595; stock. Dartex Inc., 1222 E. Pomona St., Santa Ana, Calif. Phone: (714) 542-1196.

Circle No. 282

Integrator

The model CW-1 boxcar integrator is a gated averaging device which recovers complete wave forms or incremental portions from noise. Input sensitivity is ± 0.2 V to ± 100 V in 1,2,5 sequence for ± 10-V output. Time constants are 100 μs to 100 s. Holding time is 10^6 times the time constant with a max of 10^5s.

Price: $1950. Princeton Applied Research Corp., Box 565, Princeton, N. J. Phone: (609) 799-1222.

Circle No. 283

IC tester

Testing of flat-packs, TO-5 cans or dual-in-line configurations typically takes less than 15 s with model 851 IC tester. A separate, changeable plug-in programmer is used for each IC type. Selectable pulse rates, adjustable pulse levels, adjustable power supplies, and selectable circuit loads are featured for DTL, RTL, TTL and linear circuit testing. Short testing for all diode AND and NAND gates is accomplished without programming.

P&A: about $2000; 30 to 60 days. Monitor Systems Inc., Fort Washington, Pa. Phone: (215) 646-8100.

Circle No. 284

Field intensity meter

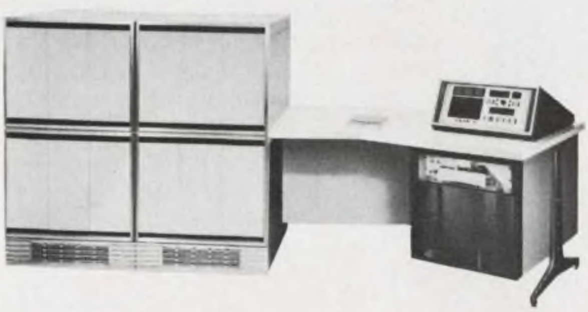
This magnetic field intensity meter has a 1-Hz to 15-kHz bandwidth at 3-dB points and an 8-in. sensor with 25-ft coax cable. Sensitivity is 2 μOe and dynamic range is 100 dB. Outputs are visual level indicator, analog output of 1 V, 600 Ω, recorder output of 10 mV, 1 kΩ. Function switches are 1 Hz to 15 kHz, 200 Hz to 15 kHz and 60-Hz filter for a 1-Hz to 15-kHz range.

P&A: $5000; 6 wks. Electro-Mechanics Co., P. O. Box 1546, Austin, Tex. Phone: (512) 452-8881.

Circle No. 285

test under actual load conditions...

. . . the ultimate test for integrated circuits, transistors, diodes, thin films, logic cards or modules. The Model 553 Dynamic Test System performs both static (dc) and dynamic tests from dc to 50 megacycles on multi-lead devices in a single socket! Variable word-length mnemonic machine language simplifies programming . . . operators can be trained in a few hours. Unique program modification eliminates repetitive instructions, speeds additions and deletions to save up to two-thirds in programming time. Let us tell you more about the 553.



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INCORPORATED
APPARATUS DIVISION
P. O. BOX 66027 HOUSTON, TEXAS 77006
118 RUE du RHONE GENEVA, SWITZERLAND

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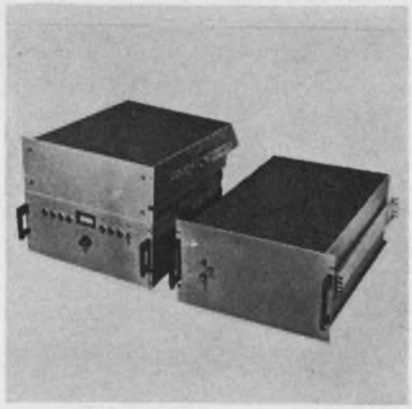
ON READER-SERVICE CARD CIRCLE 22



Synthesizer

Digitally programmable synthesizers with 0.001% accuracy are tunable from 950 MHz to 12.4 GHz in 100 kHz steps. Frequency range and granularity of frequency selection can be modified by substitution of modules. Programming can be manual or automatic. The limit on switching speed is determined by the oscillator, its power supply and the amount of incremental frequency being programmed. Units are available in octave ranges.

Frequency Engineering Labs., P. O. Box 527, Farmingdale, N. J. Phone: (201) 938-9221.

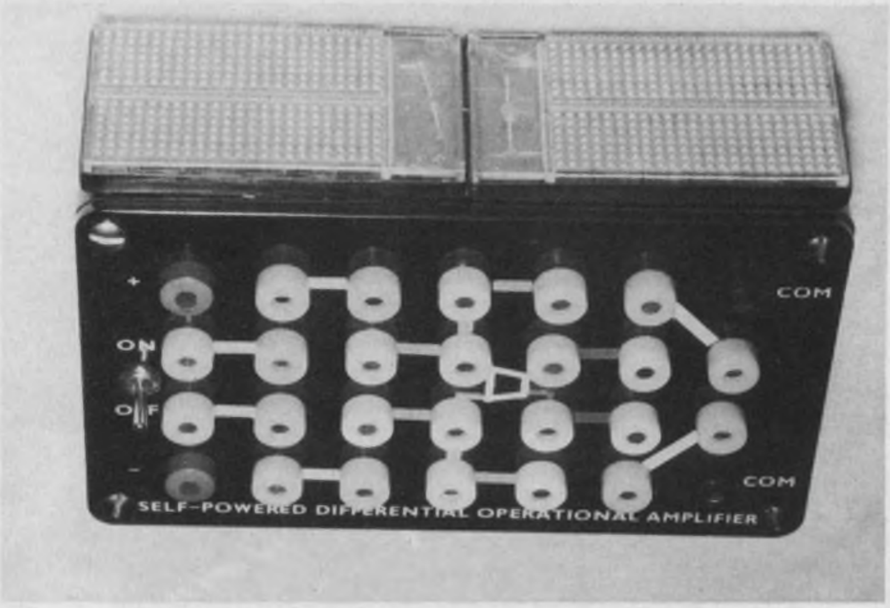
Circle No. 286

Vernier potentiometer

Model 5590B vernier potentiometer has an accuracy of 10 ppm and a range of 0 to 1.8 V with 0.1-μV resolution. An optional 1-ppm current control is available to eliminate restandardizing. A five-dial current adjustment and independent standardization circuit is provided. Any one of three external inputs are switch-selected.

P&A: $1495; 8 to 10 wks. North Hills Electronics Inc., Alexander Pl., Glen Cove, N. Y. Phone: (516) 671-5700.

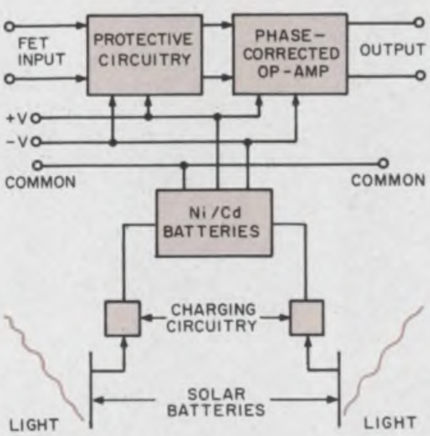
Circle No. 287



Solar power keeps amplifier operating around the clock

Another dimension has been added to operational amplifier design and packaging: Ambient light powers the self-contained model 982. Internal energy storage is sufficient for around-the-clock operation after an eight-hour exposure to visible or near-infrared radiation. An internal cut-off eliminates the risk of overcharging or undercharging when stored energy falls below a pre-set level or when the nickel/cadmium battery voltage is below 7.5 volts.

The FET input provides a differential input impedance of 1 GΩ and a common-mode input impedance of 3 GΩ. Output voltage is ±7.5 V max at 10 mA. Unity gain frequency is 300 kHz min and the amplifier has 6 dB/octave slope from knee to unity gain. Open loop gain is typically 50,000 (30,000 min). Input noise is 4 μV p-p.



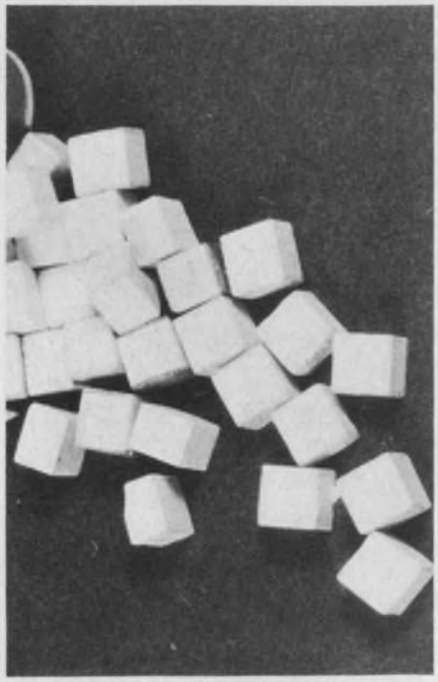
Charging circuitry prevents the batteries from overcharging and maintains charging currents under low ambient light levels.

The amplifier is available with a kit of feedback components. It will be possible to use the model 982 as a differential or single-ended amplifier having 2 MΩ input impedance with X10 gain, as an integrator or as a differentiator. The manufacturers' "logarithmic element," which behaves as a bipolar semiconductor junction, makes it possible for the 982 to be used as a logarithmic and anti-logarithmic amplifier, a half-wave ideal rectifier or an approximate sine-wave oscillator. The array of banana jacks on 3/4-in. centers eases the task of changing functions.

Originally intended as a lab or classroom tool, the amplifier's complete isolation is bringing it into the field as an analog building block or portable function module. The differential input and output suggest uses in breadboarding computation systems.

P&A: 197 (complete kit), $143 (amplifier); stock to 30 days. Optical Electronics Inc., P.O. Box 11140, Tucson, Ariz. Phone: (602) 624-3605.

Circle No. 288



Ceramic capacitors offer 1 μF in a 0.001-in.^{3} case

Deposition of uniform, pore-free ceramic dielectric sections less than 10^{-3}-in. thick results in packaging densities of 1000 μF/in.^{3} and 100 μF/in.^{3} for the ATC-300 and -200 series of ceramic capacitors. Thus, the -300 series can offer 1 μF in a 0.1 x 0.1 x 0.1-in.^{3} case.

The monolithic ceramic capacitors have been used in tests at 1 GHz, and the manufacturer projects a self-resonant frequency over 10 GHz. Insulation resistance of the two series is 10 and 100 GΩ respectively and both feature a negligible series resistance. The ATC-200 exhibits a temperature coefficient of ±2% from 25 to 125° while the -300 reaches capacity peak at 25°C. Working voltage is 50 V and capacity-voltage rating is claimed to exceed non-polarized tantalum in volumtric efficiency. Dissipation factor at 1 kHz is 2.5% max.

The cubes are terminated with standard radial-tinned copper wire or are provided as pellets with solderable pads. They are offered in ranges of 0.001 to 0.1 μF (-200) and 0.1 to 1 μF (-300). Tolerances are 5, 10 and 20% and 10 and 20% guaranteed minimum respectively. Ranges of 0.1 to 1000 pF, and Qs greater than 5000 are available.

P&A: $1 to $5; stock to 4 wks. American Technical Ceramics, P. O. Box 141, Hell Gate Station, New York. Phone (212) 256-9330.

Circle No. 289

We asked 20 of your fellow engineers

"WHY DO YOU CHOOSE CTS SWITCHES?"

HERE ARE THEIR REASONS:

"NO BREAKAGE"
They don't break on production lines or on finished equipment if dropped or jarred . . . CTS glass alkyd wafers are not brittle like phenolic . . . easy to handle.

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"MORE COMPACT"
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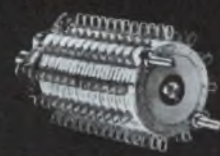
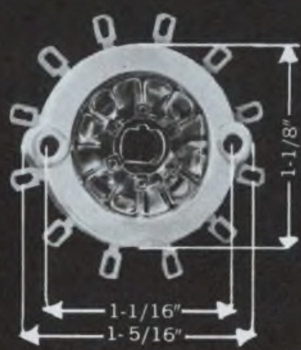
"VERSATILITY OF CIRCUITS"
Many circuit variations available due to varied rotor contact configurations. External jumpers eliminated by CTS internal connections between positions.

"AVAILABILITY OF POWER SWITCHES":
Available with 4 types of power switches and/or numerous potentiometers.

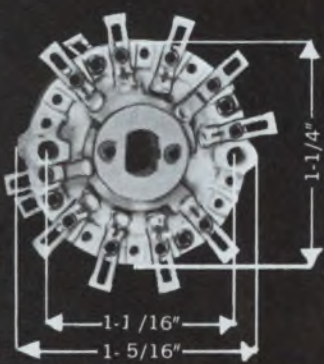
"SUPERIOR INSULATION"
Glass alkyd is superior to phenolic insulation.

- Soldering heat can't loosen terminals.
- Meet MIL-S-3786 A&B, Style SR03 (Series 211 and 212.)
- Balanced contact spring.
- Natural solder barrier provided by glass alkyd insulation.





Series 212 Wafer



Series 216 Wafer

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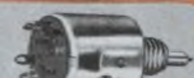
HIGHEST QUALITY • POSITIVE FEEL • 250,000 CYCLE LIFE • FREE FROM END AND SIDE THRUST • HIGH SWITCHING TORQUE 15—60" OZ.

Type 212—HILL AND VALLEY DETENT
LOW COST • DESIGNED FOR HOME ENTERTAINMENT AND LOW COST INSTRUMENT APPLICATIONS • 25,000 CYCLE LIFE • SWITCHING TORQUE 20—48" OZ.

Type 212 ND—DIE CAST DETENT
LOWEST COST OF ALL DETENTS • LOW COST STAKED CONSTRUCTION • AVAILABLE FOR 1 AND 2 WAFER SWITCHES • 20,000 CYCLE LIFE • SWITCHING TORQUE 18—40" OZ.

Type 215—DOUBLE BALL DETENT
DESIGNED PRIMARILY FOR INSTRUMENT MARKET • HIGH QUALITY • CRISP FEEL • 100,000 CYCLE LIFE • SWITCHING TORQUE 6—35" OZ.



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Series 210

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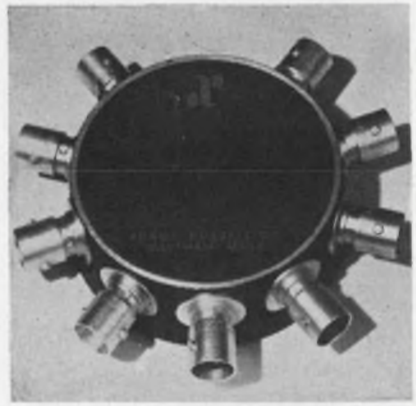
ON READER-SERVICE CARD CIRCLE 24

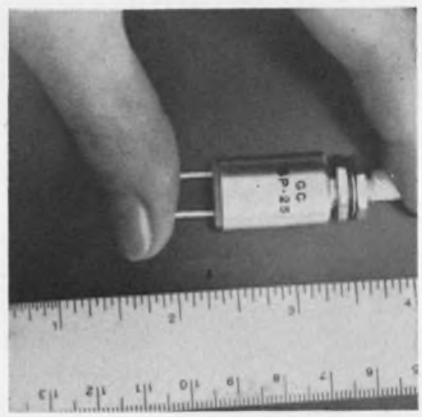


Power divider

A circular, eight-way power divider for 200 to 400 MHz use replaces seven transmission line hybrids. The 8U-50-1 power divider provides isolation of 30 dB min with even power distribution. Amplitude balance is 0.2 dB max and vswr is 1.3 max. The 2-1/4-in. diameter units have 50-Ω BNC, TNC or type N connectors.

P&A: $425; stock. Adams-Russell Co. Inc., 280 Bear Hill Rd., Waltham, Mass. Phone: (617) 899-3145.

Circle No. 290



Magnetic switch

A totally enclosed, dust, water and explosion-proof magnetic push-button switch is capable of switching high current loads with virtually no arcing. Life span of 10^6 operations is claimed with resistive loads of 25 A, 120 Vac, or 25 A, 30 Vdc or inductive loads of 15 A, 120 Vac at an ambient range of −60 to 300°F.

P&A: $4.29 to $8.00; 30 days. Gardiner Corp., P.O. Box 375, David City, Neb. Phone: (402) 367-3400.

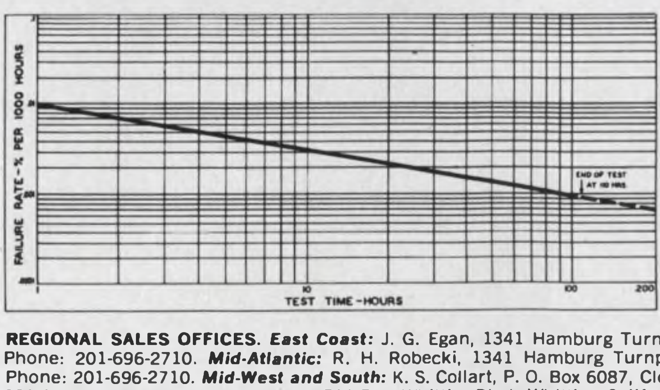
Circle No. 291

Capacitor reliability makes the grade

$$F_{(x)} = 1 - \exp.\left[-\frac{x^{\beta}}{\alpha}\right]$$

Graded reliability: exclusive with KEMET KG solid tantalum capacitors. Through accelerated test techniques, we establish reliability data covering your specific order. Graded failure rates range as low as 0.001% per thousand operating hours.

This failure rate prediction comes from an adaptation of the Weibull distribution function, in a special control test sequence and chart form. Its validity has been confirmed by test data covering billions of capacitor hours.



KEMET KG solid tantalum capacitors with predicted reliability are available from 0.0047 to 330 microfarads, 6 to 100 VDC, for continuous operation from −55 to 125°C. Standard tolerances 10 and 5%. Closer tolerances on request.

Graded reliability: another reason to think of KEMET capacitors. For details on these, or our other tantalum capacitors, call our nearest office, or mail the coupon.

Clip, fill in name and title, attach to letterhead

Union Carbide Corporation
Linde Division, Dept ED-52
270 Park Avenue, New York 10017

Please send details on High-Reliability KEMET Solid Tantalum Capacitors

Name ____________________

Title ____________________

UNION CARBIDE
ELECTRONICS

REGIONAL SALES OFFICES. ***East Coast:*** J. G. Egan, 1341 Hamburg Turnpike, Wayne, New Jersey 07472. Phone: 201-696-2710. ***Mid-Atlantic:*** R. H. Robecki, 1341 Hamburg Turnpike, Wayne, New Jersey 07472. Phone: 201-696-2710. ***Mid-West and South:*** K. S. Collart, P. O. Box 6087, Cleveland, Ohio 44101. Phone: 216-221-0600. ***West Coast:*** B. G. Bryant, 701 East Whittier Blvd., Whittier, California 90605. Phone: 213-698-8077.

ON READER-SERVICE CARD CIRCLE 26

Demodulator

Model 351 synchronous demodulator has a gain of 20 dB, an output dynamic range of ±10 Vdc, and will accommodate chopper frequencies from 4 to 100 Hz (10 kHz with phase control bypassed). A calibrated locking control provides 0 to 360° continuous phase adjustment. Phase setting is frequency-independent so that no fine tuning is required. The unit has a post-detection filter time constant control ranging from 0.015 to 5 s.

Ithaco Inc., 415 Taughannock Blvd., Ithaca, N. Y. Phone: (607) 272-7640.

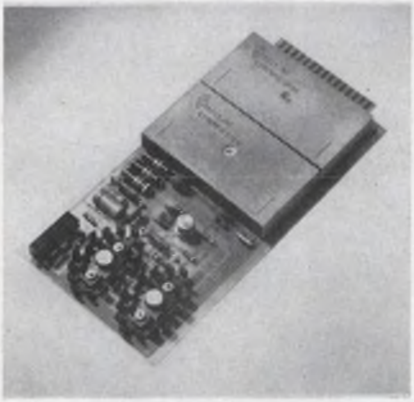
Circle No. 292

Zener voltage reference

The model 1200 temperature-compensated zener voltage references operate from 30 to 60 Vac, 50 to 500 Hz or 40 Vdc. Output is 12 Vdc from 0.1 to 15 mA. Long term stability is better than 0.003% per year. Noise is less than 50 μV p-p. Temperature coefficient of the 1-in.^{3} unit is 0.0002%/°C.

P&A: $40 to $60; stock. Norfax Corp., 1152 Morena Blvd., San Diego, Calif. Phone: (714) 276-3200.

Circle No. 293



Operational amplifier

A new chopper-stabilized operational amplifier has an output of ±150 V peak at 5 mA or ±100 V peak at 50 mA. The amplifier uses compensated FET chopper circuitry with internal drive for 2 μV/°C drift. Zero offset voltage adjustment is built in. Open loop dc gain is 10^7 and gain-bandwidth product is 0.5 MHz.

P&A: $165 (1 to 9); stock. Zeltex Inc., 1000 Chalomar Rd., Concord, Calif. Phone: (415) 686-6660.

Circle No. 294

1-mW relay

Series 8 relay has an aluminum dust cover with octal plug-in base and features 1 mW sensitivity.

Designed for dc operation, it is available for close differential requirements (high release) in which the difference between operate and release values may be as high as 80%. Coil resistance ranges from 100 mΩ to 27 MΩ. Contacts are rated from low level to 2 A resistive at 28 Vdc or 115 Vac.

Price: $3.75. General Automatic Corp., 7 Sherman Ave., Jersey City, N. J. Phone: (201) 653-8970.

Circle No. 295

Tantalum capacitors

A new type of tantalum capacitor uses a neutral electrolyte to eliminate damage by acid leakage. The type WF capacitors meet MIL-C-3965 but do not use sintered slugs in their manufacture. Voltage ratings are up to 300 Vdc at 85°C and to 200 Vdc at 125°C. Capacitance ranges are from 0.1 to 560 μF. Standard capacitance tolerance is ±20% with others available.

Transistor Electronics Inc., West Rd., Bennington, Vt. Phone: (802) 442-5473.

Circle No. 296

HELIPOT CUTS THE SIZE OF ITS 10-TURN POT

but there's not a spec of difference

It's true . . . Helipot *actually* cut the length of its ⅞″ diameter 10-turn in half. No hocus pocus. The new Model 7266 is ¾″ long . . . the shortest 10-turn ⅞″ diameter precision potentiometer you can buy. Yet its precision performance is unscathed, and the wirewound resistance element is actually *longer* than that of its predecessor. It is a *precision* pot in every respect. Resolution is better, the total resistance range is still 10 ohms to 125K, with ±0.2% linearity as good as ever.

How much was the price raised? Not a penny — it's priced at $10 for 1—9 pieces and well below $8 in quantity. (And you get two for the size of one.) Complete product information is available now from your local Helipot sales office.

Beckman® INSTRUMENTS, INC.

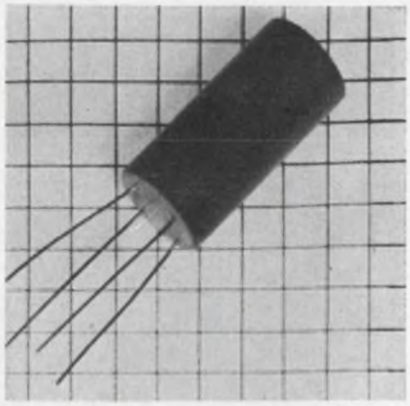
HELIPOT DIVISION

FULLERTON, CALIFORNIA • 92634

INTERNATIONAL SUBSIDIARIES: GENEVA; MUNICH; GLENROTHES, SCOTLAND; TOKYO; PARIS; CAPETOWN; LONDON

Speed Inquiry to Advertiser via Collect Night Letter
ON READER-SERVICE CARD CIRCLE 32

Voltage sensing switch



Models VS1/2 are miniature sensing switches featuring low hysteresis. The units combine silicon transistors and 1% metal film resistors in a welded cordwood assembly. With an input impedance of 8 MΩ, a 0.1-μA input is required to switch up to 150 mA of output current. The switching level is factory set within ±1%.

P&A: $12 to $18; stock to 2 wks. Electronic Modules Inc., 2560 E. Foothill Blvd., Pasadena, Calif. Phone: (213) 795-4231.

Circle No. 297

Micromin 7-A switch

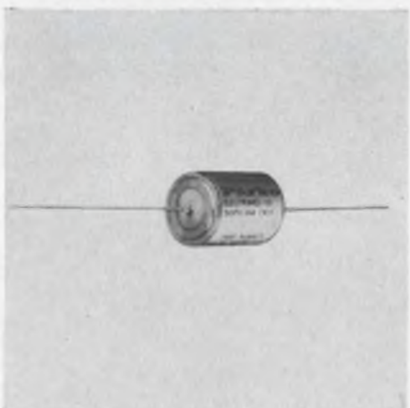
Hermetically sealed 0.045-in.³ snap-action switches, series 10AT2, feature current capacity to 7 A resistive at 28 Vdc for 25,000 life cycles.

The 1-gram switch has shock resistance of 200 G and vibration resistance of 65 G. The switch has an ambient temperature range of −85°F to +275°F and conforms to MIL-S-8805B.

Texas Instruments, 34 Forest St., Attleboro, Mass. Phone: (617) 222-2800.

Circle No. 298

Time delay module



The DJA series time delay module is designed to be wired in series with the 300 to 800 Ω coil winding of an electromechanical relay, thus converting it into a time delay/on operate relay. Factory adjustable time delays are available from 100 ms to 15 s. Voltage range is 24 to 32 Vdc.

P&A: $29.85; 4 wks. Parko Electronics Co. Inc., 1320 E. Wakeham Ave., Santa Ana, Calif. Phone: (714) 547-0184.

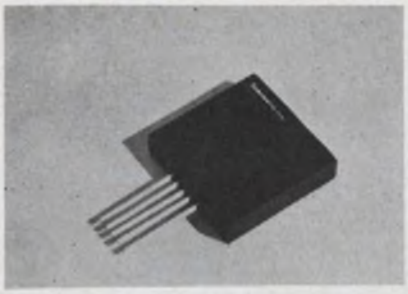
Circle No. 299

Potentiometers

Model 3460 single-turn pots guarantee a 2-x-10⁶ revolution rotational life. Linearity is ±0.5% and power is 4 W at 40°C. The mandrel-wound element is welded directly to the gold-plated solder-lug terminals. The bushing-mounted pot is available in one, two or three gangs with resistances from 100 to 50,000 Ω.

Amphenol Corp., 120 S. Main St., Janesville, Wis. Phone: (608) 754-6616.

Circle No. 300



Multiplier

Model 903 multiplier accepts two signals and multiplies them with an accuracy of ±0.5% over −40 to 110°C. Operation is in all four quadrants with input signals from dc to 100 kHz. Input impedance of the 0.4-in.^{3} unit is 1 MΩ. Power required is 6 ±0.02 Vdc at 5 mA.

Spacelabs Inc., 15521 Lanark St., Van Nuys, Calif. Phone: (213) 781-0881.

Circle No. 301

Low-pass filters

A series of 1-in.^{3} 3-pole, active elliptic low-pass filters is designated LN301. Typical output noise with input shorted is 10 μV rms and insertion loss is 2 dB ±0.5 dB. Power supply is ±12 Vdc±5% regulation at ±15 mA max. Max output linear range is ±0.5 V peak. Operating temperature of the filters is 0 to 70°C.

EG&G Inc., 170 Brookline Ave., Boston. Phone: (617) 267-9700.

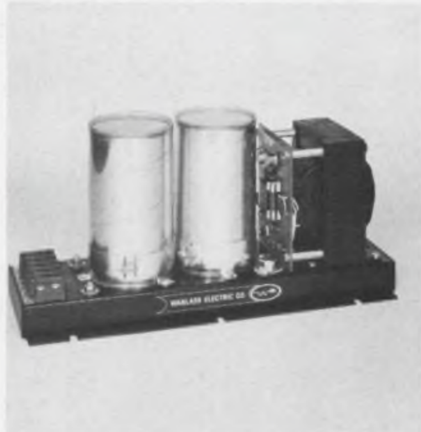
Circle No. 302

Telemetry preamplifier

A wide dynamic range preamp for updating IRIG telemetry receivers covers 215 to 265 MHz and delivers up to 200 mV (+23 dBm) into 50 Ω. A "Power Guard" circuit withstands 2 W cw incident RF power without harm to the preamp. All circuitry is encapsulated and the 10-oz enclosure uses type N connectors. Noise figure of the silicon-transistorized device is 6 dB max, 5 dB typical, gain is 29 ±1 dB and vswr is 2.0 max, 1.5 typical. Input power requirements are 22 to 28 Vdc at 150 mA via coax center conductor or separate feedthrough.

Avantek Inc., 3001 Copper Rd., Santa Clara, Calif. Phone: (408) 739-6170.

Circle No. 303



Adjustable power supply offers 1% regulation

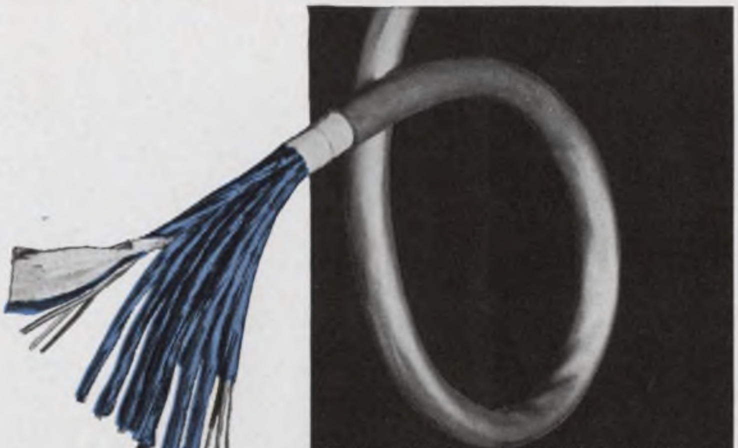
A solid-state, 1% line- and load-regulated power supply is designed to eliminate many shortcomings inherent in ferroresonant supplies. The LX series satisfies microelectronic requirements for large currents at 4 to 5 Vdc with a ±1% load regulation.

The incorporation of closed loop control is responsible for the load regulation and for a 50 μs response to line transient variations. Design eliminates tuned circuits so that the supplies are frequency-insensitive in a 47 to 63 Hz range. A pot in the control circuitry enables a ±3% adjustment to be made in the output voltage. Efficiency of the supplies is greatly increased as no significant pre-loading is required. Under partial loading, only minor circulating currents exist. Regulation is accomplished on the high voltage side of the transformer so that there are lower magnetic losses due to the reduction in magnetic components.

At 6.3 V, input frequency regulation is ±2% and ripple is 150 mV rms. Thirteen ranges (including 4, 4.5 and 5 V) are available from 4 to 240 V. All are adjustable to ±3%. Output amperes range from 15 to 0.5 A. The 14-pound supply has an energy storage capacity of 5.6 J in the 6.3 V model. Optional crowbar overvoltage protection is available. Custom equipment using the same design techniques is offered.

P&A: $125; stock. Wanlass Electric Co., 2189 S. Grand Ave., Santa Ana, Calif. Phone: (714) 546-8990.

Circle No. 355

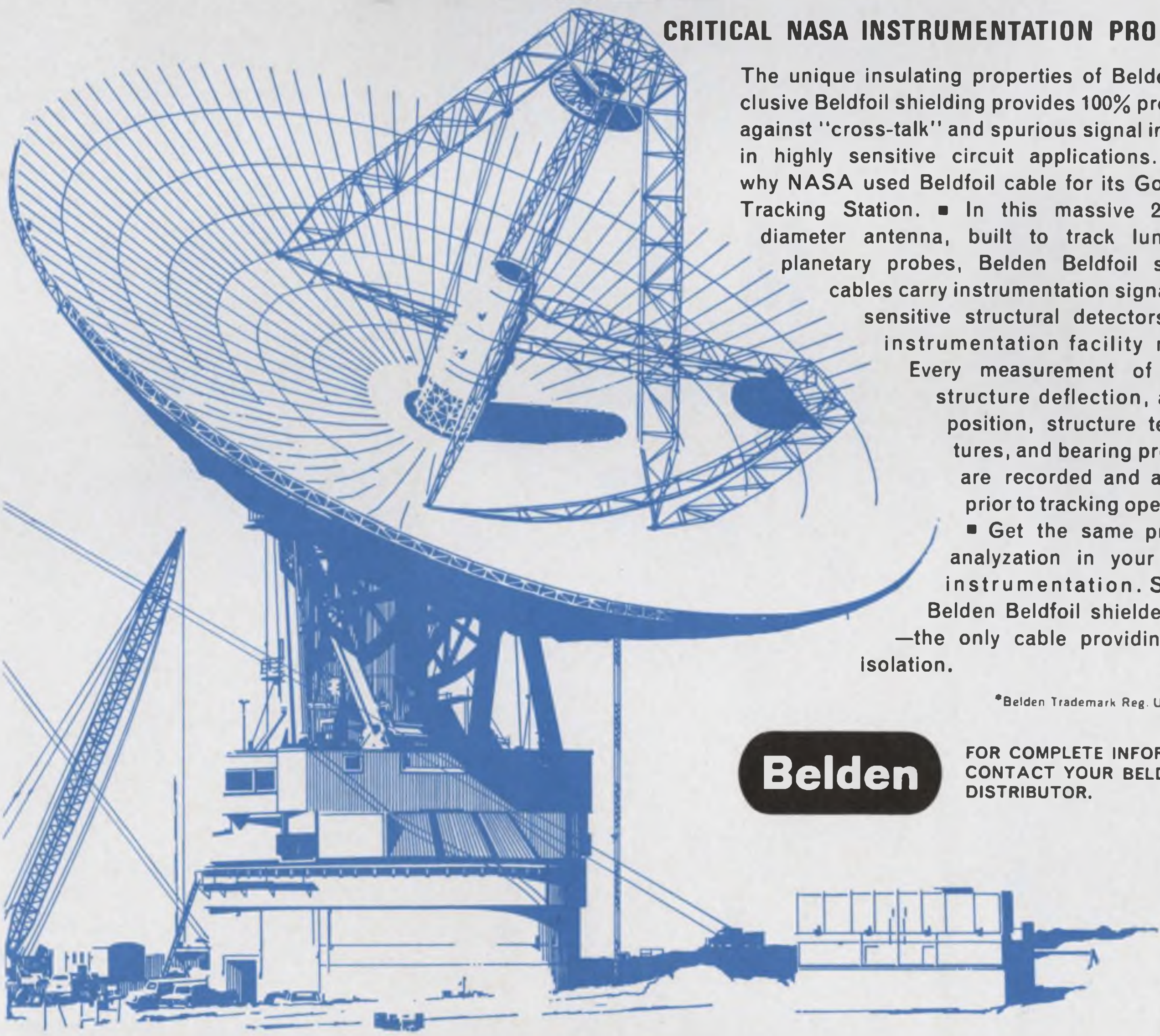


This multiple pair, Beldfoil shielded cable is typical of the types of Belden cable used in recording critical measurements on the Goldstone tracking antenna.

BELDFOIL* SHIELDED CABLE

SOLVED

CRITICAL NASA INSTRUMENTATION PROBLEM!



The unique insulating properties of Belden's exclusive Beldfoil shielding provides 100% protection against "cross-talk" and spurious signal impulses in highly sensitive circuit applications. That's why NASA used Beldfoil cable for its Goldstone Tracking Station. ■ In this massive 210 foot diameter antenna, built to track lunar and planetary probes, Belden Beldfoil shielded cables carry instrumentation signals from sensitive structural detectors to an instrumentation facility nearby. Every measurement of critical structure deflection, angular position, structure temperatures, and bearing pressures are recorded and analyzed prior to tracking operations. ■ Get the same precision analyzation in your critical instrumentation. Specify Belden Beldfoil shielded cable —the only cable providing 100% isolation.

*Belden Trademark Reg. U.S. Pat. Off.

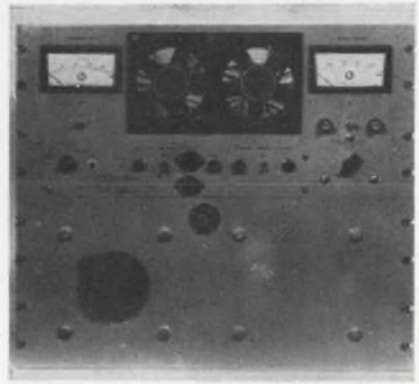
Belden

FOR COMPLETE INFORMATION CONTACT YOUR BELDEN DISTRIBUTOR.

8-1-6

BELDEN MANUFACTURING COMPANY • P.O. Box 5070A • Chicago, Illinois 60680

ON READER-SERVICE CARD CIRCLE 36



SCR switching supply

Designed for life testing diodes and rectifiers, the model 652 power supply provides up to 150 A in alternate half sine-wave pulses in each of two balanced outputs followed by alternate half sine-wave pulses of peak inverse voltage. Forward current and reverse voltage are adjustable over their entire range.

Forward voltage of about 12 V peak is delivered to the load at each half of the output. Forward current outputs are balanced to 1%. Standard supplies are available with 200, 400, 600, 800 or 1000 V max peak reverse ratings. Normal reverse conduction angle exceeds 170°. Peak reverse current is 250 mA. Two front-panel mounted blowers cool the SCR heat sinks. Input is 208 or 230 Vac.

Aerotronic Assoc., Inc., Contoocook, N. H. Phone: (603) 746-3141.

Circle No. 304

High current supply

The XR series of high current, fast recovery power supplies is fully protected against overloads and shorts. Typically, the 24- to 32-Vdc models are available at ratings up to 100 A.

Twelve models are available with voltage range from 5 to 35 Vdc, currents up to 100 A with recovery time of 50 μs max.

Price: $525 to $1714. Deltron Inc., Wissahickon Ave., North Wales, Pa. Phone: (215) 699-9261.

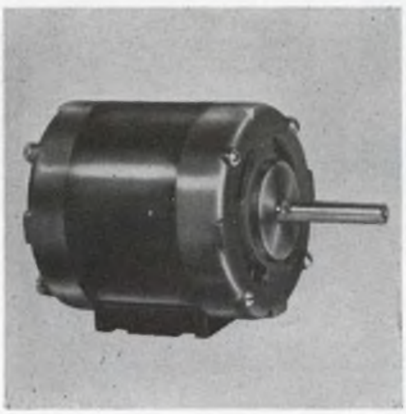
Circle No. 305

Transistorized supply

"Microsource" power supplies are contained in 3.3-in³ packages. The fully transistorized units are short proof and have 0.1% regulation and low ripple. Input is 115 Vac, 50 to 400 Hz. Output power ranges are from 5 V at 65 mA to 30 V at 15 mA. Units are available with input transformer or voltage tracking options for use with operational amplifiers.

Price: from $59.50. Elasco Inc., 33 Simmons St., Boston. Phone: (617) 442-1600.

Circle No. 306

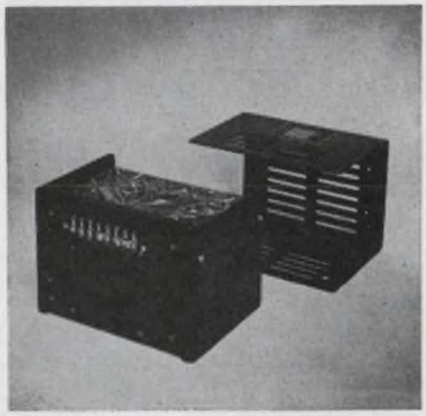


Synchronous motor

Operation automatically phase-synchronized to line frequency is provided by this polarized synchronous ac motor. The motor locks into synchronism at the same shaft location relative to the instantaneous line voltage when power is applied. A 2-pole version runs at reversible speed of 3600 rpm and a 4-pole model runs at 1800 rpm.

P&A: $85; 7 wks. McLean Engineering Labs., P. O. Box 228, Princeton, N. J. Phone: (609) 799-0100.

Circle No. 307



Wide range supply

"Transpac" power modules are available in 750-mA, 2-A, 5-A, and 10-A ratings. Outputs are 4 to 32 Vdc or 30 to 60 Vdc. Input is 105 to 125 Vac, 50 to 400 Hz. Line or load regulation is $\pm 0.01\%$ and ripple is 800 μV rms. Silicon semiconductors, double differential dc amplifiers and zener references are incorporated in a regulator circuit.

P&A: $89 to $215; stock to 30 days. Electronic Research Assoc., Inc., 67 Sand Park Rd., Cedar Grove, N. J. Phone: (201) 239-3000.

Circle No. 308

Dc module

The T24/GCL24 series of power modules converts 115 Vac to an output of 5 to 3650 Vdc at 240 W. Inputs are 400 Hz to regulated dc. These converters feature complete isolation and adjustment range of 12% from nominal output voltage. Regulation is 0.2% for line variations of 105 to 125 Vac and ripple is less than 0.2% rms.

P&A: about $445; 4 to 5 wks. Abbott Transistor Labs., Inc., 3055 Buckingham Rd., Los Angeles. Phone: (213) 731-9331.

Circle No. 309

POWER EQUIPMENT

Electron beam supply

Model CV-10 electron beam power supply provides 10 kW max for simultaneous operation of up to three electron sources. Output is adjustable from 4 to 10 kV and is regulated within 2%. Beam currents can be adjusted independently and remain stable within ±2% regardless of changes in current drawn by the other guns. Also available are 3 kW to 600 kW versions.

Temescal Metallurgical Corp., 2850 Seventh St., Berkeley, Calif. Phone: (415) 841-5720.

Circle No. 310

Dc dual supply

Model MMV 8-16/100 dc dual power supply is short and overload protected with automatic reset. Multi-turn pots independently adjust plus and minus voltages from 8 to 16 V at 100 mA for each section. Ripple and noise are 350 μV rms. Load regulation from no load to full load is ±0.1% and line regulation at full load is ±0.05%.

P&A: $95; stock to 3 wks. Electronic Design Lab., P.O. Box 7837, Philadelphia. Phone: (215) 925-9500.

Circle No. 311

From breadboard to prototype to production.

Sub-miniature coax, standard machined or formed strip contacts can be intermixed instantly in the same connector block.

You can begin wiring your breadboard or prototype with standard wire. If noise develops, just switch signal leads to subminiature coax without changing the connector block.

Here's a twist. You can also convert standard leads to twisted pair. In case we forgot to mention it, the sub-miniature coax contacts take twisted pairs as well as coax cable.

And the formed contact is a big money saver in initial and installed costs. Throw in the automatic Burndy Hyfematic,™ and crimp up to 3000 contacts per hour. Blocks available for 14 to 152 positions.

Now put it all together. Contact intermixing, economy, universality. Get in touch with Burndy for all the details. Hurry.

BURNDY

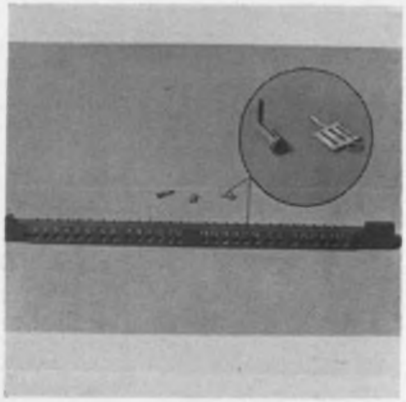
Norwalk Connecticut

Gold epoxy solder

A gold-filled electrically conductive epoxy compound is designated E-solder #E3205. The solder requires no mixing and cures at temperatures as low as 125°C. Volume resistivity is about 0.01 Ω-cm. This material is used for lead attachments in diodes and transistors and adheres to surfaces including ceramics, glass and metals.

P&A: $20 (5 grams); stock. Allied Products Corp., 166 Chapel St., New Haven, Conn. Phone: (203) 562-2171.

Circle No. 312

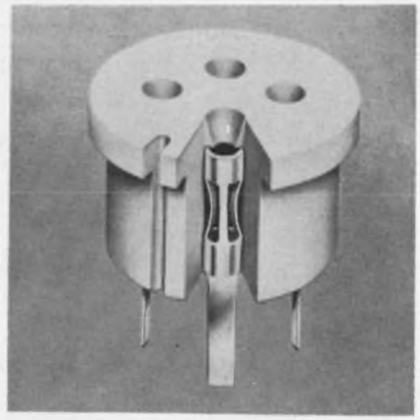


PC receptacles

A new printed-circuit receptacle utilizes stamped closed-entry contacts and accepts a 0.08-in. diameter test probe. The receptacles are available with 6, 10, 12, 15, 18, 22 and 28 contact layouts. Contacts are numbered and are made of gold-plated berryllium copper. Insulator bodies are glass-filled diallyl phthalate and mounting inserts are brass, with a nickel finish.

United-Carr Inc., 459 Watertown St., Newtonville, Mass. Phone: (617) 527-8400.

Circle No. 313



Sockets

A new line of TFE fluorocarbon sockets for mounting transistors and ICs on PC boards is offered. Three beryllium copper leaves bend slightly into each pin hole, permitting easy entry, yet firm contact. A life span of 10^5 insertions is claimed. Contact resistance is less than 0.01 Ω. Sockets are available with flat, flat right angle, and flexible mounting tabs.

Garlock Inc., 8 Fellowship, Cherry Hill, N. J. Phone: (609) 424-1470.

Circle No. 314

...NOW IN A NEW MINIATURIZED SIZE

Hermetically Sealed
ERIE BUTTON® MICA capacitors
designed for
-55° to +200°C at 2000 Mc.

Actual Size

New Miniaturized Size .410 dia. .505 dia.

Featuring **508 MECHANICAL VARIATIONS TO SUIT ANY HIGH TEMPERATURE—HIGH FREQUENCY CAPACITOR APPLICATION**

With the addition of these new miniatures, Erie further broadens the most complete selection of Button Mica Capacitors in the industry. These new miniaturized micas provide 33% reduction in mounting area.

Erie Button Mica Capacitors are designed for use in radio frequency circuits for tuning, bypassing and coupling. The outstanding properties of metallized mica dielectric combined with the radial current pattern, make Erie Button Capacitors ideal for low inductance, high frequency applications.

These high quality capacitors are designed for microwave and filter applications, for use in carrier equipment, parametric and RF amplifiers, oscilloscopes . . . any application where high temperature and high frequency are factors.

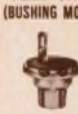
The welded hermetic seal of these excellent broad frequency Gold Seal® capacitors for military and commercial use is 100% tested under pressure steam/salt water during production to guarantee a positive moisture seal.

Consider the advantages of Erie Button Mica Capacitors in the equipment you are designing. Write for Gold Seal Bulletin 500-2 or Resin Seal Bulletin 318-3.

GENERAL SPECIFICATIONS

Capacitance:	5 pf. thru 2500 pf.	Frequency Range:	to 2Gc and beyond
Tolerance:	1% or .25 pf thru ±20%	Operating Temp.:	−55°C to +200°C
Working Voltage:	500 WVDC for ½" dia. units		−55°C to +150°C
	250 WVDC for ⅜" dia. units		−55°C to + 85°C
		Q: per MIL– C – 10950	

TYPES AVAILABLE

HERMETICALLY SEALED (GOLD SEAL®) .410" O. D. or .505" O. D.	RESIN SEALED .375",-.447" or .657" O. D.
 FEED THRU	 FEED THRU
 FEED THRU (BUSHING MOUNT)	 FEED THRU (BUSHING MOUNT)
 STAND OFF	 STAND OFF

EYELET FEED THRU 

MINIATURE BYPASS CAPACITOR SYSTEMS FOR TRANSMITTING TUBES . . .

Designed for the 10 to 3,000 megacycles range—and beyond

Erie now provides effective capacitive bypassing and coupling or filtering of all RFI signals in the range of 10 to 3,000 megacycles. Variety of systems to meet your requirements.

Write for Bulletin 525-R

Formerly Erie Resistor Corporation

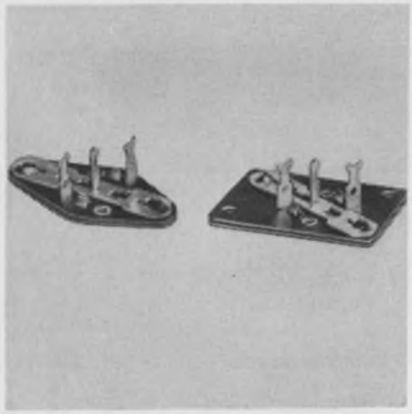
ERIE TECHNOLOGICAL PRODUCTS, INC.

ERIE

644 West 12th Street
Erie, Pennsylvania

Another Series of Components in Erie's Project "ACTIVE"
Advanced Components Through Increased Volumetric Efficiency

ON READER-SERVICE CARD CIRCLE 46



Power transistor sockets

A new line of high-reliability sockets accepts JEDEC TO-3 based power transistors or equivalent. Insulation material is laminated phenolic. Minimal contact resistance is provided by high-tension cadmium-plated brass contacts. For mounting, the formed thread accepts 6-20 screws.

Availability: 4 to 8 wks. Connector Corp., 6025 N. Keystone Ave., Chicago. Phone: (312) 539-3108.

Circle No. 315

Dopant

A new dopant, phosphorus nitride P_3N_5, is claimed to overcome the instability and sensitivity to air found with current dopants. It is non-hygroscopic, extremely stable in air and can be used without a dry-box as an N-type dopant. Phosphorus nitride is non-toxic, readily decomposed and will not penetrate silica or discolor silicon.

Electronic Space Products Inc., 854 S. Robertson Blvd., Los Angeles, Calif. Phone: (213) 657-5540.

Circle No. 316

Epoxy/silver solder

An electrically conductive epoxy solder in ready-to-use paste form is designated Dynaloy 310. The epoxy/silver compound incorporates the hardener but contains no solvents, volatiles or reactive diluents. Applications cited are in component lead terminations, assembly of solid tantalum capacitors and heat dissipation.

Dynaloy Inc, 408 Adams St., Newark, N. J. Phone: (201) 622-3228.

Circle No. 317

Resistance alloy

A 55% Cu/45% Ni alloy for resistor applications has a temperature coefficient controllable between −24 and −75 ppm/°C over a range of −18 to +100°C with a tolerance of ±2.5 ppm/°C. Nominal resistivity of 53 $\mu\Omega$-cm varies depending on the temperature coefficient.

Resistvar I is available in foil form in thickness from 0.0001-in., and widths from 0.03- to 4-in. Standard thickness tolerance from 0.0001 to 0.001 in. is +5%. Tensile strength is 70,000 to 90,000 psi and thermal emf against copper is 42 μV/°C.

Hamilton Watch Company, Lancaster, Pa. Phone: (717) 394-7161.

Circle No. 318

Silicone insulation

Deterioration, hardening, and cracking of materials such as polyethylene, PVC and TVE are not considerations with this S-2254 silicone rubber. This flame-retardant insulation for high voltage wires remains pliable and useful after extended exposure to 500°F and withstands corona. The heat stability of the unit permits assembly prior to any baking or dipping operations.

Dow Corning Corp., U. S. H'way. 10, Midland, Mich. Phone: (517) 636-8507.

Circle No. 319

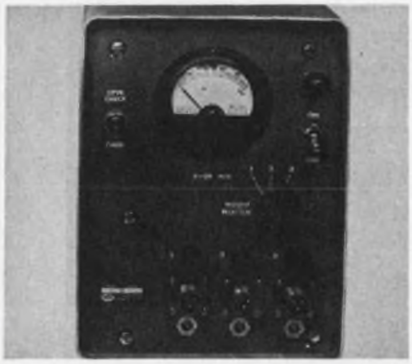
Dross eliminator

"Electro-Nox" is an anti-oxidant solder pot cover for electronic soldering. Formulated for use on PC wave-soldering machines and other solder pots at approximately 500 to 600°F, the material eliminates oxidized dross on solder pots.

Instead of inhibiting oxidation by acting as a solder/air barrier it dissipates dross by chemical action. Removal is not necessary, as it is a non-corrosive, non-oily, non-greasy and non-waxy dry material which melts on the pot and contains no salts or acids.

Urban Chemical Co., 3005 W. Franklin Blvd., Chicago, Ill. Phone: (312) 722-3060.

Circle No. 320



Power monitor

Three or more RF mounts covering 7 to 12.4 GHz can be used with the model 30-540-3 microwave power meter for systems power monitoring. Any or all of the three sources could be located up to 1,000 ft from the meter. The 30 mW full scale reading has an accuracy greater than 5%. Vswr is less than 1.5 and the output varies less than 5% over a 0 to 85°C ambient range.

A spring-loaded screwdriver-adjusted switch, the "operational check," indicates system performance without the use of waveguide switches or recalibration. Calibration power at 50 to 1000 Hz line frequency is less than 100 mW.

P&A: $245; 30 days. MSI Electronics Inc., 116-06 Myrtle Ave., Richmond Hill, N. Y. Phone: (212) 441-4620.

Circle No. 321

Reflectometer bridge

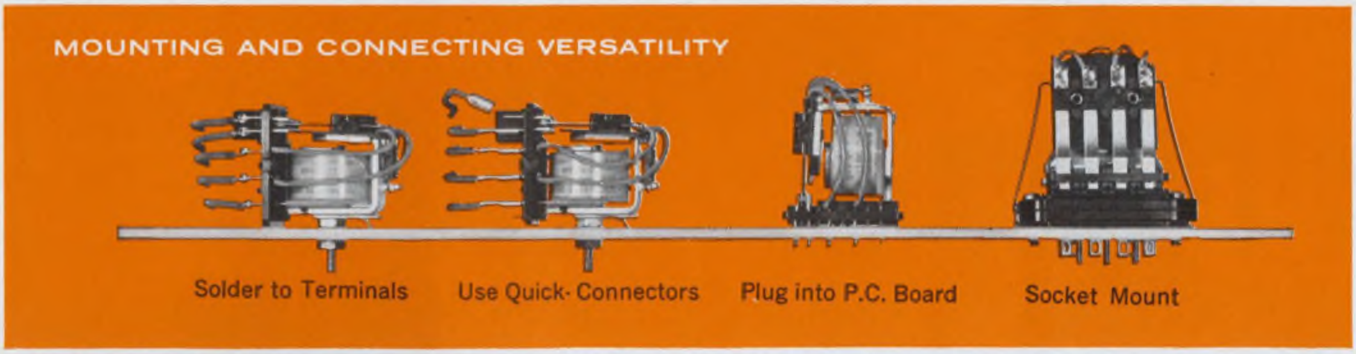
The model 3073 reflectometer bridge covers 7 to 12.4 GHz and is designed to effectively balance out reflections of the reference measurement channels. Directivity of the bridge is greater than 30 dB.

Input power is fed into a hybrid junction and splits into two signal paths equal in amplitude but 90° out of phase. The signals are then fed into a matched pair of coax directional couplers which are connected in a reverse position. Equal sample signals then appear at the inputs of a second hybrid junction. At the detected output these signals are 180° out-of-phase and cancel. The in-phase components appear at the second output and are terminated.

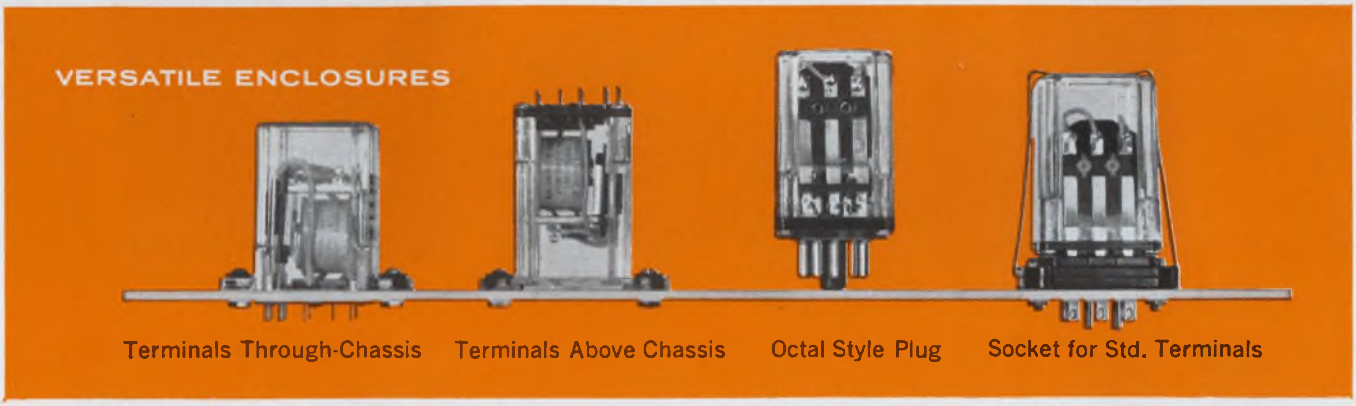
P&A: $12,000; 8 to 12 wks. Narda Microwave Corp., Plainview, N. Y. Phone: (516) 433-9000.

Circle No. 322

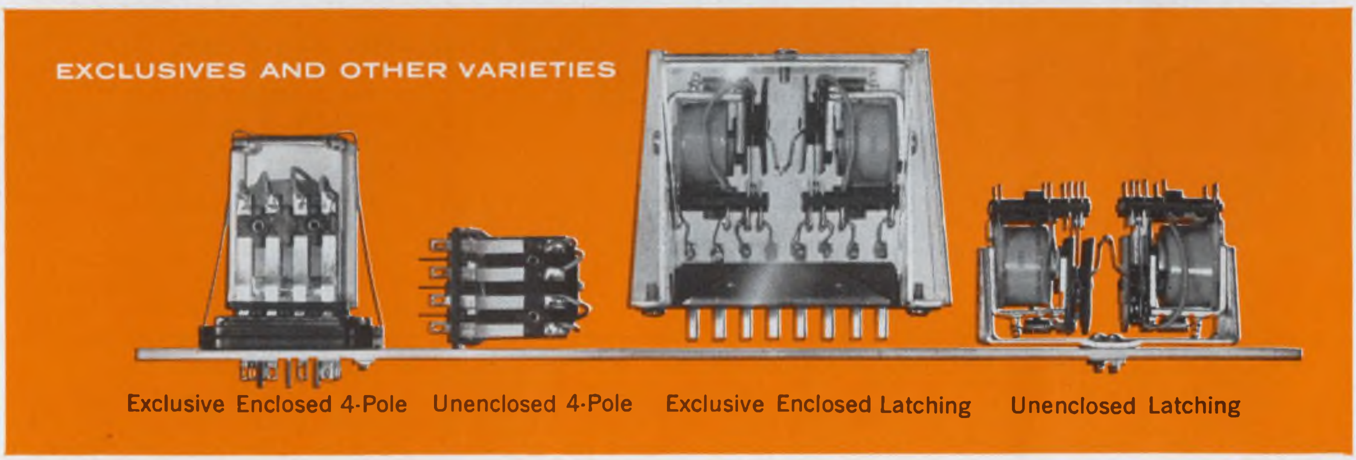
Mounting, connecting and



maintenance are easier



with OHMITE GPR relays...

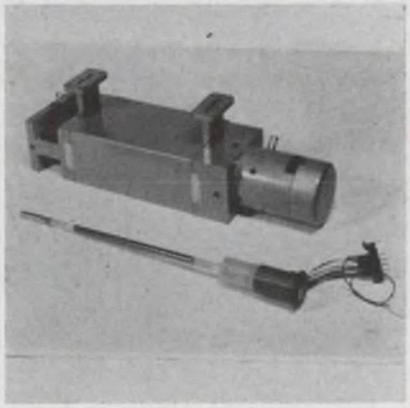


5 & 10-amp contacts... catalog 700

RHEOSTATS • POWER RESISTORS • PRECISION RESISTORS • VARIABLE TRANSFORMERS • RELAYS
TAP SWITCHES • TANTALUM CAPACITORS • SEMICONDUCTOR DEVICES • R.F. CHOKES

OHMITE MANUFACTURING COMPANY
3643 Howard Street • Skokie, Illinois 60076
Phone: (312) ORchard 5-2600

ON READER-SERVICE CARD CIRCLE 51



TWT

The TWC14 is a pulse-position modulation focused TWT operating at 10 W over 5.8 to 8.2 GHz. The tube operates in a periodic permanent magnet mount which incorporates RF input, output waveguide connections and convection cooler. It is secured within the mount with a fitting which provides for plug-in replaceability. A 10,000-hour guarantee is offered.

M-O Valve Co. Ltd., Brook Green Works, London, England. Phone: RIVerside 3431.

Circle No. 323

Switches

Stripline-insert switches which eliminate the need for connectors are offered in X, L, S, C and Ku band models. Typical for an X-band spst are an insertion loss of 1.3 dB max, an isolation greater than 30 dB, a switching speed less than 50 ns and vswr less than 1.1. Isolation on the order of 60 dB can be obtained with higher insertion loss.

Micro State, 152 Floral Ave., Murray Hill, N. J. Phone: (201) 464-3000.

Circle No. 324

Transponder

A 2-pound RF head assembly transmits at 1058 MHz and receives at 1118 MHz. Power output is 400 W for 1.5 vswr and 100 W for 2.0 vswr.

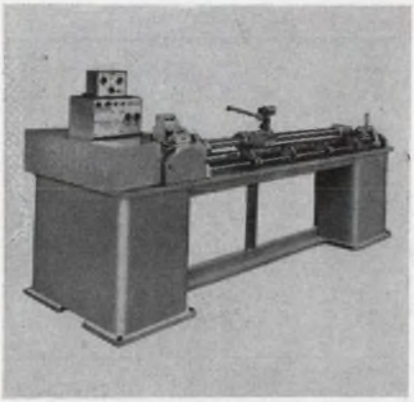
Total frequency change is less than 1.5 MHz. Spurious response is down 85 dB at antenna and transmit pulse jitter is less than 20 ns.

Trak Microwave Corp., 4726 Kennedy, Tampa, Fla. Phone: (813) 877-8341. *Circle No. 325*

Measuring counter

A counter/plug-in system makes automatic and direct reading measurements from 500 MHz to 12.4 GHz. The 5-1/4-inch high portable consists of a basic 50 MHz or 100 MHz counter and three interchangeable "Acto" plug-ins that progressively extend the range from 500 MHz to 12.4 GHz. The plug-in accepts an input signal, phase-locks an harmonic of an internally swept oscillator and automatically adjusts the counter time base to achieve direct readout. Input to readout takes milliseconds. Input is cw, with or without AM.

P&A: $975 to $1975; stock to 30 days. Systron-Donner Corp., 888 Galindo St., Concord, Calif. Phone: (415) 682-6161. *Circle No. 326*



Potentiometer winders

Model 436-AML potentiometer winder produces continuous windings up to 24 in., 48 in., or 72 in. on round copper mandrels. Winding range is 44 to 3040 turns/in. Wire size may be 0.0004-in. to 0.01-in. Winding speeds are up to 4000 rpm with the maximum usable speeds governed by actual winding characteristics.

P&A: $7500; 6 to 8 wks. Geo. Stevens Mfg. Co. Inc., 6001 N. Keystone Ave., Chicago. Phone: (312) 588-1300.

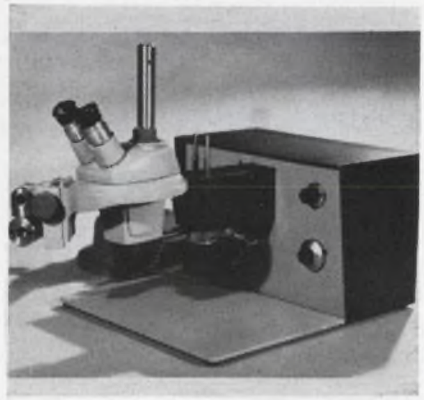
Circle No. 327

Spinning machine

A semiconductor spinning machine applies a thin, uniform coating to 4 substrates simultaneously and reduces "cobwebbing." The spinner handles substrates as large as 1-1/2 in. in diameter at any speed up to 10,000 rpm and can be used to apply any of the usual photoresists. An automatic reset interval timer and magnetic tachometer pickup are featured.

Westinghouse, P.O. Box 868, Pittsburgh. Phone: (412) 391-2800.

Circle No. 328

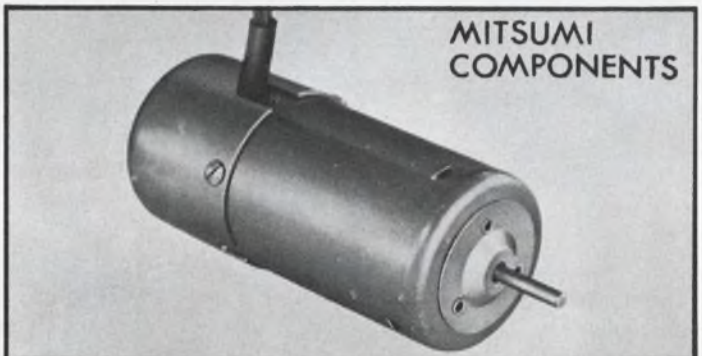


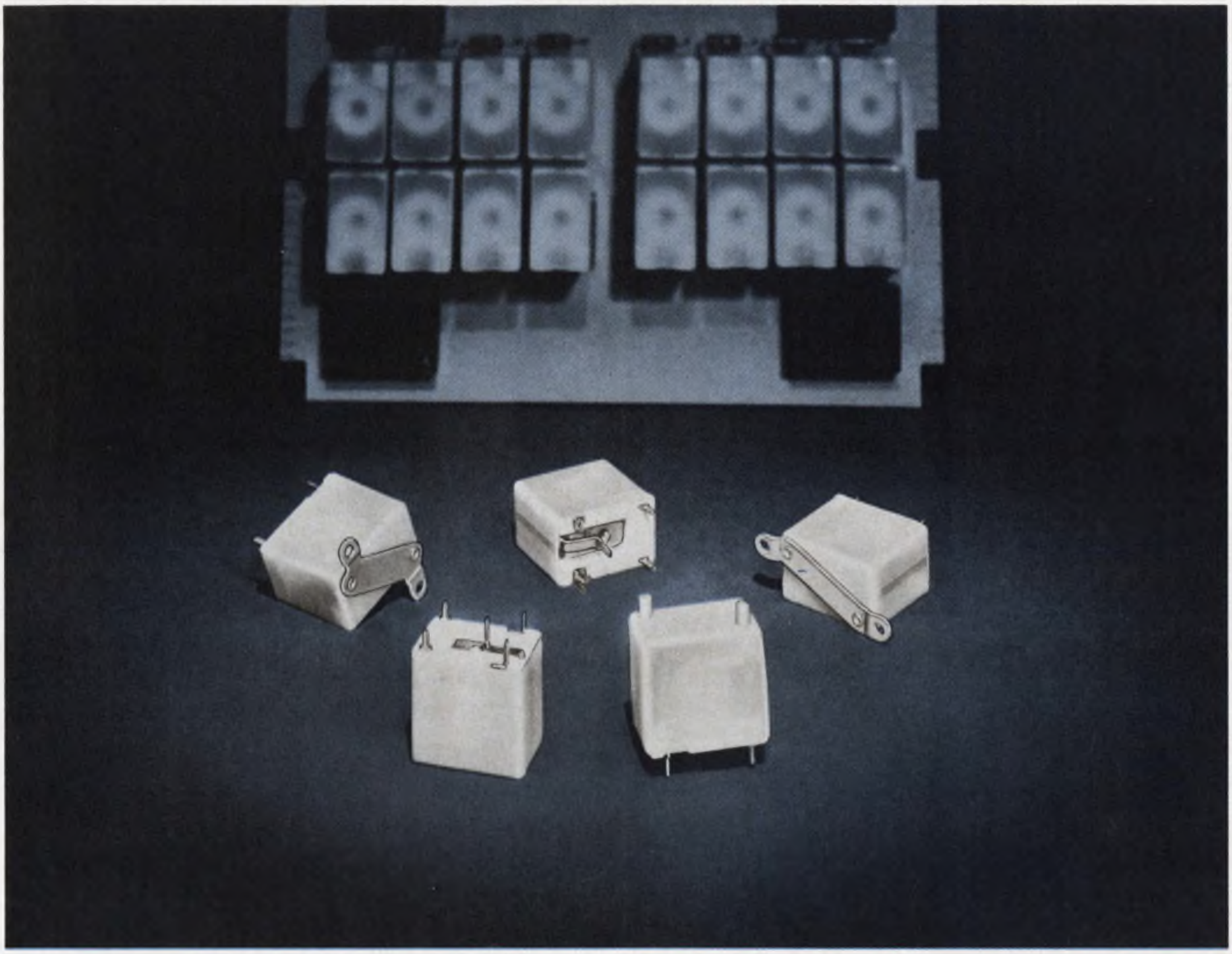
Micro-solder system

A gravity-activated soldering head for IC and module work highlights this new soldering system. The head employs two independently suspended electrodes. Fluxes are not required and there is no need to pre-form or tin. Power supply consists of a plug-in circuit board which controls 60-Hz pulses of up to 200-A amplitude ranging from 1 Hz to 60 Hz duration.

Henes Mfg. Co., 4301 E. Madison St., Phoenix, Ariz. Phone: (602) 275-4126.

Circle No. 329





A new miniature sensitive relay from RBM CONTROLS
IT WILL BE COPIED BUT NEVER EQUALED

Reason—RBM CONTROLS has more production and quality control experience and has built more sensitive miniature relays than any other manufacturer in the industry.

The new miniature Type 64 is an isolated contact relay for maximum sensitive applications where reliability, rugged construction and low cost are of major importance. This low level circuit switching relay is designed for compact areas and may be stack assembled in close proximity to each other. A protective nylon cover eliminates physical contaminance or mishandling. A variety of mounting brackets are available making this relay the most versatile in the industry.

ENGINEERING SPECIFICATIONS

CONTACTS
Ratings: 28V DC or 115 V AC 1 Amp (Non-inductive)
Form: SPNO, SPNC, SPDT
Type: Cross-Bar

COIL RATINGS
Maximum—1 Watt
Minimum—.050 Watt
Resistance—10,000 Ohms Max.

TERMINALS
Contact: To Mount To Printed Circuit Board

APPROXIMATE DIMENSIONS
(Overall Including Brackets and Mountings)

Printed Circuit	L 1-3/16"	x W 3/4"	x H 1-3/8"
Bottom	L 1-3/16"	x W 3/4"	x H 1-9/16"
Top	L 1-11/16"	x W 3/4"	x H 1-15/32"
Parallelogram	L 1-3/16"	x W 1-7/16"	x H 1-15/32"

MOUNTINGS
Printed Circuit Board
Bottom
Top—Parallelogram Replacement
Top Mounting Also Available

RBM CONTROLS

Serving Major Markets Since 1921

RBM CONTROLS
Division Essex Wire Corporation
Logansport, Indiana

RBM
STANDARD CONTROLS ARE AVAILABLE FROM YOUR ELECTRONIC PARTS DISTRIBUTORS

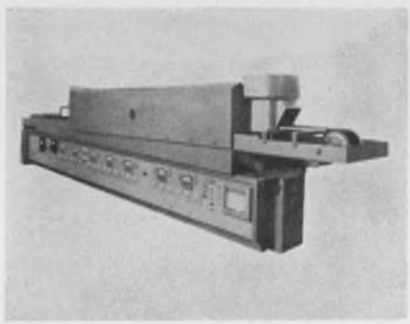
Speed Inquiry to Advertiser via Collect Night Letter
ON READER-SERVICE CARD CIRCLE 58

PRODUCTION EQUIPMENT

Ultrasonic soldering

A series of soldering pots uses ultrasonically agitated solder and eliminates flux. The pots typically draw 100 W with a peak output of 200 W at 18.5 kHz. Power can be controlled from 0 to 100% and is applied through a solid nickel magnetostrictive transducer brazed to the bottom of the pot. Temperatures can be maintained to 700°F with bimetallic or variac control.

Blackstone Ultrasonics Inc., 103 Horton Ave., Sheffield, Pa. Phone: (814) 968-3222. *Circle No. 330*

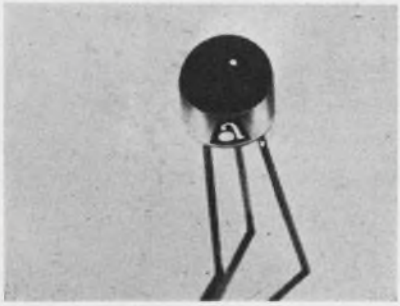


Resistor firing furnace

The "IQ" series of resistor firing furnaces is designed for volume production of thick film resistors and conductors. On a "continuous load" basis, firing capacity is 3000 1/4-in.^{2} pieces/hour. A combination hearth and thermocouple system detects an alumina substrate 1/2 x 1/2 x 1/32-in. on the belt and produces equal results for any load between one substrate and full belt loading. Temperature uniformity is ± 1°C across an 8-in. belt. Furnaces are available with 4, 5 or 8 zones operating from 200 to 1100°C. A radiant dryer is available as an option.

BTU Engineering Corp., Bear Hill, Waltham, Mass. Phone: (617) 894-6050.

Circle No. 331

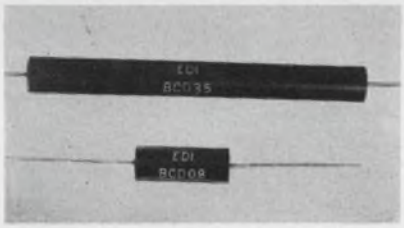


Epoxy FETs

Three new types of epoxy field effect transistors meet all requirements of MIL-S-19500. Typical values for transconductance are 2000 to 3000 μmhos. Drain-to-gate capacitance is 2.0 pF and pinch-off voltage is 4.0 to 10 V.

Teledyne Inc., Amelco Semiconductor Div., P.O. Box 1030, Mountain View, Calif. Phone: (415) 968-9241.

Circle No. 332



SCRs

A new "BCD" series of miniature silicon controlled rectifiers offers a forward current rating of 100 mA. Peak inverse voltages range from 8000 to 50,000 V. Units have 3/8-in. diameter and a typical 10 kV unit is 1-1/8-in. long.

Price: about $3.90 (100). Electronic Devices Inc., 21 Gray Oaks Ave., Yonkers, N. Y. Phone: (914) 965-4400.

Circle No. 333

Switching diodes

Diffused silicon high-voltage diodes TID40 through TID44 feature mesa wafer construction. Voltages up to 250 V are handled with currents to 200 mA at 1 V.

Prices: TID40-44: about $2.30 (1-99), about $1.75 (100-999) Texas Instruments, 13500 N. Central Expwy, Dallas. Phone: (214) 235-3111.

Circle No. 334

Design Aids

SCR slide rule

An SCR selector and calculator features a cross-reference of JEDEC and house numbers covering 4.7 to 235 A rms and peak forward and reverse voltages from 25 to 1300 V. Scales include output voltage as a function of firing pulse angle or phase retard for single- through 12-phase circuits. Critical dv/dt test circuit and scales relate time constant values to dv/dt as a function of peak forward blocking voltage of 1500 V. Design constants for single- through 12-phase rectifier circuits are given.

Available for $1.00 from International Rectifier, 233 Kansas St., El Segundo, Calif. Phone: (213) 678-6281.

Thermocouple tables

A 40-page booklet of standard reference tables for thermocouples is offered. Thermocouples covered include: Iron/constantan, chromel/alumel, platinum 10% rhodium/platinum, platinum 13% rhodium/platinum, copper/constantan and chromel/constantan. A thermocouple resistance table is also featured. West Instrument Corp.

Circle No. 335

Photoconductive cells

A designer's guide to choosing Cd and CdSe bulk-effect photoconductive cells is offered. The 16-page manual covers photocell theory, design, and properties from an applications viewpoint.

Included in the manual are sections on photocell theory, spectral and color temperature response, sensitivity, temperature coefficients, response speed, light history effects and maximum voltage. A discussion of photometry with a nomograph completes the two-color reference manual. Clairex Corp.

Circle No. 336

New Literature

Controlled rectifier

"The Controlled Rectifier," Vol. I, defines the properties, characteristics and values of the controlled rectifier as a power control device. The material presented is based on those device characteristics which can be observed and measured, avoiding the introduction of theory or analytical concepts which cannot be supported. Structure and operation, static, dynamic, gate and thermal characteristics, cooling methods and testing are among the topics covered.

Available for $2.50 from International Rectifier, 233 Kansas St., El Segundo, Calif. Phone: (213) 678-6281.

Coax circulators

A new catalog describes a line of high-power coaxial circulators. Standard and special models from uhf to X-band are covered. Coaxial circulators are used as duplexers or isolators in radar systems. Raytheon Co.

Circle No. 337

Frequency standards

A 6-page brochure, "Selection of a Frequency Standard" is offered. The bulletin is a comprehensive report on the factors to be considered in selecting a frequency standard, and tells how to evaluate aging rates in determining anticipated performance. Tracor, Inc.

Circle No. 338

Magnetrons

"Voltage Tunable Magnetrons" is a 20-page handbook describing hf continuous-wave oscillators that operate in the microwave region. Theory, basic operation and power supply requirements for three major groups of VTMs are given.

Parameters such as tuning characteristics, power output, and operating frequency are detailed and illustrated. General Electric, Electronic Components Div.

Circle No. 339

Standards manual

A 92-page 1966 "Engineering Standards Manual" contains design data for a broad range of electronic components. Specifications are given for insulated terminals, encapsulation cups, weldable terminals, terminal boards, instrument panel hardware, and tooling and retainers. Litton Industries Inc.

Circle No. 340

Capacitor guides

Guides to the selection of computer-grade alumalytic capacitors and mylar capacitors continue a series of capacitor guides. Capacitors are listed in numerical sequence by μF and working voltage for quick selection. Schweber Electronics.

Circle No. 341

Reed reliability

The results of a broad range of life and reliability tests on 3,241 reed switches for more than 103 billion operations are reported in a 4-page brochure. For objectivity and validity, tests are also shown from three leading reed switch manufacturers. Load levels, cycling rate and failure definition were intentionally varied so that their effect on reed life and reliability can be seen. Wheelock Signals, Inc.

Circle No. 342

Attenuators

A new catalog on attenuators illustrates drum, push-button, solenoid and other remote operated types. Also covered are cam, vertical, rotary and fixed pads, single, dual and stereo type attenuators. Frequency range is from dc to 400 MHz. Included are complete specifications for each type. Tech Laboratories Inc.

Circle No. 343

Reed relays

Multi-pole dry reed and mercury-wetted contact relays are the subject of an illustrated 4-page brochure. Application data include specifications, switching schematics, dimensional drawings, contact configurations and coil characteristics. Magnecraft Electric Co.

Circle No. 344

NEW LITERATURE

Silicones

A 24-page reference guide to silicones is geared to materials selection for aerospace electronics. Bulletin CDS-716 contains sections on properties, product forms and functions. potting, encapsulating and sealing compounds, dielectric coolants and insulating compounds. Special features include a MIL-spec guide and product selector chart. General Electric, Silicone Products Dept.

Circle No. 345

Operational amplifiers

Catalog 66A completely covers 33 dc operational amplifiers, universal electronic rack housing and plug-in modules. All specifications are presented in a single chart showing model number and 39 performance specifications. Dimensions, diagrams, mounting configurations and complete pin designations for standard packages are shown for systems amplifiers on printed-circuit board and encapsulated models. Computer Dynamics, Inc.

Circle No. 346

Integrating DVMs

A pair of 2-color brochures provide information on the features, operating principles and specification of all-electronic, 5-digit integrating DVMs. Hughes Aircraft Co., Vacuum Tube Products Div.

Circle No. 347

Trimmer capacitors

This catalog features a new line of metallized glass miniature trimmer capacitors. Also included are specifications on a full line of precision trimmer capacitors and inductors. LRC Electronics Inc.

Circle No. 348

Mercury ballast guide

A buyer's guide to mercury lamp ballasts is offered. The two-color, 12-page bulletin MV-200 describes and depicts a line of constant-wattage and mercury vapor ballasts for indoor and outdoor service. The illustrated brochure includes specifications, charts and technical data on mercury ballasts as well as mounting accessories. Sola Basic Industries.

Circle No. 349

Analog computer guide

A comprehensive comparative study of 81 performance and operational characteristics of six leading desk-mounted analog computers is offered in the form of a buyer's guide. Subjects covered include performance, operator convenience and analog and hybrid capacity and capability. Computer Products Inc.

Circle No. 350

Magnetic tape

A sample length of magnetic tape with five suggested ways to "torture it" is attached to this 4-page folder. Standard reel sizes, roll lengths and test standards are also given. U.S. Magnetic Tape Co.

Circle No. 351

Investment casting

A 44-page brochure details the basic steps in investment casting. Applications, a designing guide and a wide range of ferrous and nonferrous alloy specifications are featured. Arwood Corp.

Circle No. 352

Rectifiers and zeners

A 32-page catalog covers a line of zener, rectifier and other diodes. Full information on high surge zeners, fast recovery rectifiers and radiation-tolerant rectifiers is included. A section on application data details mounting and derating, recovery time and forward and reverse surge ratings. Unitrode Corp.

Circle No. 353

Gyro instruments

A 6-page gyro test instrumentation catalog is offered. Included in the catalog are typical test configurations. Inland Controls.

Circle No. 354

Reprints Available

The following reprints are available free and in limited quantities. To obtain single copies, circle the number of the article you want on the Reader-Service Card.

High Volume, Low Cost: Designers Challenge (No. 740)

Harmonic Generators (No. 741)

Hall Effect Multiplier Simplifies Polar Displays (No. 742)

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An address change for a subscriber requires a restatement of his qualifications. To expedite the change, and to avoid missing any issues, send along a label from a backcopy.

Microfilm copies of all 1961, 1962, 1963 and 1964 issues of ELECTRONIC DESIGN are available through University Microfilms, Inc., 313 N. First Street, Ann Arbor, Mich.

Design Data from

Relay Price and Product Bulletin

This new illustrated, two-color, 12-page bulletin provides descriptions and complete pricing information for general purpose, power, plug-in, antenna switching, hermetically sealed, and magnetic latching relays, as well as clapper mechanisms and a continuous or intermittent buzzer. A color key easily identifies models immediately available from distributors' stock.

Milwaukee Relays, Inc.
606 E. Pioneer Road
Cedarburg, Wis. 53012

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Low-Impedance Crystal Accelermeter

Bulletin 259865 contains description and specifications on revolutionary Model 812A Piezotron, a low cost quartz transducer for precision measurement of vibration, shock and acceleration. Used with any single-wire shielded cable, the instrument eliminates the cable noise, attentuation, and insulation resistance usually associated with conventional piezoelectric systems. Generating a high amplitude, low impedance output signal, the Piezotron can be connected directly to a meter, scope, or recorder.

Kistler Instrument Corporation
8969 Sheridan Drive
Clarence, N. Y. 14031

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New Continuous Plating Saves 40%!

New continuous reel-to-reel precious metal plating (gold, silver, Rhodium, etc.) on strip reduces materials cost up to 40%. Provides extremely accurate depositing to specifications, allows *selection* of plated area (i.e.: 20 microinches one side, 100 microinches on opposite side).

Process also permits plating of pre-die cut integrated circuits for semi-conductors, etc., and allows forming after plating.

Burton Research Laboratories, Inc.
Division of
Burton Silverplating Co.

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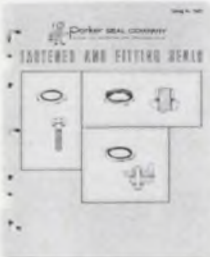
Manufacturers

Advertisements of booklets, brochures, catalogs and data sheets. To order use Reader-Service Card.

Reliable Fastener Seals Described



Parker Seal Company's Fastener Seals are well-known for their superior reliability in mechanical sealing. These famed "seal-for-sure" designs are described in a new catalog-handbook containing sizes, dimensions, engineering data, etc. It includes their new Thredseal, an extremely reliable, easy-to-use seal for sealing directly against threads as well as information on Stat-O-Seals, Lock-O-Seals, etc.

Parker Seal Company
10567 Jefferson Blvd.
Culver City, California 90230

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Dope On Doping Gases

Data Sheets list Physical Constants, Typical Analysis, Recommended Controls, use suggestions, etc., for Matheson Doping Gases. Arsine, Diborane, Germane, Hydrogene Selenide, Phosphine and Silane are available pure, or as mixtures, diluted with carrier gas. (Diborane available only as a mixture.) Gases shipped from our plants in East Rutherford, N. J., Joliet, Ill., La Porte, Texas, Newark, Calif., Morrow, Ga.

The Matheson Company, Inc.
P. O. Box 85
East Rutherford, N. J.

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Electronic Liquid Level Control

The Curtis LLS is a versatile, electronic static device incorporating a silicon-controlled rectifier (SCR) for operating the control relay. Operation is accomplished by sensing a minute current flowing between submerged probes. This AC current triggers the SCR and energizes the control relay. One set of control relay contacts allows internal pump-up or pump-down control, leaving two sets of contacts for the control operation function. Fully described and priced on new 2-page brochure DS-162.

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

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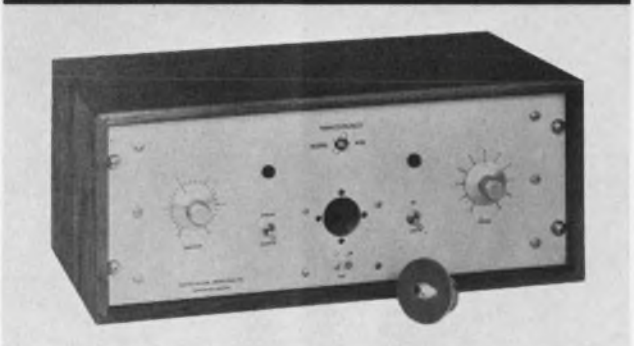

Advertisers' Index

NIGHT LETTER PROGRAM
*PARTICIPANTS IN

Designer's Datebook

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May 10-12

1966 National Telemetering Conference (Boston, Mass.) Sponsors: AIAA, IEEE, ISA; Paul Barr, Raytheon Co., Norwood, Mass.

May 11-12

Seminar on Photographic Systems for Engineers (San Francisco) Sponsor: Society of Photographic Scientists and Engineers; Suite 204, 1330 Massachusetts Ave. N.W., Washington, D. C.

May 14

Seventh Annual West Coast Reliability Symposium (Los Angeles) Sponsor: Society for Quality Control; S. Goldklang, TRW Systems, One Space Park, Redondo Beach, Calif.

May 16-18

9th National ISA Power Instrumentation Symposium (Detroit Mich.) Sponsor: ISA; Robert R Donaldson, Hagan Controls Corp., 5757 Trumbull Ave., Detroit, Mich.

May 16-19

1966 International Microwave Symposium (Palo Alto, Calif.) Sponsor: IEEE, G-MTT; Marvin Waldman, Waldman Assocs., 1094 W. Evelyn Ave., Sunnyvale, Calif.

May 16-19

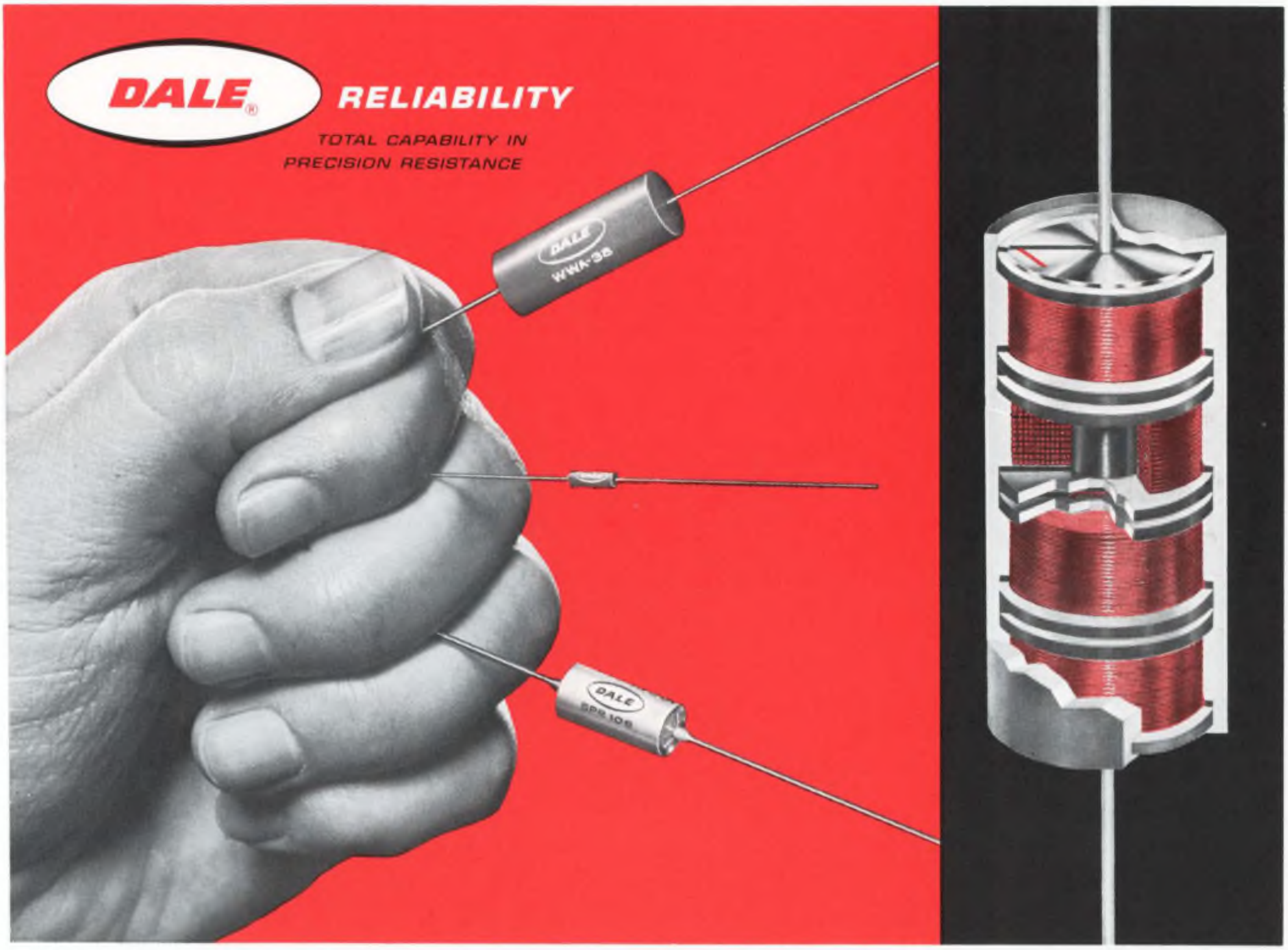
4th National ISA Biomedical Sciences Instrumentation Symposium (Anaheim, Calif.) Sponsor: John F. Bishop, Dana Labs., Inc., Irvine, Calif.

May 23-25

12th Annual Meeting of the American Astronautical Society (Anaheim, Calif.; Dr. Donald B. Duncan, Philco Corp., Newport Beach, Calif.

June 7-9

20th Annual Convention of the Armed Forces Communications and Electronics Association (Wash., D. C.) Sponsor: AFCEA; W. J. Baird, 1725 Eye St., N.W., Washington 6, D.C.



DALE can do a better job of making the BOBBIN you need

Here are four solid reasons for putting Dale to work on your bobbin requirements:

1. **BETTER BASIC CONSTRUCTION.** Termination and winding patented due to strength and stability advantages. MWA & WWA now use high-rel methods from Dale Minuteman Program. Both meet applicable requirements of Mil-R-93C and *new Mil-R-39005.*
2. **BETTER WIRE QUALITY.** Exclusive vendor reliability improvement program yields wire with maximum spool-to-spool homogeneity.
3. **BETTER ALL-MOLDED COATINGS.** New Dale-developed molding compounds give denser package; pass salt-water immersion test. All precision bobbins now molded.
4. **BETTER "SPECIAL" CAPABILITY** for supplying bobbins with special windings, special housings, special screening and acceptance testing.

WRITE FOR CATALOG A

MWA & WWA SERIES BOBBIN SPECIFICATIONS

DALE TYPE	MIL-R-93 TYPE	POWER RATING (WATTS)	RESISTANCE RANGE (1% TOLERANCE)	DIMENSIONS (L. x D.)
MWA-8	—	.1	1 ohm – 100K ohms	.250 x .078
MWA-10	—	.125	1 ohm – 125K ohms	.312 x .078
WWA-13	—	.125	1 ohm – 300K ohms	.375 x .125
WWA-22	—	.15	.1 ohm – 350K ohms	.250 x .250
WWA-23	RB-56	.15	.1 ohm – 600K ohms	.375 x .250
WWA-24	RB-55	.20	.1 ohm – 800K ohms	.500 x .250
WWA-26	RB-54	.25	.1 ohm – 1 Megohm	.750 x .250
WWA-36	RB-53	.33	.1 ohm – 3 Megohms	.750 x .375
WWA-38	RB-52	.50	.1 ohm – 4 Megohms	1.000 x .375

Standard Tolerances: 1%, .5%, .25%, .10%, .05%

Load Life: .5% Max. ΔR in 1500 hours at MIL-R-93 conditions. Power ratings may be doubled for commercial applications.

Operating Temperature: $-55°$ C to $+145°$ C

Special Modifications Available: Tolerances to .005%; Matched Resistor Tolerances to .001%; Special TC's to $\pm$ 2 PPM/°C; Special Matched TC's to an accuracy of 1 PPM/°C.

DALE

DALE ELECTRONICS, INC.
1328 28th Avenue, Columbus, Nebraska

SEE OUR SPECIFICATIONS IN VSMF THE MICROFILM CATALOG FILE

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