Electronic Design 21

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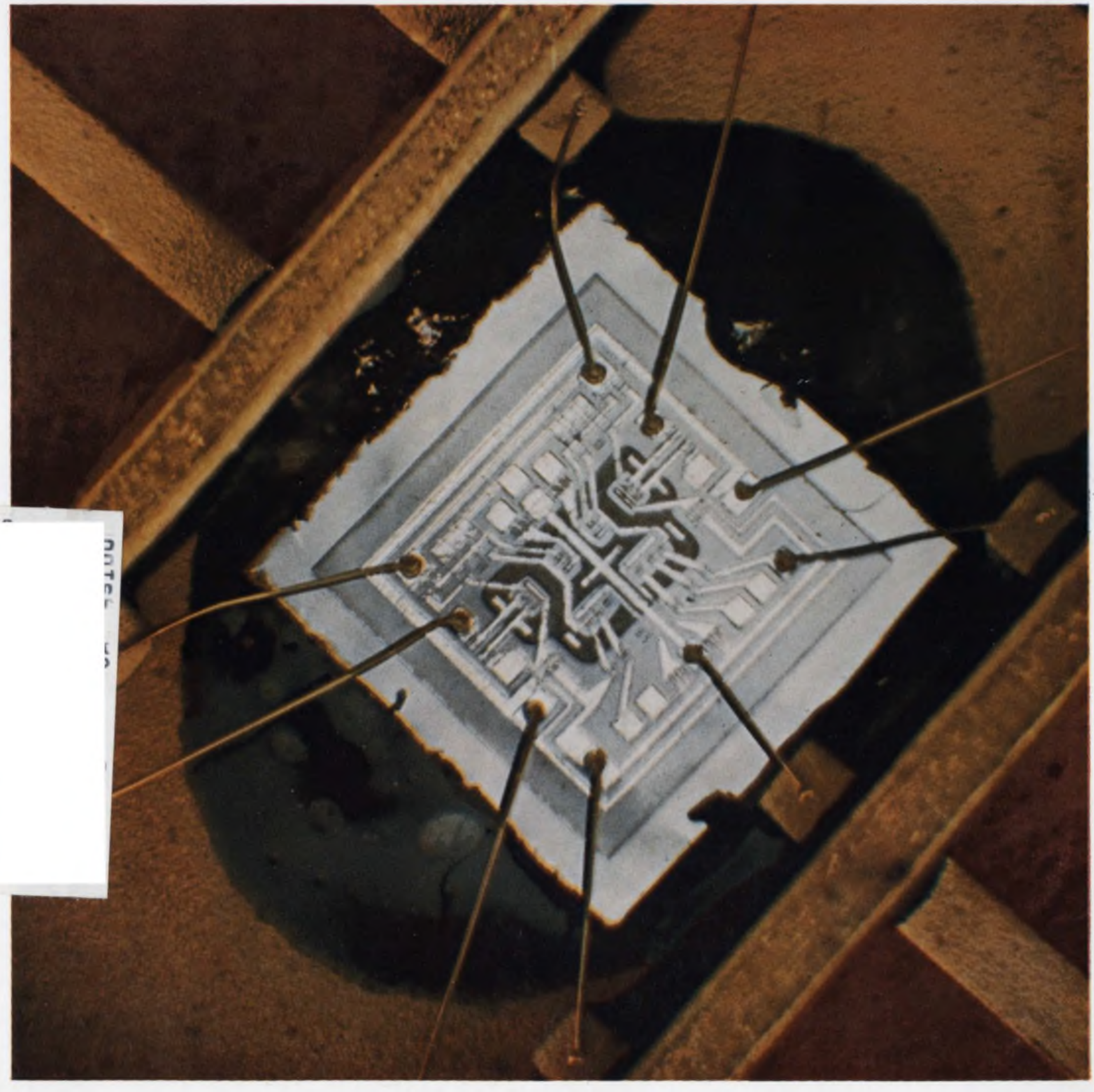
THE MAGAZINE OF ESSENTIAL NEWS, PRODUCTS AND TECHNOLOGY

SEPTEMBER 13, 1966

Isolation innovations close gap between desired and actual performance in integrated circuits. These IC advances (such as this ceramic-isolated chip) hold the promise of higher reliability, improved electrical characteristics and lower cost. The impact will be in military, industrial and consumer IC applications (see p. 17).



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Electronic Design

VOL. 14, NO. 21

THE MAGAZINE OF ESSENTIAL NEWS, PRODUCTS AND TECHNOLOGY

SEPTEMBER 13, 1966

NEWS

TECHNOLOGY

PRODUCTS

Departments

ELECTRONIC DESIGN is published biweekly by Hayden Publishing Company, Inc., 850 Third Avenue, New York, N. Y. 10022. James S. Mulholland, Jr., President. Printed at Poole Bros., Inc., Chicago, Ill. Controlled-circulation postage paid at Chicago, Ill., and New York, N. Y. 61,042 copies this issue.

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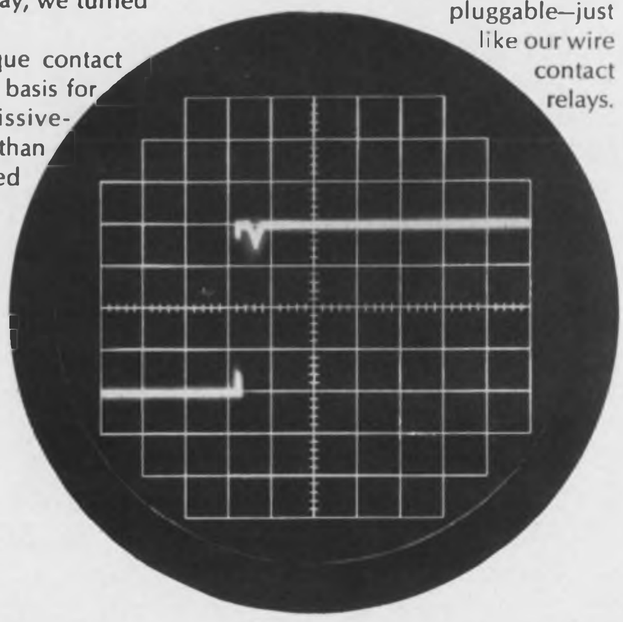

Typical bounce characteristics of the IBM permissive-make relay appear at the right. Time base is 20 microseconds per centimeter-amplitude base is 0.5 volts per centimeter.

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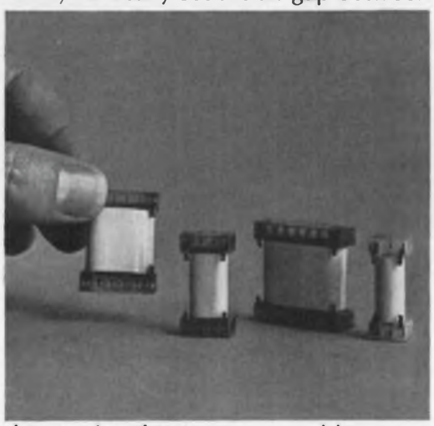

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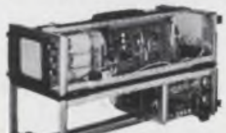
More Performance Than Any Other High-Frequency Scope! Big Picture  8 x 10 cm CRT Display. Plug-In Versatility  with 5 mv/cm, 50 MHz Dual Channel Amplifier; Time Base and Delay Generator with Mixed Sweep; Time Base with 5 nsec/cm Sweeps. Rugged, Easy-to-Carry  30-Pound Package. 100% Solid State Circuitry. Convenient Snap-Off Covers for Easy-to-get-at Circuitry.  Optional 5¼" Rack Mount. 

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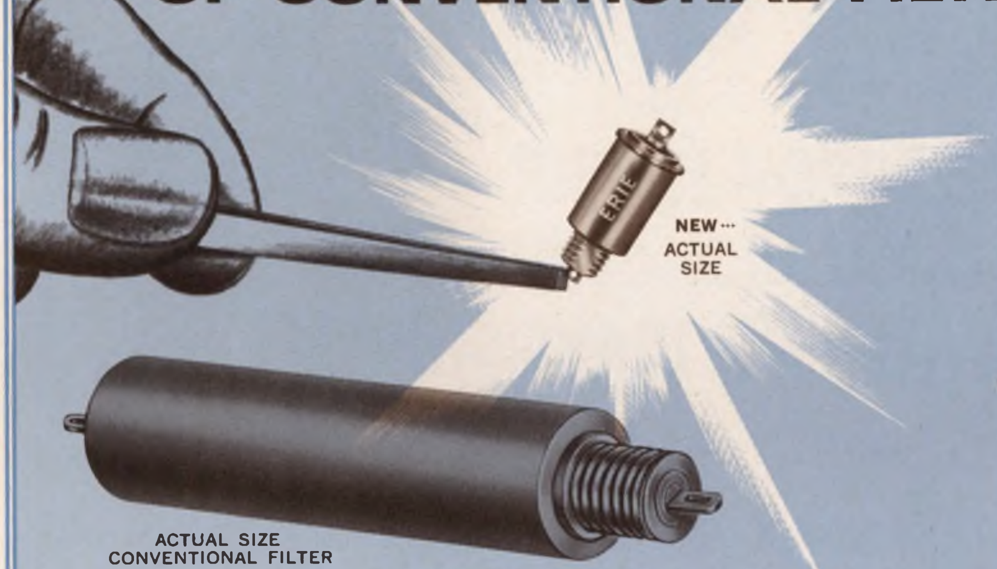

ACTUAL SIZE
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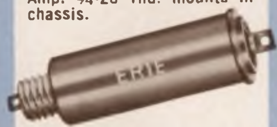
100 Volts DC line Filter; For L, π and T Circuits; Insertion Loss...67 DB at 150KC DC Current Ratings to 8.0 Amp. 1/4-28 Thd. mounts in chassis.



115 Volts AC @ 60 cycles; Insertion Loss, 12 DB @ 150 KC and 60 DB @ 10 Mc.; 1/4-28 Thd. mounts in chassis.

SUBMINIATURE STRIPELINE FILTERS

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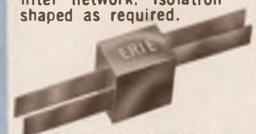
Two components in one for π circuits...1. Precision capacitor values for selective bias...2. Signal line filter network. Isolation shaped as required.



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Ribbon leads; 50 DB @ 1 Gc. Excellent VSWR. Effective filtering beyond 4 Gc.

ERIE'S NEW FILTER TECHNOLOGY PERMITS DRASTIC REDUCTION IN SIZE

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Volume reduction of these high reliability filters ranges to 13 times smaller than conventional filters of equal capability. Weight is correspondingly reduced, thus providing ideal RFI (electromagnetic interference) Filtering for equipment in aerospace, military and commercial markets.

Erie's new filter technology permits insertion loss ratios of 67 DB @ .25A @ 150 KC ...volumetric efficiencies which were never before possible.

In addition to the standard line filters described at right, Erie offers a full line of compact Bypass Capacitor Systems for transmitting tubes. Also, if you have particular electromagnetic interference problems not covered by standard Erie filters, we will be happy to custom design a filter connector package to suit your application.

Write TODAY for Bulletin 9000 and the name of your nearby Erie Field Sales Engineer.

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Erie now provides effective and reliable capacitive bypassing and coupling or filtering of all RFI signals in the range of 10 to 3,000 megacycles and beyond. Screen grid values from 1000 pf. to 10,000 pf. at 1000 WVDC. Variety of systems to meet your design requirements.
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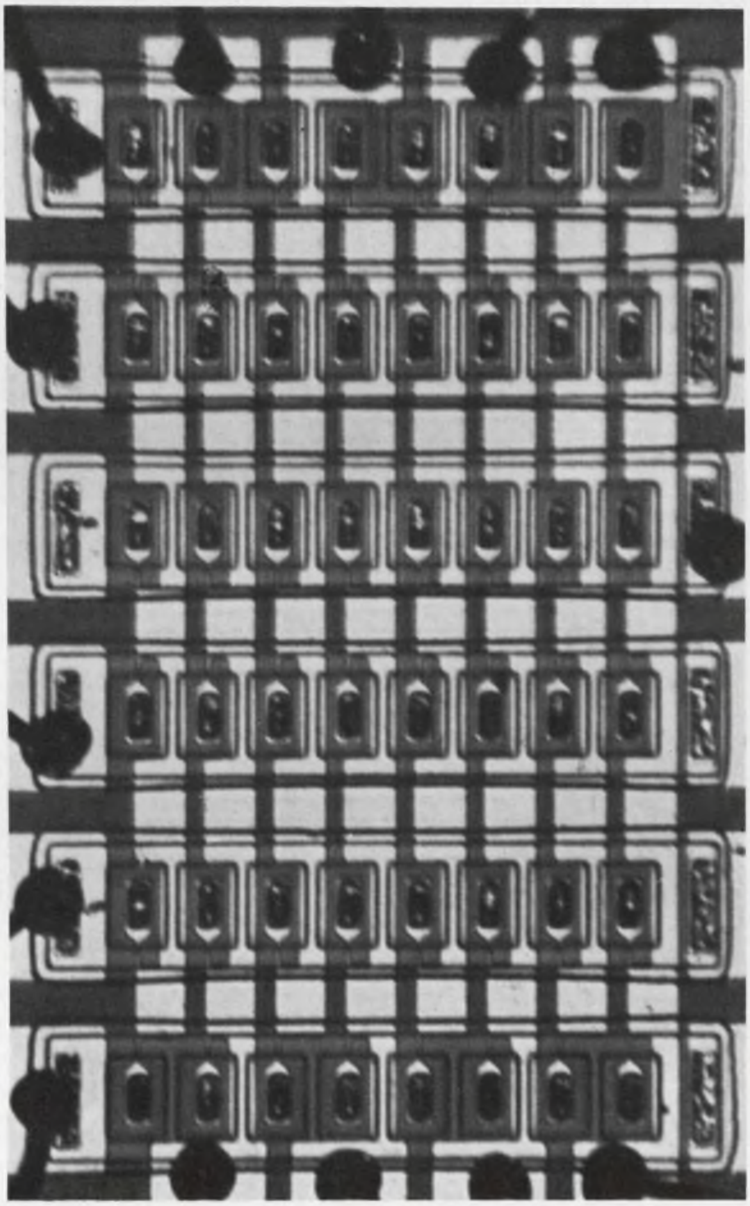
ON READER-SERVICE CARD CIRCLE 8

News

Future moon shots depend on close-up photography of Lunar Orbiter. Page 24.



Better isolation techniques are expected to result in improved IC performance that may match discrete semiconductors'. Page 17.

Also in this section:

Ford Foundation satellite: plan stirs controversy

Officials of the Ford Foundation have stirred up a hornet's nest with their proposal to create a new non-profit company to beam domestic television via satellite. At recent Congressional hearings, Ford Foundation president McGeorge Bundy and TV advisor Fred Friendly were kept busy alternately dodging bouquets and brickbats.

Most of the kind words for the satellite plan came from members of the Senate Communications Subcommittee who viewed it, in the words of Chairman John O. Pastore (D-R.I.), as "of tremendous moment to the public." As expected, though, existing carriers like Comsat, AT&T and ITT stopped fighting each other long enough to make common cause against the proposal.

The Ford Foundation plan (see ED 19, Aug. 16, 1966, p. 73) would embrace a satellite system to service both commmercial radio and TV as well as educational TV. Actually, Ford Foundation officials feel that the term educational TV is inappropriate. The proposed plan, said Bundy, calls for programing of an information-cultural nature, not just educational.

Regardless of what it is called, the noncommercial programing would be subsidized by profits realized from commercial users. A review board, to be established under the plan, would decide on the types of programs and on who would be subsidized to show them.

Although the Ford proposal was made to the Federal Communications Commission, which has the authority to authorize domestic communication satellites, Congress is extremely interested because of its involvement in educational TV. Under the Educational TV Facilities Act, the Federal Government has been providing money to the states on a matching-funds basis. The Act is due to expire soon and Congress is looking for ways to ensure the continued growth of educational television.

According to Sen. Pastore, however the FCC acts on the Ford proposal, "Congress can still step in."

In opposing the Ford plan, Comsat, through its chairman, James McCormack, maintains that only Comsat can legally own satellites. Comsat bases this contention on the Communications Satellite Act of 1962. Ford Foundation officials contend, however, that the 1962 Act applies only to nondomestic satellites. Ford officials have stated, though, that they have no objection to Comsat supplying the satellites for the proposed system, provided that it makes available the same funds to subsidize the noncommercial broadcasting. There seems little chance of agreement on this approach, since Comsat and the other carriers are opposed to having commercial broadcasters subsidize educational TV by paying artificially high rates to use satellites.

TV industry awaits outcome of satellite debate.

U.S.A.F. to catalog spacecraft radar images

The Air Force is making electronic portraits of spacecraft shapes for a catalog of radar images of possible future satellites.

The portraits will be taken of some two dozen satellite models during 2000 hours of tests between now and December at the Radar Target Scatter installation near Holleman Air Force Base, N. M.

Col. Thomas O. Wear, director of the Air Force's Space Track Program, explained: "In attempting to identify objects in space, which may be from 80 miles high up to hundreds of miles, radar signals reflected from completely symmetrical objects are not difficult to analyze. But irregularly shaped space vehicles which may be tumbling present difficult problems. There are five basic points of information that we need to pin down for space object identification."

Col. Wear said these were body motion about the center of mass, size and shape, mass and distribution of mass, electrical composition of the body, and fin structure.

NASA outlines costs of post-Apollo plans

The National Aeronautics and Space Administration has made its first estimates of the funds required for five alternative programs that might be used as follow-ups to its

News Scope CONTINUED

Apollo man-on-the-moon project.

An analysis of the five possible future space programs was given to the House Manned Space Flight Subcommittee by Dr. George E. Mueller, NASA associate administrator for manned space flight. His funding estimates did not include the costs of NASA's science, applications and research programs.

The plan that seems most favored by NASA would be a long-term balanced program that would lead gradually to an operational Earth-orbital station, a lunar station and Mars and Venus fly-bys with an ultimate goal of a manned landing on Mars. Its estimated annual cost could be a maximum of $4.2 billion after six years.

The most costly program followed the same pattern, but for reasons of national prestige on an accelerated basis with a Martian landing by 1980. It would cost at least $6 billion within five years.

Dr. Mueller also cited a $3 billion project to concentrate on the building of space stations for economic benefits to Earth. A program with an early peak budget of $3.4 billion dropping later to $2 billion a year would push ahead with lunar exploration and related scientific experimentation. NASA's last alternative was a six-year program of planetary exploration with heavy emphasis on early manned landings to cost some $4.3 billion a year.

Are UFOs really only ball lightning?

Two Westinghouse scientists have a campaign that may clarify many unidentified flying object (UFO) sightings (see Editorial, ED 19, Aug. 16, 1966, p. 63). They are making transmission gratings that can be used to indicate whether these strange lighted objects might be ball lightning plasmas. If so, they would appear as a series of spectral lines through the grating, including a bright red one due to hydrogen and a blue one due to nitrogen. A solid lighted object would appear as a continuous color spectrum.

A strong argument that corona discharges generated at high-power transmission lines are what is behind many so-called UFOs was presented by Philip J. Klass in Aviation Week, Aug. 22, p. 48. He attributes the increasing number of reported sightings in recent years to a combination of many more high-voltage lines and more pollutants in the air that could induce breakdowns.

Drs. Martin Uman and J. L. Moruzzi of the Westinghouse Research Labs. who have been making a study of the ball lightning phenomena, are producing the gratings in a home workshop. The public may buy them for $1 each by writing to their makers at 579 Lucia Road, Pittsburgh, Pa. 15221.

Comsat will purchase satellite earth station

The Communications Satellite Corp. (Comsat) has agreed to buy from the American Telephone and Telegraph Co. (AT&T) the satellite earth station at Andover, Me. Under the agreement, which requires Federal Communications Commission approval, Comsat will pay AT&T some $5 million.

Comsat presently leases the station from AT&T to transmit and receive signals to and from its Early Bird satellite for telephone, television and data communications.

The Andover station includes a giant horn antenna, 177 feet long and 94 feet high, and its associated equipment. A microwave transmitter and 2-kW TWT beam signals to Early Bird, launched in April, 1965. Signals from the satellite are picked up at power levels as low as 1 pW and are amplified by means of a ruby crystal maser.

Philco consumer articles may bear Ford's name

The Ford Motor Co.'s name may soon appear on the countless commercial and industrial electronic products manufactured by its subsidiary, the Philco Corp.

Authoritative sources say that the move is likely to be announced next month by Henry Ford II in person when he visits Philco's advanced research and development facilities at Blue Bell, Pa.

Philco has sought for some time to use Ford's name to help strengthen its position in a highly competitive field. Ford is engaged in a campaign to associate its image with other than automotive products.

Both companies, however, are at present reserving comment on the report of this latest move.

High-speed computers to employ MOS arrays

The "world's fastest computer" is the aim of a classified military project now underway. The completely parallel machine would use 50,000 MOS integrated circuit arrays. The limited speed of present MOS devices would be compensated for by the parallel machine organization.

In the late '50s a similar program, called Project Lightning, involved IBM, RCA and Remington Rand. Three techniques (cryogenics, tunnel diodes and thin films) were explored with tunnel diodes eventually winning the nod. But there turned out to be major problems in building big TD machines. Now the MOS seems to be taking over the top spot for the "fastest computer" role.

One obvious application for such large-scale, rapid computing would be the discrimination problem in anti-missile defense. Telling decoys from the real thing would have to be done PDG.

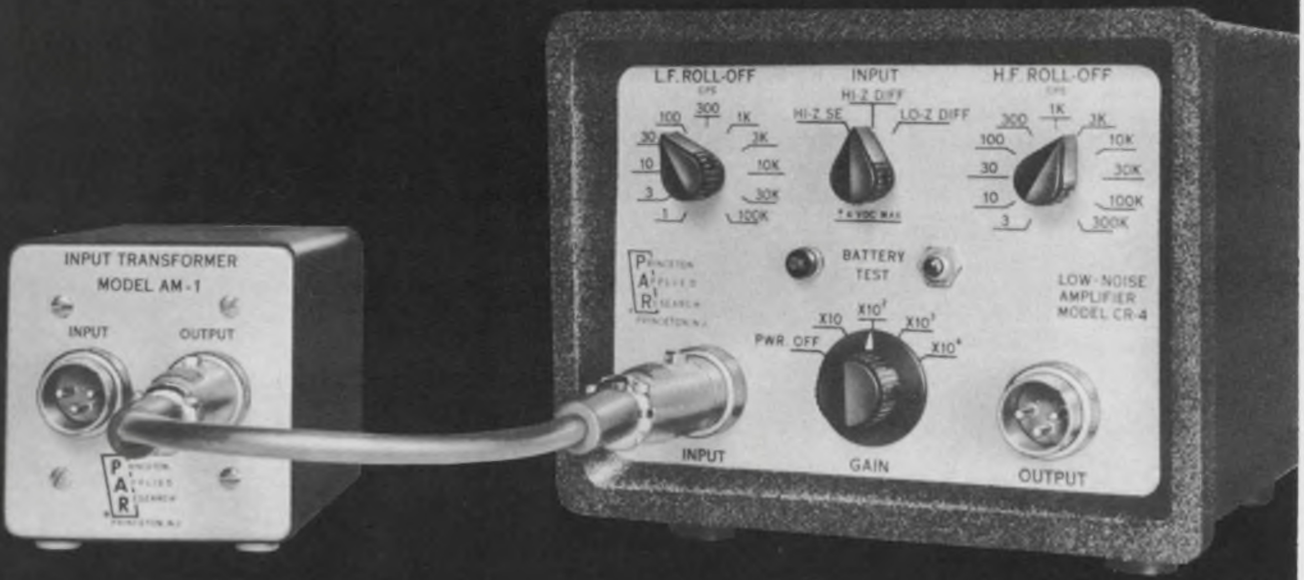
Wescon engineers tap Nixon for President

Lyndon Johnson was trounced as a candidate for election to the Presidency in a public opinion poll among engineers visiting Wescon in Los Angeles last month.

The poll, conducted by Motorola-Cubic Corp., gave Richard Nixon an edge over George Romney as the most popular occupant of the White House.

Asked if a Presidential election were held tomorrow whom would they vote for, the engineers gave 1864 votes to Nixon, 1730 to Romney, 932 to Robert Kennedy and 817 to Johnson.

Ballots were divided 4450 in favor of bombing the area round Hanoi in North Vietnam and 651 against. A total of 3461 engineers voted against a national firearms control bill; 1810 were for it.

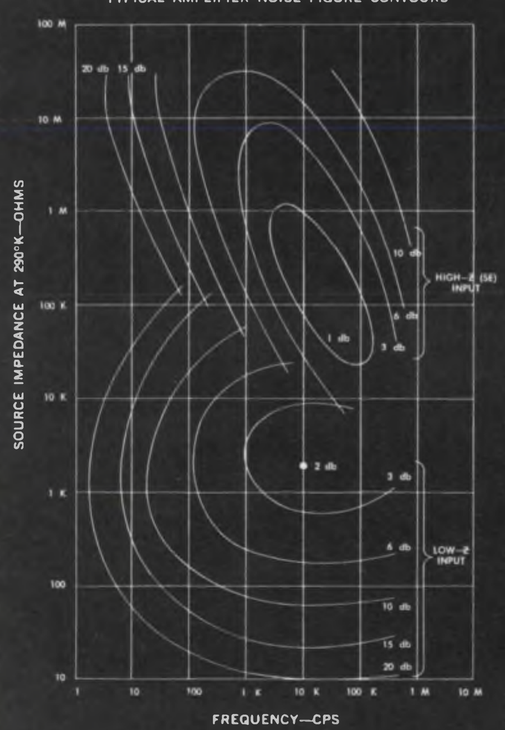


Low-Noise High-Gain Amplifier

The PAR Model CR-4 Low-Noise High-Gain Amplifier is designed for extremely small signal pre-amplifier applications and for use with PAR Lock-In Amplifiers to extend their low-level signal recovery capabilities. The unit features:

- differential or single-ended input
- selectable high (50M) or low (50K) input impedance
- 20 to 80 DB gain
- selectable bandpass 1 CPS to 300 KC
- long-life Hg or rechargeable NiCd battery pack
- completely transistorized
- easily panel mounted
- rugged printed circuit construction
- 6½" wide, 5" high, 8¾" deep
- price without batteries $575.00
- also available: several optional features such as impedance matching input transformer and fast-recovery Model CR-4A with selectable bandpass from 10 CPS to 300 KC

TYPICAL AMPLIFIER NOISE FIGURE CONTOURS



NOISE FIGURE CONTOURS

Experiments in general are performed at some definite source impedance level and over some definite frequency bandwidth. Noise referred to shorted input as frequently specified does not provide meaningful information for actual experimental applications. It is instead essential to know the noise characteristics of an amplifier not only at the particular operating frequencies but also with the particular source impedances actually encountered. Noise figure contours are the loci of points of constant noise figure (F) plotted as a function of source impedance and operating frequency, and, therefore, provide this complete information. They indicate the degradation in signal-to-noise ratio obtained with the pre-amplifier at a particular frequency with a particular source impedance, input noise being the Johnson noise generated by that source impedance at 290 degrees Kelvin. The contours are obtained from the following equation:

$$F = 20 \log_{10} \frac{\text{total measured amplifier noise (including Johnson noise)}}{\text{calculated Johnson noise}} \text{ DB}$$

Write for Bulletin No. 117

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ON READER-SERVICE CARD CIRCLE 11

Better isolation boosts IC performance

Introduction of ceramic and refinement of dielectric improve microelectronic capability and reliability.

Mark B. Leeds
Technical Editor

The day may not be far off when integrated-circuit performance will be on a par with that of discrete semiconductor circuits. This goal is being made feasible by innovations in IC isolation techniques.

Major manufacturers are reporting advances. Among the developments are these:

- Texas Instruments is isolating active integrated-circuit components with ceramic. The company has produced and sold some of the ICs for evaluation.
- The entire integrated-circuit line of Radiation, Inc., and "at least 95%" of the ICs made by United Aircraft's Norden Div. are employing polycrystalline silicon dielectric isolation. In both cases the companies have abandoned the standard p-n junction type of isolation. A Norden spokesman says that the company expects its isolation to enable it to develop a 40-watt linear amplifier on a monolithic chip.
- Westinghouse reports that it has overcome a key problem of dielectric isolation by using a layer of silicon carbide.

The improved integrated circuits that are emerging offer:

- Voltage-handling capabilities suitable for operation in direct-line applications and higher.
- Fast switching speeds in the same region as those now prevailing in discrete logic circuits.
- Radiation-resistance levels as high as those possessed by conventional semiconductors.
- Higher degrees of over-all circuit reliability.

These advantages will be exploited not only in military, space and nuclear programs but also in advanced, high-speed computer systems, line-driven industrial processing and control complexes, and consumer entertainment equipment. Some of the new isolation methods have already been employed in ICs for military programs.

The major drawback of the new isolators, however, is their present relatively high cost. The new ICs in which they are employed cost from 20% to 50% more than standard integrated circuits. For this reason, most manufacturers warn, widespread use of p-n isolation is likely to continue for some time. Furthermore, the innovations are still being evaluated individually; no comparative study has even begun on ceramic vs improved polycrystalline silicon dielectric isolation.

Junction isolation has limitations

Present p-n junction isolation—in essence a back-biased diode that separates the chip's active components—is inexpensive and compatible with manufacturing processes. But it, too, has limitations—for example, voltage limits typically do not go above 80 V; radiation immunity is considerably lower than that in discrete components; and operating frequencies and switching speeds are limited by such parasitics as capacitances (see table).

A minor battle may be in the making between the proponents of ceramic and dielectric isolation. Besides Texas Instruments, RCA[1] and Motorola[2] are also doing work on ceramic ICs but have not yet marketed any of the circuits. And among the companies backing dielectric isolation, Fairchild—in addition to Radiation, Norden and Westinghouse—is pursuing its own method of building extra-high-performance logic ICs.

Texas Instruments reports that its ceramic-isolation technique is less costly than standard dielectric isolation and offers high yields and improved capabilities (see table).

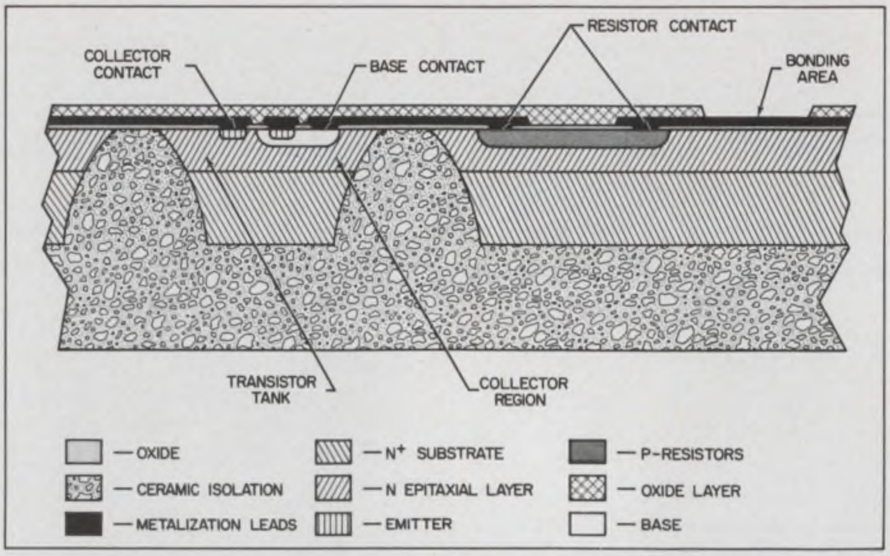
The saving in costs is ascribed to the use of inexpensive starting materials and the elimination of the critical, expensive and lengthy p-n junction diffusion process.

The insulating properties of ceramic are both electrically and mechanically superior to those of conventional isolators. The better semiconductor surface that ceramic thus affords makes possible higher device yields per slice than are obtainable with conventional isolation

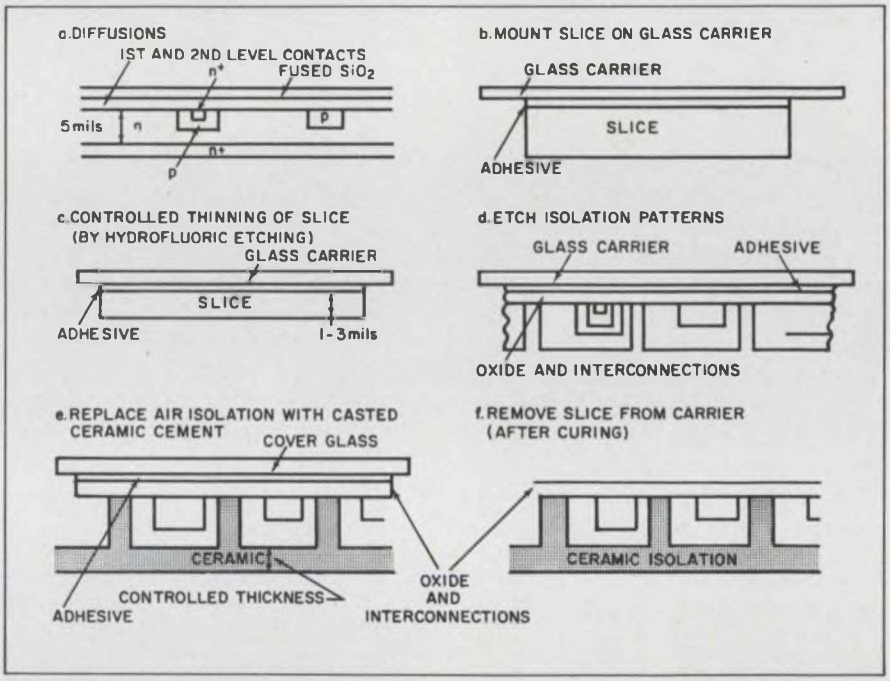
Table. Ceramic and junction isolation contrasted.

Consideration	With Junction Isolation	With Ceramic Isolation
1. Junction capacitance (collector to substrate)	2 pF	0.1 pF
2. Breakdown voltage (collector to substrate)	80 V	$\geqq$200 V
3. Gain-bandwidth product	(100)(100 MHz)	(200)(200) MHz)
4. Speed-power product	50 mW-ns	20 mW-ns
5. Radiation resistance Neutron type Transient gamma type	 10^{12} neutrons/cm^2 10^8 rads/s	1-2 orders of magnitude higher for both.
6. Latch-up type destruction	hazard	immunity
7. Leakage (collector to substrate)	1-500 nA	a few pA; usually unmeasurable

(**new isolation,** *continued*)



1. **Cross section** of integrated circuit using ceramic isolation shows how ceramic layer separates the active elements. The isolation yields electrical properties superior to those realizable with p-n junction-type isolation.



2. **Ceramic isolation process** is accomplished in six major steps, many of which resemble the processing techniques of conventional, junction-isolated ICs. The result shows how the ceramic cement completely surrounds the sides and bottom of each active area (also see Fig. 1). Hydrofluoric etching is used to control the thickness of the thinned-down slice. Air pockets between active regions are filled in with the ceramic slurry.

processes. As much as 75% of the area of a ceramic slice may contain usable devices, in fact.

Because of leakage, breakdown, chemical resistance and similar factors, the conventional isolating diode junction limits the over-all reliability of standard ICs. But in the ceramic-isolated chip, as in discrete designs, no special safeguards have to be taken with the diode junction, and the reliability of the circuit (Fig. 1) is consequently higher. The ceramic-isolated IC also resembles discrete designs, in that there are no parasitic capacitances across back-biased junctions.

True complementary transistor units can be placed on the same ceramic chip. With conventional monolithic ICs, on the other hand, the pnp devices are comparatively low-grade transistors, which are not the complete counterparts of the npns.

Dynamic performance is higher

Dynamic performance is also higher with ceramic ICs. Texas Instruments reports that application of a standard loop test has shown that the circuits are dynamically equivalent to discrete designs and approximately 30% better than junction-isolated ICs. Propagation delays of 1.6 ns have been noted—compared with the 6 to 10 ns typical of conventional ICs of this type (ECL logic circuits).

Life, shock and thermal tests conducted by Texas Instruments on the ceramic ICs have demonstrated that "these units are as reliable or better than standard ICs," says Richard Abraham, manager of the company's Integrated Circuit Engineering facility in Dallas, Tex.

"TI, like many other firms," Abraham reports, "has investigated standard dielectric-isolation methods to supplement the junction-isolated integrated circuit lines. We now lean toward the use of ceramic here as superior to conventional dielectric techniques. Our intent is to market a line of premium-performance ICs, not to replace our existing junction-isolation IC products."

This supplemental role for ceramic ICs in new applications has been seconded by Motorola and RCA.

Motorola's director of applied science, Dr. Arnold Lesk, considers "the degree of isolation associated with ceramic to be almost perfect." He adds: "These near-ideal semiconductor surfaces will enable us to build very high-frequency linear integrated circuits, just to cite one area for new applications."

Motorola's Semiconductor Products Div., in Phoenix, Ariz., has not yet begun to produce ceramic-isolated units in quantity. Lesk explains that this is because "we are not completely satisfied with the processing procedures, although we have no complaint with the concept itself."

"One of the processing problems is along compatibility lines—namely, that special diffusions are needed by the glass-like material," Lesk reports. "A second difficulty relates to the thermal conductivity; ceramic matrices have a higher thermal resistance than silicon units, thus get-

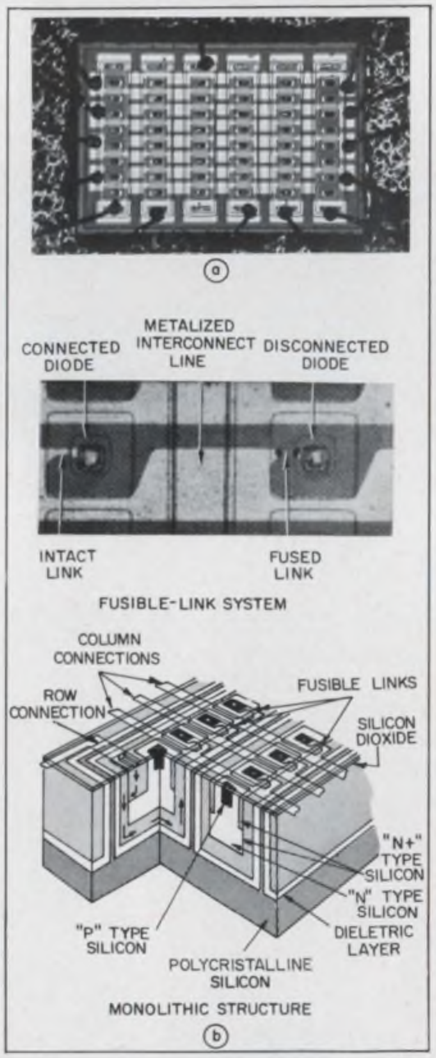
ON READER-SERVICE CARD CIRCLE 12

(**new isolation,** *continued*)

ting rid of excess heat may be a problem."

Lesk says that "neither of these problems is insurmountable, however, although they are holding up our formal introduction of ceramic-isolated chips."

Significantly, Texas Instruments has no qualms about the diffusion cycle or the thermal properties. It avoids any special diffusions by completing the diffusion steps before the ceramic is added. Tight control of the thickness of the ceramic layer also circumvents the problem of heat removal. Abraham points out that "the package itself is often more critical in terms of heat dissipation than the thermal properties of the chip materials."



3. **Monolithic diode matrix** (a) is made by a dielectric-isolation process. This 6 x 8 array is suited for applications in coding, decoding and addressing-type networks. Each diode in a column (b) is connected to the line by a fusible link.

RCA, like Texas Instruments, is not troubled by the heat-removal problem. According to Arthur I. Stoller, research engineer at RCA Laboratories in Princeton, N.J., "we take the heat away from the top surface of the chip, instead of the usual practice of removing it from the back." But as with Motorola, RCA still looks on the processing with some concern, and this has delayed market introduction of the chips.

New ICs for communications

Stoller, however, expects "to see off-the-shelf ceramic-isolated circuits for communications applications within a year or so." He continues: "These will be in areas where both the higher frequency and voltage properties are needed. The ceramic method will do this, and most of the resulting ICs will be of the linear and analog variety. Moreover these will be new integrated product lines, rather than replacements for a significant number of our standard ICs."

Abraham anticipates that military applications will be the practical testing ground for ceramic ICs. He said: "We have sent over 1000 ceramic units to a military customer [whom he declined to identify] that has tested and used them with success." A classified program was involved and high radiation-resistance was a governing IC specification.

Abraham also expects "ceramic units for industrial IC applications to be made available on an off-the-shelf basis in 6 to 18 months."

Part of the delay is attributed to the processing of the ceramic ICs. More careful handling than with conventional ICs is called for. But "once the ceramic is applied, the circuit becomes exceptionally durable, well beyond the level of junction-isolated units," claim Dr. Thomas H. Ramsey and Timothy Smith, engineers in Texas Instruments' Integrated Circuits Dept.

The physical structure (see Fig. 1) and the manufacturing-cycle chart (Fig. 2) show how the active, isolated regions are separated by the ceramic. The lead and contact system is covered by a thick layer of SiO_2. This helps to hold the air-isolated components together before the ceramic is applied. The ceramic completely surrounds the bottom and sides of each active region rather like a cement-lined moat. Texas Instruments' manufacturing process is "completely compatible with standard IC production procedures," Ramsey (developer of the ceramic IC) notes.

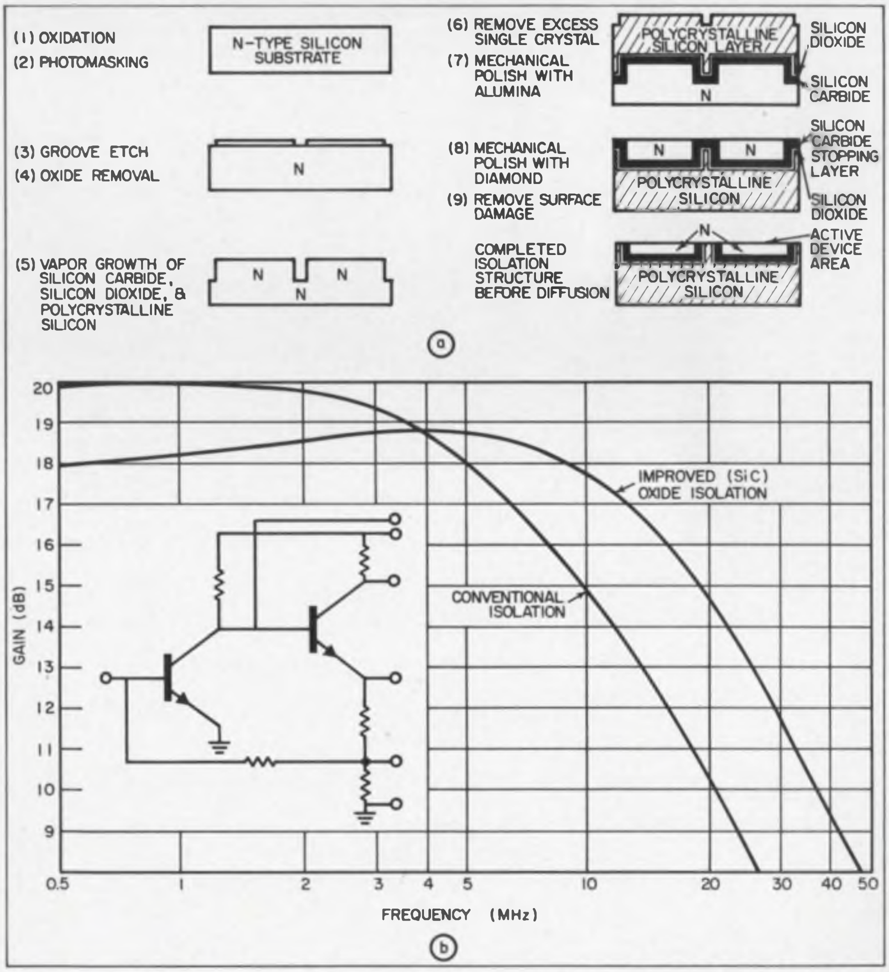
The starting material used for most ceramic-isolated IC devices has been single-layer expitaxial n on n+. Standard diffusions (base, emitter, buried resistors, etc.) are then made. Typically, these diffusions are shallow. This fact, coupled with the high isolation of the ceramic, is largely responsible for the final, high-speed characteristic (Fig. 3a). Figures 3b-3d shows how the slice is prepared for the ceramic.

A ceramic isolation medium in the form of a slurry is applied as a thin layer (Fig. 3e). This cement has high thermal conductivity, high breakdown voltage, and high resistance to chemicals and to mechanical and thermal shock. The ceramic medium is then cured to provide the necessary final rigidity (Fig. 3f).

Dielectric as alternative to p-n

Off-the-shelf IC products employing dielectric isolation are a growing reality, whereas ceramic isolation is still largely in the experimental stage; an in-depth comparison of the two has therefore not yet been made. What can be stated with certainty, however, is that both isolation types have better electrical properties than p-n junction isolation. These properties include radiation hardening, higher breakdown voltage and lower capacitances. Moreover, dielectric isolation is already considered superior to junction isolation in certain specific applications[3]. It is, however, costlier and relatively more critical in terms of manufacturing requirements.

Radiation, Inc., of Melbourne, Fla., which is using the dielectric technique exclusively, reports that it is suitable for "linear and digital circuits and diode arrays, for both military and industrial IC use."



4. **Silicon carbide** is used in a dielectric type of isolation for integrated circuits. This innovation (a) serves as a shield during the critical removal of excess crystal material from the functional side of the wafer. To a linear IC, SiC oxide isolation brings a higher gain-bandwidth product (b).

(**new isolation,** *continued*)

Warren Vergason of the company's Marketing Services Dept. cites monolithic diode matrics (Fig. 3), a high-gain amplifier, a broadband operational amplifier and three complete DTL logic series as representative of Radiation products that employ the new isolation technique. Vergason says: "In addition to the extremely low parasitic capacitances and radiation hardening, our circuits also feature unconditionally stable amplification."

40-W linear amplifier forecast

The Norden Div., of United Aircraft, Norwalk, Conn., another company heavily committed to dielectric isolation, began the conversion from p-n junction isolation about a year ago.

According to Herschel Hochman, chief of Solid-State Research and Development, "at least 95% of our off-the-shelf monolithic integrated-circuit chips are now made with the dielectric isolation process."

Of a 40-watt linear amplifier that Norden is developing, Hochman says: "We hope to market this amplifier and an integrated, 10-ampere power-switching circuit in a year or thereabouts.

"Without detracting from the improved radiation hardening that accrues with the dielectric technique, we are at least equally interested in the high breakdown voltages and lower parasitics that also result. We feel these are the keys to a new generation of high-performance linear ICs."

Meanwhile dielectric-isolation production headaches are receiving treatment. Westinghouse's Molecular Electronics Div., Elkridge, Md., is using a layer of silicon carbide (SiC) to solve the problem of excess single-crystal material. The layer is vapor-grown on the n-type silicon; silicon dioxide is grown on top of that; and all three layers are then covered with polycrystalline silicon (see Fig. 4). The SiC provides a shield or stopping layer during the etching and lapping of the slice to permit selective removal of excess single-crystal material from the functional side of the silicon wafer. The stopping layer can also be used as a heavily doped semiconductor region to improve the high-frequency characteristics of the circuit.

A pilot line of SiC dielectric-isolated ICs has been developed. It is being applied in high-speed digital circuits, high-frequency linear circuits and for military ICs requiring radiation hardening.

T. V. Sikina, an engineer in the Thin-Film and Surface Development Dept. at Westinghouse, believes that this isolation technique will make its presence felt in complex subsystems and systems. Predicting that "large-scale digital arrays, with greater numbers of digital junctions, will become common in monolithics," Sikina points out that "because of the superior isolation, there will be less cross-talk and far fewer unwanted interactions between logic circuits."

He continues: "The initial costs will be higher here, largely because of the processing complexities and the fact that the new technique is more suitable now for special designs and custom circuit functions." But, he adds, "in the long run dielectric-isolation forms may well become cheaper than the junction isolation that is prevalent today."

Radiation resistance a plus

A different form of dielectric isolation is being used by Fairchild Semiconductor, Mountain View, Calif. Fairchild has developed and produced a DTL line of custom ICs in which radiation resistance is a critical factor.

As reported by Dr. Gordon Moore, director of R&D at Fairchild, "these were specially manufactured for a military user, but both the technique's details and the identity of the customer are proprietary." Dr. Moore goes on: "We are also considering this isolation means for some new linear circuits and a basic line of ICs containing high-voltage transistors." ■ ■

References:

1. "Ceramic insulation isolates IC elements," ELECTRONIC DESIGN, XIV, No. 5 (March 1, 1966), p. 13.

2. Present work is based on experience gained during development of Motorola's EPIC isolation process. "Isolation advances may end parasitic plague," ELECTRONIC DESIGN, XII, No. 13 (June 22, 1964), pp. 80-81.

3. "Oxide barrier boosts dual-transistor performance," ELECTRONIC DESIGN, XIII, No. 21 (Oct. 11, 1965), pp. 76-77.

NASA looks to Orbiter 2 for real close-ups

Faulty camera degrades recent Lunar Orbiter mission, but useful data still obtained.

Ralph Dobriner
West Coast Editor

Despite assertions by NASA that the Lunar Orbiter mission was 75% successful, one of the spacecraft's primary objectives—to take high-resolution photographs of possible future Surveyor and Apollo landing sites—was apparently not accomplished.

Engineers are now looking to Lunar Orbiter 2, slated for launching in November, to provide the detailed close-ups.

Scientists had not only planned to obtain photos of features on the lunar surface as small as one yard across but had also hoped to obtain stereographic close-ups of the landed Surveyor I spacecraft. Instead, a malfunction in Orbiter's high-resolution camera system resulted in transmission of unusably smeared and blurred photos of the sites.

Close-ups essential to Apollo

Leon Kosofsky, NASA program engineer, said that the one-yard resolution objective was not an official goal. "The primary objective of the Orbiter mission was to get topographic information useful to the Apollo program," he said.

A spokesman for Boeing Co., Seattle, Wash., prime contractor for the Lunar Orbiter spacecraft, said that high-resolution close-ups of the landing areas were absolutely necessary before an Apollo lunar landing would be attempted.

Engineers at Eastman Kodak Co., Rochester, N. Y., builders of the camera system, are trying to pin down the cause of the camera malfunction. They hope to redesign the camera in time to meet the November launch schedule for Orbiter 2.

Despite its camera problems, Orbiter is said to have provided astronomers with more revealing information about the Moon than had been gathered from Earth in the last half century. So far, Lunar Orbiter has:

- Transmitted back to Earth numerous high-quality, medium-resolution photos showing terrain features as small as 8 meters across.
- Photographed the back side of the Moon—essentially a carbon copy of the front side.
- Provided scientists with their first look at Earth from a distance of about 240,000 miles.
- Revealed that the Moon apparently bulges by one-fourth of a mile at its north pole while it is depressed by one-fourth of a mile at the south pole.

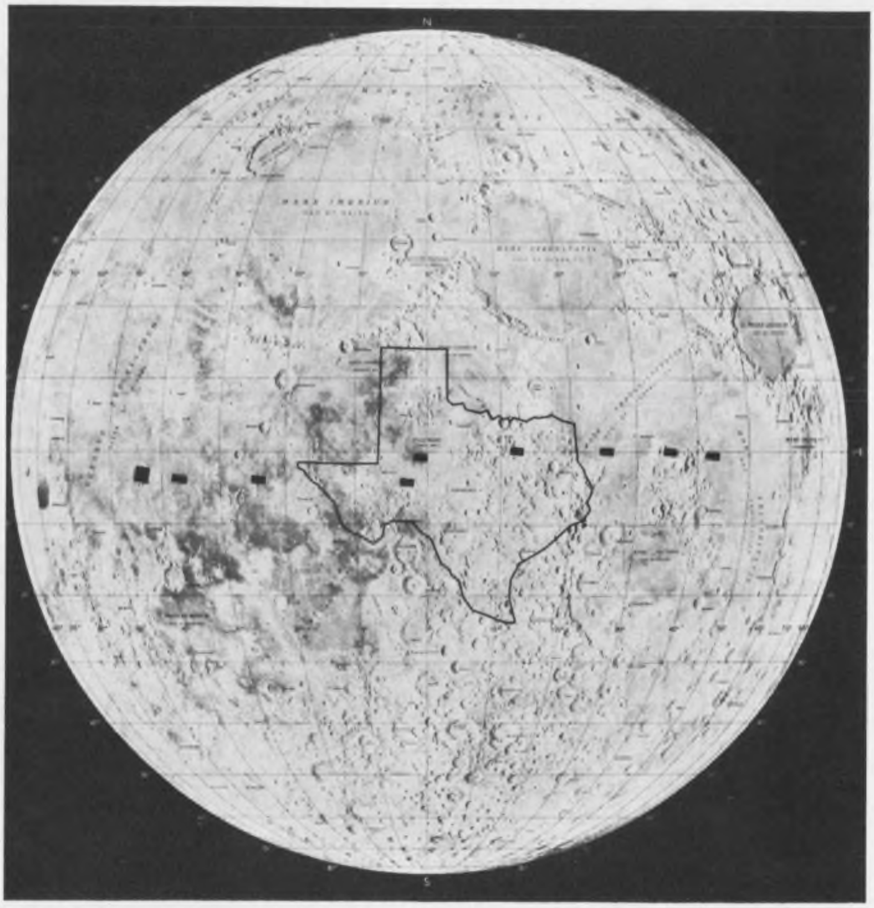
The spacecraft is also continuing to send back useful information on the lunar gravitational field, radiation levels and the presence of micrometeorites.

With the launching of Lunar Orbiter A earlier last month, the U.S. entered the final phase of a four-year unmanned program to scout the Moon's surface and environment prior to the first manned Apollo landings.

Ranger and Surveyor came first

Rangers VII, VIII and IX provided the first close-range views of the lunar surface and clues to its character. The Ranger spacecraft were guided to a selected area on the Moon's surface. The multiple television camera payload was activated minutes prior to impact and signals were relayed back to Earth showing the impact area in detail.

The remarkably successful Sur-



Targets photographed by Lunar Orbiter are the nine dark areas on the Moon shown above. The spacecraft can photograph an area of the Moon roughly equal to a continuous strip one mile wide extending from Seattle to Cape Kennedy and with enough clarity to show objects as small as a card table. The outline of Texas matches the Moon's scale and shows relative size.

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(**orbiter,** *continued*)

veyor I spacecraft made a soft landing at a predetermined area on the Moon earlier this year. During landing, television cameras scanned the landscape and sent back to Earth 11,237 close-up pictures of the Moon's surface.

Lunar Orbiter, after completing a series of tricky maneuvers in space, was placed in an elliptical orbit around the Moon. At its closest approach (perilune), within 25 miles above the lunar surface, Orbiter began photographing the nine potential landing sites with its dual-lens camera system.

V/H sensor causes photo blurs

The cause of the high-resolution camera's failure to send back clear pictures has been tentatively ascribed to the V/H (velocity over height) sensor, an image compensation device designed to prevent blurring of the image at the spacecraft's high orbital speed (about 4500 mph) and the relatively low film exposure rate. NASA scientists believe that the sensor is sending some spurious impulse to the high-resolution camera, causing the shutter to click at an improper sequence in the camera cycle.

The Lunar Orbiter's mission is commanded and controlled from the Jet Propulsion Laboratory, Pasadena, Calif., and NASA's Langley Research Center, Hampton, Va.

Here's how it works

As shown in the illustration, the 850-pound spacecraft is about 5-1/2 feet high and 5 feet in diameter, excluding the solar panels and antennas. The span across the deployed antenna booms is about 18-1/2 feet.

Lunar Orbiter carries a conventional solar panel-storage battery type of power system with provisions for voltage regulation and charge control.

The primary source of power is an array of four solar panels, each slightly more than 13 ft^2 in area. There are 10,856 n-on-p silicon solar cells on the spacecraft panels, 2714 per panel.

In full sunlight the panels produce about 375 watts. While the Lunar Orbiter is in shadow, the energy produced is stored in a 20-cell nickel cadmium battery rated at 12 Ah. The battery consists of two identical 10-cell modules.

Early in the mission a shorted transistor in the solar array caused some concern; however, the array was found to produce more than enough power for the mission requirements and the short posed no problem.

Tracker problem overcome

The star Canopus and the sun are the primary references for spacecraft attitude orientation. When these references are occulted and during maneuvering, a strap-down gyro system is used.

During the mission, the Canopus tracker had some difficulty in locking on to the star. This was attributed to light reflected from some unknown source falling across the Canopus sensor's field of view.

Proper locking was achieved, however, when the spacecraft was on the dark side of the Moon and the problem was overcome by simply switching to the inertial system when Orbiter was in sunlight.

The "brain" of the spacecraft is a programer which accepts inputs from Earth via the command system. The programer is essentially a digital data-processing system controlling about 65 functions within the spacecraft.

Dual lens system used

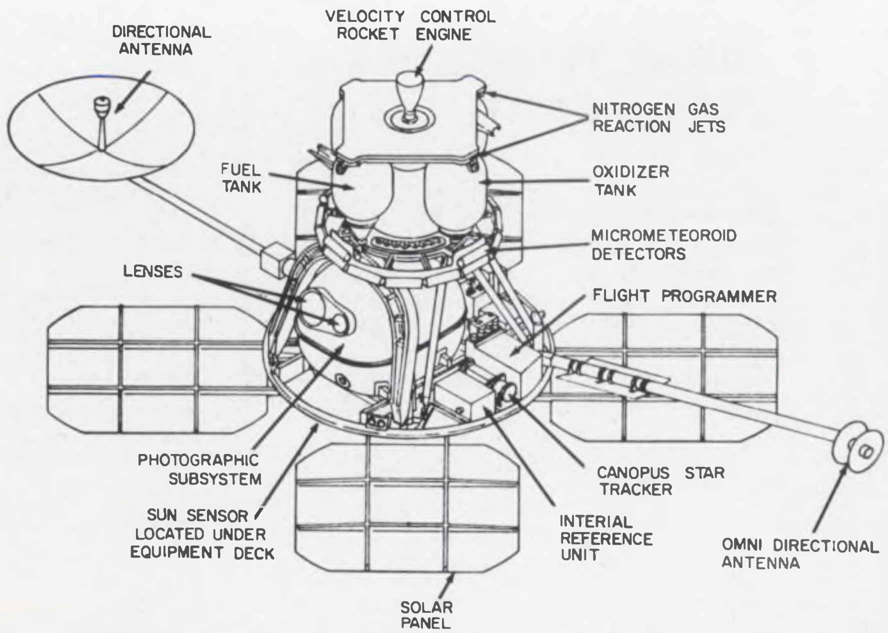
To achieve the extremely high-resolution photos required, the Lunar Orbiter uses a film-exposing camera system instead of a television system like that used on the Ranger and Surveyor flights.

The Orbiter camera system employs two lenses which take simultaneous pictures on a 200-ft roll of 70-mm-wide aerial film. One of the lenses has a 24-in. focal length and can take pictures of 12,000 km^2 of lunar surface from an altitude of 46 km with a resolution of about 1 meter. The other lens, which has a focal length of about 3 inches, will take pictures of 200,000 km^2 with a resolution of about 8 meters.

A NASA spokesman estimated that about one million standard commercial TV pictures would be required to photograph that area with comparable resolution.

The film is developed on board the spacecraft by a method that presses the film into contact with a web that contains a single-solution processing chemical. After the film has been dried, it is ready for read-out and transmission to Earth.

The film-scanning read-out process is accomplished in small increments by a very narrow light beam projected through the film negative on to a photomultiplier tube. The resulting electrical signal is conditioned and mixed with synchronous and blanking pulses and fed to the communication system modulator for transmission back to Earth. ■ ■



Lunar Orbiter, an unmanned lunar reconnaissance satellite built by Boeing Co., is designed to take high-resolution close-up photographs of large areas of the Moon's surface.

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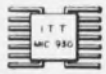

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MIC945	R-S or J-K Flip-Flop
MIC946	Quad 2-input Gate
MIC948	R-S or J-K Flip-Flop
MIC949	Fast Quad 2-input Gate
MIC950	Pulse-triggered Binary

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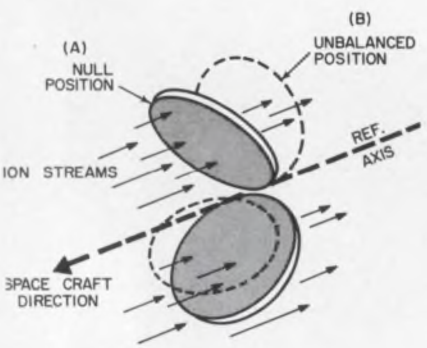
Ions help determine spacecraft's attitude

An unusual control system that senses attitude by collecting ions proved so successful in initial tests on Gemini 10 that it will be used again on Gemini 12 in November.

The system, developed and built at the Air Force Cambridge Research Laboratories, Bedford, Mass., was not a part of the primary Gemini control system. But future versions, competitive with present gyro-stabilized attitude systems, are expected to be particularly useful in spacecraft docking maneuvers.

The new attitude sensor system collects ions rammed at high velocity into collector plates. More than 20 million charged particles per cubic inch are found at altitudes of about 160 nautical miles above the earth, where Gemini 10 was in orbit in July.



Two collector disks mounted 90° apart form the ion-attitude sensor. When the angles between the disks and the reference axis are equal (A)—that is, without pitch or yaw—the output currents are nulled. When spacecraft pitches or yaws (dotted outlines, B), unequal currents are produced proportional to the angular deviation.

Sensor assemblies on two booms extend out three feet from the craft to intercept the particle streams, which act as the attitude reference.

The sensors use the positive ions because the spacecraft speeds along at more than eight times the random velocity of these charged particles. The spacecraft, in fact, moves through the ions much as an auto moves through rain. Electrons, because of their relative speed (25 times greater than that of the spacecraft), move too fast to be used as the attitude reference.

With a spacecraft ion-stream reference axis established, attitude can be determined by measuring variations of the spacecraft from the axis. As charged particles impinge on collector disks, currents are produced. Disks placed normal to the particle stream produce maximum currents and disks with their planes in the spacecraft's direction of motion in the particle stream produce minimum current. Current from the disks at intermediate positions between maximum and minimum changes sinusoidally.

The sensor assemblies that actually determine pitch and yaw make use of pairs of disks set 90 degrees apart. Two identical sensor assemblies are used: one for yaw determination and one for pitch. If the assembly is positioned so that each disk is 45 degrees from the pitch or yaw reference axis of the spacecraft, the flow of current from each disk is equal, and a null is achieved.

Since the current flow in each disk depends on the alignment of the assembly with respect to this reference axis, angular variations result in unequal currents from the disks. The differences between currents are a measure of the spacecraft's angle of pitch or yaw.

The project was under the direction at the Air Force Laboratories of Dr. Rita Sagalyn, a physicist specializing in upper-atmosphere studies.

In addition to the collector disks, each sensor includes grids to reject impinging electrons. The collector pairs and the electronics for the system are packaged in two protective cases, each the size of a shoe box. Subtraction and ratio circuits are mounted on five circuit boards within each case.

Electronic circuitry is also used to bias the system, reject electrons, enhance ion collection and reduce emittances from the grids and the collectors.

Each complete sensor assembly weighs seven pounds; the complete system weighs 14 pounds. Power consumption for the system is 16 watts, compared with 750 watts for a conventional gyro-stabilized attitude system.

The next step in the evolution of a prime attitude system, according to Dr. Sagalyn, is the inclusion of automatic pilot controls. Using the present experimental open-loop system, the astronauts must perform spacecraft attitude corrections manually.

Dr. Sagalyn believes that the system concept may be useful not only for attitude control of interplanetary spacecraft but even for supersonic transport aircraft. ■ ■

Navy to communicate on a 'Moonbeam'

A new communication system that uses the Moon as a relay for ship-to-shore messages has been delivered to the Navy. Called Moon Bounce by the Lockheed Electronics Co., which developed it, the system will beam teletype messages from ships at sea to the Moon. The signals will then be reflected back to Earth and received by shore-based stations.

The initial Moon Bounce equipment consists of a 16-foot-diameter dish antenna for mounting on the deck of a ship, and transmitting, receiving and control equipment for installation below deck. An analog computer gives tracking orders which keep the antenna aimed at the Moon whenever the system is in use. The tracking system is passive. It does not require return signals from the Moon to verify correct aiming.

The passive tracking is accomplished by programing the computer to include the Moon's position and direction of motion. The course and speed of the ship are fed automatically into the computer, which then computes antenna directional orders. ■ ■

Antenna for the Moon Bounce system is a 16-foot-diameter dish.

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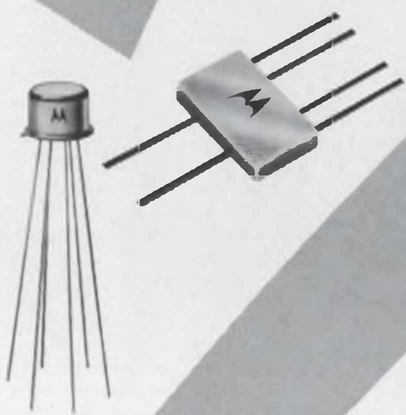

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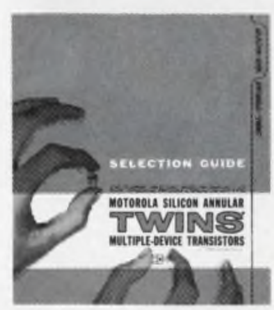

Your local Motorola semiconductor distributor or nearest district office can provide complete information (or units for prototyping). Or write: Motorola Semiconductor Products Inc., Dept. TIC, Box 955, Phoenix, Arizona 85001.

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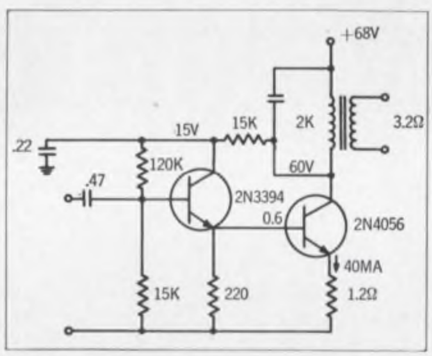

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V_{CEO} (I_C = 1.0ma) volts	300	250	200	150
V_{EBO} (I_E = 100μa) volts	7	7	7	7
I_C ma	100	100	100	200
P_T (70 C case temperature) watts*	4	4	4	4
h_{FE} (I_C = 50ma, V_{CE} = 10v)†	30	30	30	30
$V_{CE(SAT)}$ (I_E = 2.5ma) volts	2.5	2.5	2.5	2.5

* Derate 50 mw/°C increase in case temperature above 70 C.
† Pulsed conditions at 2% duty cycle 300 μsec pulse width.

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GENERAL ELECTRIC

New draft plan means more teaching aids

Washington Report

S. DAVID PURSGLOVE
WASHINGTON EDITOR

Draft regrading needs electronics

The Pentagon's plan to regrade as many as 100,000 draft rejects a year will entail the immediate purchase of considerable hardware and software, Defense Department officials indicate. These will supplement the electronic simulators, programed teaching techniques and audio-visual systems that were pioneered by the armed forces.

Officials add that since basic education rather than on-the-job training is involved, Defense Secretary Robert McNamara's plan will also require development of new systems and techniques that will be applicable later to civilian education. These aids, they point out with an eye to Congressional reaction, would have been needed eventually anyway. The plan to recategorize young men not accepted for service because they cannot meet the draft's educational requirements will merely accelerate development and procurement of such equipment.

DOD runs nation's largest school

The Defense Department is the nation's largest educator with some 400,000 military and civilian students attending class at any given time. The department's system of schools for dependents is the ninth largest system in the nation, employing 6800 teachers using advanced equipment to give lessons to 166,000 students in 327 schools. It is into this vast system that McNamara says he can integrate his program to teach the so-called unteachables. Through the use of advanced techniques, observers in Washington contend, he probably can.

Of the program's many aspects of importance to the electronic industry, two are paramount. One obviously is the boost that the Defense Department's influence, budget and ubiquitous presence will give to advanced teaching techniques. Thomas D. Morris, Assistant Secretary of Defense for Manpower, has made it clear that every form of "teaching machine" and programed device presently in existence or shortly to become available will be brought into play. The other major consideration is that the program will not be experimentation, it will be application. By using many techniques and devices still considered experimental, the department is likely to induce many school systems to buy them also.

McNamara's new plan has carefully circumvented the political pitfalls that beset his earlier STEP program. The Special Training Enlistment Program required Congressional approval because it involved setting up a special school system for a special category of volunteer. It failed to get it. The new proposal needs no Congressional approval. The Pentagon says it will simply stop rejecting so many undereducated men, will induct them into the service, and will teach them within the framework of the existing military school system. About 40,000 men will be enlisted between now and next June 30; thereafter some 100,000 men a year will be taken on.

Little Capitol Hill opposition is foreseen for McNamara's plan, but some observers anticipate some objection from Sargent Shriver's Office of Economic Opportunity and Harold Howe II's Office of Education.

This could be the reaction to a wave of popular enthusiasm for the Pentagon plan and demands that it take over running the Job Corps centers. Office spokesmen—and Howe himself—believe that many of the advanced techniques that are likely to be publicized are not yet ready for public school use.

Plan will need more than just teaching aids

Apart from the actual teaching devices, the Pentagon plan will also require other electronic equipment. Just test-scoring and record-keeping for such a huge, widely dispersed school will be a colossal task. A spokesman for Morris' office says an adaptation of the highly successful Air Force system is likely to handle this part of the program. At Maxwell A.F.B., Ala., an RCA Videoscan Optical Reader with an RCA 501/301 computer complex keeps track of more than 300,000 U.S.A.F. test papers a month.

Scheduling of special elementary education mixed with military training may be handled similarly to how the Air Force arranges flight training for personnel scattered all over the U.S. who have only a limited number of aircraft to use. The automated air-training scheduling system was developed at Vance A.F.B., Okla., last year with the aid of an IBM 1401. The program is currently undergoing an Air-Force-wide test and employs a network of Burroughs 263 computers installed at all undergraduate pilot training bases.

Actual teaching will depend heavily on closed-circuit TV, even to the point of administering many tests by TV, according to one Army official. The Army has been impressed by the multi-channel closed-circuit TV system that is being tried out at seven Army schools. Soon—probably by year's end—all Army schools are expected to have at least a TV playback capability by this system.

Pollution R & D need confirmed

The House Committee on Science and Astronautics has reported its findings on the requirements for the nation's ambitious air- and water-pollution control programs (see ED 18, Aug. 2, 1966, p. 29). At the end of the hearings, Emilio Q. Daddario, (D-Conn.), chairman of the Subcommittee on Science, Research and Development drew three conclusions: present technology is inadequate; new research and development must be undertaken; and many such programs should be turned over to industrial contractors.

Pollution abatement interests electronic firms, not only because it involves such traditional measures as electrostatic stack precipitators, but also because the growing amount of monitoring, reporting and evaluating equipment is largely electronic.

Daddario's conclusions were predictable for they re-echoed the findings of a blue-ribbon panel of scientists and industrialists called in by the subcommittee to help it plan its investigations. Both Daddario and the panel dwelled at length on the role of industry in research and development for pollution control. Both urged the Federal agencies to turn more work over to industry in the form of contracts and reverse their present preference for doing the work themselves or resorting to universities and nonprofit bodies.

Daddario laid particular emphasis on the need to find ways of reducing the cost of abatement. He noted that the cost of "catching up in pollution abatement" over the next decade or two would be on the order of $100 billion, let alone "several billion dollars each year" just to operate treatment plans and devices.

Police shy of needed electronics

The most heavily electronically equipped man in the U.S. is likely to be the cop on the beat, if the Federal agencies have their way. But he doesn't want to be. The consensus of police chiefs interviewed at a recent Washington meeting was summed up: "Keep your gadgets, just give us more men."

But Sen. Jocob Javits (R-N.Y.) and other members of Congress agree with the Justice Department and White House officials who say privately that most police departments would not be equipped to handle larger forces even if they had them. Congressmen have been urging increased funds to provide new communications and advanced data-processing equipment for police departments, even cascaded image intensifiers for better night vision, portable radars and similar aids. The Justice Department's Office of Law Enforcement Assistance has accelerated its program of grants for these very things. Even the Army, primarily through the Institute for Defense Analyses, is ready to offer police departments the results of its research and development work on counterinsurgency and "sublimited warfare" devices.

Despite the lack of police enthusiasm, word is being passed that industry should go ahead with development of "gadgets" and then be prepared to teach the police how to use them. It is even suggested that the present system of awarding grants only to cities, states and regional groups of police departments may be extended to include giving contracts directly to electronic firms to produce devices and train police in their use.

Meanwhile, Javits has introduced a bill to provide $10 million a year for the next three years for the Justice Department to hand to police departments specifically for the purchase of "computers and electronic systems."

New CO_2 laser delivers 500 watts

A 500-watt carbon dioxide laser, believed to be the highest cw output available commercially, has been announced by Raytheon Company's Laser Advanced Development Center, Waltham, Mass.

The new unit, known as model LG16, is capable of a minimum of 500 watts and Raytheon expects it to perform in the 750-watt-to-1-kilowatt output range. It is 44 feet long, and has an efficiency of approximately 15 per cent.

The dc-excited system has an output beam diameter of 1-3/4 inches and a beam divergence of less than 2 milliradians, with multimode output at 10.6 microns. The discharge tube is water-cooled from ordinary tap-water sources.

Output at 10.6 microns takes advantage of a favorable "window" for transmission of the beam. Atmosphere attenuation at this wavelength is low relative to other middle and far IR wavelengths.

The LG16 is a flowing gas system utilizing an N_2CO_2He mixture at 100 cubic feet per minute. ■ ■

At least 500 watts of cw power is delivered by Raytheon's CO_2 laser.

LETTERS

Power supply ratings are more useful in ac

Sir:

I have just had an opportunity to examine your April 19, 1966, issue of ELECTRONIC DESIGN [ED 9] designed as a guide for power supply selection. You have apparently contacted quite a number of power supply manufacturers and have done an excellent job in doing that.

There is one particular problem which I would like to bring to your attention, and perhaps in this way to all power supply manufacturers'. This is the problem of the use of the power supply. All ratings given for the use of a supply are based on dc. Yet, for the user, the dc is just a means to an end since, for information transfer, he has to use ac.

The simplest example would be a Class-A audio power amplifier. Let us say it required 30 V dc at 2 A dc. If you buy a power supply rated at 30 V and 2 A, you would be automatically in trouble since the peak demand at the crest of the ac wave is 4 A. For a simple supply, the gate tubes or transistors are now overloaded by a factor of 1.4 to 2, depending on wave shape. And for a complicated, current-limiting supply, the output wave shape would be horribly distorted and the power output cut by a factor of 2 to 4.

A more complicated example would be the use of a power supply for, say, a radar transmitter. If the dc requirements are 300 V dc at 10 mA dc, and the power supply is purchased to this specification, we find the actual peak current demand at 1000 times 10 mA—10 A.

The regulator of the power supply cannot supply this peak, so the current comes from the storage capacitor whose voltage drops much more than the "rated" ripple in a typical case. This sudden large drop in turn overloads the feedback amplifier whose dc operating point shifts. I have seen cases where this dc shift amounted to 30% of the no-load voltage for a supply rated and tested for less than 0.25% load regulation under the power supply manufacturers' "load regulation" test.

The user is thus generally left with the choice of testing a number of the manufacturer's designs to find one whose units by chance behave acceptably, or providing his own filtering, or both. None of these choices is good nor the net regulation anywhere near published data.

The no-load/full-load test used by the power supply manufacturers is highly unrealistic and does not give the user a true appraisal of the unit in the user's circuits. As a minimum, I would recommend testing under audio-load conditions at full modulation with rated dc voltages and current. Pulse test equipment should be available at the manufacturers' test stations for specialized tests by users using pulses.

William Kestenbaum
Sr. Research Section Head
Sperry Gyroscope Co.
Great Neck, N. Y.

A case of color blindness

Sir:

In your extremely interesting article, "Major advance in wafer-making forecast" [ED 15, June 21, 1966], you say on page 18:

"The organic photoresist used in processing semiconductors is (like panchromatic photographic emulsions) most sensitive to the blue-green and ultraviolet portion of the spectrum."

This is characteristic of "natural" photographic emulsions that do not incorporate any sensitizers. These emulsions are also called "color-blind." The incorporation of various dyes led to orthochromatic, panchromatic and finally to infrared-sensitive photographic emulsions, each representing a step in light wavelength from the short wave toward the longer wavelengths of the light spectrum.

Most panchromatic emulsions have a higher sensitivity to red than to blue and ultraviolet. Kodak photoresist is blue-sensitive and so are the other resists of this group, particularly Kodak Ortho-Resist, which will respond to most of the visible spectrum but not to red. This rules out the use of ruby lasers for the purpose discussed.

I therefore believe that you actually wanted to write nonpanchromatic.

Kaye Weedon
Gamledrammensvei 135
Blommenholm, Norway

Editor's reply:

Mr. Weedon's point is well taken. My principal statement was correct, but as he points out, the parenthetical simile should have read "nonpanchromatic or orthochromatic," not "panchromatic."

Roger Kenneth Field

Roadworthiness depends in part on design

Sir:

I would like to comment on a letter to the editor by D. M. Myers [ED 15, June 21, 1966, p. 64].

He apparently bases his argument that most accidents are caused by poor driving rather than unsafe automobiles on the premise that an automobile must have a mechanical failure in order to be faulty. I would like to introduce the idea that it is *not* necessary to have a mechanical failure in order to have a faulty automobile. Poor handling characteristics resulting from improperly designed or constructed braking, suspension, or steering systems can contribute to the accident rate even though there is no mechanical failure.

Unfortunately relatively few drivers have driven an automobile having good handling characteristics. These are the characteristics that enable a driver to maneuver his automobile quickly and accurately at speed and under adverse conditions. This is not to be confused with driving skill, but is merely a measure of the capability of the automobile.

All too often a smooth ride on the freeway in quiet, cool comfort is considered the ultimate in performance for an automobile. These are worthwhile objectives, but they should not receive higher priority than good handling characteristics.

I feel very strongly that in the design of an automobile more emphasis should be placed on a capability of avoiding an accident. The next step would be to improve

(continued on p. 36)

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(continued from p. 34)

one's chance of survival in the event of an unavoidable accident. These actions along with a vigorous compulsory driver training program should reduce the accident rate as well as the death rate.

H. Yates Holleman
Engineer
Systems Development Office
U.S. Department of Commerce
Washington, D. C.

Professionalism cannot be taught, only learned

Sir:

I am writing in reference to your editorial in ELECTRONIC DESIGN, July 5, 1966 [ED 16, p. 35]—"An Ill Wind Blows for the Baccalaureate." The question of when an electronic engineer, or for that matter any engineer, is a professional is one that has been of considerable interest to me in the past. I feel that many recent surveys have missed some very basic facts.

No university can educate a person to be a professional anything except to be a professional student. An engineer is a person who makes practical application of basic scientific principles. If a university is capable of instilling these basic scientific principles and exposes a few practical applications to the "engineer in training," it has done an excellent job. A BEE or BSEE is merely a certificate that indicates this exposure to a program with a certain set of minimum standards and that the student was tested satisfactorily for knowledge. It takes many years' experience in the practical application of this basic scientific knowledge before the holder of a degree can be considered a professional.

I have known quite a few men who received their BS and MS in engineering, spent a very short period of time in engineering practice before going into management, and have done quite well for themselves. None of these men considers himself, nor could anyone else consider him, a professional engineer; they are professional businessmen.

I cite this instance merely to point up the fact that a training program alone does not make a professional.

Paul D. Keser
Development Engineer
Speer Carbon Co.
Research & Development Labs.
Niagara Falls, N. Y.

Sir:

Your question, "When is an electronic engineer a professional?" has been often debated and never resolved.

One thing is certain—four, five, six or even seven years of college training do *not* make a professional! They certainly help—but much more is needed.

Professionalism requires a mature attitude, requires one to do his best in every job, to practice ethics in every contact, to participate *actively* in his professional society, and to continue his education by courses, seminars, technical meetings and published reports. This last is a must if we are to keep up with technology.

The original issue—whether a four- or five-year engineering curriculum—only defines the base. My feeling is in favor of a four-year base and then specialization, preferably by graduate training, but on-the-job training also has definite merit.

George F. Chadwick
Development Supervisor
Speer Carbon Co.
Research & Development Labs.
Niagara Falls, N. Y.

Sir:

You are entirely right in saying that contemplated actions would have far-reaching impact.

There is already great disagreement about what a "professional" is. In many states the designation is reserved for those who have passed a state licensing examination. The National Society of Professional Engineers, it seems, would like the term restricted to its paid members. But this is a minority organization, drawing most of its members from the few self-employed, not the mass of engineers in industry. The former are the only engineers whose conditions of work justify in any way the designation "professional," in the sense that it is commonly connected with physicians and attorneys.

If it becomes necessary to have a master's degree in order to enter the engineering profession, then obviously the master's degree will be debased until it is no more valuable than the bachelor's at present; the doctorate will fall to the position of the master's; and some kind of postdoctoral work will be necessary to achieve the distinction that now attends the PhD. Thus nothing will be gained; only the names will be changed, and an engineering education will become that much more expensive.

The writer would like to advance the suggestion that identifiably homogeneous work in industry be allowed to count toward an advanced degree. This would take truer account of experience and contributions than ignoring them does at present.

What is needed is more generalization—not in the academic sense of having taken one or two courses in every specialty, but in the sense of being able to come abreast of the current state of the technology in any field, as well as being able to pick up a soldering iron or a drafting pencil and implement ideas.

Make no mistake: It is no degradation or underutilization for an engineer to do laboratory work. Inherent in the definition of the engineer is that his work concerns the practical, and if he declines to work in the laboratory, as already seems often to be the case with holders of advanced degrees, he will never understand what "practical" means.

A hasty perusal of the help-wanted columns can easily lead to incorrect conclusions. Examination will show that in only a few employers of engineers do the holders of advanced degrees make up any more than a small minority. Often the splashiest advertisements are trying to fill a few specific positions, in which a PhD would lend luster to a specific program. When the same companies go out to hire just plain engineers, baccalaureates are welcome enough.

The writer believes it is improper to label as "professional" the college graduate who embarks on a professional career, no matter what his degree. Professionalism is

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(continued from p. 36)

gained only by experience. For that matter, it may be said that one does not come out of college an engineer; one merely has learned the language, so that, with experience, one can become an engineer.

Anthony H. Perles
Scientific Data Systems
Santa Monica, Calif.

Sir:

Reference your editorial: "An ill wind blows for the baccalaureate." An ill wind indeed! I am glad someone takes a stand for professionalism instead of scholastic status. In our ever increasing specialization and quest for engineering detail we sometimes neglect to pause and reflect where we have been and what we will do with our newly acquired achievements.

It is not a question of whether a master's degree would be useful. Many colleges teach specialized subjects in the undergraduate program and offer master's degree courses of a generalized nature. Most so-called engineering schools offer for a master's degree courses which were taken by seniors in first-rate colleges. Why drag the level of the bona fide engineering schools through the mud by requiring graduates of second-rate schools to acquire a master's degree, so that they may more effectively compete with a first-rate college graduate who has a bachelor's degree?

A baccalaureate should entitle a person to an engineering apprenticeship. Few practicing engineers use a significant percentage of their undergraduate work. Therefore the BS degree should provide a good foundation for future growth. A master's degree should be in the specialty most closely related to the particular engineering practice and then only if absolutely necessary.

Look at some of the degrees we now have—BE, BEE, BSEE and even the BS for physics or chemistry. One can graduate in anywhere from 24 to 60 months depending on college and course. Degrees by themselves do not seem to be the answer. An apprenticeship followed by a professional registration would more closely regulate professionalism and therefore quality. Degrees by themselves do not indicate ethical behavior or solidify moral obligations to both employers and the public. Competence is better indicated by the graduating college rather than by the degrees held.

I believe the answer lies in a four-year degree from an accredited institution followed by an apprenticeship similar to the preceptor philosophy followed in law practice. After successful completion of the above first two steps, a technical test can be given (verbal or written) and evaluated by a board. Upon passing, the candidate is given the title of engineer, and not before.

Improvements can be effected by increased professional registration, by legally defining the position and title of an engineer and by education of present and future professional candidates. Every state has a professional engineering program. This is a good place to begin to elevate the engineering profession while at the same time standardizing engineering undergraduate curricula.

D. Lawrence George
Southampton, Pa.

Sir:

In her editorial of 5 July, Maria Dekany ignores the real point of making the master's degree the minimum qualification for an engineer.

Firstly, the EE is hardly a professional when he receives his BS. He is not allowed to call himself one legally in most states—he must receive a PE license before he can call himself a professional engineer, or even an engineer frequently. The main object of the PE license is to cut down on the competition with established consulting engineers like me. Notice that engineers not in competition with the consultants are allowed to call themselves engineers, but would-be consultants are not.

The main point is one that I implied above—that most "engineers" are really pretty incompetent. As both a student and a professor, I know that from half to two-thirds of BS graduates couldn't design their way out of a paper bag. Most graduates haven't

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LETTERS

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the foggiest idea of the basics of physics and mathematics. Put it this way: How many of your classmates would you trust to design something that your life depended on?

Raising the ante to MS from BS serves the same function as the PE license—it separates out the gross incompetents, more or less. Actually it doesn't, but personnel men, who are unable to tell the difference between a good engineer and Bela Lugosi, jump on the MS as a convenient handle. It saves thinking. They are not alone in this. Try to convince the administration of a college on the make that there is no particular relationship between possession of a PhD and teaching ability. Or for that matter, between possession of a PhD and common sense.

As far as professional status with the public is concerned, why do physicians and lawyers have it and not engineers? Firstly, nobody can call himself a physician or lawyer without a license, but the driver of a garbage truck can call himself an engineer, and so can the janitor. Anybody can fix a TV set, but just you try splinting a finger of someone you find lying in the street or inventing a cure for cancer. Also, the engineering "profession" tries, unsuccessfully in general, to explain what it is doing. The medicos and lawyers surround themselves with vast quantities of ritualistic mumbo jumbo designed to keep the public out.

Engineering can become a profession in the sense of medicine or law by adopting the tactics used by them. Make what you are doing incomprehensible to the general public, restrict the competition, and never admit a mistake. Upgrading to the master's is a step in this direction. This is now voluntary; eventually it will become compulsory, and we will have no more Edisons. Carry it far enough, continue resurrecting the guild system, and we will have no more progress either.

Yale Jay Lubkin
Consultant Engr.
Lubkin Associates
Port Washington, N. Y.

Sir:

Maria Dekany's editorial on the need for advanced degrees struck a sensitive nerve in my own feelings on engineering as a profession. I agree with her general thesis that each industry and discipline answers the question by its hiring practices, albeit that some insist on hiring PhDs to be dissatisfied administrators. The single sentence that causes my demurrer is, "But would any engineer with an advanced degree deign to do down-to-earth hardware-oriented work?"

Miss Dekany seems to misidentify engineers with physical scientists, who might be more likely to prefer the ivory tower. A real engineer, no matter how highly educated, gets his greatest kicks from seeing his own designs in production. I don't mean to minimize the scientists' accomplishments, but many of their raw concepts gathered dust for a century, until an engineer developed the down-to-earth hardware that metamorphosed a pipe dream into a product.

Miss Dekany is far from alone. Too many "engineers," who would never rank Buonarroti or Breughel with house painters, avoid opportunities in hardware design because they don't want to be considered draftsmen. These men, whose academic and industrial experience has been all philosophy and no hardware, are deluding themselves when they title themselves engineer.

Leonard S. Horner
Project Engineer
Littleton, Colo.

Neo-Nazis' patriotism is questionable

Sir:

Paul Doerr, in a letter entitled "People who live in glass houses . . ." appearing in ED 15, June 21, 1966, [p. 50], took issue with an editorial that described a group of "neo-Nazi" hecklers on the sidewalk during a peace march. Doerr questions whether these people were "neo-Nazis" or just patriots.

Firstly, on the date in question, I was returning from a hospital visit at Mt. Sinai Hospital on New York's Fifth Avenue, when I witnessed the parade—and the brown-shirted Nazis shouting

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anti-Semitic and anti-Negro slogans at the marchers.

As a "stable, considerate engineer with a cold, reasoned approach" who has already served three years in the U.S. Army, I question the reasons why these Nazi-uniformed "patriots" are not joining the service and fighting for their country.

"Practice what you preach" works both ways, Mr. Doerr.

Donald Davidson
Consulting Engineer
Chase Consulting Company
Jamaica, N. Y.

Engineers cannot govern quality

Sir:

As a reader of your magazine, I must express disappointment at your interviews with the men of the green beret [ED 18, Aug. 2, 1966, p. 36 ff.]. This is not because of the content of their remarks, which are obviously true and important, but because your article may have given them the impression that their opinions might lead to some results.

The article addresses engineers. Engineers are not the people whom the Army deals with. They are wage-earning employees of manufacturing companies. As employees, they have no choice but to do as they are told. If the company orders a quick-and-dirty design job, the employee has no choice but to do it or quit. The management controls the quality of the engineering job, and there is absolutely nothing that any engineer can do about it.

An article of this sort should be addressed solely to owners, managers, and stockholders in electronics manufacturing companies. The Department of Defense deals solely with businesses, mainly big businesses. As an employee of such businesses, an engineer should realize that he is nothing more than a unit of labor, being bought and sold at the prevailing market price. It is unfair to our armed servicemen to give them the impression that such units of labor are in any position to influence the quality of the matériel upon which their lives depend. Address such interviews, rather, to the businessmen who make the rules their employees operate under.

Dr. B. Martin Steeger
Design Engineer
San Marino, Calif.

Accuracy is our policy

In the schematic of "SCS and UJT form count generator," in ED 13, May 24, 1966, p. 82, the component designation of R_0 should have appeared next to the 100-Ω resistor in the cathode of SCS_0.

In "Ultra-stable resistors" in the components list of the Products Section of ED 17, July 19, 1966, p. 126, the manufacturer, Vishay Resistor Products, states that the line of resistors covers a range of 10 Ω to 30 kΩ (not 30 Ω as printed) in the case style illustrated, and up to 120 kΩ in other cases.

In "BCD counter uses ICs to minimize component count," ED 17, July 19, 1966, p. 89, the supply voltage to the K inputs of the J-K flip-flops should have been +4 V and not −4 V as shown in schematic.

In "Touring the exhibit areas," ED 19, Aug. 16, 1966, WESCON-USA section p. U102, the caption under the bottom righthand picture should read: "Find burn-outs and hot-spots of up to 1000°F. . . ." (not 100°F as shown).

In "Clues to Gemini's wake lost during undocking," ED 18, Aug. 2, 1966, p. 13, the name of the company responsible for the NASA-conducted experiment was accidentally omitted. The wake experiment was designed by Electro-Optical Systems, Inc., of Pasadena, Calif.

In "Microwave parley sees room for IC growth," ED 15, June 21, 1966, pp. 21-22, the price of the International Microwave Symposium digest was omitted. For IEEE members, it is $3.00; for nonmembers, it is $6.00; and for schools and libraries, $4.50.

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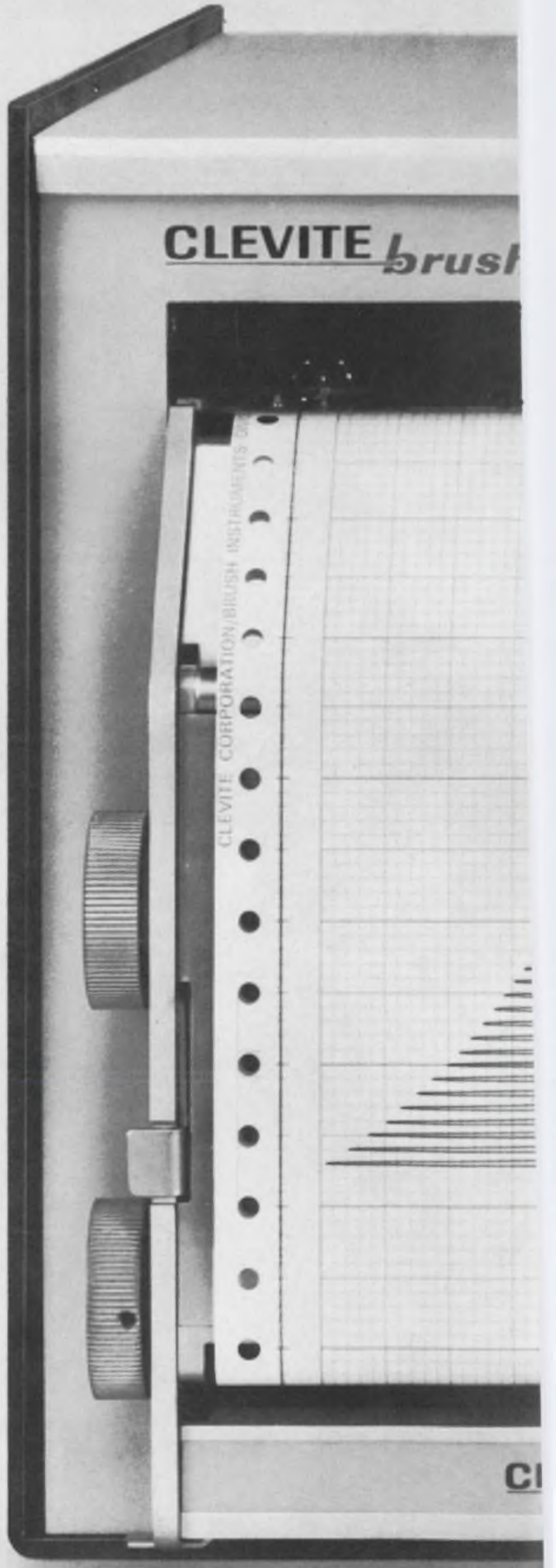

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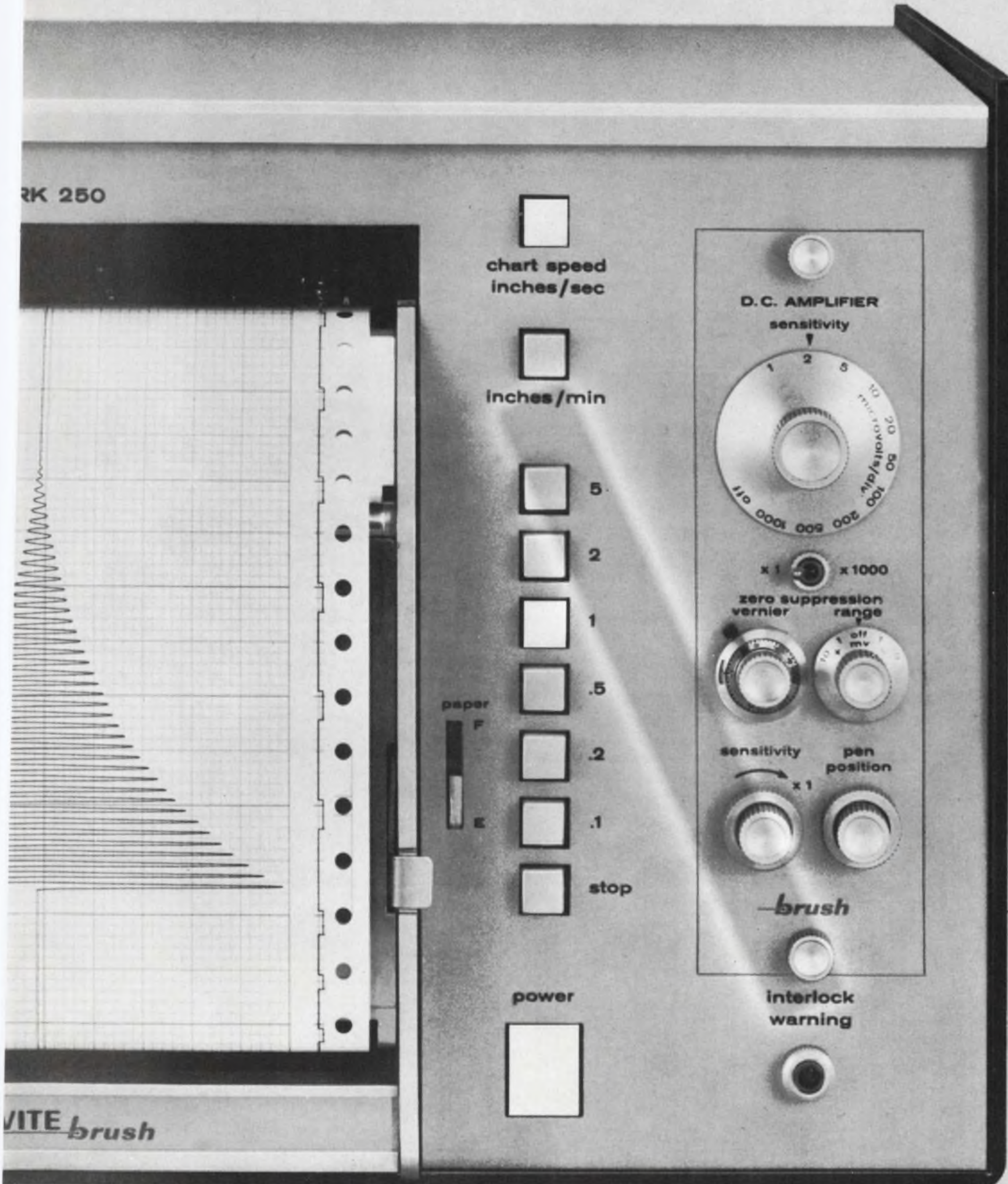
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These capacitors—when designated TRW Type 693—are available to high reliability specifications, and in custom capacitances and tolerances beyond the range of MIL-C-19978B/2.

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TRW CAPACITORS

EDITORIAL

Let's pay more than lip service to matters of life and death

More than 30 years ago, workers who painted luminous watch dials died from irradiation. An investigation disclosed that the fine numbering on the dials required a pointed brush, and for this the painters touched the brush tip to their tongues before making a stroke. The paint they applied glowed in the dark: its active ingredient was radium. These deaths taught us a painful lesson. Or did they?

In 1949, the manufacturers of fluorescent lights agreed to stop using beryllium in their products. But this was more than six years after the first known death from beryllium poisoning.

Many brilliant researchers have prematurely lost their lives because they did not understand or concern themselves with the personal dangers associated with their work. But there is no such excuse for design engineers and production workers. They don't tread the perilous frontiers of knowledge. Their safety can be assured with money and care.

Guards and cages around moving machinery cost money. Fireproof doors cost money. This is money most wisely spent. But safety is not merely a question of money. A little thought, concern, compassion for workers who must handle equipment that you design may help to preserve their lives. This is not as unnecessary a plea as you may be tempted to think.

Within the last year, two technicians died in New Mexico after inhaling soldering fumes. Doctors were puzzled because one of the victims mentioned that he had cleaned the work beforehand with ammonia, but both autopsies linked the deaths to cadmium fumes from silver solder. The solder was labeled with a warning that the product contained cadmium and could emit "dangerous fumes if overheated."

We believe that state and federal governments are not doing enough to protect workers from such dangers. For example, betanaphthylamine, a chemical used in dye-making, is outlawed in almost every European country. Inhaling it causes cancer of the bladder with such certainty that no one has ever established a safe limit of exposure. Yet it is legal in every state except Pennsylvania.

Information is readily available on dangers associated with metals and organic materials. The Superintendant of Documents, Government Printing Office, Washington, D. C. 20025, will send you a 375-page book entitled *Occupational Diseases: A Guide to Their Recognition* (Public Health Service Publication no. 1097) for $2.25. The same office also publishes a bibliography of available monographs indexed by material. It is *Bibliography of Occupational Health* (PHS Publication no. 300) and it costs 35 cents.

Our industry does remarkable things with exotic materials. But it must learn of the dangers of these substances, and it must develop new ways to handle them safely. Right now. Before they claim another life.

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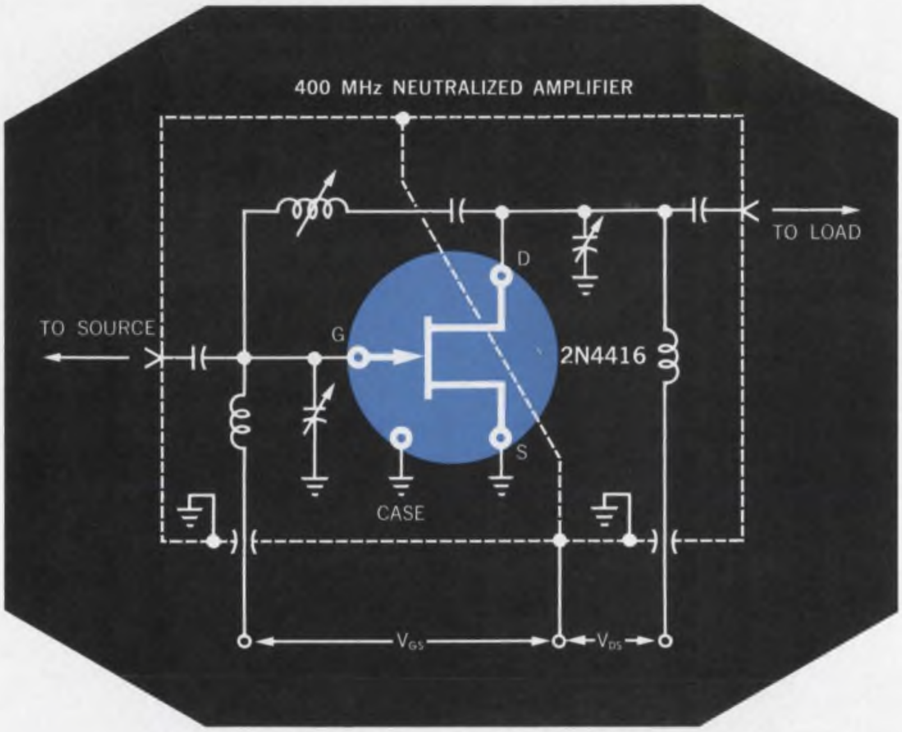

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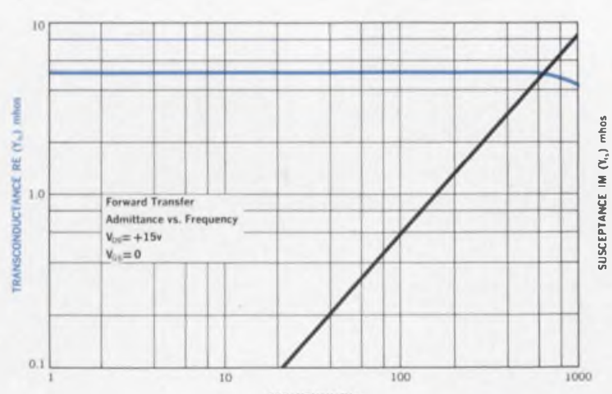
Output Capacitance, C_{oss} (max.)	2.0 pf	1.0 pf	1.0 MHz
Reverse Transfer Capacitance, C_{rss} (max.)	0.8 pf	0.8 pf	1.0 MHz
Spot Noise Figure (Neutralized), NF (max.)	4.5 db	4.5 db	400 MHz
Spot Noise Figure, NF (max.) (Neutralized)	2.0 db	2.0 db	100 MHz
Power Gain, G_{ps} (min.) (Neutralized)	12.0 db	12.0 db	400 MHz



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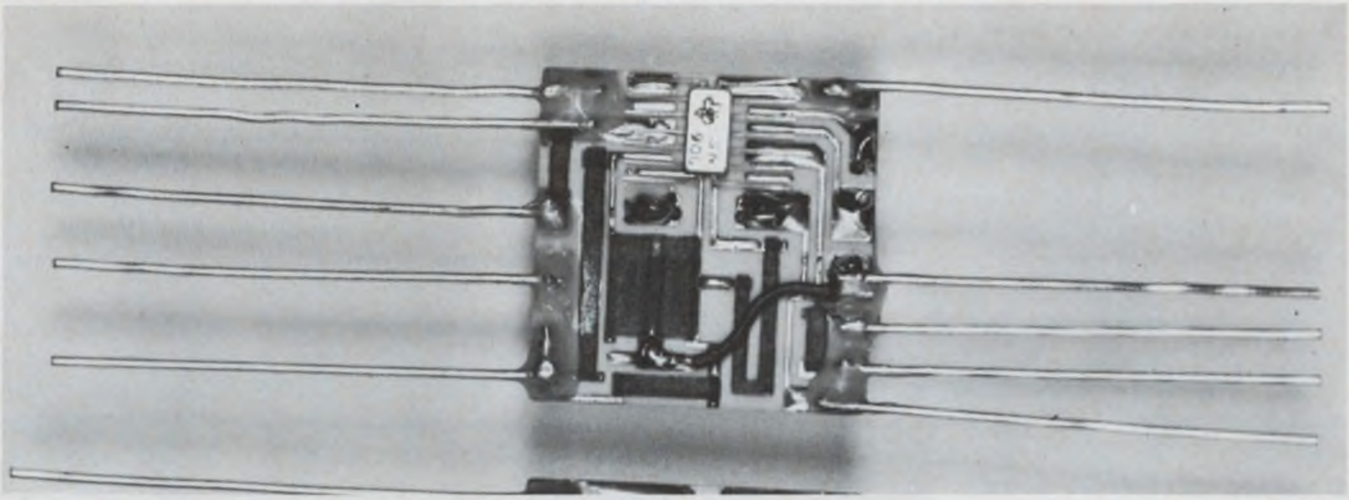
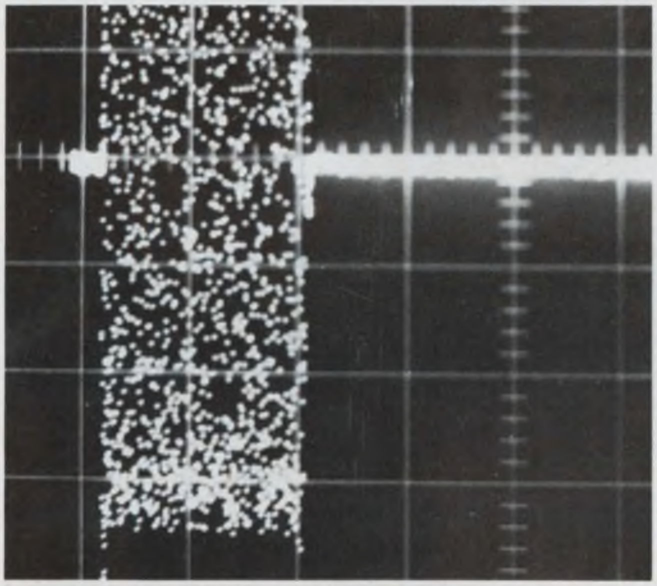
Technology



Thick-film hybrids like the summing circuit above may be built in the laboratory simply and inexpensively. The technique affords high flexibility and quick results. Page 52.



Modulators combining shunt and series diodes yield fast, balanced RF pulses. Page 78

Pulsed drivers offer advantage in reading out magnetic shaft encoders. Page 72

Also in this section:

Make your own thick-film ICs. Simple equipment and inexpensive materials suffice for you to produce your own circuit designs.

Reducing the size of your present circuit may not be too difficult, if you use thick-film techniques to do it. The flexibility and low cost associated with this process provide the freedom to experiment with your own special circuits right in your lab. The circuitry discussed here consists of thick-film resistors and interconnection patterns used with discrete components. A few of the advantages of this technique are:

- **Immediate results.** The equipment and materials required to produce evaluation quantities are readily available.
- **Simple process.** Relatively unskilled persons can quickly learn how to process and manufacture thick-film circuits.
- **Low cost.** Since the thick-film process lends itself to mass production and automated machinery, high-volume requirements would reduce costs sharply.
- **High flexibility.** Inks can be easily changed to vary resistor and conductor characteristics. Design changes are also made easily. Different active components can be substituted and the thick-film resistors can be trimmed without difficulty to achieve high precision.
- **Easy circuit design.** Because the thick-film hybrids are essentially an extension of existing circuitry into a smaller dimension, the circuit designer's job becomes much simpler than with more "exotic" types of microcircuitry. He can use exactly the same circuit as he would have designed using discrete components.
- **Excellent circuit qualities.** Good isolation properties, coupled with smaller size, allow high operating frequencies. Low substrate thermal resistances make possible extremely high power dissipations (20 W/in.^{2}). Greater ruggedness, because of fewer solder joints and hanging components, leads to increased reliability and lower maintenance costs.

Thick-film process is described

As background information, let's first briefly go over the process of making thick films, and later go into the details on each of the process steps.

Leonard I. DeGennaro, Senior Development Engineer, Honeywell, Inc., West Covina, Calif.

Thick films, as their name implies, are layers of resistive, dielectric, and conductive inks that are deposited on a substrate. The deposition process, similar to graphic silk screening, employs a fine mesh screen to hold the pattern for the components that are to be deposited. The pattern is produced by photographic means and wherever the inks are not to be deposited, the holes in the mesh are blocked by an emulsion.

Substrates, usually ceramic, are cleaned and then screened with conductive inks to provide the first pattern—hole locations. The substrates are then drilled out and cleaned. A second screening with conductive inks provides the conductor pattern, terminal points, bonding pads, and the bottom plates of capacitors, if used. Though these first two screenings could be combined, they are performed separately to ensure that the drilling and cleaning operations do not damage the circuit patterns. A third screening provides the resistor elements.

If capacitors are included in the circuit, a fourth

Table. Materials for thick-film circuits

Material	Mfr. & #	Characteristics	Price
Resistive inks	DuPont, 7826 7827 7828 8020 8021 8024 8025	500Ω/sq. 3.5 kΩ/sq. 10 kΩ/sq. 1 kΩ/sq. 100Ω/sq. 10 kΩ/sq. 20 kΩ/sq.	$10 to $20 per oz
Conductive inks	Dupont, 7553	platinum-gold	$10 to $20 per oz
	6320 6730	silver silver	$2 to $3 per oz
Dielectric inks	Electro-Science, 4747	$\epsilon_r = 100$	$10 to $20 per oz
	DuPont ——	$\epsilon_r = 400$ (experimental)	——
Substrates	American Lava, CT60401-L	1 in. square unglazed 96% AlO-AlSiMg	40¢ to $1 per square
Mesh screen	Dorn	400 mesh-stainless steel	$20 per ft^2
		200 mesh-stainless steel	$6 per ft^2
Ruby mask	Dorn	high stability	40¢ per ft^2

and fifth screening must also be performed: one for the dielectric material, the other for the second capacitor plate. After each screening, the substrate is first air-dryed and then oven-dryed. A number of screening inks are available and only a few of them, together with some of the other materials required for thick-film circuits, are listed in the accompanying table.

When screening is completed, the substrates are fired in a high-temperature oven. Afterwards, the components can be measured and trimmed by an abrasive technique to bring them into tolerance. Discrete components are then attached, and the substrates dipped in a solder bath. After final circuit testing, the units are ready for encapsulation or other packaging.

This is essentially the thick-film process. Though materials or equipment can get more expensive and more sophisticated, the process will follow the same steps. Let's take a closer look at each of the manufacturing steps.

First step is the layout design

Utmost care should be exercised in designing and making the layout. Since we use 1-in-x-1-in. substrates, we have found that a five-to-one (5 in. x 5 in.) layout is ideal to work with. If the layout becomes too large, additional reduction may be required and this can introduce dimensional errors. Printed and discrete components are located according to design needs and within the limits of practicality. In fact it is like laying out a printed-circuit board: thick-film conductors, resistors, capacitors and discrete, components like flat-packs are placed on one side of the substrate; discrete components with axial and radial leads are located on the other side.

The design equations for thick-film resistors are given in the accompanying box. Combining the two equations gives:

$$w = (\rho P/RD)^{1/2}. \qquad (1)$$

This equation is used to determine the width of the resistor. Once w is known, l can be found by:

$$l = P/wD. \qquad (2)$$

Let's take a practical example. Assume $t = 1$ mil; if the processing is consistent, the thickness of the mesh screen determines the thickness of the resistor. Also, assume that the allowable power dissipation is 10 W/in.² per mil. This value is used where the ink-substrate combination has been tested to 20 W/in.² per mil. If we wished to construct a 20-kΩ, 1/8-watt resistor using a 5-kΩ/square resistive ink, we get:

$$w_{20k\Omega} = [5000(0.125)/20{,}000(10)]^{1/2} = 0.056 \text{ in.},$$

and

$$l_{20k\Omega} = 0.125/0.056(10) = 0.223 \text{ in.}$$

The resistor layout is shown in Fig. la. If a dimensional limitation existed, the pattern could be bent, as in Fig. lb, to conform to the available space. The corner squares would then possess half-square resistive values and this effect would have to be taken into account in calculating the

Basic design formulas

Resistors:

$$R = \rho(l/w)t, \qquad (1)$$

and

$$lw = P/D, \qquad (2)$$

where

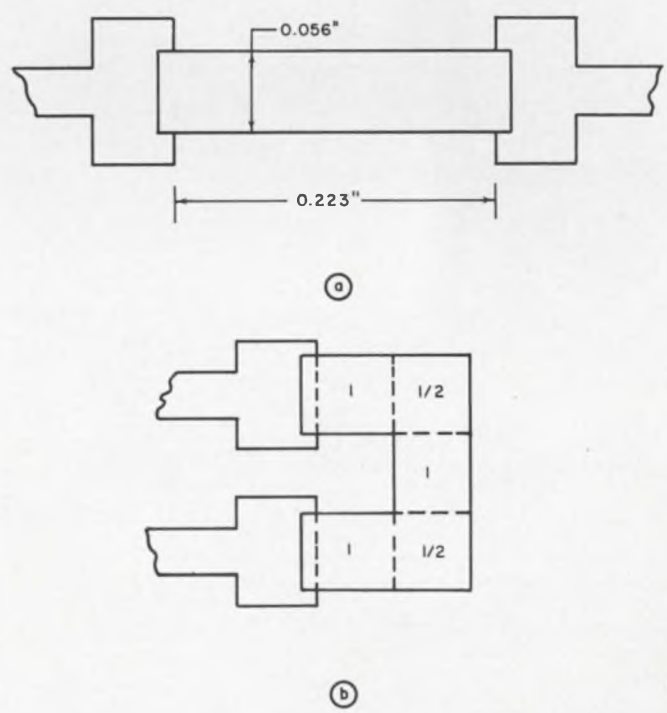
R = resistance, Ω;
w = width, in.;
l = length, in.;
t = thickness, mils;
ρ = surface resistivity, Ω/sq. per mil;
D = allowable dissipation, W/in.² per mil; and
P = power rating, W.

Capacitors:

$$C = 225\, \epsilon_r\, A/t, \qquad (3)$$

where

C = capacitance, pF;
ϵ_r = dielectric constant (relative to air);
A = area of one side of one plate, mil²; and
t = dielectric thickness, mils.



1. **Thick-film 20-kΩ resistor is deposited** with 5000 Ω/square ink (a). Should space be at a premium, the resistor can be folded (b); the corner squares then have half the resistance of the in-line squares.

effective length. As a rule, resistor lengths and conductor pads are made larger than required. This allows for registration errors, without affecting the resistance tolerance. In order to allow enough material for trimming, the minimum resistor width should be 0.060 inch.

Conductors are naturally simpler to design: A minimum conductor width of 0.030 inch is recommended and conductor spacing should be at least 0.020 inch. With these dimensions, conductors will safely carry up to one ampere; the 0.02-inch spacing allows a maximum voltage rating of 60 wvdc. The conductor width and spacing, however, should be made as large as possible. If the unit is subsequently to be encapsulated, the conductor separation can be reduced below the suggested minimum. To reduce registry problems and because the conductive inks are cheaper than other inks, the drilling information is marked on the substrate by putting circles of conductive material over each hole to be drilled.

Capacitors require considerably more care and are, unfortunately, still none too easy to manufacture. One of the major problems is the scarcity of usable dielectric inks. The capacitor design equation, given in the accompanying box, is straightforward, but making the capacitor can be quite tricky. Improper registration and thickness variation can greatly affect the final capacitor value. Trimming by abrasion (see section on trimming resistors) can offset some of these effects as long as the capacitor is a higher value than required. If the process is well controlled, the thickness of the screen determines the thickness of the dielectric. As an example of what can be accomplished, a 47,000-pF, 25-wvdc capacitor can be constructed, using the experimental DuPont ink listed in the Table, in a 30-by-30-mil area.

Artwork is generated from layout

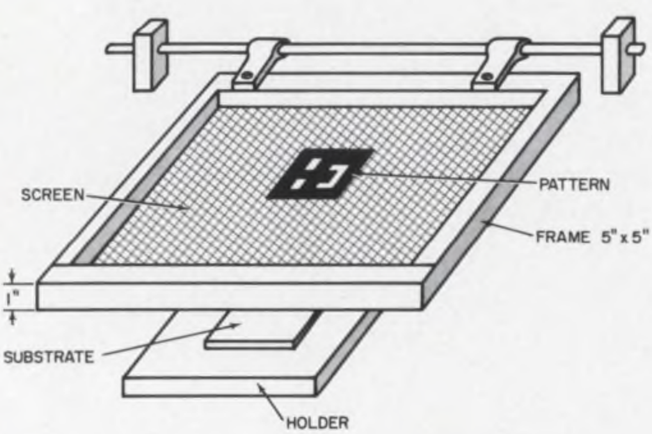
Once the layout has been decided on, ruby mask masters are cut from the layout. One master is required for each screening. For a circuit with just resistors and conductors, three masters are used: one for hole location, one for conductors, and one for resistors. When capacitors are included, two more masters are required.

The masters are photographically reduced by a factor of 5 to 1 to produce a positive print. This print is then used to expose (emulsion to emulsion) the screen film, a thin film with backing that is used especially in screen-making. After processing, the screen film is attached to the screen (emulsion side to screen). The screen is dryed, the backing is removed and the screen is mounted on a frame, as shown in Fig. 2. Actually, though we do our own photographic processing, the ruby masters could be sent out to any industrial photographer for processing. Such people are usually qualified to perform the work.

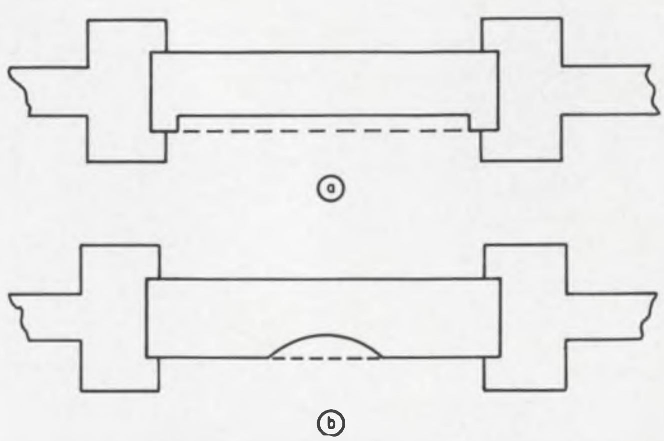
Inks must be uniform for screening

Inks should be mixed just prior to application. This ensures a uniform consistency and viscosity. Since viscosity is related to the ohms-per-square value (the inks are a mixture of solid materials with a liquid carrier), the viscosity should be carefully measured, and the measurements recorded. These can be used to control and generate future design in order to achieve correct resistor values.

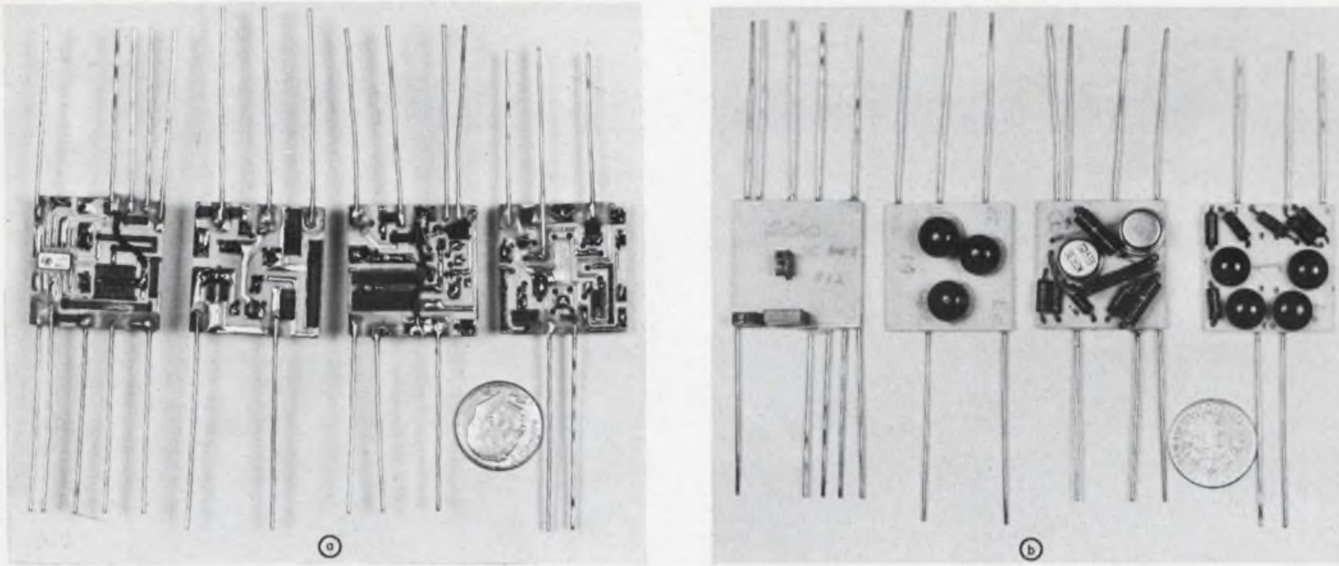
The selected ink is placed on one end of the screen. The squeegee picks up the ink and spreads it across the screen pattern and on to the substrate. Screen height and tension, and squeegee pressure, length, angle and speed, are all important factors that affect the quality of the screened components. Though an automatic screen printing machine takes a lot of the guesswork out of the operation, it is not necessary. The screen is between 0.025 in. and 0.040 in. above the substrate and the screen tension is such that the weight of



2. **Set-up for screening is simple and economical.** Various holding jigs are used to guarantee alignment from screen to screen. Screens can be stored for some time and used again at a later date.



3. **Proper method of trimming thick-film resistors** (a) requires a fine hand, but ensures a constant current concentration through the resistor. Improper method (b) creates a hot spot at the center.



4. **Four thick-film hybrids** (l to r: summing amplifier, switching circuit, one-shot multivibrator, integrator-and-switching circuit), that were built by the author, are shown in these back (a) and front (b) views. Note the use of monolithic ICs in two of the circuits and discrete resistors in one of them. (Equivalent resistances, in thick film, would require too large a surface area to dissipate the required power.)

the squeegee causes the screen just to touch the substrate. The squeegee overlaps the substrate by at least 1/2 in. on each side. Best performance requires that the squeegee be passed at a 90° angle over the pattern with a consistent, medium pressure.

After each screening, the substrate must be air-dried for 10 to 15 minutes to eliminate screen impressions, and subsequently oven-dried at 150°F for another 10 to 15 minutes.

Once all the patterns have been screened and dried, the substrate is placed in a furnace for firing. The firing enables the glass frit binder, contained in the inks, to react with the substrate to form an intermediate oxide binder between the metal particles in the inks and the substrate. To make a really strong bond, only unglazed ceramics should be used.

Though the firing is generally done in a temperature-profile furnace, any regular furnace that reaches 1700°F can be used for low-volume work. The important thing is to maintain a flow of oxygen into the oven that sustains the oxidation process. This is a simply done by leaving the furnace door ajar. The firing should continue for 45 minutes. The 1700°F temperature is not critical and can vary as much as 10%.

Firing is followed by dip soldering. The solder coats the conductor paths but does not adhere to the resistor patterns. To eliminate substrate breakage, the substrates should be preheated to the solder bath temperature.

Since this process is reasonably crude, we can only expect a tolerance on resistors of 10% at best. Should finer tolerances be needed, the resistors have to be trimmed. Trimming is performed by abrading material away from the resistor. Since this changes the *l:w* ratio, the initial layout has to be made with this consideration in mind, and the resistors designed on the low side. Care should also be taken to preserve the power rating of the resistor after abrading. Trimming is done either with an abrasive tool or by the electric-arc method.[1] Among the possible abrasive tools are air abrasive equipment, a dentist's drill, an emery drill, or even an electric eraser. (This last is rather large and clumsy in comparison with the thick-film resistors and consequently less effective.) Figure 3 demonstrates the proper and improper methods for trimming resistors. The improper method results in excessive current concentrations and causes hot spots.

The next step is to mount and solder the discrete components and terminal leads. The leads may be mounted in any configuration; however, mounting them perpendicular to the substrate provides greater packaging efficiency. The photographs in Fig. 4 demonstrate a number of circuits that have been built. Note the use of standard, off-the-shelf integrated circuits; making your own circuits is fine, but if circuits are already available that fulfill your requirements, these will almost alway be far better from the point of view of price, quality, size, and reliability.

Once the components are mounted, all circuit tests can be performed. Though the circuit can be used in the unencased package, it is recommended that a conformal coating or encapsulant be used to prevent moisture and contaminants from shorting the closely spaced conductor patterns. ■ ■

Reference:

1. *Fired-on Resistors—Manufacturing Procedures* (Wilmington, Del.: E. I. du Pont de Nemours & Co., Inc., Publication No. A29656).

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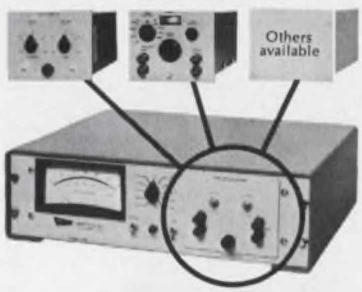

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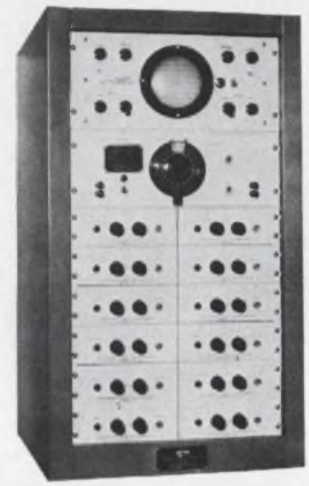

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Beat the heat in electronic systems

by using this step-by-step procedure for designing and specifying blower cooling setups.

An engineer drafts his designs, fabricates the breadboard and tests the equipment, only to find that it isn't dissipating heat properly. At this stage he tacks on a fan or blower, in the hope of solving his problem. Can this be called good design procedure?

Obviously not, particularly today when miniature, high-component-density systems are common. Heat problems must be attacked early in the design process to ensure that the cooling system delivers maximum performance at minimum cost, space and weight.

Let us, then, use a step-by-step approach that brings the theory of fluid flow and thermodynamics to bear on the practical problem of providing the right cooling system for your design.

Optimum cooling-system design can be broken down into three stages:

- Choose the type of coolant.
- Determine the amount of coolant (flow rate) and static pressure needed to keep it circulating.
- Select the pump or blower that will deliver the most efficient coolant circulation.

We will analyze each of these three design stages in detail and then apply them to two specific cooling system problems.

Air is the best coolant

The best type of coolant for a given application depends both on the nature of the cooling system and on the physical properties of the cooling fluid itself. The nature of the cooling system is affected by the design of the equipment being cooled and by factors in the operating environment, such as ambient temperature and altitude. Coolant characteristics that should be considered include:

- Heat transfer properties.
- Ease of handling.
- Electrical properties.
- Compatibility with the materials used in the electronic equipment.

Berard J. Braganza, Project Engineer, The Torrington Manufacturing Co., Torrington. Conn.

- Cost and availability.

Air is the most commonly used fluid in electronic cooling systems. While other fluids (such as water or special refrigerants) are inherently superior heat-transfer media, air cooling is generally preferred because it answers the four other considerations that we have listed. We shall, therefore, concern ourselves specifically with air-cooling systems.

Air flow rate (Q): The temperature of the electronic elements is the prime factor that determines the mass flow rate of air. The higher the efficiency of heat transfer for a given power dissipation, the smaller the quantity of air required.

Heat transfer from electronic components to the cooling fluid is mainly through convection. The amount of heat transmitted and the temperatures of a cooled component depend on the mass flow rate of the air, the specific heat of the air, its heat transfer coefficient, and the temperature differential between the components and the air. It is difficult to define precisely the actual heat transfer equation for a particular cooling system. It is usually more satisfactory to monitor and evaluate component temperatures through actual test of the equipment when operating at rated or design loads. These tests can be conducted with any convenient air supply available, and the air flow for satisfactory cooling measured.

A good starting point for these tests is a proven design for a flow rate in a system similar to the one being designed. This flow rate can then be adjusted to provide the desired cooling in the new system.

Heat flow (kW): Lacking such a starting point, the designer can make a rough calculation of heat flow from Eq. 1, which is based on an average specific heat of 0.24 Btu/lb:

$$kW = Q\rho(T_o - T_i)/237, \qquad (1)$$

where

kW = heat removed by air flow, kilowatts,
Q = air flow rate, ft³/min,
ρ = air density, lb/ft³,
T_i = air inlet temperature, °F, and

T_o = air discharge temperature, °F.

To find the amount of heat that must be removed, kW, Eq. 2 is used and the results substituted into Eq. 1.

Heat transfer (W): The heat dissipated from a single circuit element by forced convection cooling is given, in watts, by:

$$W = 0.293\, h_c A (T_c - T), \qquad (2)$$

where

h_c = forced convection heat transfer coefficient, Btu/hr/ft²/°F,

A = cross-sectional area through which heat flows, ft²,

T_c = maximum surface temperature of the heat source, °F, and

T = mean circulating air temperature at the heat source, °F.

The independent variable in Eq. 2 for a given flow system is the heat-transfer coefficient,. h_c, which is a function of the Reynolds number, the Nusselt number, the thermal conductivity of the fluid, and some dimension of the object being cooled.

By restricting the problem to a particular object being cooled by air under a particular set of conditions, we find $h_c \approx V^r$ Btu/hr-ft² °F, since all other terms have become constant. The variable V is air velocity in ft/min, and r is an exponent that changes with the type and orientation of the heat transfer surfaces (r = 0.6 is commonly used for electronic cooling systems).

Since V is directly proportional to air flow rate and inversely proportional to the cross section of the air flow path, it may be changed by varying either Q or A. The coefficient h_c, however, varies more slowly than V (doubling V only increases h_c about 50 per cent). Once the flow cross section, A, has been established, the heat transfer problem of holding the maximum surface temperature, T_c, to desired values requires a certain V and then becomes simply a blower-system problem of producing Q cubic feet per minute ($Q = AV$).

Static pressure (P_s): Power required for cooling is directly proportional to the quantity of circulating air and the static pressure that the cooling blower must introduce to overcome system losses. Treating air as an incompressible fluid, the basic relationship between static pressure and air flow rate is given by the pressure-flow equation:

$$P_s = kQ^x, \qquad (3)$$

where

P_s = static pressure loss, in. of water, and

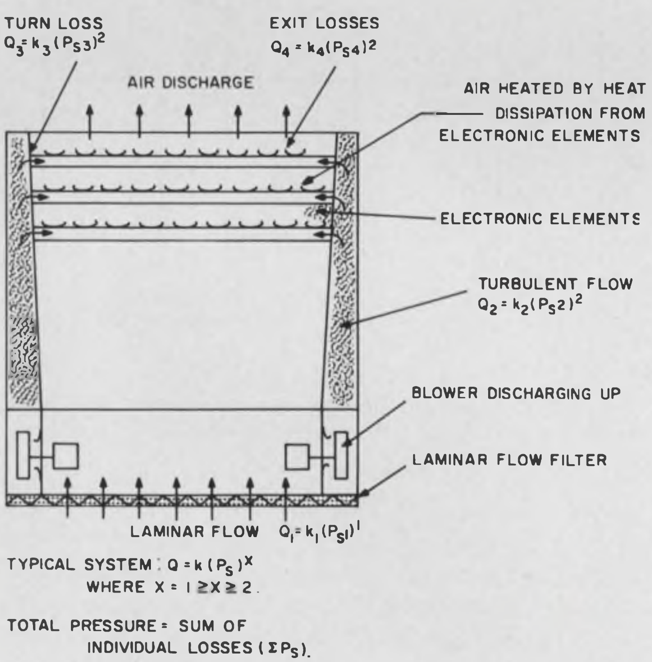
k, x = constants for a given air flow system.

Air flow rate, Q, is usually determined as previously described.

The value of static pressure, P_s, for a given flow rate is a function of air density, ρ, and the aerodynamic losses in the cooling system. The exponent x is a function of the type of air flow, laminar or turbulent or a combination of these, and may vary from point to point across and along a cooling system path. For pure laminar flow, $x = 1$; for pure turbulent flow, $x = 2$. For a given flow rate, Q, and exponent, x, it can be seen from Eq. 3 that the value of the constant k is fixed by the system pressure loss, P_s, and includes the effect of density. To minimize the static pressure needed to maintain the desired flow rate, the designer must do the utmost to reduce the aerodynamic losses and so reduce the value of k.

Since heat transfer is higher with turbulent flow, $P_s = kQ^2$ for most cooling systems. But rarely is air flow either purely laminar or purely turbulent, and therefore the value of x may vary between 1 and 2. The hypothetical cooling system in Fig. 1, for example, includes both turbulent and laminar regions and can be represented in total by a pressure-flow equation with x between 1 and 2.

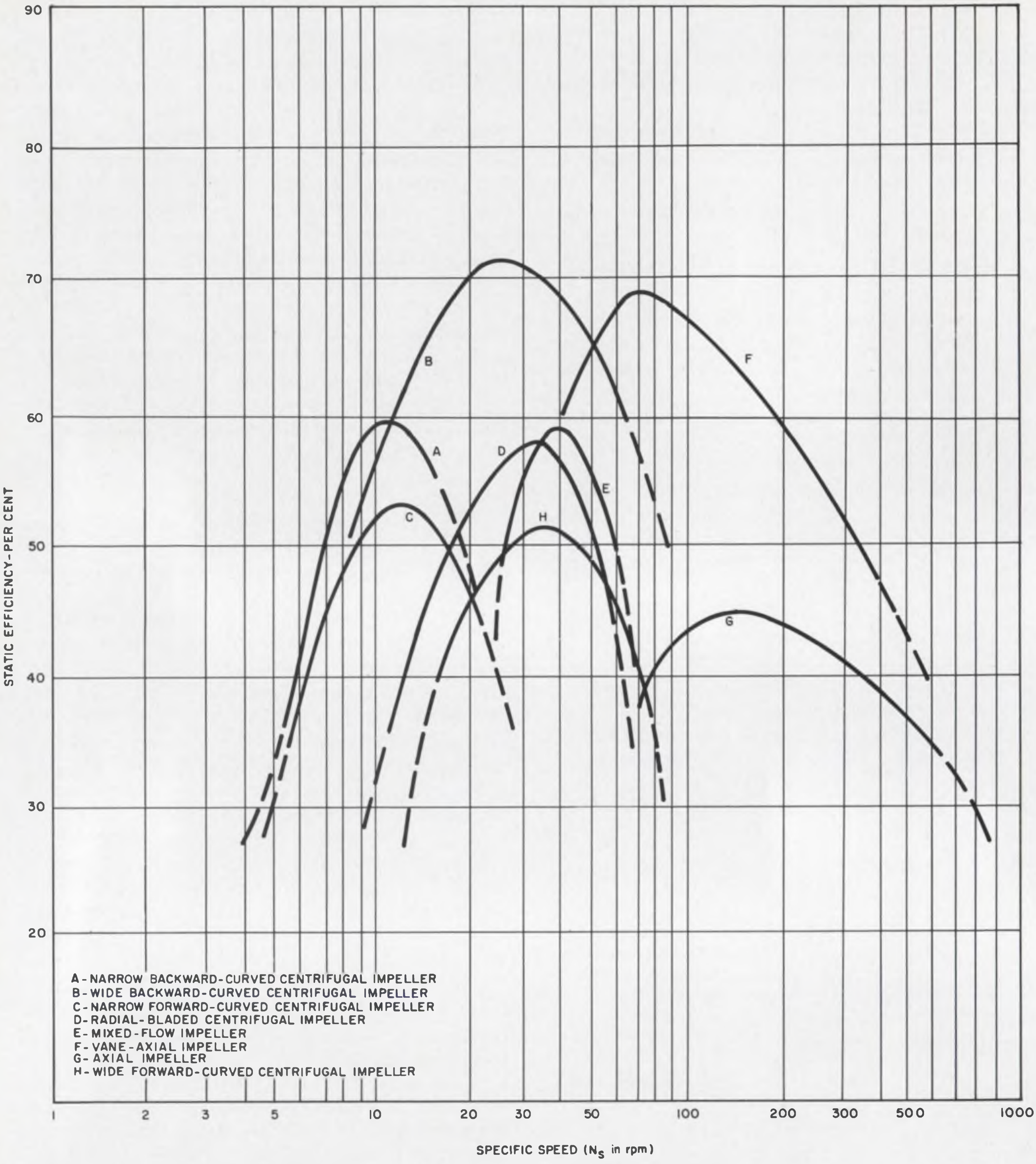
With the cooling system thus defined, the designer can select the circulating blower that is matched to application needs, with minimum blower size, weight and power input.



1. **This hypothetical cooling system** includes both turbulent and laminar air flow. As shown, each part of the total system can be described by the pressure-flow equation and the results summed to provide a quantitative indication of system requirements.

What to consider in selecting the blower

The blower type, size, weight and power can be estimated early in the design process. The blower specialist can then refine the blower design at the same time as the electronic engineer is completing the equipment development. An off-the-shelf blower unit, either as it is or with some



2. **Blower selection is simple** with the use of this plot of static efficiency vs speed. Seven basic types of blower units are represented. Design examples in the text demonstrate the ease of using these curves.

modification, may do the job. On the other hand, the blower specialist may find that an entirely new design is needed to meet the heat transfer requirements. The electronic designer should specify only critical limits on air-system or blower characteristics, and should make them as realistic as possible, since tight limits often mean higher cost, greater weight, increased size, more power.

Here are the main design factors to be considered when selecting a blower:

A. *Air flow rate*, Q, and *air density*, ρ (in lb/ft^3): In airborne applications, Q and ρ should be given at sea level and at maximum altitude.

B. *Space available:* If available mounting space is too small, improperly shaped, or poorly located, the blower may be mismatched to the system or its output may be inadequate. Inlet and discharge conditions, ductwork or proximity of other components, for example, can have a significant effect on performance and must be accommodated in the blower design.

C. *Weight allowable:* A smaller, lighter blower can be used if the blower speed is increased, but the increased speed will shorten its useful life.

D. *Power available:* The blower should be allotted as much power as possible. If the available power is too low, the blower type and rotational speed necessary to obtain the required efficiency may be incompatible with other specifications. An elaborate, costly unit may result.

E. *Environmental specs:* While military specifications are beyond the designer's control, applicable portions of the specification should be clearly defined to avoid costly overdesign. For example, stating that the blower must meet the environmental requirements of MIL-E-5272 without specifying the appropriate procedure leaves the designer with no choice but to design for the worst conditions. Cost and possibly weight are then higher than necessary.

F. *Noise:* A blower that was 100 per cent efficient would produce sound. This is obviously unrealistic and therefore the designer should have some familiarity with acoustical noise requirements and specifications. This is helpful in establishing realistic noise levels for blowers. It would be absurd, for instance, to specify a minimum noise level for a blower located near another component that is generating a higher sound level. Noise levels should be specified only as targets, since sound level is usually far too difficult to estimate accurately.

G. *Operating life:* Minimum acceptable useful life of bearings and brushes may be specified by the electronic designer. The span is controlled in large part by the equipment's duty cycle (continuous or intermittent) and the operating environment, both of which must be accepted as they are. The rotational speed of the blower unit, which also very much affects bearing and brush life, is selected by the blower designer for optimum life—usually the lowest speed that will do the job in the space available.

What type of blower unit?

The most efficient type of blower unit for a particular application can be determined through the parameter, specific speed (N_s):

$$N_s = \frac{NQ^{1/2}}{P_s^{3/4}(\rho/0.075)^{3/4}}, \qquad (4)$$

where

N = rotational blower speed in rpm, and

ρ = air density, lb/ft^3 (ρ=0.075 lb/ft^3 at sea level).

The required specific speed of the blower can then be calculated for a desired blower speed N and the values of P_s and Q defined by the application.

The curves in Fig. 2 give static efficiency as a function of specific speed for each of seven basic types of blower units. The blower designer's objective is then to match the required value of N_s with a blower unit that is efficient at that value.

What does the designer do when all types of blower units that are otherwise acceptable are relatively inefficient at the calculated N_s? It's evident from Eq. 4 that he can shift the system N_s proportionately by changing the blower speed. With sufficient freedom in speed selection, he can then arrive at or near peak efficiency for the type of blower that best fulfills other requirements. Failing flexibility in speed, the blower N_s can be shifted by:

- Parallel staging—dividing the total Q among two or more blower units generating the same P_s. The N_s of each blower is then reduced.
- Series staging—dividing the total P_s among two or more blower units delivering the same Q (passed from one to another). The N_s of each blower is then increased.

Since staging is more expensive than changing the speed, staging is used only where the desired Q and P_s cannot be otherwise obtained or where the added cost is justified by a significant application advantage.

Determining blower size

After the most efficient type of blower unit has been selected for specific speed, the unit's dimensions can be determined, or at least approximated, for air flow rate and static pressure. The performance capability of a blower unit is represented by its pressure coefficient, ψ, and flow coefficient, φ, which are given in the Table for each of the seven types of impeller found in blower units.

Impeller tip diameter, in inches, is given by the equation:

$$D = (1.53\times10^4)(P_s/\psi)^{1/2}/N \qquad (5)$$

where P_s is static pressure at standard air density (ρ = 0.075 lb/ft^3), and ψ is defined as the ratio of the potential energy developed by the impeller to the kinetic energy corresponding to the impeller tip velocity.

The widths of centrifugal impellers, W, and hub diameters, D_H, for axial impellers are:

Centrifugal $\quad W = 175Q/\varphi ND^2$ = impeller width, in.; (6)

Axial $\quad D_H = D(1-700Q/\varphi ND^3)^{1/2}$ = hub diameter, in.; (7)

where φ is defined as the ratio of mean air velocity leaving the impeller to impeller tip velocity.

Since the pressure and flow coefficients are established by the geometry of the particular impeller model, their values are given in the table as ranges for each type. It can also be seen that these dimensionless coefficients are indirectly

Table: **Constants needed for calculating blower size.**

	Impeller type	Single-stage high-efficiency range (N_S) (rpm)	Pressure coefficient (ψ)	Flow coefficient (φ)
Centrifugal Impellers	Narrow backward-curved	5000- 15,000	1.0 -0.5	0.04-0.15
	Wide backward-curved	8000- 45,000	1.0 -0.45	0.03-0.2
	Narrow forward-curved	5000- 15,000	1.33-1.0	0.03-0.09
	Radial-bladed	1000- 45,000	1.8 -1.3	0.3 -0.7
Axial Impellers	Mixed-flow	25,000- 55,000	1.1 -0.6	0.3 -0.5
	Vane-axial	45,000-130,000	0.6 -0.25	0.4 -0.6
	Tube-axial	90,000-250,000	0.2 -0.06	0.1 -0.35

related to specific speed, shown in the table as a range for high static efficiency. At high specific speeds, φ is relatively high and ψ is low. Conversely, φ is low and ψ high at low specific speeds. The values of φ and ψ should be selected at the same positions in their ranges as the position of the calculated N_s in its given range.

The impeller dimensions in Eqs. 5, 6 and 7 do not, of course, represent the total outside dimensions of the cooling blower package. Centrifugal units are mounted in housings, and axial units may include orifices and guide vanes. In addition, the space occupied by the motor must be considered. While the size and shape of blower units vary widely, the approximate outside dimensions of single-stage centrifugal blowers are given in Fig. 3 in relation to the impeller diameter. In staged centrifugals, the axial widths are added.

The dimensions of axial units are far more difficult to estimate. The outside blower diameter normally is just slightly larger than the impeller diameter. The axial length of a vane-axial or pure axial unit can be roughly assumed to be about 1.5 times the impeller diameter.

Calculating blower unit power

The required power input to a blower unit at standard air density (0.075 lb/ft^3) is given in brake horsepower by:

$$hp = QP_s/6356\nu. \quad (8)$$

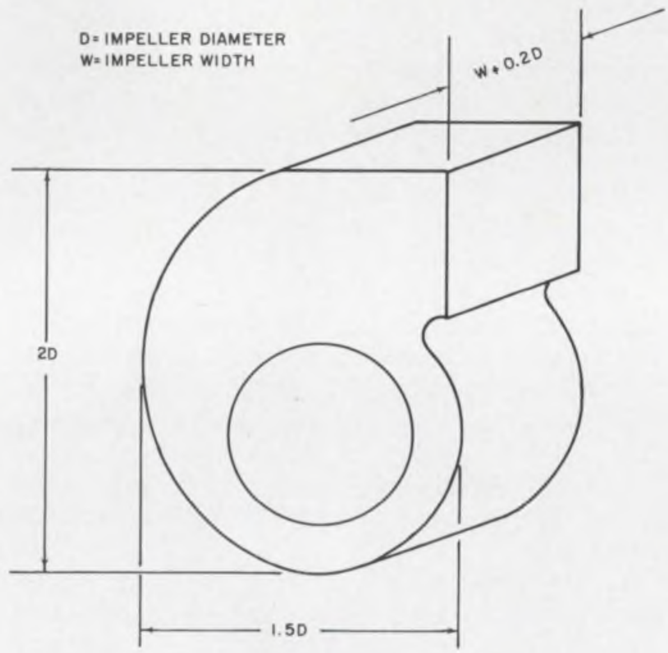
where ν = static efficiency at the calculated N_s (Fig. 2). Since P_s is directly proportional to density, hp also varies directly with density and so must be adjusted for application conditions.

Design examples illustrate method

Two sample design problems will show how a cooling system can be designed.

Example 1:

A cooling blower for a military device is required to deliver air at a minimum rate of 18 ft^3/min when P_s = 4 in. of water and air density is standard. The significant limitations on the



3. **These are the important blower dimensions** that must be considered when selecting a blower to fit into your cooling-system design.

blower, as listed by the user in decreasing order of importance, are:

1. *Power*—a maximum of 25 watts from a 7.7-volt dc supply.
2. *Operating life*—1500 hours to a major overhaul, 300 hours total service life.
3. *Size*—must fit into a space envelope 5-1/2 in. in diameter by 5 in. long.
4. *Weight*—a maximum of 9 ounces.

Specific speed is calculated with Eq. 4:

$$N_s = N(18)^{1/2}/[(4)^{3/4}(0.075/0.075)^{3/4}] = 1.5N.$$

Since the power supply is dc, the value of N_s is established by free choice of rotational speed. The size and weight limitations indicate a high speed; the life requirement suggests a low speed. To achieve the desired service life, the motor manufacturer states that speed should not exceed 12,000 rpm. At this speed, the specific speed is 18,000.

Both forward-curved and backward-curved impellers operate efficiently when N_s = 18,000.

However, the backward-curved type is more efficient than the forward-curved for the given performance and speed (Fig. 2). On the other hand, a forward-curved impeller would be smaller. Since power is a higher priority limitation, the choice is clearly then backward-curved impeller.

The pressure and flow coefficients are first determined from the table. When $N_s = 18{,}000$ in a specific speed range of 8000-45,000 for a wider backward-curved impeller, the values of ψ and φ are interpolated in their tabulated ranges as follows:

$$\psi = 1 - (18{,}000 - 8000) \times (1 - 0.45)/(45{,}000 - 8000) = 0.85;$$

$$\varphi = 0.03 + (18{,}000 - 8000) \times (0.2 - 0.03)/(45{,}000 - 8000) = 0.08.$$

The dimensions of the impeller itself are calculated from equations (5) and (6):

$D = (1.53\times10^4/12{,}000)(4/0.85)^{1/2} = 2.8$ in.;

$W = 175(18)/[(0.08)(12{,}000)(2.8)]^2 = 0.42$ in.

Referring to Fig. 4, we see that the outside housing dimensions are:

Height: $2\times2.8 = 5.6$ in. or 5-5/8 in.;

Width: $1.5\times2.8 = 4.2$ in. or 4-1/4 in.;

Depth: $W + 0.2D = 0.42 + 0.2(2.8) = 1$ in.

Weight is roughly 6 ounces, and the motor is rated at 0.02 hp (15 watts) at 12,000 rpm.

In this case the motor efficiency would have to be 60% to produce 15 watts output for 25 watts maximum allowable input power. According to the motor manufacturer, the best motor efficiency that can be expected is around 50 to 55%, requiring a power input of 27 to 30 watts. A motor that would handle this amount of power weighs, about 9 ounces, and it is 1 to 1-1/2 in. in diameter and 2-5/8 in. long. Complete package size would then be 5-5/8 in. x 4-1/4 in. x 3-5/8 in., and estimated weight 15 oz.

It is evident that some compromise must be made in the design. An increase in allowable power and weight is apparently necessary.

Example 2:

A blower is required to deliver a minimum of 4 lb/min of air varying in density from 0.075 lb/ft³ to 0.04 lb/ft³. The estimated total system resistance at 0.075 lb/ft³ density is 4 in. of water. An estimate of blower type, size and power is required for a blower whose rotational speed N = 10,000 rpm.

The volume flow rates for 4 lb/min are: Q_1 = 53.4 ft³/min at 0.075 lb/ft³ density and Q_2 = 100 ft³/min at 0.04 lb/ft³ density.

If we assume a system equation $P_s = kQ^2$ (exponent x = 2), then the total system resistance P_{s2} where Q_2 = 100 ft³/min would be:

$$P_{s2} = (Q_2/Q_1)^2 P_{s1} = (100/53.4)^2(4) = 14 \text{ in. of water.}$$

It is evident that the blower must be capable of delivering Q_2 = 100 ft³/min of air (0.075 lb/ft³ standard density) with P_s = 14 in. of water to furnish 4 lb/min of air at 0.04 lbs/ft³ density.

On the other hand, if the system equation is, instead, $P_s = kQ^{1.5}$, then P_{s2} where Q_2 = 100 ft³/min would be:

$$P_{s2} = (Q_2/Q_1)^{1.5} P_{s1} = (100/53.4)^{1.5}(4) = 10.6 \text{ in. of water.}$$

When exponent $x = 1.5$, the blower must be capable of delivering Q_2 = 100 ft³/min of standard air with $P_{s2} = 10.6$ to furnish 4 lbs/min at 0.04 lbs/ft³ density.

Specific speeds when the exponent $x=2$ and $x=1.5$ are:

(a) $x = 2$: $N_s = 10{,}000(100)^{1/2}/(14)^{3/4} = 10{,}000/7.25 = 13{,}700.$

(b) $x = 1.5$: $N_s = 10{,}000(100)^{1/2}/(14)^{3/4} = 10{,}000/5.87 = 17{,}000.$

Both blowers then will use backward-curved centrifugal impellers efficiently. Using the same calculation procedure as in Example 1, we find the approximate blower housing dimensions are:

(a) 11.5 in. × 8.6 in. × 2 in.

(b) 10 in. × 7.7 in. × 1.8 in.

The approximate power inputs required are:

(a) 0.35 hp @ standard density;
0.18 hp @ 0.040 lb/ft³ density.

(b) 0.24 hp @ standard density;
0.13 hp @ 0.040 lb/ft³ density.

Based on the same motor efficiency, the power input at 0.075 lb/ft³ is then in the ratio 1.46:1 for $x=2$ and $x=1.5$; at 0.040 lb/ft³, in the ratio 1.39:1. Motor weights furnished by the manufacturer are about:

(a) 2.5 lbs: (b) 6 lbs.

Over-all widths of the blower unit including motor length are about:

(a) 8.0 in. (b) 5.8 in.

The estimated power is based on the speed remaining constant at 10,000 rpm. Since the blower is essentially a constant-volume device, the volume flow will be independent of density. As a result, the mass flow rate at 0.075 lb/ft³ density will necessarily be almost twice the required value. ■ ■

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Try the hybrid-pi the next time you need an accurate transistor model that must hold over a wide frequency range.

Many engineers tend to use the same transistor models over and over, without giving much thought to which might be best for the job at hand. Such adherence to habit may seem to save them time and worry, but from the standpoint of efficiency, it could be costly. They could, for example, be passing up the outstanding versatility of the hybrid-pi method.

The hybrid-pi offers a compromise between the so-called "block-box" parameters (h, y and z) on the one hand, and complex and cumbersome equations derived from semiconductor physics on the other.

At its best in broadband analog applications, the hybrid-pi (Fig. 1) is a relatively simple, linear model usable from near dc to the cut-off frequency of the transistor.* It is thus particularly applicable to stability analysis of broadband feedback amplifiers. The designer can also use low frequencies to measure the model's parameters. And as an added advantage, he can easily relate these parameters to transistor variations introduced in manufacture.

What are the parameters?

The parameters are shown in Fig. 1. Each will be examined in detail to demonstrate how they can be related to easily measured quantities.

First is $r_{bb'}$, the base spreading resistance. This is the resistance from the transistor's base contact to the base-emitter junction. It is dependent upon the base resistivity and geometry. As such it is practically constant for a given transistor type and does not vary significantly with the transistor's operating point. Typical values for small-signal transistors are from 5 to 50 ohms.

Next is the base-emitter resistance, which can be expressed as:

$$r_{b'e} = r_e\ (1 + h_{fe}) \approx r_e\ h_{fe}.$$

The emitter-diode resistance, r_e, shown above, is fundamentally related to emitter current, for:

$$r_e = kT/qI_e,$$

where

k = Boltzmann's constant = 1.38×10^{-23} watt/s/°K,
T = Absolute temperature in °K, and
q = electronic charge = 1.6×10^{-19} coulombs.

This simplifies to $r_e = 26/I_e$ in ohms, where I_e is in mA.

The term h_{fe} is the low-frequency, ac, common-emitter current gain, often designated as β.

The third parameter $C_{b'e}$, is an artificial capacitance used to account for the decrease in transistor gain and increasing phase shift with frequency. It is defined as the frequency-determining parameter. The time constant $C_{b'e}\ r_{b'e}$ is the 3-dB point on the current-gain-vs-frequency curve. If $C_{b'e}$ is defined in terms of f_T, the gain-bandwidth product, and r_e, as:

$$C_{b'e} = 1/2\pi f_T\ r_e,$$

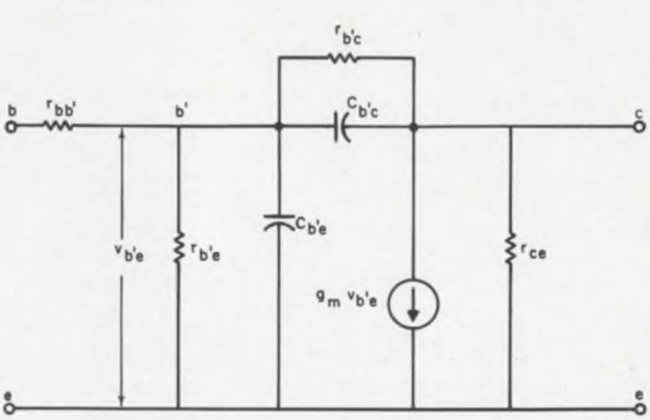
then the effect of h_{fe} variations will be included in the frequency-response calculations by modification of the value of $r_{b'e}$. The half-power frequency then becomes:

$$\omega_{3dB} = 2\pi f_T/h_{fe}.$$

Note that $C_{b'e}$ also varies with the operating point such that the $C_{b'e}\ r_{b'e}$ product remains constant.

The fourth parameter is $r_{b'c}$, the feedback factor:

$$r_{b'c} = [r_e\ (1 + h_{fe})]/h_{re} \approx r_{b'e}/h_{re}.$$



1. **The hybrid-pi is simple and versatile.** It is at its best in broadband analog applications because of its near-dc to cut-off accuracy.

*The model must be modified to include the base-to-emitter voltage drop in order to go completely to dc.

Robert A. Mammano, Assistant Program Manager, ARINC Research Corp., Santa Ana, Calif.

This factor in most modern diffused transistors is usually greater than one megohm and so may be neglected. This is particularly true as the operating frequency is raised and the collector-base capacitance begins to bypass $r_{b'c}$.

The fifth parameter is $C_{b'c}$, the capacitance of the reverse-biased collector-base junction, and it is usually defined as C_{ob} on the data sheets. For diffused-base transistors, this capacitance is a function of the area of the collector-base junction and the cube root of the collector-base dc voltage:

$$C_{b'c} = A(k/V)^{1/3},$$

where k is a constant related to the dielectric constant of silicon and the impurity profile of the junction.

The sixth parameter, current gain of the hybrid-pi, is equal to the voltage from b' to e times the transconductance, which is defined as:

$$g_m = h_{fe}/[r_e\ (1+h_{fe})] \approx 1/r_e.$$

This means that g_m is also directly proportional to the dc operating current so that the current gain, $g_m V_{b'e}$, is constant.

The final parameter, r_{ce}, is related to the common-emitter output impedance as:

$$r_{ce} = 1/(h_{oe} - h_{re}/r_e).$$

This parameter is quite large and is often neglected without much loss of accuracy.

Model accuracy is easily verified

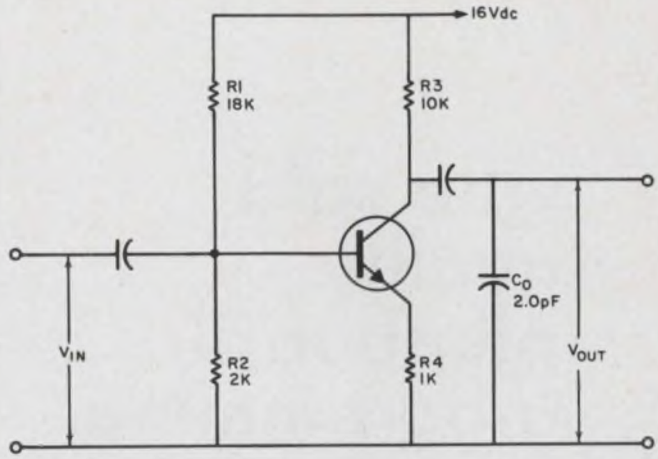
To determine the accuracy of the hybrid-pi model, several transistors were characterized by accurate measurement of their parameters. These units were then inserted in the circuit shown in Fig. 2, and their performance was measured as a function of frequency. An exact analysis was then performed mathematically, by use of the equivalent circuit of Fig. 3, and the calculated results were compared with those experimentally obtained. Both calculated and measured data for 2N918 and 2N-3507 transistors are plotted in Fig. 4.

The curves of Fig. 4 show a high degree of correlation between theory and practice. Slight differences that do exist can be attributed to instrumentation error and the 5% resistors that were used for the laboratory tests.

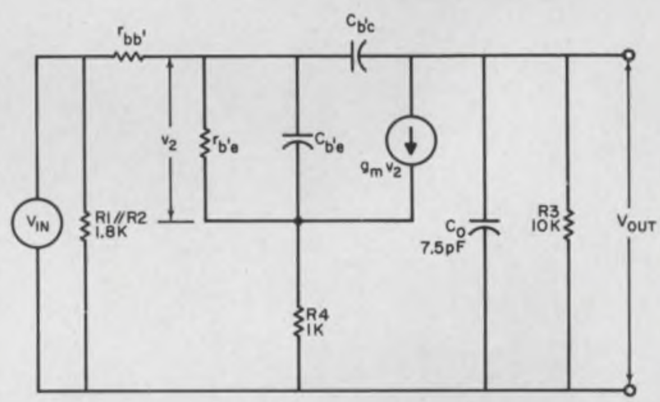
Putting the hybrid-pi to work

To use the hybrid-pi in parameter variation studies or worst-case analysis, tolerances must be determined for each of the parameters, which may then be used in any combination to provide realistic performance characteristics. A reasonable tolerance for each of the parameters that must either be measured or taken from the data sheets is as follows:

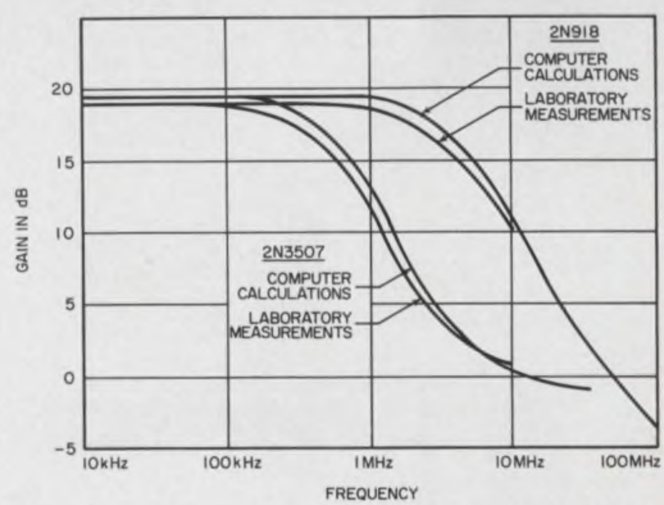
$r_{bb'}$ ±10% due to primary dependency upon geometry and resistivity.



2. **Check the hybrid-pi's accuracy** with this circuit. C_o represents the test equipment input capacity.



3. **Here's the equivalent circuit of Fig. 2.** It can be analyzed by computer to obtain the circuit's frequency response.



4. **The hybrid-pi's accuracy is demonstrated** in this graphical comparison of the calculated and measured values of frequency response for two different transistors connected in the circuit of Fig. 2.

r_e	$\pm 5\%$ due to fundamental relationship with dc current.
h_{fe}	specification limits.
f_T	$\pm 20\%$, since the major bandwidth variability is due to both geometry and diffusion depths.
$C_{b'c}$	$\pm 5\%$ due to the major dependency upon geometry.
h_{re} and h_{oe}	$+100\%$ and -50%, since these are the most dependent parameters and are also the most loosely controlled.

The parameter that best describes unit-to-unit variations between transistors is h_{fe}. This results from the dependence of h_{fe} on both the base width defined by diffusion depths and on the resistivities. Base width and resistivity are, in turn, functions of the manufacturing process. Possible variations in these physical characteristics within a particular process are roughly:

Geometry control:	$\pm$ 1%
Resistivity:	$\pm$10%
Diffusion depth:	$\pm$20%

Note that different manufacturers of the same transistor type often use different geometries; therefore units from each should be measured before the rough tolerances are assumed to apply equally to all.

The procedure for defining the model parameters for a given application, whether the computations are performed by hand or with the aid of a computer, should be as follows:

1. Obtain values for h_{oe} and h_{re}, either by measurement or from manufacturers data, and compare with the circuit impedances to determine whether they need be considered.
2. Determine values for $r_{bb'}$, f_T, and $C_{b'c}$, again either by measurement or from data sheets.
3. Determine the dc emitter current from which the value of r_e may be calculated with the use of $r_e = kT/qI_e$.
4. Calculate $r_{b'e} = r_e h_{fe}$.
5. Calculate $C_{b'e} = 1/2\pi f_T r_e$.
6. Calculate $g_m = 1/r_e$.
7. If necessary calculate $r_{b'c} = r_{b'e}/h_{re}$ and $r_{ce} = 1/(h_{oe} - h_{re}/r_e)$.

If the parameters in steps 4 through 7 are calculated from the more independent quantities in steps 1, 2, and 3, the tolerances may be applied in any combination to obtain worst-case performance while still describing realistic transistors. A high-gain transistor then automatically has high input impedance, since $r_{b'e}$ is calculated from the appropriate value of h_{fe}. ■ ■

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Joyce, M., and Clarke, K. *Transistor Circuit Analysis*. Reading, Mass.: Addison-Wesley Publishing Co., Inc., 1961.

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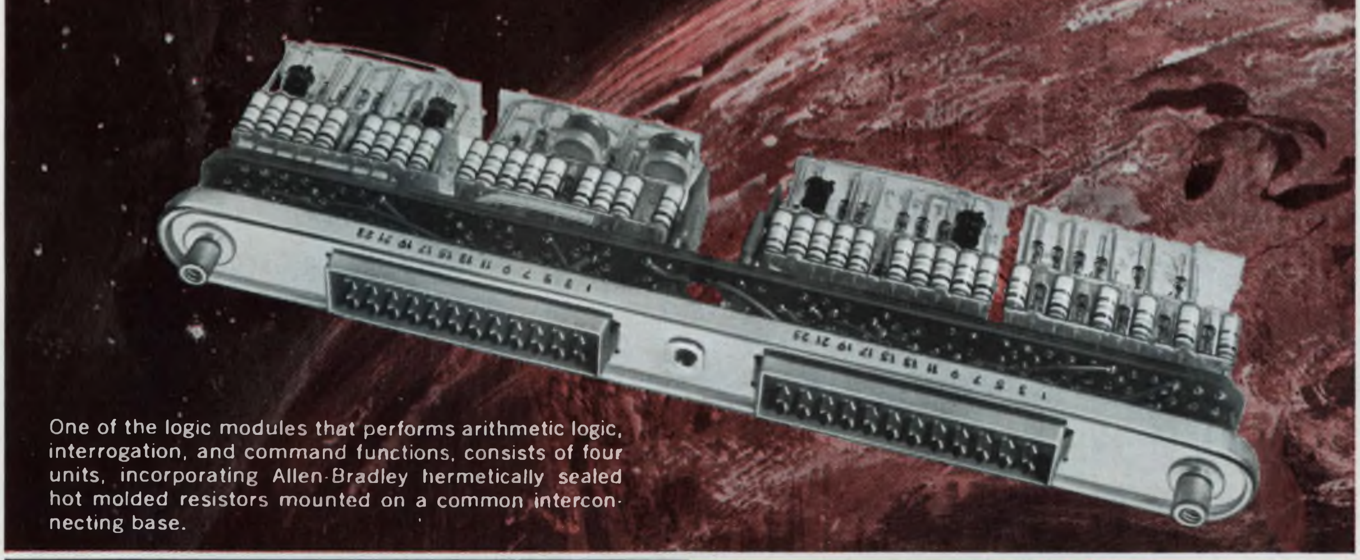
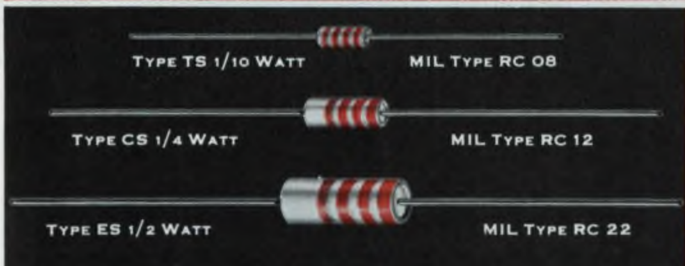
Allen-Bradley hermetically sealed hot molded resistors help guidance computer in Saturn I space vehicle put payload into orbit



One of the logic modules that performs arithmetic logic, interrogation, and command functions, consists of four units, incorporating Allen-Bradley hermetically sealed hot molded resistors mounted on a common interconnecting base.



HERMETICALLY SEALED HOT MOLDED RESISTORS available in all standard EIA and MIL-R-11 resistance values and ±2% or ±5% tolerances. Other than standard values can be furnished. Shown actual size.

Saturn I guidance computer continuously determined the vehicle's course to achieve orbit. In six test flights, these computers in the NASA Saturn I vehicle controlled the direction and thrust of six second-stage engines. The computer on four of the flights controlled four of the first-stage engines as well, and also timed engine cut-off.

From the instant of "blast-off" this guidance computer set the course of the space vehicle. The ultimate in precision was essential, for even the slightest misdirection could mean total failure. Reliability had to be maintained under hardly believable conditions of shock and vibration. Given such conditions, it is small wonder that the A-B hermetically sealed hot molded resistors were selected for this assignment.

All Allen-Bradley resistors are made by an exclusive process—pioneered and perfected by A-B—in which the resistance element and the insulating jacket are hot molded into a solid integral element. For the ultimate in environmental protection, this unit is then hermetically sealed in a ceramic tube. The hot molding process results in such exact uniformity from one resistor to the next—and from one year to the next—that long term resistor performance can be accurately predicted. Furthermore, unlike film resistors, no A-B hot molded resistor has ever been known to fail catastrophically.

For more complete specifications on the Allen-Bradley hot molded resistors, please write for Performance Specifications 5003: Allen-Bradley Co., 1344 South Second St., Milwaukee, Wis. 53204. In Canada: Allen-Bradley Canada Limited. Export Office: 630 Third Ave., New York, N.Y., U.S.A. 10017.

These are the same hot molded resistors as used in the hermetically sealed construction described above. Shown actual size.

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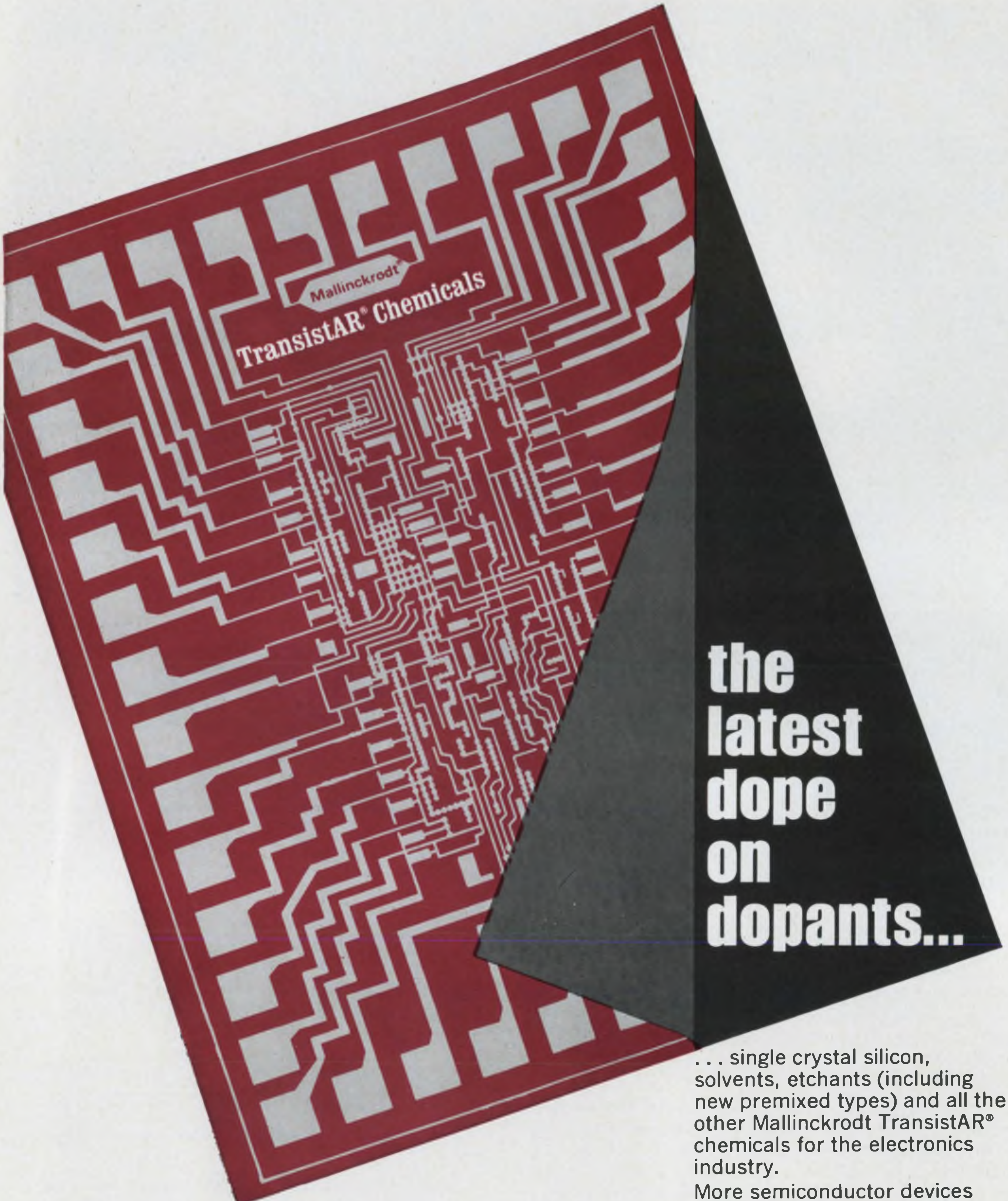

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Read out magnetic shaft encoders with pulsed drivers. Systems using blocking oscillators draw less current than sine-wave types.

Pulsed drivers are seldom used to read out information from magnetic shaft-position encoders. Yet they offer advantages over the commoner, simpler sine-wave drivers.

- They require no demodulators at the code-wheel output.
- They impose a smaller current drain because they run only when interrogated.
- They produce an output only when required to.

Because they use blocking oscillators, pulsed drivers are more difficult to design than sine-wave types. This drawback is compounded by a paucity of information on the pulsed technique in the literature.

But design need not be a great problem. Take, for example, a pulsed driver that was designed to read out a magnetic shaft-position encoder used in underwater tracking equipment. It is pulsed, or interrogated, every time a digitized output is desired, the repetition rate synchronized with the clock running the over-all digital system.

Robert Bruce, Senior Engineer, Sperry Gyroscope Co., Great Neck, L. I., N. Y.

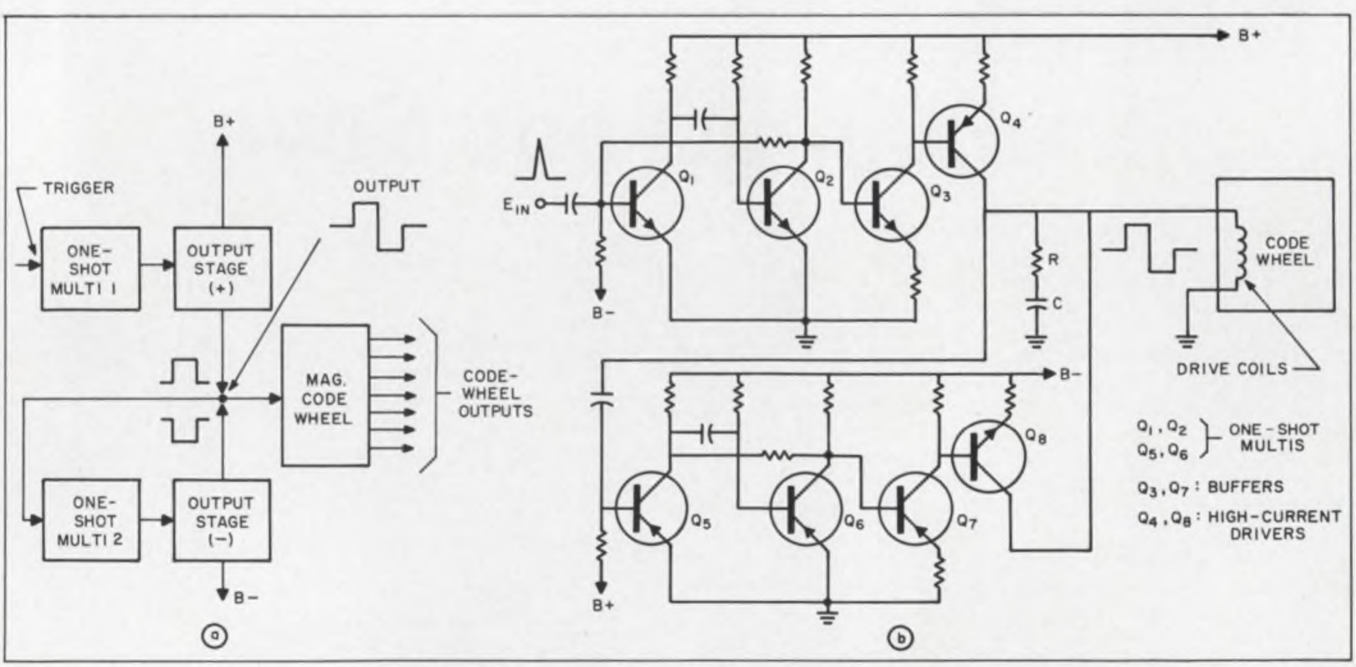
Usually the repetition rate is chosen so that successive outputs differ only by a small amount—the change of the least significant bit. In general, the code wheel should be pulsed every T seconds to fulfill this criterion:

$$T \leqslant \frac{60}{rpm} \times \frac{1}{2^n}, \qquad (1)$$

where rpm = revolutions per minute of the shaft and n = number of bits in the code wheel.

Figure 1a shows one of the more obvious circuits for a pulse driver. In the schematic (Fig. 1b), Q_1 and Q_2 constitute a one-shot multi, which receives the input pulse and generates a gate of fixed interval. Q_3 raises the current level to drive Q_4, which supplies a positive pulse of (typically) 1/2-A-peak to the code wheel. The trailing edge of the pulse at Q_4 triggers the second one-shot multi, consisting of Q_5 and Q_6. The output of Q_6 drives Q_7, which supplies the proper current level for Q_8. Q_8 puts out a negative 1/2-A current pulse to the code wheel.

Both positive and negative pulses feed to the same point and are, in effect, one cycle of a bipolar square wave. The positive half cycle sets all the cores in the code wheel; the negative half cycle



1. **Typical pulse-driver circuit** (a) uses separate one-shot multis to produce bipolar square wave to interrogate code wheel. Too complicated, the bipolar drivers (b) require two power supplies and eight transistors.

resets them. The RC network at the output absorbs the inductive energy stored in the code wheel at the end of the negative pulse, preventing overshoots.

Blocking oscillation simplifies driver

The shortcoming of the circuit of Fig. 1b is that it requires two power supplies and eight transistors. A far simpler circuit can be built around a blocking oscillator (BO).[1, 2, 3] Such a two-transistor circuit (see Fig. 2) requires only one power supply. Its most critical part is the pulse transformer and the RC damping network across the primary. The pulse width is determined by the primary inductance, turns ratios, the alpha of Q_2 and load resistance. In general:

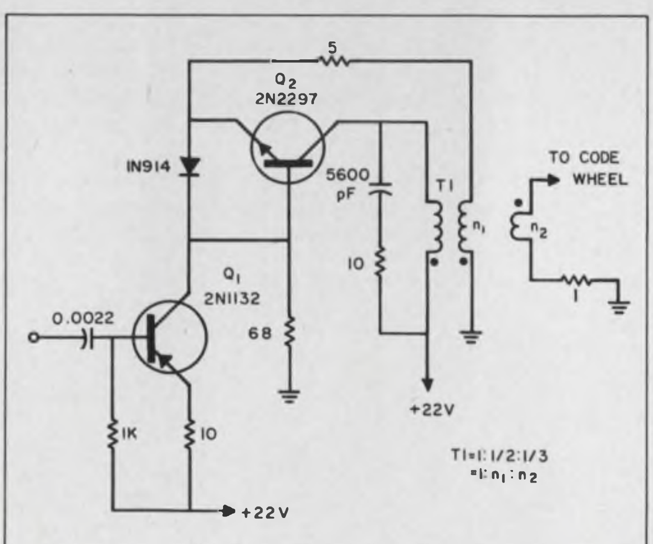
$$\tau = L\left[\frac{n_1}{R_e}(\alpha - n_1) - \frac{n_2^2}{R_L}\right], \qquad (2)$$

where

L = Primary inductance, τ = BO period,
n_1, n_2 = turns, α = alpha of Q_2,
R_e = emitter resistor, R_L = code wheel drive coil resistance.

This equation can also be used to determine whether there is enough feedback to support an oscillation. If τ comes out negative, there is not. In this case, the circuit would become a regenerative pulse amplifier with the period of the output determined by the input.

This equation does not account for the core losses and magnetic nonlinearities in the code wheel. These have the effect of an even heavier load than the code-wheel coil resistance; they shorten the pulse width. The proper pulse duration depends on the switching time of the cores in the code wheel and on the amount of surplus current they receive over and above the minimum required



2. **Blocking oscillator driver** needs at least two transistors and a single power supply. Inductive kick of BO resets the cores in the code wheel. Signal-to-noise ratio of the wheel output was better than 20 dB before thresholding, 30 dB after thresholding.

to switch them.[4]

With a rectangular pulse of 500 mA peak, most cores will switch in 2 μs. Between 4 and 8 μs for a half cycle leaves margin for variation in circuitry and cores. The circuit in Fig. 2 has a pulse duration of about 5 μs, but the inductive kick, used to reset the code wheel cores, is only 2 μs. This means that the code wheel cores are not completely reset and thus put out a lower voltage. The S/N ratio of the code wheel output is therefore poorer with a BO driver than with a true bipolar pulse driver (Fig. 1b).

The inductive kick at the end of a blocking-oscillator cycle can cause a voltage spike that will destroy the transistor.[2] To prevent this, many BO circuits have a catching diode across the transformer primary which permits the primary current to flow after the transistor cuts off. It also prevents the transistor collector voltage from going more positive than B+. The code wheel, however, needs a bipolar drive pulse to set and reset it. Without a catching diode, the BO ouput spike can go as high as 150 volts. The energy in the inductive kick could be used to reset the cores in the code wheel, but this part of the pulse has too short a duration to be effective. A catching diode would only clip the negative portion of the pulse.

The RC network across the transformer primary in Fig. 2 controls the rise and fall times, limits the voltage amplitude and spreads out and decreases the pulse from the inductive kick. The RC values are best determined empirically.

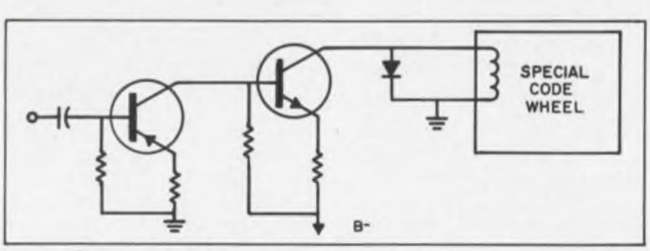
A word of caution is necessary. It is very easy to turn this circuit into a free-running oscillator. The circuit must have enough damping to prevent it from free-running. The 1-Ω resistor in series with the code wheel is used to monitor the drive current.

The circuit in Fig. 2 yielded a signal-to-noise ratio better than 20 dB before thresholding except in the 2°, or least significant, digit of a Librascope model 813 code wheel. The 2° bit had 15-dB S/N ratio before thresholding. After thresholding, all outputs had a S/N ratio better than 30 dB.

Unipolar driver for less square cores

It is clear that most magnetic code wheels must have a bipolar drive pulse, and that most of the design effort goes into obtaining a sufficiently simple circuit with bipolar output. However, not all magnetic code wheels need a bipolar driver. Some have cores with low squareness ratios (0.8 or less), so that they put out large signals with a unipolar drive.

The circuit in Fig. 2 will put out an essentially unipolar pulse if the 5600-pF capacitor is replaced with a catching diode. A simple pulse amplifier with no transformer at all can do the same thing (see Fig. 3). The cores in the code wheel must, however, be specified to have squareness ratios of 0.8 at most. ■ ■



3. **Unipolar driver** can also be used if cores in code wheel have low squareness ratio (0.8 or less) so that they put out large signals.

Shaft encoders: how they work

Shaft-position encoders are used to translate a shaft angular position—an analog quantity—into digital form. Most familiar is the brush encoder with concentric annular tracks, each with alternating conducting and nonconducting segments.[5, 6, 7]

The operating principle of the brush encoder applies to the magnetic type: each output lead puts out either a voltage to indicate a one or no voltage to indicate a zero. However, there is a basic difference. The brush encoder uses conduction to put out its dc signals; the magnetic encoder relies on magnetic induction to put out ac pulses.[7, 8]

With inductive coupling, there is no physical contact between the stationary and rotating portions of the wheel, except for bearings. Thus, the magnetic code wheel offers much longer life and much higher rotational speeds. The price for this is higher cost (about 4:1) and more complex drive and read-out circuitry.

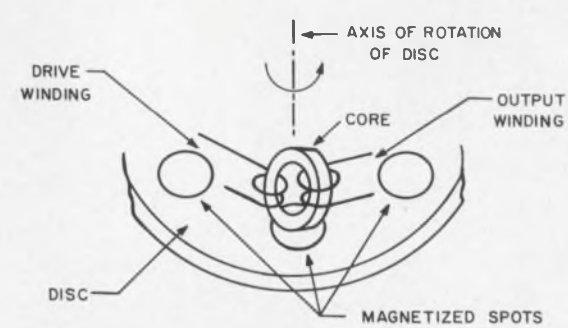
One 13-bit brush encoder, for example, has a life expectancy of 2 million rotations at 100 rpm, while a 13-bit magnetic encoder offers 1 billion revolutions at 4000 rpm.

Each Track Has Read-out Core

The input to a magnetic code wheel is high-frequency ac—either sine-wave or pulse—which feeds each of the read-out heads. The heads consist of fixed square-loop ferrite cores, one for each track, or bit, in the code wheel (Fig. A).

A track on the wheel is occupied by the pattern for one bit, such as the 2° bit. The pattern alternates magnetized spots and unmagnetized areas. The core is next to, but does not touch, the rotating track.

When the core is above a magnetized spot, the magnetic flux from the spot saturates it. Any signal to the drive winding is not coupled to the



A. **Magnetic code wheel disc** uses ferrite-core read-out heads adjacent to rotating track of magnetized spots to detect ones and zeros.

Acknowledgment:

The author acknowledges the prior work of P. Hartung of Sperry Gyroscope Corp. on magnetic code wheels and his valuable advice on this development.

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1. J. G. Linvill and R. H. Matson, "Junction Transistor Blocking Oscillator," *Proc. of the IRE*, XLIII, No. 11 (Nov., 1955).

2. *Handbook of Selected Semiconductor Circuits* NAVSHIPS 93484), pp. 6/18-6/21

3. D. J. Hamilton, "A Transistor Pulse Generator for Digital Systems," *IRE Trans. on Electronic Computers*, Sept., 1958.

4. E. C. Geissler, "*Magnetic Circuitry and Applications*" (Sprague Technical Paper No. 62-3).

5. Alfred K. Susskind, *Notes on Analog to Digital Conversion Techniques* (New York and Cambridge, Mass.: John Wiley & Sons, Inc., and MIT Press, 1957), Chap 6.

6. John Bunnell "*In Introduction to Shaft Position to Digital Encoders*" (Librascope Inc. paper dated 3/6/61).

7. "Shaft Angle Encoders" *Computer Design*, Dec., 1963.

8. Jerrold Asher, "Magnetic Encoder," *Electromechanical Design*, March, 1963.

output winding. When the core is above an unmagnetized area, it can couple the drive signal to the output winding. In this manner, the code wheel has an output whenever there's an input of the proper amplitude and polarity.

Each has a low-impedance drive winding (less than 10 ohms) and a higher-impedance read-out winding (over 100 ohms). The drive windings are connected in series or in parallel, and are interrogated by a high-current drive signal.

For example, Electro-Mechanical Research recommends for its code wheels a 1000-mA peak-to-peak signal with a minimum rise time of 1000 mA/μs. Librascope recommends 1500 mA peak-to-peak; Norden, 350 mA rms, which is 990 mA peak-to-peak. Since the cores in the read-out heads have a square hysteresis loop, they require a bipolar drive signal. In other words, every interrogate pulse should have a positive and negative half cycle to set and reset the core. Otherwise, each successive pulse would produce only a very small output, as with a half-selected memory core.[8]

The tracks are arranged geometrically to change in binary sequence. The table below shows how the outputs of the various tracks vary with shaft angle in a hypothetical code wheel.

	Tracks								
Shaft angle	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
(degrees)									
1	0	0	0	0	0	0	0.	0	1
2	0	0	0	0	0	0	0	1	0
3	0	0	0	0	0	0	0	1	1
•									
•									
256	1	0	0	0	0	0	0	0	0
•									
•									
359	1	0	1	1	0	0	1	1	1

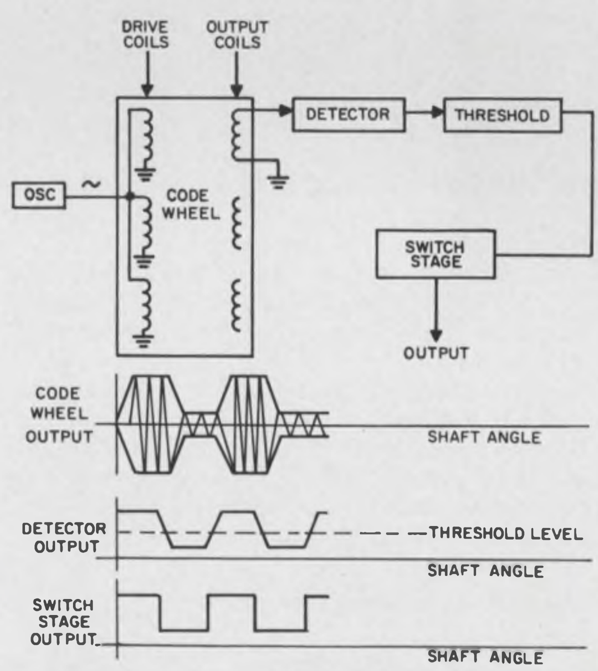
As the shaft is turned, the nine heads put out ones and zeroes in a binary sequence. This hypothetical code wheel divides one revolution into 360 increments; this requires a nine-stage counter, with 359° yielding the outputs shown. An actual code wheel divides a rotation into 2^n increments where n is the number of bits or pickup heads.

An important characteristic of magnetic encoders is the signal-to-noise ratio of the output. This is the ratio of the output voltage when it puts out a one to the voltage when it puts out a zero. With a well-designed driver circuit the S/N ratio is over 15 dB, which makes it easy to distinguish a one from a zero.

With a poorly designed driver, it can be 10 dB or less. Such a poor S/N ratio requires elaborate thresholding circuits at the output of the code wheel. There, a well-designed driver pays off.

One of the first drive systems used with magnetic code wheels was continuous sine-wave interrogation. With this method, an amplifier feeds a continuous high-frequency sine wave (in the range of 20 to 200 kHz) to all drive coils. The output, however, is not sinusoidal but a series of bipolar pulses. These must usually be demodulated and their envelope used to perform logical operations.

Figure B shows a block diagram of one channel of a magnetic code wheel with sinusoidal drive, and the output as a function of shaft angle. Note that the code-wheel output does not drop to zero instantly as the shaft angle increases. This is because the code wheel has a definite region of transition from one to zero. The slope of this transition region can be used as a figure of merit for the code wheel: the steeper the better. Manufacturers do not generally publish specs or data on this, so that the user must evaluate which model is superior in this respect. The threshold circuit in Fig. B makes the decision as to where the boundary is located between adjacent ones and zeroes.



B. **Carrier-driven code-wheel system** converts sine wave at the input drive coils into bipolar output pulses, which are then demodulated. Logic operations are performed with pulse envelope.

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For fast and balanced RF pulses, any experienced designer might recommend modulating a cw signal. The trouble with this approach is that standard series- or shunt-diode modulators either lack good on-to-off ratios or produce a pedestal in the output.

Engineers at LTV Electrosystems, Inc., came up with a simple, ingenious circuit that solves the problem by combining the best properties of both the shunt- and series-diode modulators (Fig. 1). Their modulator can generate RF pulses with 5-ns rise times, which are needed to test pulsed radar receivers, telemetry receivers and similar systems. While series modulators are less susceptible to pedestals in the output, their on-to-off amplitude ratio is not so good as the shunt type's. In the kilohertz range, the series modulator performs satisfactorily, but as the ac signal reaches the megahertz level, the diode's parallel capacitance will pass enough signal to prevent good on-to-off ratios.

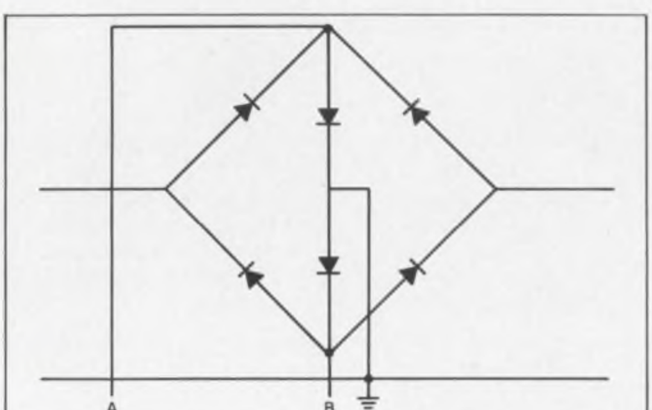
W. Glen Urbach, Jr., Electronic Systems Engineer, LTV Electrosystems, Inc., Dallas, Tex.

Shunt modulators, on the other hand, have better on-to-off amplitude ratios but produce a pedestal in the output. A pedestal, superimposed on an RF signal, produces variable results that depend on the manner in which the signal is used in the succeeding circuitry. Generally, RF circuits are coupled by low values of capacitance that differentiate the pedestal, filtering the low-frequency components of the pulse. Detection of this envelope produces a distorted pulse, instead of the expected flat-topped video pulse (Fig. 2). Two effects give rise to this pedestal in shunt modulators:

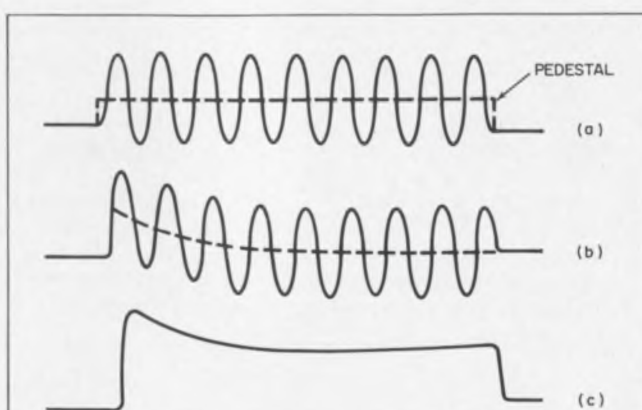
- If the forward resistance, R_f, is not matched for all four diodes in the ring, the turn-on current, I_f, will produce an $I_f R_f$ voltage, which appears as a pedestal in the output.
- An additional offset will be added to I_f if the forward curves of the diodes do not break at the same voltage point.

The simplicity of the new circuit is evident in Fig. 1. Its operation is just as straightforward.

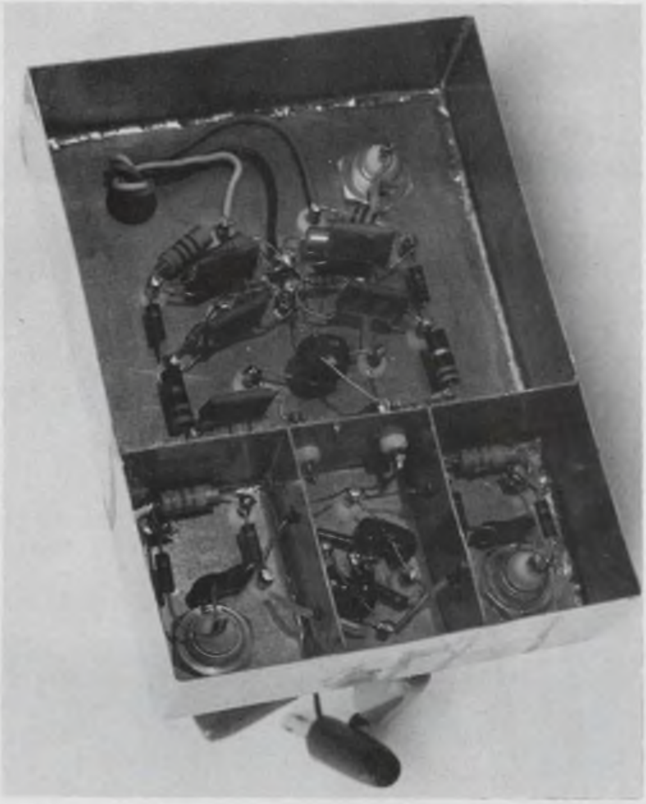
When the voltage at A is positive with respect to the voltage at B, the series diodes are reverse-biased, the shunt diodes are forward-biased and



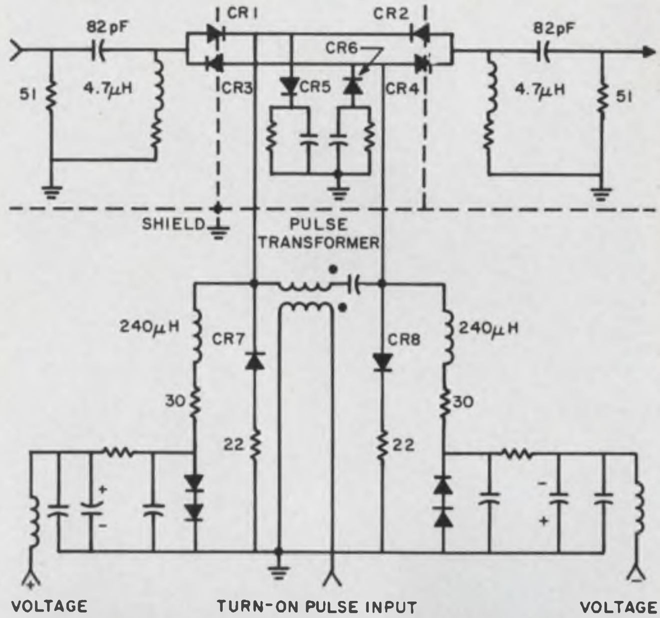
1. **Diode modulator** combines best properties of conventional series and shunt types. The circuit conducts when point B is positive with respect to point A.



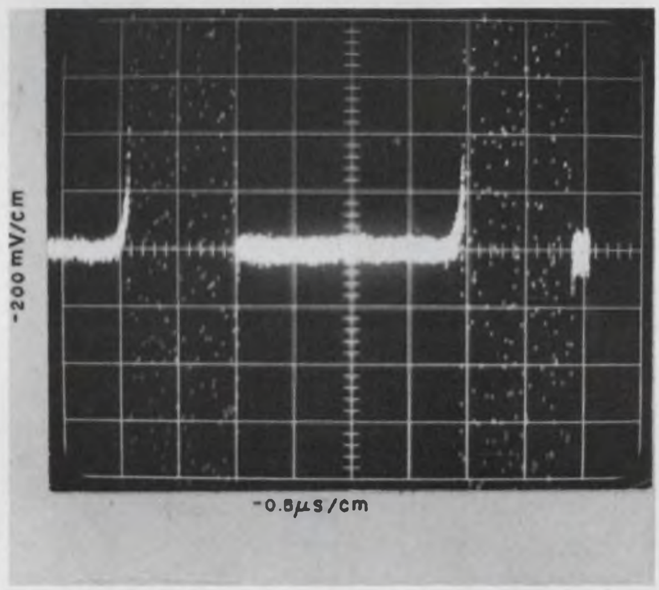
2. **Pedestal superimposed on RF pulse** (a) gets differentiated by coupling RF capacitors (b) and distorts the envelope of the RF pulse (c).



3. **Breadboard of diode modulator** indicates shielding, necessary in the megahertz range. The diodes protrude through holes in the shield.



4. **Circuit diagram** of diode modulator shows associated matching and biasing networks. The pulse transformer supplies floating turn-on pulses.



5. **Modulator uses hpa 2303 diodes** to produce two 1-μs pulses with 2-μs separation from a 150-MHz cw signal. No feedthrough is apparent.

there is no output. Signals leaking through the input diodes encounter a low impedance across the line and a high impedance in series with the signal path. When the voltages at *A* and *B* are reversed, the conduction states of the series and shunt diodes are reversed, and the slightly attenuated signal passes through the switch.

In the upper megahertz range, shielding prevents radiation feed-through of the modulated RF (Fig. 3). Note that the diodes in the modulator ring protrude through holes in the shield.

The final circuit, shown in Fig. 4, includes input and output matching networks and power supplies for forward and backward biasing.

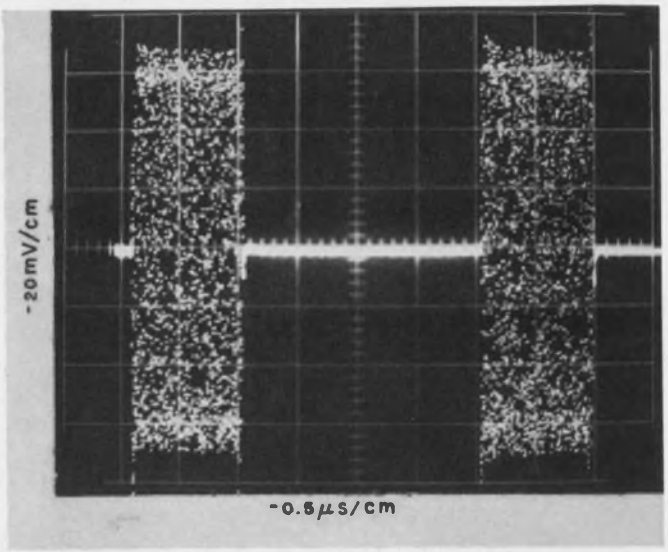
A large inductance in series with each supply prevents the turn-on pulse from being loaded through the supplies.

The turns ratio of the transformer should be such that the secondary voltage will cancel the reverse-biasing voltage during the turn-on period and also appear as a current source to the diodes.

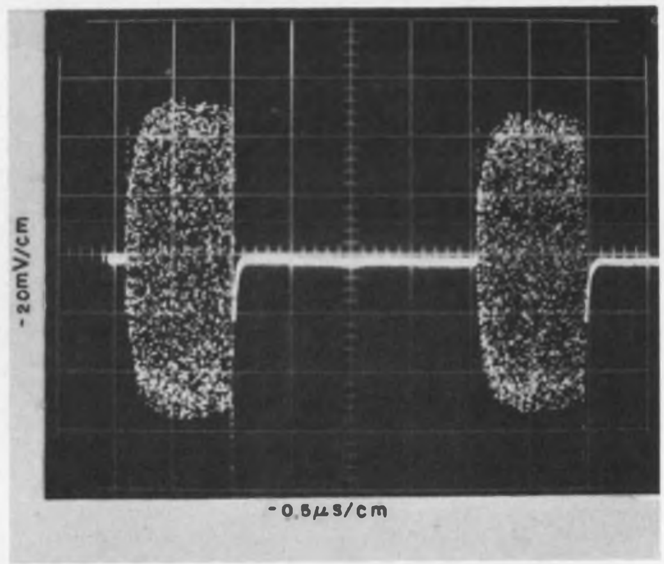
To ensure a balanced turn-on pulse with reference to ground, resistors in series with *CR7* and *CR8* provide a balanced load with respect to ground for the transformer secondary. As a result, the turn-on signal is a floating pulse from the transformer. If the pulse were tied to ground, its leading and trailing edges would generate transients. *CR7* and *CR8* prevent the reverse-bias voltages from being loaded by these resistors.

The parallel RC circuit in series with the shunt diodes improves the operation. The resistors limit the current through the diodes during inhibit periods, and the capacitors bypass the resistors for any leakage signals being shunted to ground during the inhibit periods. Too large a capacitor value here will cause spikes at the leading and trailing edge of the turn-on pulse. The capacitance must, nevertheless, be large enough to present a low impedance to the signal being modulated.

Three diode types—a hot-carrier diode, hpa 2303; a silicon diode, 1N914B Uni-G, and an inexpensive germanium diode, 1N67A—were



6. **Modulated output** of circuit with 1N914B UNI-G diodes at 150 MHz has the same quality as with the hot-carrier-diodes.



7. **Deteriorating rise time** characterizes the output of the modulator with 1N67A germanium diodes.

evaluated in the circuit. Performance criteria were insertion loss during conductance, on-to-off output ratio, rise time and recovery time of the switching circuit.

With the hpa 2303 diode, the modulation of a 1-mW, 150-MHz, cw-input signal yielded two 1-μs pulses, 2 μs apart, and a loss of 14.7 dB through the diodes and matching networks. No feed-through was apparent (Fig. 5).

The 1N914B Uni-G silicon diode performed like the hpa 2303 diode at 150 MHz cw (Fig. 6).

When 1N67A germanium diodes modulated the 150-MHz cw signal, the rise time deteriorated at the leading edge of the pulse (Fig. 7). Although invisible on the photographs, there were leading- and trailing-edge spikes on the waveforms. The insertion loss went up to 21 dB. ■ ■

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- Independent load control.
- Explosion-proof circuitry.

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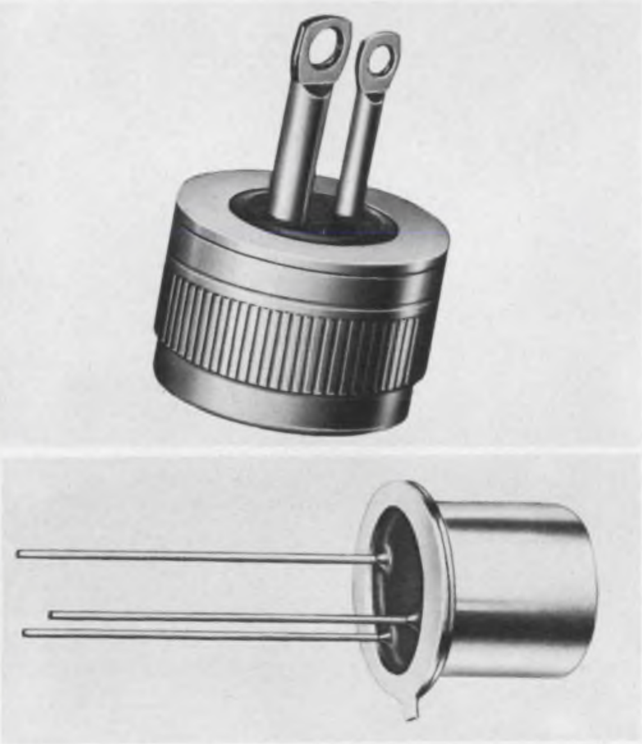
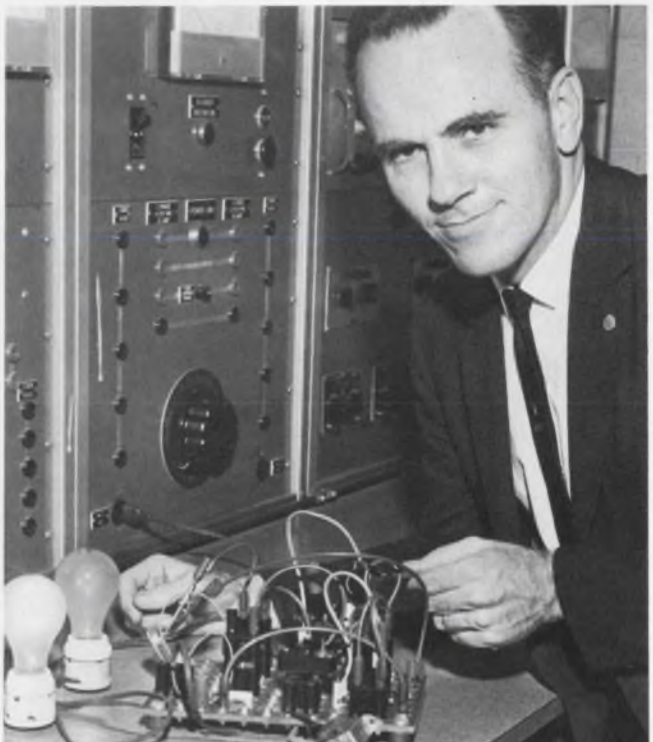
E. Keith Howell, Manager-Light Industrial and Consumer Controls, General Electric Co., Auburn, N. Y.

Weaknesses of mechanical design

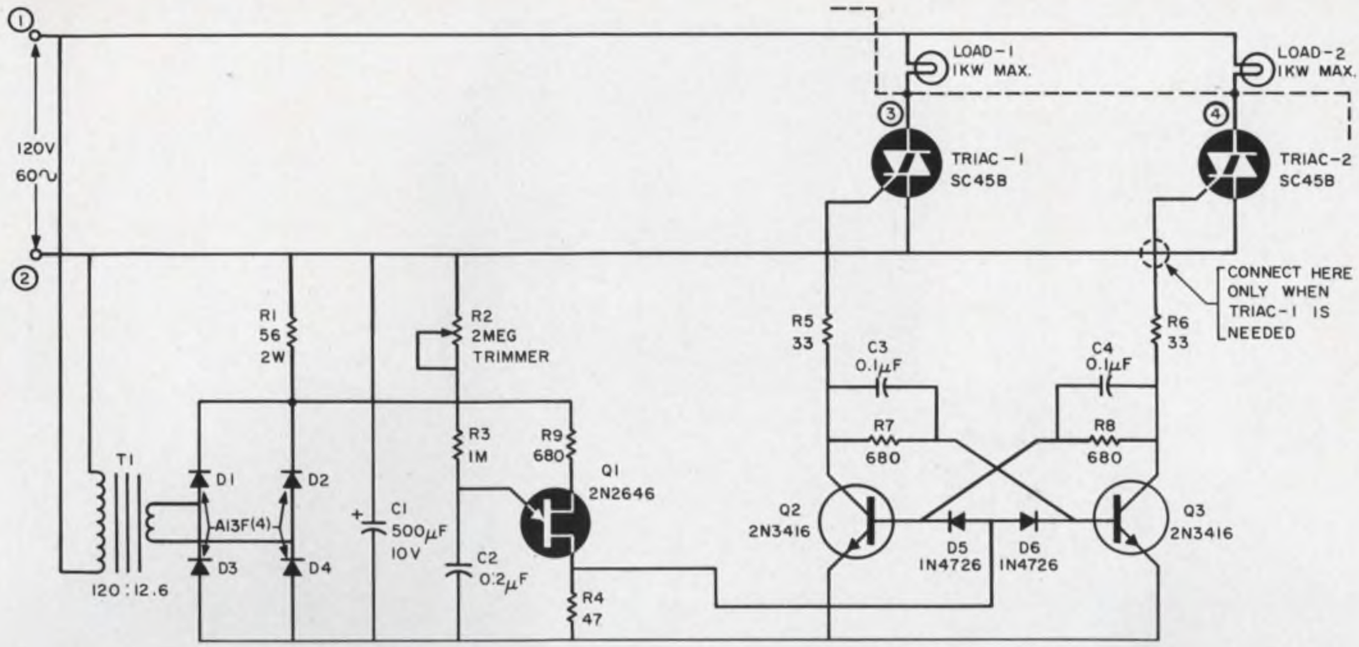
In general, flashing lamps are frequently used in industrial and traffic-signal applications. Although many of these applications use single-circuit flashers, a large number require dual circuits that flash lamps alternately in a flip-flop



Semiconductor components like this Triac (top) and unijunction transistor (bottom) improve flasher designs. Lasting, more reliable operation and small size are just a few of the benefits brought by the solid-state units.



To make one light dimmer Author Howell uses his all-solid-state dual flasher design. It provides balanced control of the intensity of the two lamps.



Dual flasher is all-solid-state. One kW of power is handled without a motor-driven cam actuator. The semiconductor system is smaller, quieter, costs less and has longer life than its electro-mechanical counterpart.

arrangement. Associated with these dual systems are the limitations of conventional electromechanical control.

Flashers for these applications typically consist of a small motor-driven cam actuating heavy silver contacts. The electrical wear on these contacts is the major limitation on their life; it is caused by the high inrush current when a tungsten lamp is turned on.

The speed of rotation of the cam is generally set to produce approximately 55 flashes per minute. This speed, instead of 60 flashes per minute, is chosen to avoid having the contacts close at the same point on the 60-Hz waveform. If the points coalesce, excessive wear and very short life result.

With the new system (see schematic), in which the circuit provides flip-flop operation of two 1-kW lamp loads, this is no problem. Also, since the control circuit is completely independent of the loads, it can provide simple on-off flashing of either load alone.

The transformer and bridge rectifier form a low-voltage dc supply that is filtered by *R1* and *C1*. Unijunction transistor *Q1* is connected as a simple, free-running relaxation oscillator with an adjustable range of operation between 30 and 90 Hz. The interbase voltage for *Q1* is taken from the raw output of the bridge rectifier in order to synchronize the relaxation oscillation with the supply frequency. This connection also provides modulation of the interbase voltage, which permits the use of a charging current for capacitor *C2* that is well below the required peak-point current for the UJT.

Switching technique minimizes RFI

Output pulses developed across *R4* occur near the point of zero voltage in the supply waveform. Note that this switching, when the line voltage is low, minimizes radio frequency interference.

The output pulses are coupled into a transistor flip-flop circuit that alternately drives the gates of the two Triacs.

If only a single-circuit flasher is required, load 2 and Triac 2 may be eliminated and *R6* connected to line 2, as indicated in the diagram. Since the transistors provide a negative dc gate signal to the Triacs during the conduction time, and because the occurrence of the signal is synchronized with the line voltage, the operation of this switch generates very little electrical noise.

The point on the waveform of the supply voltage at which the Triacs are first turned on is governed by the phase shift in transformer *T1*. This phase shift can cause switching to occur a short time after the zero-voltage crossover. The action causes an overlap in the switching operation whereby both loads are energized for one-half cycle of the supply frequency. This overlap can occur only during a switching transition; hence it is not theoretically possible to have both loads visibly energized at the same time.

The only possible exception to this would be if the Triac were so sensitive that the normal transistor base current would be enough to turn it on. In this case the Triac could be desensitized by a suitable resistor placed between the gate and anode 1.

The solid-state system also offers design flexibility. Modifications of this flasher circuit are easily made, to accommodate a switching action controlled by signals from photocells, themistors or dc control sources. ■ ■

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Op amp drives capacitor to measure 3-ns-pulse heights

An inexpensive, simple time-gate generator measures the height of 3-ns pulses, can generate linear ramps and may also be used as a peak follower, as a variable delay or as a fast operational amplifier.

The circuit (see schematic) consists of an operational-type amplifier, *Q1*, *Q2* and *Q3*, that drives a timing capacitor, *C6*, through a fast diode, *D1*. The capacitor is charged to the peak negative input voltage and this voltage is used to hold back the input at the base of *Q2*.

When the input voltage falls below the peak level, the diode will be reverse-biased by 8 V until the capacitor discharges with the aid of a constant current that passes through *Q5*.

The time-gate's output level is provided by the inverter, *Q4*. The output goes from ground to −3 V during the discharge period. Since the current is kept constant, this duration is proportional to the negative peak of the input. The output may be used to gate a counter to obtain a digital output.

Although inexpensive components may be used, the operation remains stable and fast.

When *R1* = 100 ohm, *C1* = 0 pF, and *C6* = 470 pF, an output duration of about 20 μs is obtained for a −6-V peak input of any duration between 3 and 300 ns. The duration of the output will allow the measurement of pulse heights with an accuracy of ±5%.

When *R1* = 1000 ohm, *C1* = 470 pF and *C6* = 4700 pF, pulse heights from 10 mV to 10 V may be measured with an accuracy of ±1%. The input pulse should last from 300 ns to about 3 μs under these conditions. A 10-V input will be converted to about 300 μs.

Input pulses as short as 1 ns with peak amplitudes over 1 V will produce an output duration of more than 1 μs.

The operation may be made more accurate and may cover a wider range of slower input pulses if *R1*, *C1* and *C6* are adjusted. *R1* and *C1* smooth out the input noise, and *R14* and *C6* improve the discharge time or the sensitivity of the amplitude-to-time conversion.

P. de Bruyne, Engineer, Harvard Cyclotron Lab., Cambridge, Mass.

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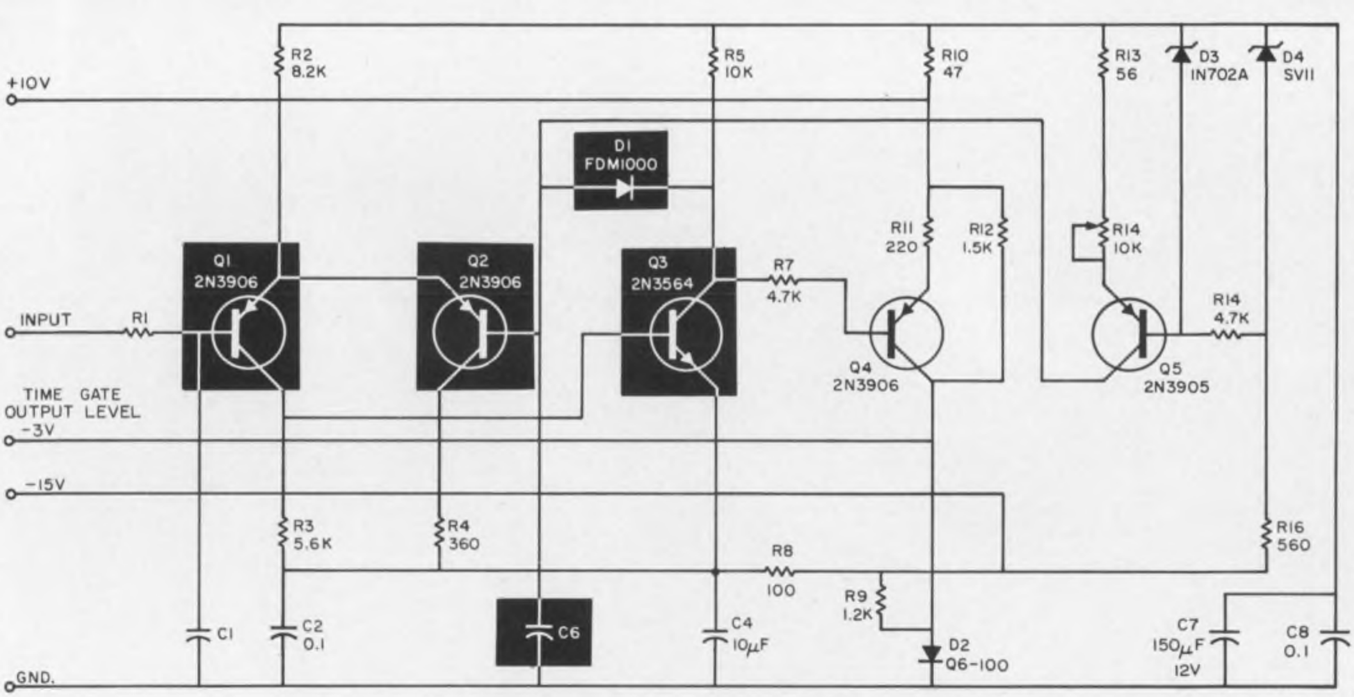

Time-gate generator formed by operational amplifier (Q1-Q2-Q3) driving timing capacitor (C6) through diode (D1). Circuit measures height of pulses as short as 3 ns and generates linear ramps.

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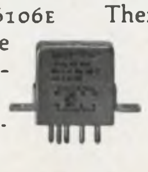

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IC and bipolar form compact pulse generator

A single integrated circuit (IC) and one bipolar pnp transistor may be combined to form a voltage-controlled pulse generator. Circuit simplicity and compactness are the result.

The circuit (see schematic) produces a pulse in response to an applied trigger. The width of the output pulse is controllable over a 500-to-1 range by a reference voltage. The pnp transistor, the FV3502, is housed in an 0.150-inch-diameter flat package; the integrated circuit is in a 0.25-by-0.25-inch flat-pack case.

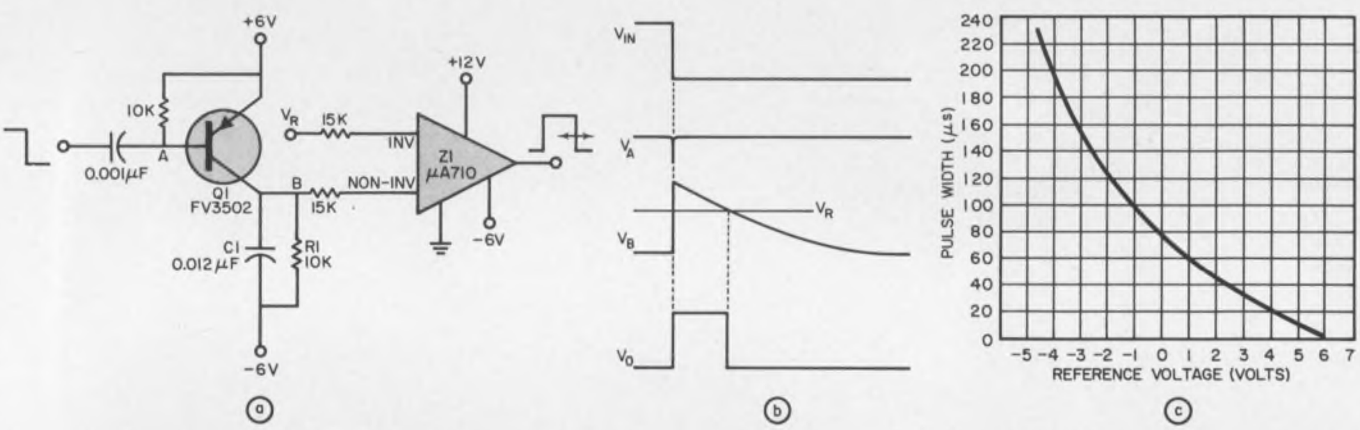
During operation of the circuit (see "a"), *Q1* is statically cut off with its collector at a negative voltage. The negative portion of a differentiated input trigger saturates *Q1*, and rapidly charges *C1* to +5 V less the saturation voltage of *Q1*. At the conclusion of the trigger pulse, *C1* discharges through *R1* at a speed determined by their time constant. Essentially, stretching and inversion of the differentiated input pulse has been achieved. This waveform is V_B in the timing diagram ("b").

V_B and a reference voltage are applied to a comparator such that when V_B is more positive than the reference voltage we have a positive output and when V_B is less positive than the refrence voltage we have zero output. Then the output pulse width is indeed controlled by the reference voltage (as shown in the timing diagram). In this configuration, the comparator is the μA710 operational amplifier. This amplifier has very high gain, good dc stability, two stable output states when overdriven and excellent rise and fall times. It effectively squares the stretched pulse at the level of the reference voltage.

With values shown, pulse width can be varied from 0.5 μs to 230 μs (see "c"). Excellent stability can be attained if temperature-stable components are used for *R1* and *C1*.

If negative output pulses are preferred, they can be obtained by simply reversing the inverting and noninverting inputs of *Z1*. And if it is desired to make pulse width vs reference voltage a linear function, a single transistor, constant-current generator may be substituted for *R1*.

Bert Pearl, Project Engineer, Hallicrafters, Chicago, Ill. VOTE FOR 111



Just one integrated circuit and a single pnp bipolar are used in this simple, compact pulse generator (a). The μA710 operational amplifier unit serves as a voltage comparator; Q1 stretches and inverts input pulses (b). Voltage-controlled by reference V_R, the unit has a 500:1 output pulse-width range (c).

Integrated dual-storage system solves synchronization need

A common and perplexing problem facing logic designers is to synchronize asynchronous data or pulse streams with a system clock. Use of a dual-storage network consisting of integrated circuit flip-flops and NOR gates solves this difficulty.

The difficulty of nonambiguous sampling (sampling during a data-transition interval) is often compounded by sporadic errors. The resolution of the logic elements is then the error-limiting factor.

The storage circuit (see "a") uses two J-K flip-flops and two NOR gates to sample incoming asynchronous data and produce data synchronous with the local clock. There are no problems of resolution or ambiguity. Data are always properly synchronized, even if the synchronizing clock samples at the exact time that a data transition edge occurs.

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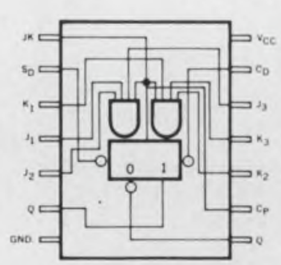
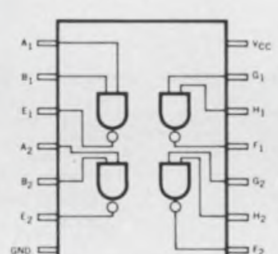
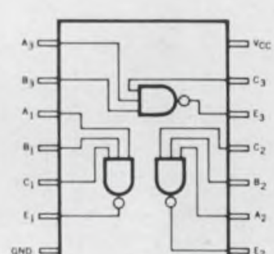


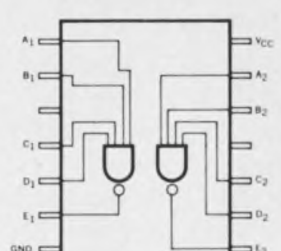
9000 J-K Flip-Flop: master-slave (dual rank) flip-flop with 3 J and 3 K inputs, J-K input, internal J-K connection, positive edge trigger, data input inhibit line (clock pulse), and asynchronous direct inputs to set and clear FF.



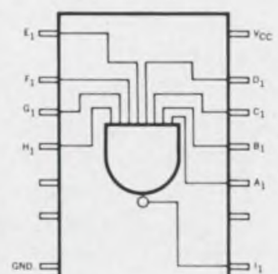
9002 Quadruple 2-input positive NAND gate.



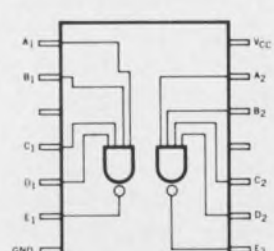
9003 Triple 3-input positive NAND gate.



9004 Dual 4-input positive NAND gate.



9007 8-input positive NAND gate.



9009 Dual 4-input positive NAND "Power" gate.

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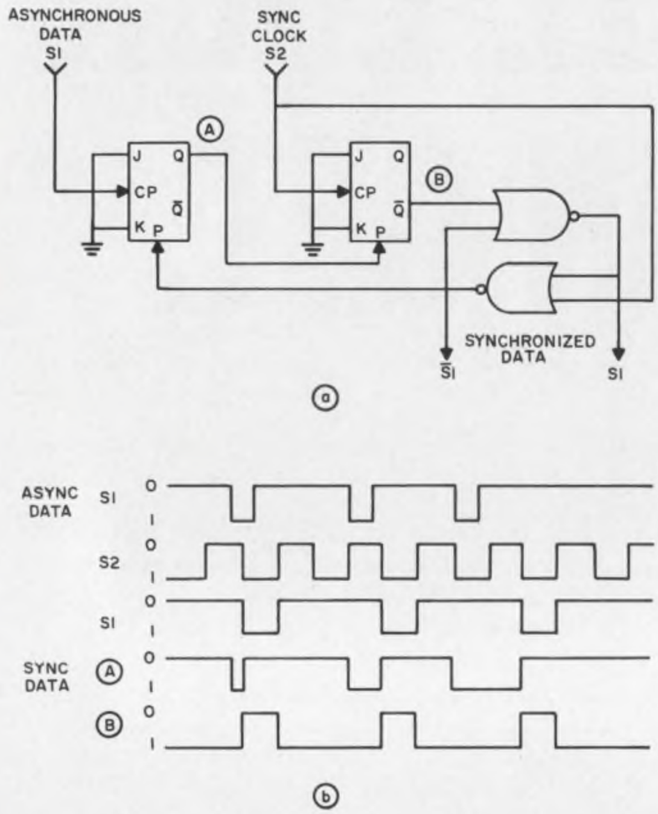


Dual-storage unit consisting of J-K flip-flops and NOR gates (a) solves logic synchronization problems. Incoming asynchronous data are sampled and synchronized with local clock (b).

This is accomplished by the dual-storage configuration in which one flip-flop stores a negative data transition (asynchronous clock *S1*). A second flip-flop is released by removal of its preset level whenever this happens (see waveshape *A* in "b").

After release, the first negative edge produced by synchronous clock *S2* toggles the second J-K flip-flop. This sets an R-S flip-flop (two NOR gates back to back) which also resets the first J-K flip-flop. Unless synchronous clock *S2* has succeeded in toggling the second flip-flop, the first one will not be reset. Since the process of reading out the synchronous data also resets, there is never any ambiguity. If the synchronous clock just misses the data read into the first flip-flop, it will definitely pick it up on the next clock edge.

Note that one design precaution is absolutely necessary—clock *S2* must be such that its period is less than the data period. Moreover, the IC components are not restricted to a single specific "brand." Any integrated circuit line may be employed, providing it has storage devices using transition edges for toggling.

Jay Freeman, Design Engineer, Sperry Gyroscope Co., Great Neck, N. Y.

VOTE FOR 112

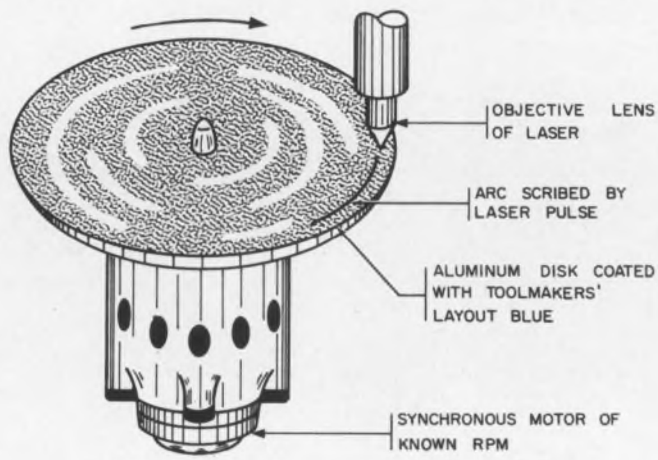
Disk offers simple means of measuring laser pulses

The duration of laser pulses may easily be measured with a rotating disk setup. This test method is inexpensive and can be constructed out of a few, simple parts.

A variety of ruby lasers which have outputs of a few joules and pulse durations of a few milliseconds are now commercially available. Many of these lasers are equipped with variable inductances which can be used for altering pulse duration without changing the total energy of the output pulse.

The following method for measuring pulse duration is applicable whenever an intensity measurement is not required or photometric equipment is not available.

In the setup the laser is focused near the periphery of a steel or aluminum disk driven at a known rate, as shown in the illustration. Low-power laser pulses will scribe a readily visible and measurable arc in a coating of toolmakers' layout blue (such as Dykem Steel Blue DX-100, The Dykem Co., St. Louis, Mo.). Pulse times, t, are easily calculable from the length of the arc, L, the radius, r, and the rpm, n, of the drive motor with the formula:



Driven disk setup is used to measure duration of laser pulses. Laser energy scribes arc on disk surface; length of arc determines pulse duration.

$$t = 30\,L/\pi r n.$$

For example, a point near the edge of a 5-inch-diameter disk rotating at 3850 rpm has a linear velocity of about 1 inch per millisecond. Thus, measurements sufficiently accurate for most purposes can be obtained. The disk can be used repeatedly simply by painting over the arcs after each measurement.

W. O. Freitag and R. H. Storck, Materials Research Engineers, UNIVAC Div. of Sperry Rand Corp., Blue Bell, Pa.

VOTE FOR 113

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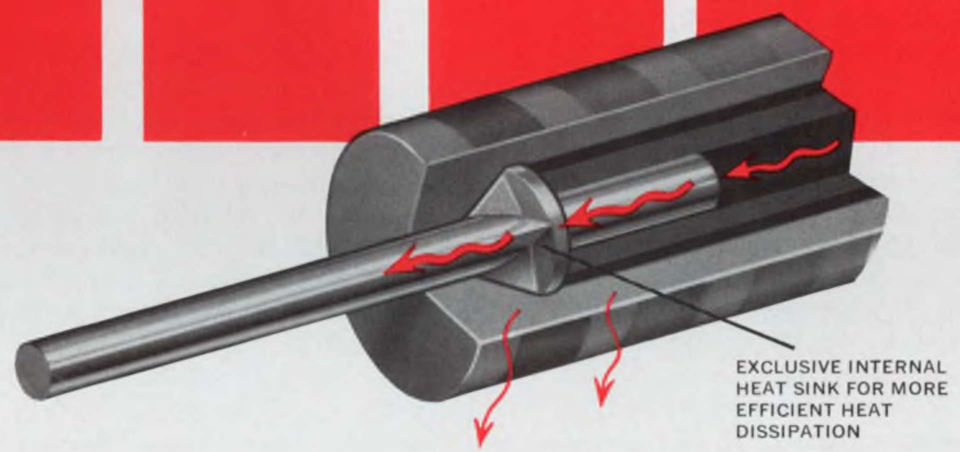

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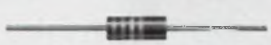

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ON READER-SERVICE CARD CIRCLE 42

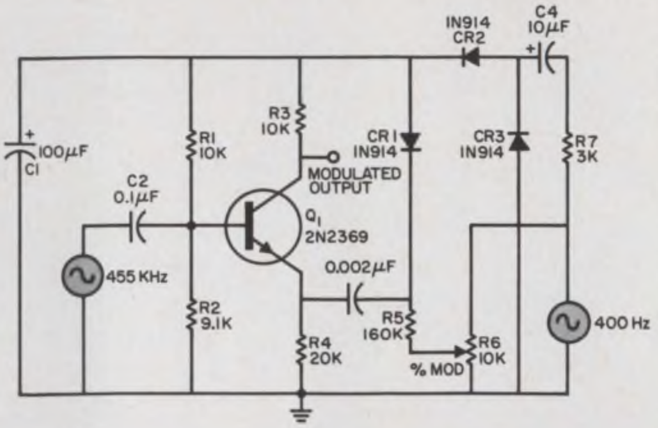
Self-contained modulator is free of coils, bias supplies

Here is a self-contained, 400-Hz-455-kHz modulator that contains no coils or transformers, nor a power supply. The circuit uses two test oscillators to provide a 200-millivolt peak-to-peak, 455-kHz signal, modulated up to 80% with 400 Hz.

The 400-Hz oscillator (see schematic) performs two functions: It provides power for operation of *Q1* and it modulates the 455-kHz signal. The use of 400 Hz is arbitrary; the circuit works with 100 Hz to 1 kHz modulators. With 400 Hz, the required oscillator voltage is 15 volts (pk-pk).

Dc power for the operation of *Q1* is supplied by the 400-Hz oscillator and the network comprising *C1*, *C4*, *R7*, *CR2* and *CR3*. Approximately 5 volts dc are generated. *R7* prevents excessive loading of the 400-Hz oscillator. *CR2*, *CR3*, *C1* and *C4* make up a voltage-doubler circuit with associated coupling and filter capacitors.

Modulation of the 455-kHz signal is accomplished through the control of *Q1* stage gain at the *Q1* emitter. The *Q1* stage gain is an inverse function of the impedance at the emitter of *Q1*. This emitter's effective impedance is the parallel combination of *R4*, *R5* and the impedance of *CR1* (neglecting the reactance of *C3*). As *CR1* is forward-biased, its impedance is low compared to *R4* and *R5*, so *R4* and *R5* may be neglected. Hence, the *Q1* stage is controlled by the impedance of *CR1*. The 400-Hz signal controls the impedance of *CR1* and therefore the gain of the transistor stage. Coupling of the 400-Hz audio signal is prevented by *C3*, whose reactance is 200 kΩ at 400 Hz.



Modulator unit is self-contained. Note the absence of biasing supplies, coils and transformers. The 400-Hz oscillator serves as a power source and modulator. The 445-kHz oscillator is the carrier.

Component *R6* controls the amount of audio presented to *R5* and *CR1*, and therefore the percentage of modulation. A 200-mV peak-to-peak signal of fairly low distortion is available with up to approximately 80% modulation. This is based on inputs of 60 mV peak-to-peak at 455 kHz and 15 V peak-to-peak at 400 Hz.

William J. Travis, Design Engineer, Ceracircuit Dept., Sprague Electric Co., North Adams, Mass.

VOTE FOR 114

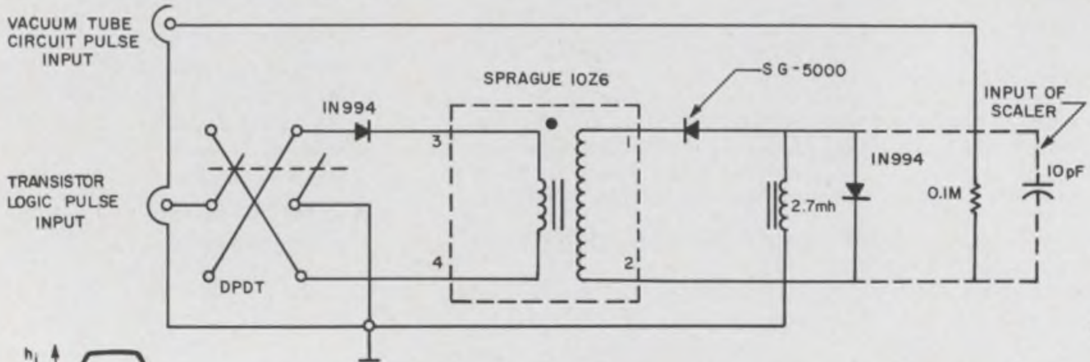
Passive adapter circuit drives decade scaler

In some research laboratories, it is not unusual to find experiments instrumented with both vacuum tube and transistor circuits. One of the minor compatibility problems is the driving of slow (1 µs) decade scalers, requiring pulses of about 5 V height and at least 0.5 µs duration, with the output of fast transistor logic circuits (15 mA into 50 ohms, 10-50 ns).

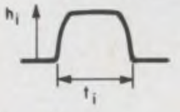
A very simple, passive adapter, which takes advantage of the high input impedance of vacuum tubes, solves this problem (see schematic). This circuit uses a pulse transformer to match the input roughly to 90 ohms. Input and output pulse shapes are as shown. Basically the system stretches input pulses and renders them useful for driving the slower decade scaler.

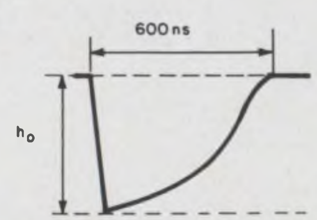
Karl G. Porges, Reactor Physics Div. Engineer, Argonne National Laboratory, Argonne, Ill.

VOTE FOR 115

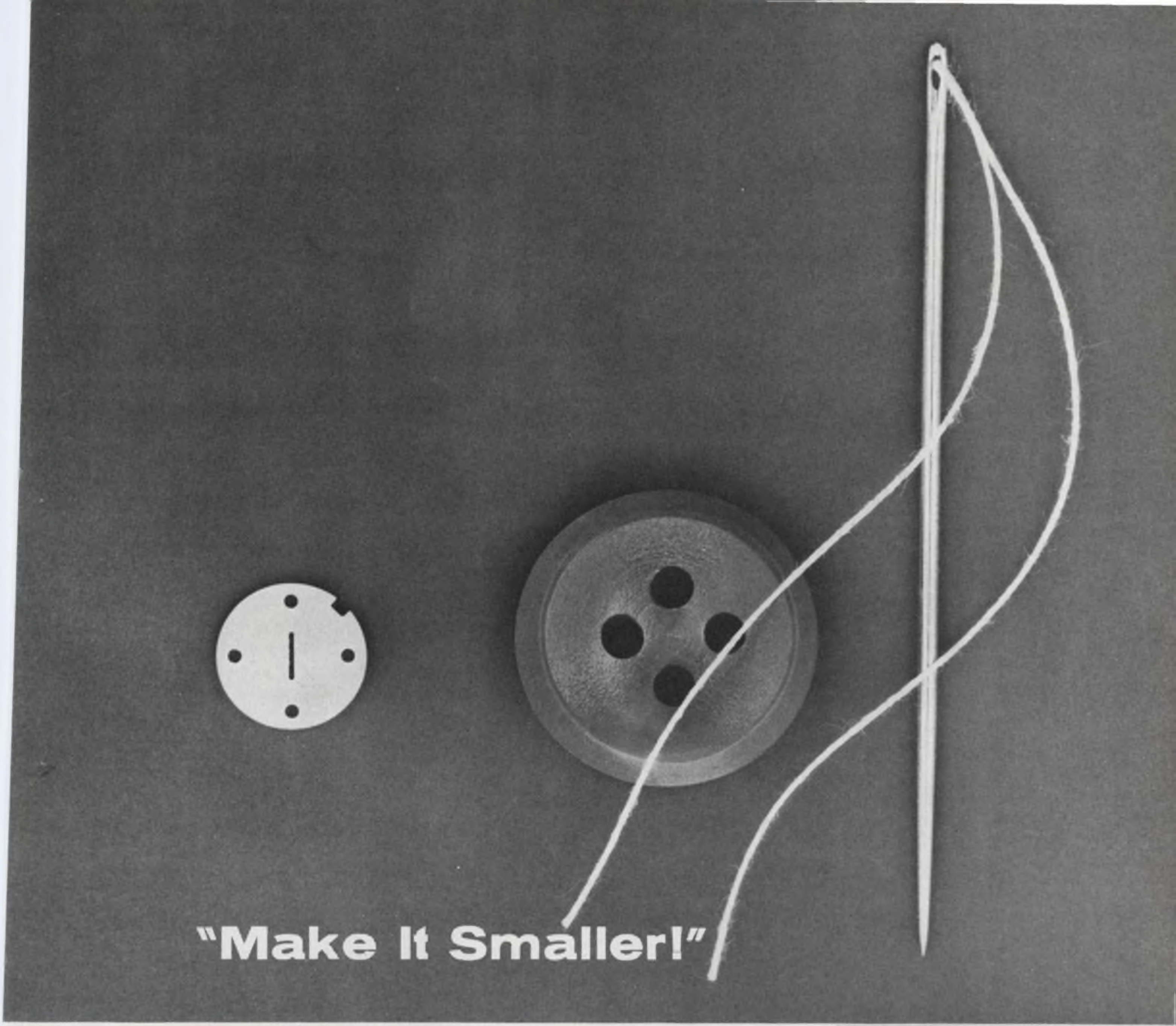


h_i, V	t_i, nsec	h_o, V
±2 ±0.75	40 20	10 3





Pulse stretching is achieved by this passive adapter circuit. It is used to drive slow decade scalers by widening transistor input pulses.



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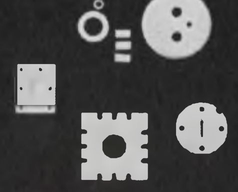

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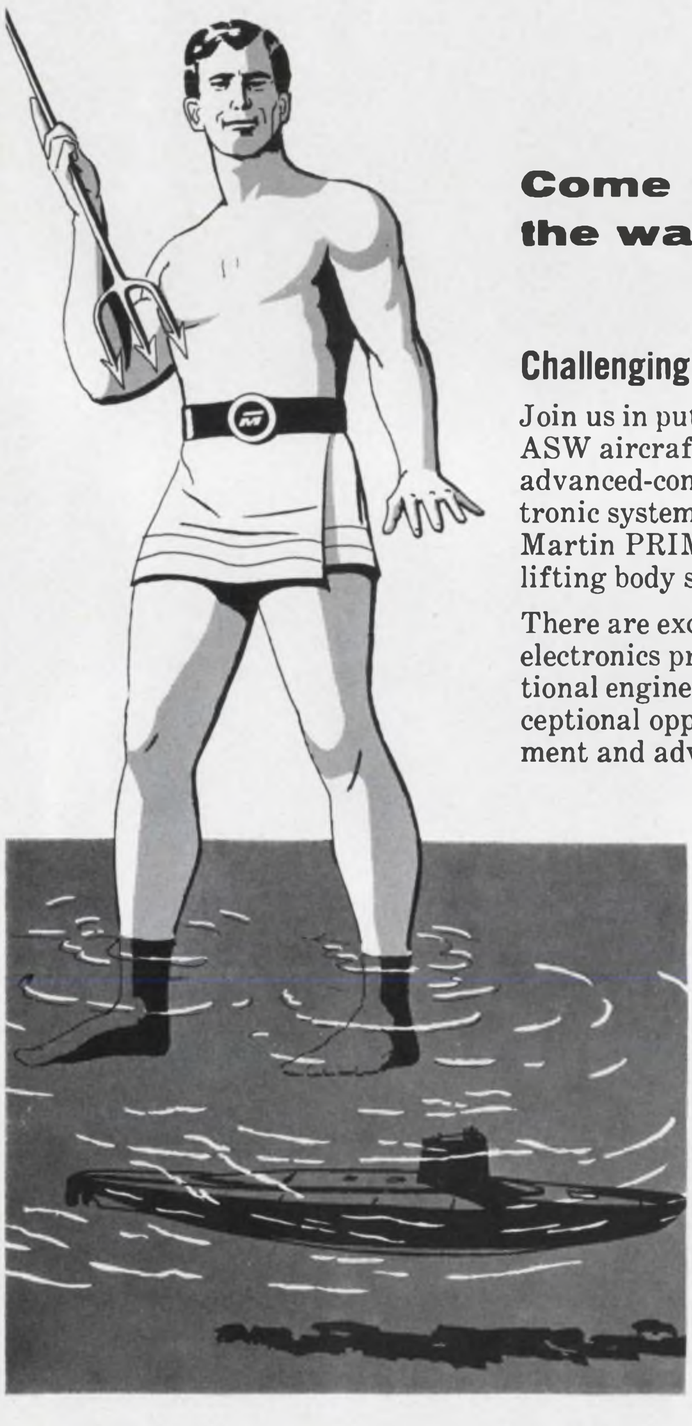

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21

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Prime Experience	Secondary Experience

Desired Salary	**Availability Date**

Employment History – present and previous employers

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City, State			
Dates	to	to	to
Title			
Specialty			

Education – indicate major if degree is not self-explanatory

Degree			
College			
City, State			
Dates	to	to	to

Additional Training – non-degree, industry, military, etc.

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910	911	912	913	914	915	916	917	918	919

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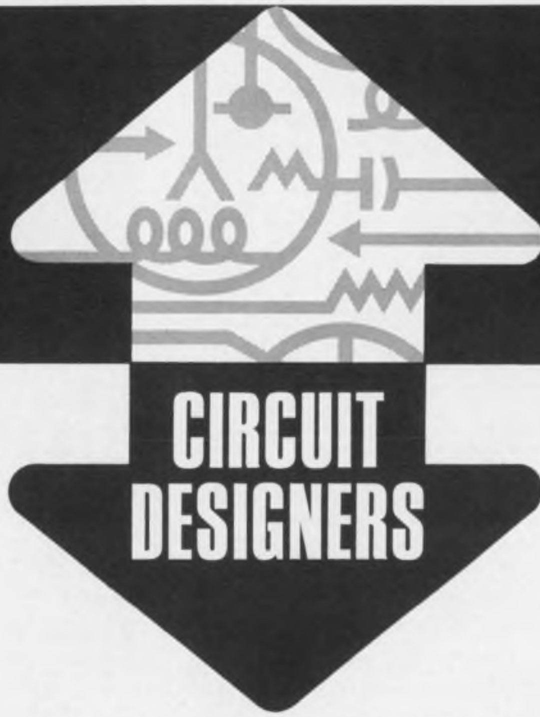

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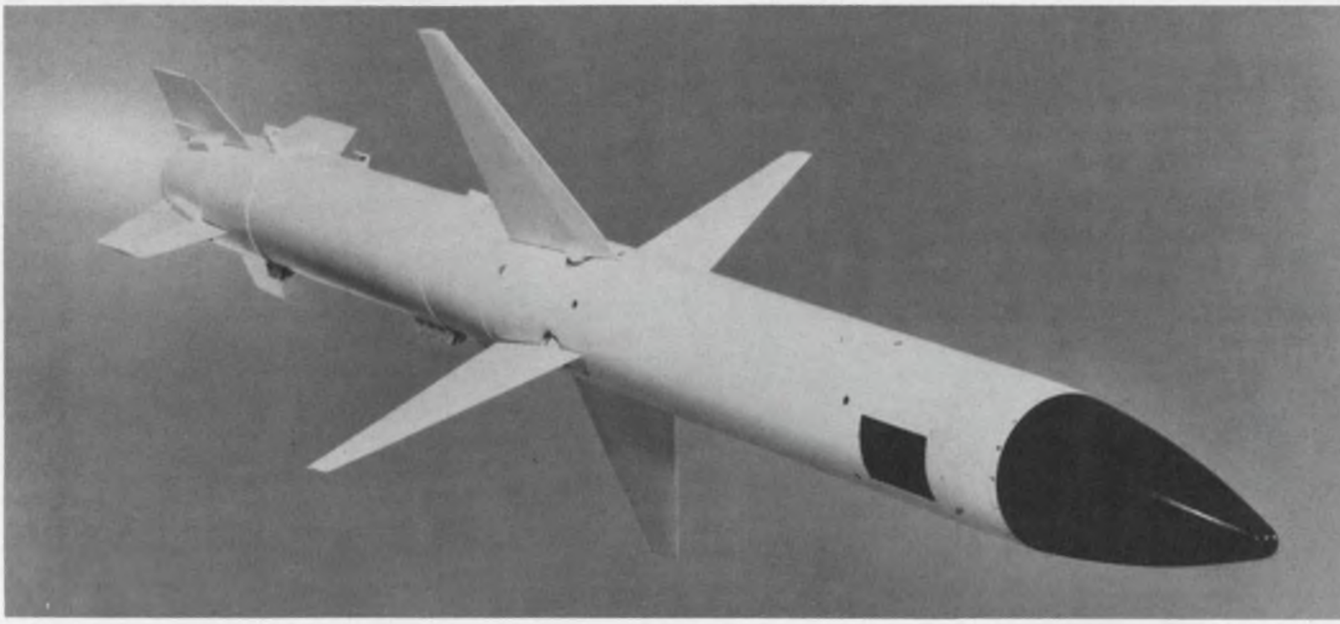

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Please send confidential resume to Tom Milner, advance design manager, Texas Instruments Incorporated, P. O. Box 997, Ridgecrest, California.

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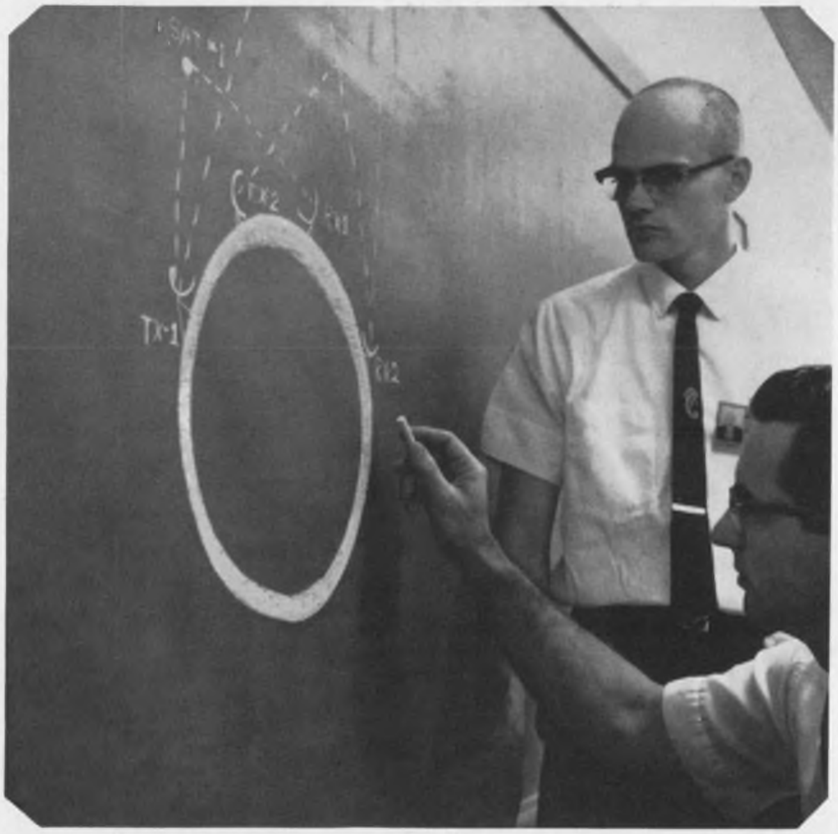

Book Reviews

Keep pace with microelectronics.

Just what will the position of the design engineer be in a future electronics technology dominated by micro- and possibly picoelectronics? He need not be left out of increasingly modularized systems design, providing he broadens his interdisciplinary base of knowledge, according to Howard Bierman, Editor of Electronic Design. Broadening the base is the theme of the book, "Microelectronic Design." The electronic designer is faced with a new technology. Packaging, interconnection schemes, interference control, and cost reduction are fully developed in the book, with emphasis on the practical conversion from the conventional to the microelectronic equivalent. Microelectronic Design compiles almost 90 authoritative articles by expert engineers in the field, to provide an overview of developments in the technology as well as a sourcebook of valuable design ideas. Coverage extends from fundamental theory to design guidelines, circuit conversion, prototype planning, and testing techniques. Included are sections on thick and thin film techniques, an important bibliography, and data charts for more than 500 devices.

Microelectronic Design, edited by Howard Bierman, selected from Electronic Design. (Hayden Book Company, Inc, New York) 312 pp, clothbound $11.50

SUCCESS

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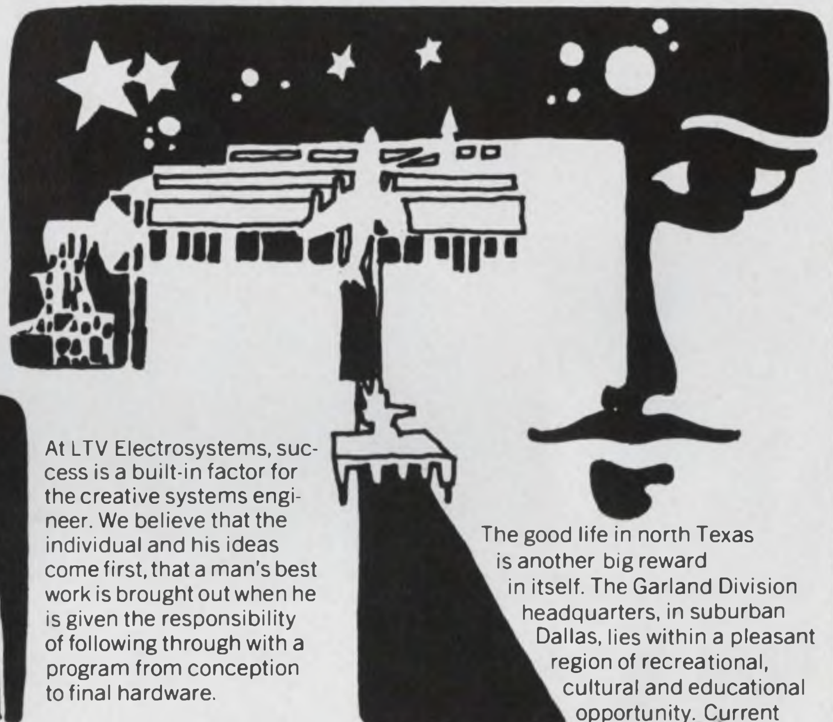

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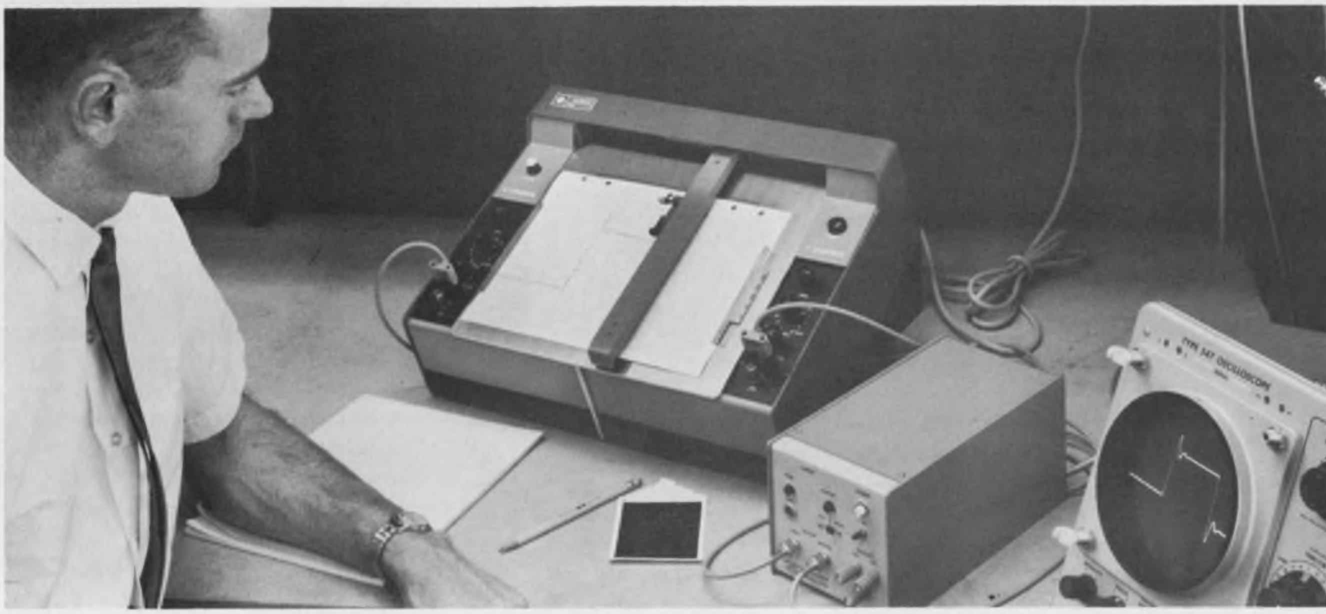
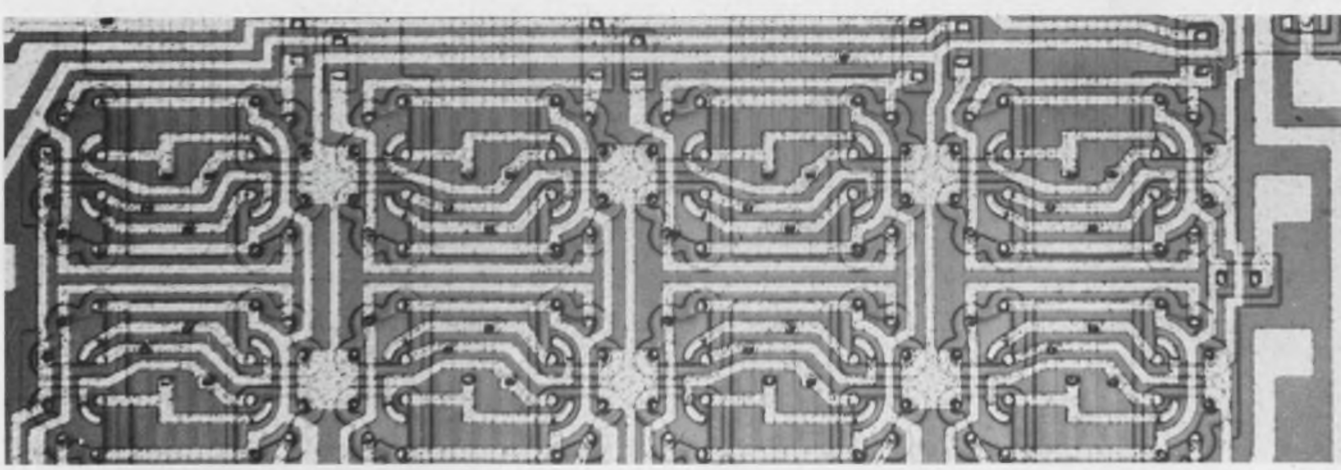


Make X-Y recordings to 50 MHz with any scope/recorder combination. Display converter samples CRT deflection plates for low cost, accurately scaled traces. Page 102



Monolithic 16-bit array is designed for nanosecond digital computer "scratch pad" memories. The 4 x 4 matrix provides parallel information storage and retrieval. Page 112

Also in this section:

Dc differential voltmeter features 0.0025% accuracy, no loading error. Page 104

IC op-amp has ±8-V common-mode input range. Page 114

Fix-it-yourself tape system has bidirectional drive to cut skew effect. Page 118

P-channel MOSFET solves high-temperature stability problems. Page 124

Converter samples CRT signals, acts as scope/recorder interface

By sampling the high-frequency signal from the deflection plates of any oscilloscope, this CRT display converter "slows down" repetitive waveforms so that they can be recorded with any strip-chart or X-Y recorder. Connected between a scope and recorder, this unit can, in a few seconds, convert 50-MHz signals into outputs of 50 Hz without distorting the display.

The converter replaces scope cameras, which require installation and adjustment each time a record is needed. Cost of the trace is about 1/20 that of photographs. Unlike a camera, the converter doesn't interfere with observation of the CRT. Brightness and focus do not affect the 2% accuracy of the converter.

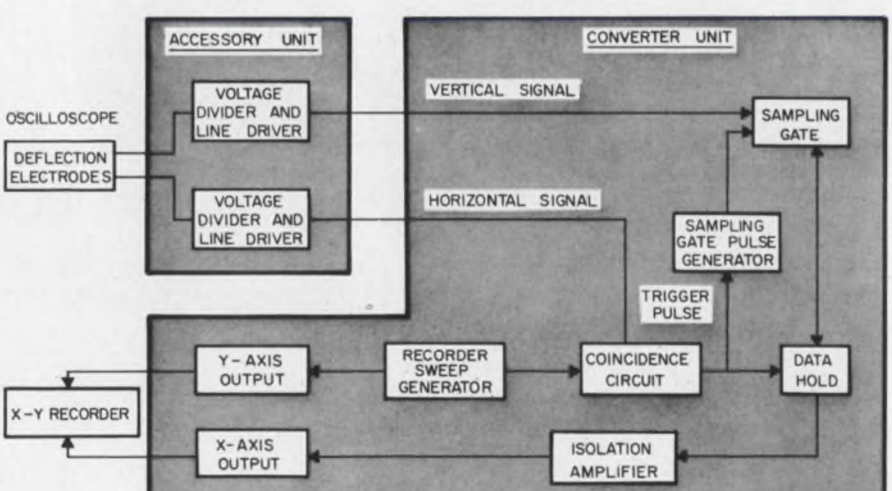
With a scan speed adjustable from 10 to 60 s/scan, the converter can handle any scope sweep rate greater than 30 sweeps/s. Thus, the unit can be used with spectrum analyzers as well as scopes. Because the horizontal deflection signal does not have to be a linear time sweep, the converter can also be used for device characteristic plots. Output of the unit is 1 V per CRT scale division. With sensitivity and position adjustments, the recorder can reproduce the CRT plot with identical scale intercepts.

To use the converter, an adapter unit must be installed in the scope. Consisting of two high-impedance connections, each made to an RC signal divider and line driver circuit, the adapter picks off and lowers the impedance of the CRT signal while adding less than 1 pF to interplate capacitance. This signal is coupled out to drive the converter.

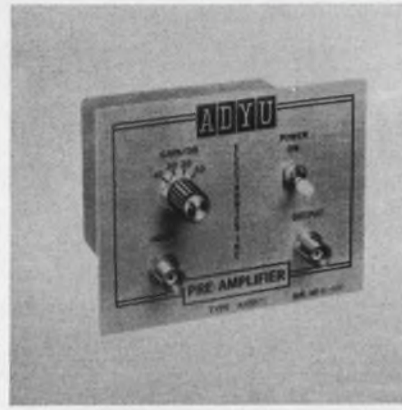
The converter generates a slow sweep voltage to drive the X-axis of the recorder. The coincidence circuit compares this sweep voltage with the horizontal scope sweep. When the sweeps are coincident, the circuit triggers the sampling gate pulse generator which then opens the sampling gate. When the gate is open, a constant voltage applied to the "data hold" circuit follows the vertical signal at the same speed that the trigger pulse moves along the horizontal sweep.

P&A: $490, $50 (additional adapters); stock. Pacific Measurements Inc., 940 Industrial, Palo Alto, Calif. Phone: (415) 328-0300.

Circle No. 121



Accessory unit (adapter) takes signal from scope deflection plates to the converter. The coincidence circuit compares converter-generated slow sweep voltage to horizontal scope sweep and triggers the pulse generator to operate the sampling gate when the sweeps are coincident. When the gate is open, a constant voltage is applied to the data hold circuit until the next pulse.

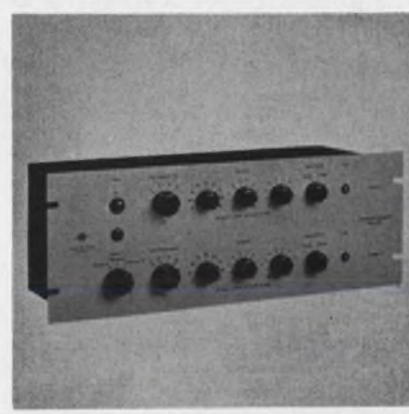


Low-noise preamp

Noise over 150 dB below 1 V and input resistance of over 1 GΩ is featured in this preamp. Bandwidth is 3 Hz to 400 kHz and input capacitance is 4 pF max plus connector capacitance. Maximum output (open circuit) is 12 V p-p at 100 Hz. As a pre-amp or isolating amplifier between a capacitive source and a low impedance cable, the system transmits signals to a remote measuring device.

Ad-Yu Electronics Inc., 249-259 Terhune Ave., Passaic, N. J. Phone: (201) 472-5622.

Circle No. 122



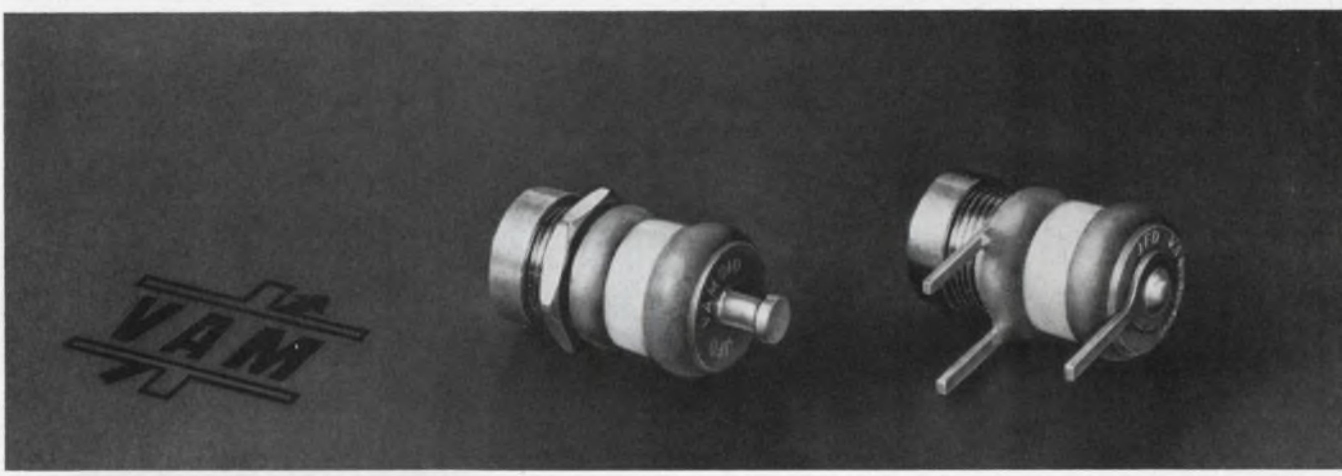
Accelerometer preamp

Either a charge or voltage preamplifier, this accelerometer preamp with decade attenuator normalizing control is compatible with most piezoelectric crystal transducers. Each channel incorporates three decade attenuators for scaling accelerometer sensitivities of 10 to 100 mV/G or 10 to 100 pC/G to 10 mV/G output. Each channel includes a built-in high-pass filter which limits frequency at 2, 5, 10 or 50 Hz.

P&A: $915; stock. B&K Instruments, Inc., 5111 W. 164th St., Cleveland. Phone: (216) 267-4800.

Circle No. 123

Air variables from JFD solve your high Q high frequency problems



Capacitors shown enlarged 120%

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These units which measure less than ½" in length are completely interchangeable with competitive devices.

Internal air meshing shells are silver plated to provide good surface conductivity and to prevent corrosive effects. Internal contact springs assure positive electrical contact of rotor at all times. Leads on printed circuit model are tinned for ease in soldering . . . and these units are engineered to resist heat, won't come apart during soldering.

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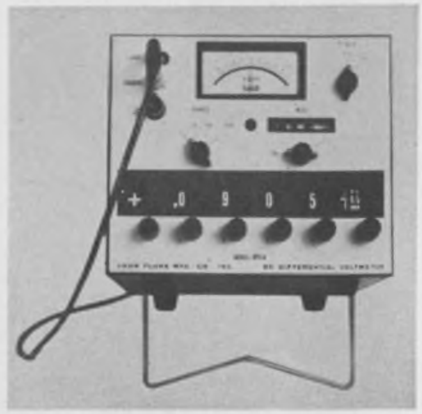


Dc voltmeter

Infinite resistance at null eliminates loading errors in this differential voltmeter. Dc voltages from 1 mV to 1100 V are measured with an absolute accuracy of 25 ppm of indication ±1 ppm of range ±5 μV. Positive and negative ranges of 1, 10, 100 and 1000 V with 10% overranging are provided. As a ratiometer the unit has accuracy of 0.0012%. The grounded recorder output is linear to within 0.5% of end scale. The null meter has a full scale sensitivity of 100 μV. A photo-chopper-stabilized 1100-V supply is referenced against a zener emf. Reference voltage has a p-p stability of 13 ppm/60 days and is regulated to within 0.002% despite line voltage variation of ±10%. The reference divider has 6-digit readout with 1 ppm dial resolution.

P&A: $1095; 30 days. John Fluke Mfg. Co. Inc., Box 7428, Seattle. Phone: (206) 774-2211.

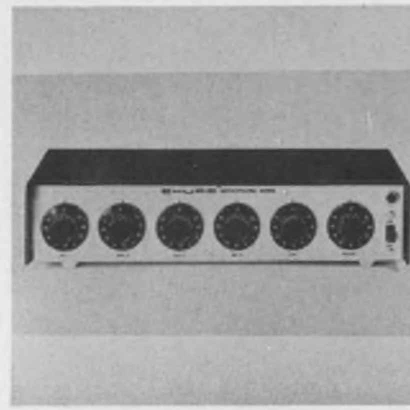
Circle No. 124

8-receiver commutator

Up to eight receivers are commutated by this unit in a time multiplex arrangement. The eight gating waveforms of the output each have a repetition period of 10 s. Start and stop times of each gate are adjustable in steps of 100 ms from 0 to 9.9. An external synchronizing pulse establishes "zero" time. Programing of ON and OFF times of four of the gating waveforms is accomplished by panel switches. The remaining four are programed by the placement of diodes on plug-ins.

P&A: $2585; 6 wks. RMS Engineering, Inc., 486 14 St. N. W., Atlanta. Phone: (404) 873-5257.

Circle No. 125



Microphone mixers

Inputs of this microphone mixer accommodate up to four dynamic or ribbon microphones eliminating external line transformers. Because each input has an impedance selection switch, these microphones may be high or low impedance. An auxiliary high-level input accepts a tape recorder or AM-FM tuner signal. One output provides high- or low-impedance output. The other output provides high-impedance and high-level output.

Price: $125. Shure Brothers, Inc., 222 Hartrey Ave., Evanston, Ill. Phone: (312) 328-9000.

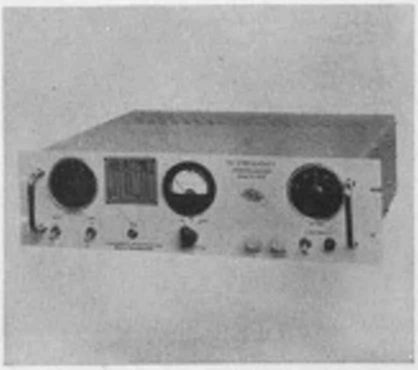
Circle No. 126

Stepper motor drive unit

This stepper motor drive unit features two modes of operation. A slewing circuit automatically accelerates a stepping motor to high speeds. The adjustable internal pulse generator is used for lower stepping rates. Both the maximum slewing speed and acceleration are adjustable. This device functions as a bidirectional speed controller or a central control unit in more complex systems.

P&A: $450; 45 days. Houston Instrument Corp., 4951 Terminal Ave., Bellaire, Tex. Phone: (713) 667-9307.

Circle No. 127



RF frequency translator

Reciprocal conversion of signals between the hf and uhf regions is performed by this frequency translator. Translation of 2 to 30 MHz and 225 to 400 MHz permits direct communication among hf and uhf nets. Input from a 50-MHz external oscillator can be accepted. Power output at uhf is 100 mW. Translation is linear and will translate modulation formats such as cw, am, fm or frequency shift keying. Spurious responses are more than 50 dB below signal level.

Aerospace Research, Inc. 130 Lincoln St., Boston. Phone: (617) 254-7200.

Circle No. 128

Leakage tester

Determining very low leakage currents in semiconductors, this assembly has a programable power supply with a 0- to 99.9-V output in 0.1-V steps. Voltage accuracy is 1%. The self-calibrating ammeter has a full scale indication of 1 pA to 300 mA. The test fixture switch selects measurements of semiconductor characteristics of bipolar and field-effect devices. The unit gives low noise measurements of up to 10^{14}-Ω resistances.

Price: $2800. Hexem, Inc., Los Gatos, Calif. Phone: (408) 354-1260. *Circle No. 129*

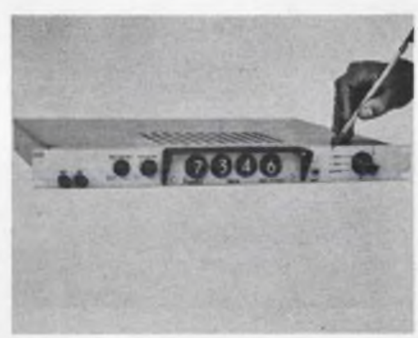
Leak detector offers fast component testing

Employing krypton-85, this leak detector nondestructively tests hermetically sealed components and equipment over a range of 10^{-4} to 10^{-11} cm^3/s. For small components such as ICs, transistors, micro relays and diodes, testing rates depend on the number and combination of activation and counting stations.

Model 10010-1A utilizes the principle of isotope tracer gas referred to in MIL-202C, method 112 and NAS 728.

Availability: 3 months. Ardel Corp., 619 Justin Ave., Glendale, Calif. Phone: (213) 245-9255.

Circle No. 130



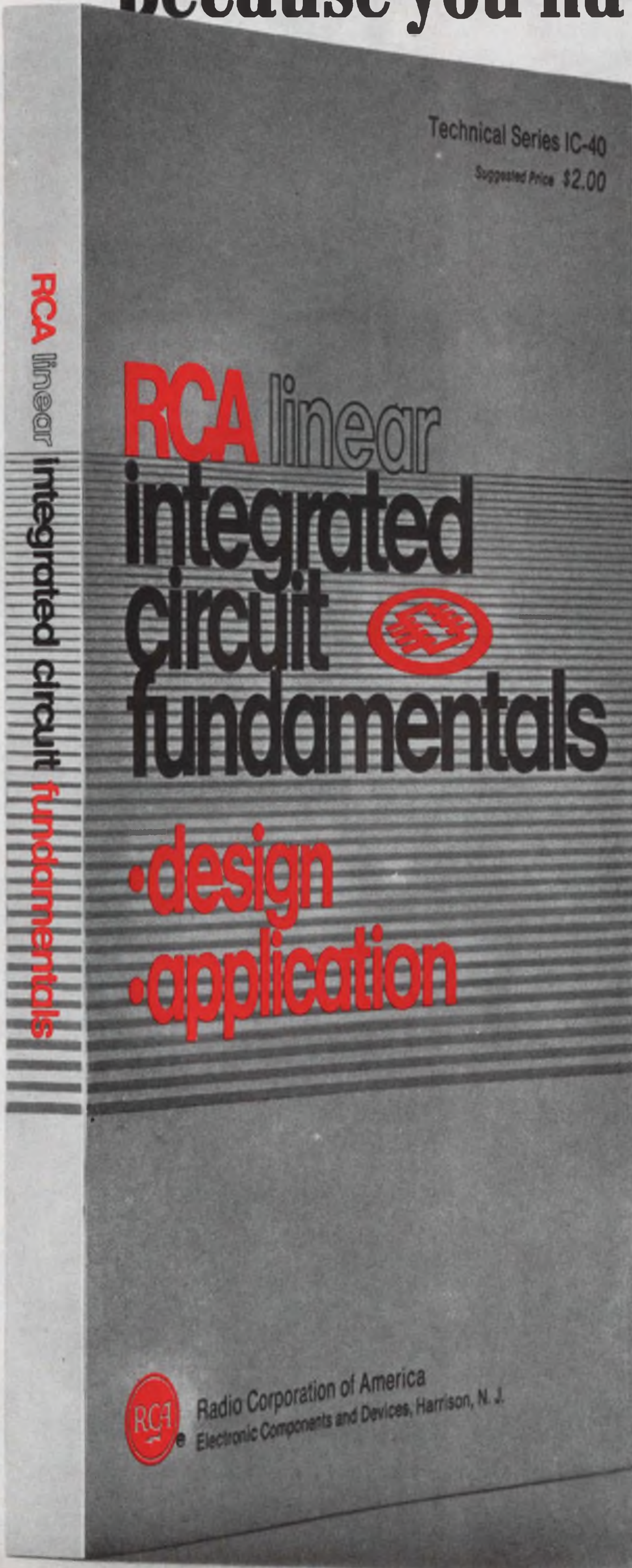
Frequency counter

Measurements from 0 to 200 kHz are made by this four-decade frequency counter. Applications include use with turbine flowmeters, tachometers, oscillators and other frequency-generating devices. Time bases of 0.1 and 1 s are derived from a 60-Hz line frequency. Gate time of 10 s is available. Variable display time is from 0.2 to 6 s and hold. Sensitivity is 10 mV.

Anadex Instruments Inc., 7833 Haskell Ave., Van Nuys, Calif. Phone: (213) 782-9527.

Circle No. 131

Because you have to know NOW!



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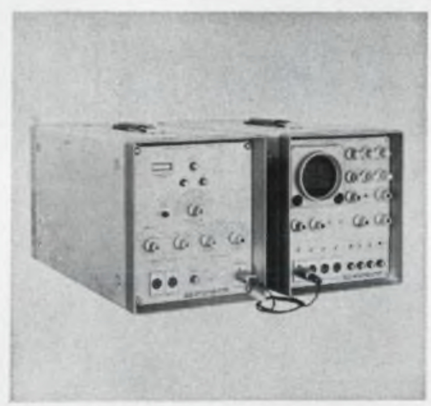
CITY__________ STATE________ ZIP_____

Variable capacitor

Used as a reference arm for high voltage bridges or capacitance comparators, this variable capacitor can also tune high power resonant circuits or antennas. The unit provides continuous settings from 50 to 10,000 pF in four ranges. It has a continuously adjustable 2000-pF vacuum capacitor and fixed steps of 2000 pF. Voltage is 10 kV peak and current is 10 A rms max.

Dranetz Engineering Labs. Inc., 1233 North Ave., Plainfield, N. J. Phone: (201) 755-7080.

Circle No. 132

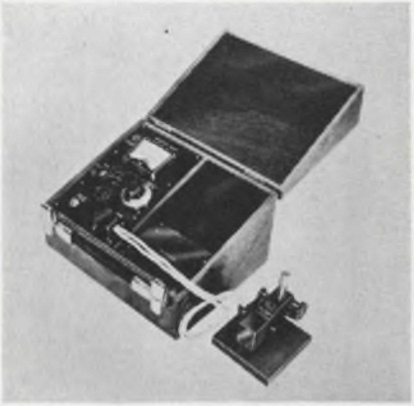


Correlation computer

On-line determination of both auto and cross correlation functions is performed by this computer system. Employing analog and digital circuitry, model 258 computes up to 256 points of a correlation function simultaneously without tape loops. All calculations are performed in real time. On-line operation allows monitoring and re-directing of the course of an experiment while it is occurring.

Technical Measurement Corp., 441 Washington Ave., North Haven, Conn. Phone: (203) 239-2501.

Circle No. 133

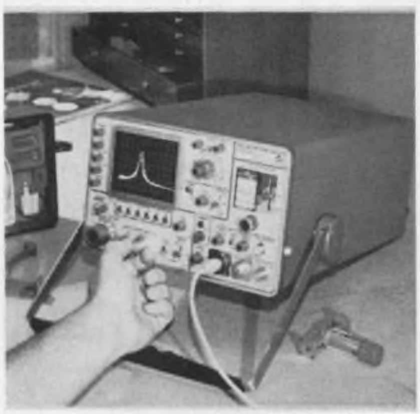


Resistivity bridge

Direct resistivity readings are given by this self-calibrating semiconductor resistivity bridge. Measurement range is 0.01 to 1000 Ω-cm with accuracy of ±5%. Requiring no sample preparation, the unit will correct for and directly measure semiconductor wafers, dice, rods and blocks. The bridge has self-contained batteries and a four-point probe head.

Geoscience Instruments Corp., 435 E. 3 St., Mount Vernon, N. Y. Phone: (914) 664-5100.

Circle No. 134



Spectrum analyzer

This 10-MHz to 40-GHz analyzer makes measurements directly from the CRT display with cw sensitivity from -110 to -70 dBm. Internal phase lock provides stable displays even at 1-kHz/division dispersion. Resolution range is 1 to 100 kHz and dispersion range is 10 kHz to 100 MHz. Display flatness is ±1.5 dB over 100-MHz dispersion. Scope triggering is internal, external or line and sweep rates are 0.5 s/division to 10 μs/division in a 1-2-5 sequence.

Price: $4200. Tektronix, Inc., Box 500, Beaverton, Ore. Phone: (503) 644-0161.

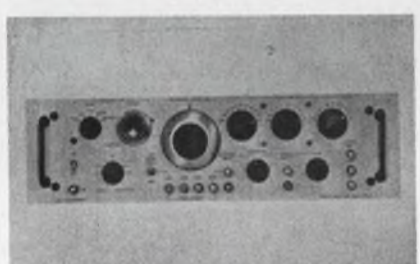
Circle No. 135

Connector gage set

Deviation from nominal of six critical mating dimensions of male and female C or SC connectors is measured by this gage set. It consists of a dial indicator, male and female measurement adapter shells, interchangeable buttons corresponding to the three A and B dimensions to be gaged and a calibration gage block. The indicator shows the deviation. The dial is marked with 40 divisions per rotation, each representing a deviation from nominal of 0.001 in.

P&A: $300; 60 days. Weinschel Engineering, Gaithersburg, Md. Phone: (301) 948-3434.

Circle No. 136

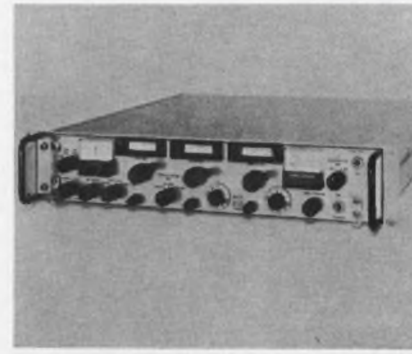


Servo analyzer

A range of 0.01 to 10,000 Hz is featured in this servo analyzer. The 110-dB attenuator used for servo system gain measurements is switchable between input and response signals. A separate level control permits fine adjustment of stimulation signal levels. The analyzer may be used with either dc or carrier systems. A referenced output is phase variable over 360°.

Price: $1750. Ling Electronics, 1515 S. Manchester Ave., Anaheim, Calif. Phone: (714) 774-2000.

Circle No. 139

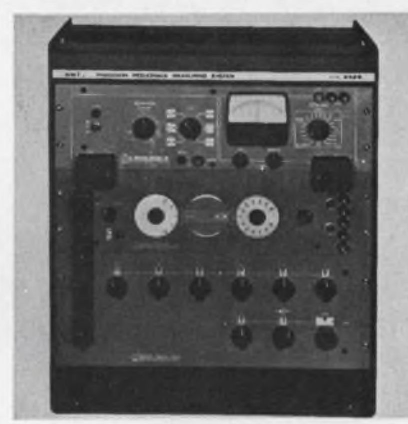


20- to 300-MHz receiver

Designed for am, fm and cw reception from 20 to 300 MHz, this solid-state receiver has 20- and 300-kHz IF bandwidths. The three RF tuners have a two-section pre-selector at the RF input providing maximum reduction of cross-modulation and inter-modulation interferences. Each tuning head has time tuning and an internal calibration oscillator.

P&A: $3500; 90 days. Astro Communication Lab. Inc., 801 Gaither Rd., Gaithersburg, Md. Phone: (301) 948-5210.

Circle No. 138

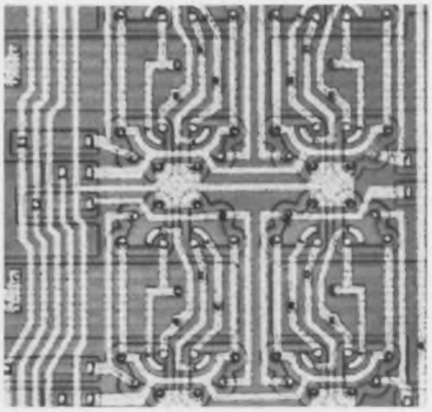


Resistor test system

Using a 9-dial decade resistance standard, this unit compares resistors to 1 ppm by substitution and gives direct readings with 50-ppm accuracy. Differences of 1 ppm to 0.6% are covered by three deviation ranges. Measurements from 1 Ω to 120 MΩ can be made. Output of the dc generator-detector is adjustable up to 1 W. The detector has sensitivity better than 1 μV end-scale. Measurements to 1 kV have 5% accuracy.

P&A: $3400; 30 days. Electro Scientific Industries, Inc., 13900 N.W. Science Park Dr., Portland, Ore. Phone: (503) 646-4141.

Circle No. 137



16-bit memory array

A 16-bit word organized memory array, for digital computer temporary storage memory applications, consists of 16, two-transistor set/reset flip-flops with two write and two sense amplifiers in a 4 x 4 matrix which provides parallel information storage and retrieval. The arrays are on individual 48 x 80 mil silicon chips. This single chip permits non-destructive read-out of all 16-bits. Reading and writing is done through four X and four Y lines which are brought out to eight external terminals. Read and write control is performed by four internal dual-sense amplifiers for "1" and "0" writing. Each flip-flop in the matrix is logically connected to its own address combination, and to the sense and write amplifiers. The memory cell operates from a nominal 5-V supply voltage.

The SM-80 series is designed for operation from 0 to 75°C. The arrays are available in a 14-lead dual-in line, plug-in package and TO-85 flat-pack. Write time and read time are 25 ns and 35 ns, respectively, power consumption is 250 mW and noise margin is ±1 V.

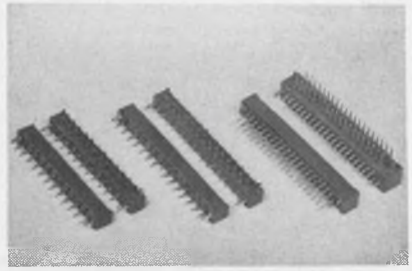
Sylvania Electric Products Inc., 730 Third Ave., New York. Phone: (212) 551-1693. *Circle No. 140*

Mixed-level matrix board

This mixed-level matrix board contains two patch areas with three-deck bussed contacts, one area with a two-deck bussed contact matrix and a fourth area with a two-level matrix having bussed contacts in deck one and isolated contacts in deck two. A 0.25-in. grid has phenolic block construction.

Availability: 4 wks. Co-Ord Switch, 102-48 43 Ave., Corona, N. Y. Phone: (212) 899-5588.

Circle No. 141

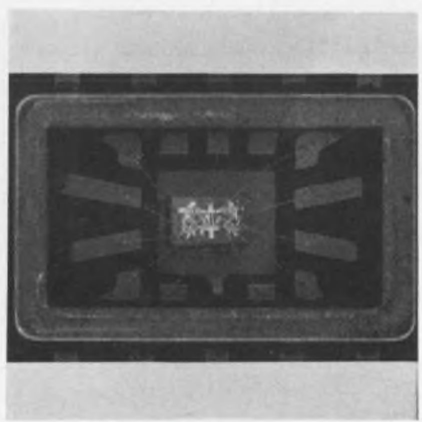


Micromin PC connectors

Designed for use with single-sided, double-sided or multilayered boards, these connectors have contact arrangements of 0.15-in. and 0.1-in., center-to-center spacing in two staggered rows and 0.05-in. spacing in three staggered rows. Contacts are beryllium copper, gold plated to MIL-G-45204. Both plugs and receptacles are terminated by dip soldering the terminal pins to the boards.

Burndy Corp., Norwalk, Conn. Phone: (203) 838-4444.

Circle No. 142



TTL NAND gates

A dual 4-input TTL NAND gate, UEX-1070, with a propagation delay of 5 ns, is claimed to be the first of a series of the fastest saturating ICs available. A high-noise immunity, high-speed TTL NAND gate, type UEX-1100, offers 1.7 Vdc noise immunity at a propagation delay of 8 ns. Other features of the high-speed gate are a fanout of 12 and a noise immunity of 1 V. Power dissipation is 25 mW and both circuits require a 5 V power supply voltage. The high-noise immunity gates have a fan-out of 10 with a rated power dissipation of 35 mW. Both logic series are initially available in 14-lead flat-packs.

Sprague Electric Co., 347 Marshall St., North Adams, Mass.

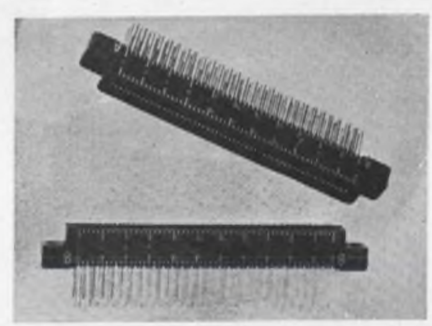
Circle No. 143

12-V IC op-amps have 70-dB gain

Two 12-V operational amplifiers deliver 14 V p-p output and 70-dB gain. Both can be used as oscillators, comparators, servo-drivers, scaling adders, balanced modulator drivers, multivibrators, dc and video amplifiers, feedback amplifiers and narrow- and band-pass amplifiers. The silicon monolithic ICs, types CA3015 and CA3016, are of a balanced direct-coupled, two-stage, differential amplifier design, with a controlled constant-current source. Temperature range is −55 to 125°C. The output voltage swing is 14 V with a 15-kΩ load. With a load impedance as low as 1 kΩ, peak-to-peak voltage swing is 5.5 V. Additional features include 320-kHz bandwidth at −3-dB point, 103.5-dB common-mode rejection ratio, 92-Ω output impedance and 1-mV input offset voltage. The CA3016 is a 14-terminal flat-pack and the CA-3015 is a 12-terminal TO-5 package.

P&A: $7.50 and $8.50 (1000-up); October. RCA, Electronic Components and Devices, Harrison, N. J. Phone: (201) 485-3900.

Circle No. 144



PC board connectors

Beryllium copper "bellows" contacts are used in these micromin connectors with 0.00005-in. gold plating. Contacts may be soldered or welded and are spaced on 0.05-in. centers. They are available from 6 (double row 12) to 64 (double row 128) standard configurations. Contact tails protrude from the diallyl phthalate body in two available configurations: two single rows spaced on 0.05-in. centers or staggered in 4 rows with each row at 0.1-in. centers.

Viking Industries Inc., 21001 Nordhoff St., Chatsworth, Calif. Phone: (213) 341-4330.

Circle No. 145

high-speed

Tektronix Oscilloscope with general-purpose convenience

Type 585A / 82 unit features

- **Dual-Trace Operation** with 4 operating modes and independent controls for each channel—for individual attenuation, positioning, inversion, and ac or dc coupling as desired.
- **Bandwidth DC-TO-85 MHz** (3-db down) at 100 mV/cm (12-db down at 150 MHz), and typically DC-TO-80 MHz (3-db down) at 10 mV/cm.
- **Calibrated Sensitivity in 9 steps** from 100 mV/cm to 50 V/cm, and in *10X Amplifier Mode*, from 10 mV/cm to 5 V/cm, variable between steps.
- **Internal and External Triggering** to 150 MHz.
- **Sweep Range from 10 nsec/cm** to 2 sec/cm.
- **Single-Sweep Photography** at 10 nsec/cm.
- **Calibrated Sweep Delay** from 2 microseconds to 10 seconds.
- **Bright, High-Resolution Display** with small spot size.
- **Conventional Passive Probes** for convenience.

plus

- **Compatibility with Letter and 1-Series Plug-Ins** to permit differential, multi-trace, sampling, spectrum analysis, other laboratory applications —when used with Type 81 adapter.

Type 585A Oscilloscope	$1725
Type RM585A Oscilloscope	$1825
Type 581A Oscilloscope	$1425
No sweep-delay capabilities, but other features similar to Type 585A.	
Type 82 Dual-Trace Unit	$ 650
Type 86 Single-Trace Unit	$ 350
Type 81 Plug-In Adapter	$ 135
Allows insertion of 17 Tektronix letter-series plug-ins. Passband (up to 30 MHz) and Sensitivity depend upon plug-in used.	

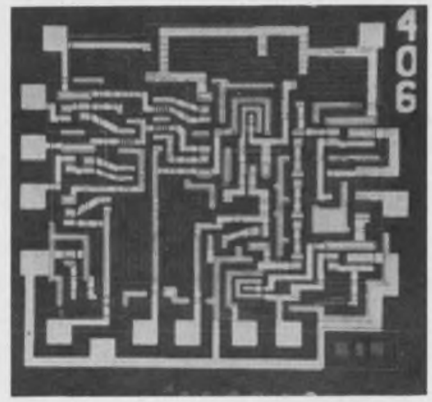
U.S. Sales Prices, f.o.b. Beaverton, Oregon

Type 585A Oscilloscope with Type 82 Plug-In Unit displaying fast-rise waveforms in a dual-trace application. Note measurement convenience of small-size passive probes hooked into circuit of instrument under test.

Tektronix, Inc.

For complete information, contact your nearby Tektronix field engineer or write: Tektronix, Inc., P.O. Box 500, Beaverton, Oregon 97005

ON READER-SERVICE CARD CIRCLE 52

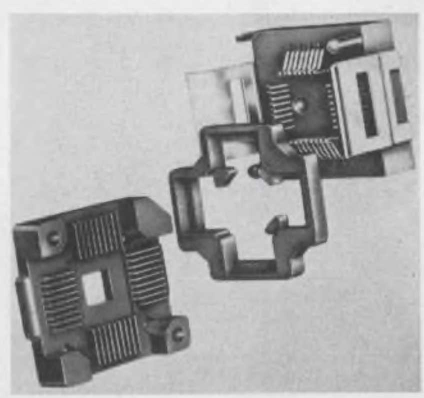


IC op-amp has ±8-V common-mode input

Silicon planar epitaxial op-amps reportedly have a higher common-mode input range (±8 V at Vcc = 15 V) than other available units. Low offsets, high Z_{in}, thermal stability and output short protection are featured. Series 805 op-amps have a typical open-loop voltage gain of 60,000. Input offset voltage is 3 mV, bias current is 250 nA and offset current is 30 nA. Packaging is in a TO-5 can.

P&A: $27 to $45; stock. Amelco Semiconductor, Div. of Teledyne, 1300 Terra Bella Ave., Mountain View, Calif. Phone: (415) 968-9241.

Circle No. 146



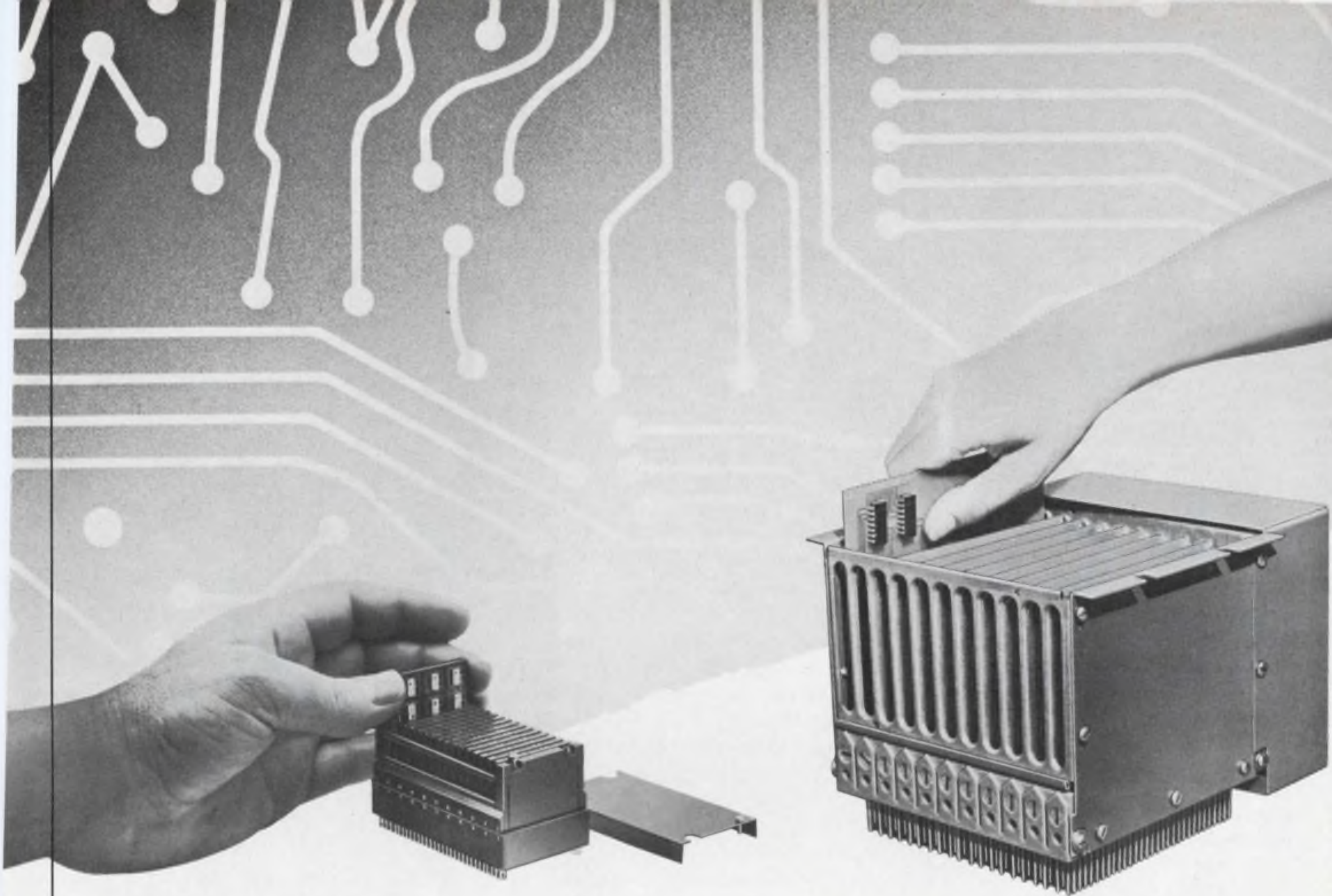
IC carrier/contactor

This carrier and contactor accepts 1/2-in.^{2} 32-lead flat-pack ICs having eight leads per side on 0.05-in. spacing. Once tested, ICs can then be shipped in the carrier. The body section has molded-in lead separators and indication of the #1 lead position. Both the lid and body sections have cutouts for marking and ventilation.

Barnes Development Co., Lansdowne, Pa. Phone: (215) 622-1525.

Circle No. 147

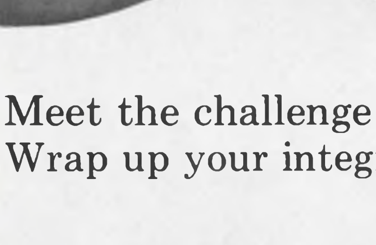
ON READER-SERVICE CARD CIRCLE 220 ➤



Meet the challenge of change...
Wrap up your integrated circuits with a helping hand from ITT Cannon

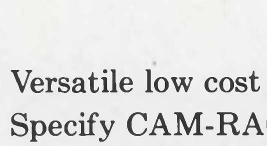
Lightweight aircraft and space applications? Specify the CHICO Pac!

The new CHICO Pac meets industry's need for a high density standardized system which enables designers to effectively package integrated circuits as well as discrete components. CHICO Pac eliminates the major bottlenecks which have blocked full utilization of today's integrated circuit packages... meets the four key requirements demanded by every packaging and systems designer: reliability, versatility, maintainability and size/weight reduction.



Versatile low cost for 2-sided PC boards? Specify CAM-RAC™ Modules!

The lightweight aluminum CAM-RAC integrated circuit packages offer the same benefits of the CHICO Pac but in larger, economical modules. Cam actuation of the contacts in the CAM-RAC modules assures zero mating and unmating forces. Contacts do not engage the printed circuit pads until they are actuated by the cam system. Discrete components, as well as ICP's, can be accommodated in CAM-RAC modules which contain up to 10 two-sided printed circuit boards from 4" x 5" to 12" x 15" card size. The fully shielded module and circuit boards minimize crosstalk and RFI. For the complete package, write ITT Cannon Electric, 3208 Humboldt St., Los Angeles, California 90031. A division of International Telephone and Telegraph Corp.



CANNON® PLUGS

CANNON ITT

MICROELECTRONICS

J-K flip-flop family offers 50-MHz logic

A family of dual J-K flip-flops is guaranteed to deliver speeds of 50 MHz, reportedly the highest available. The circuits, which concentrate 100 discrete components on a 50- x 85-mil monolithic chip, are designed for high-speed digital communications as well as data processing applications.

Logic rates of 50 MHz and typical propagation delays of 10 ns are obtained through the use of ultrafine line geometries to minimize parasitic capacitances and the use of stable, high-speed integrated transistors. They are designed to trigger on clock negative edges and will trigger reliably on clock pulses as narrow as 10 ns. The units, which have a single J terminal and a single K terminal for each of the dual flip-flops, are available in dual-in-line, plug-in and TO-85 packages.

The units are available in two distinct configurations. The first allows a separate clock input for each of the dual J-K functions in the package. Separate clock lines are necessary for ripple counters, a common subsystem in digital communications. The second configuration is designed with a clock line and reset line common to both J-Ks for temporary storage of data trains. Both configurations have separate set input terminals.

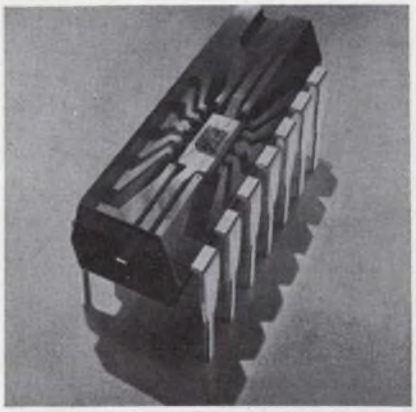
The circuits exhibit virtually no settling time and produce a symmetrical output waveform. Propagation delays are 9 ns off and 11 ns on, and logic offset is 3.5 V at logic "1" and 0.2 V at logic "0".

Price: $9.45 (1000 quantities). Sylvania Electric Products Inc., 730 Third Ave., New York. Phone: (212) 551-1693. *Circle No. 148*

Rack/panel connectors

Miniature rack and panel connectors have 0.045-in.^{2} wire-wrap terminations. This series includes 7-, 14-, 18-, 20-, 21-, 26-, 41-, 50- and 75-contact rectangular connectors meeting MIL-C-8384. Contact current rating is 7.5 A max. Center-to-center contact distance is nominally 0.15 in.

U.S. Components, Inc., 1320 Zerega Ave., Bronx, N. Y. Phone: (212) 824-1600. *Circle No. 149*



Plastic DTL ICs

Digital ICs in the 930-series DTL configuration are offered in a molded plastic package for operation in the 0 to 70°C range. The complete family of 11 DTL circuits including dual, triple, and quadruple gates, buffers, expanders, binary elements and a one-shot is reportedly priced 25% lower than comparable units. The transfer-molded package features 14 plug-in pins on 100-mil centers for low-soldering and wire-wrap techniques. The two rows of pins are 300 mils apart and are adaptable to high-speed automatic or manual insertion techniques.

Typical gate propagation delay for series 15830N is 25 ns, power dissipation is 5 mW, fan-out is 8, dc noise margin is 750 mV and supply voltage is 4.5 to 5.5 V.

Texas Instruments, 13500 N. Central Expwy., Dallas. Phone: (214) 235-3111.

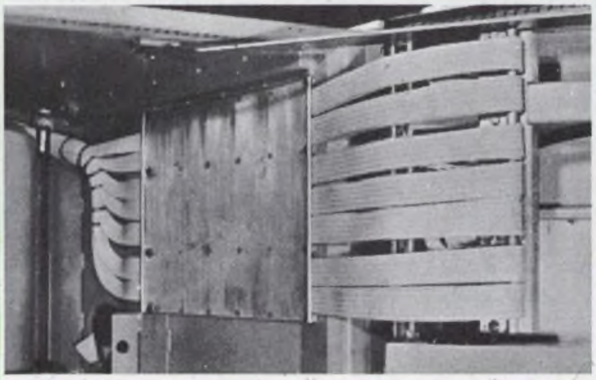
Circle No. 150

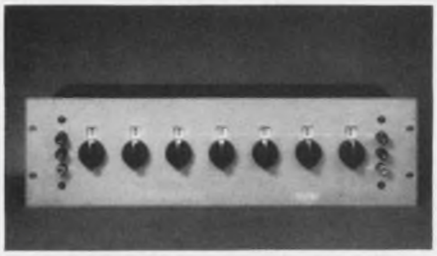
Voltage pick-off element

For voltage position pickoffs where accuracy and size are considerations, this linear element is less than 1-in. long. The element is a conductive plastic chip 0.17-in. wide and 0.075-in. thick. The chip contains an infinite-resolution resistance track and a take-off track, and is supplied with Teflon leads. Mating multi-finger wiper assemblies are also available. Independent linearity is ±0.25% with no quadrature to 100 kHz. Power dissipation is 0.25 W at 20°C. Operating temperature range is −65 to 125°C. The element is available in 2- and 5-kΩ resistances.

Markite Corp., 155 Waverly Pl., New York. Phone: (212) 675-1384.

Circle No. 151





Magnetic tape system minimizes skew effect

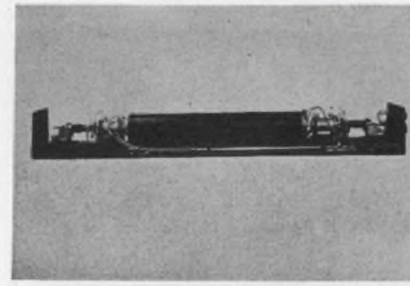
A bidirectional tape drive unit is built into this magnetic tape system. The capstan motor assembly keeps the tape under control of the capstan in all operational modes. Only the capstan and isolation roller contact the tape in the critical head area. Upper and lower vacuum columns balance tape tension by isolating the record/playback heads from the reels. The vacuum columns are also chute guides for the friction-driven tape.

Electronics of system 7600 allows for direct recording of data to 1.6 MHz, FM recording to 80 kHz and digital recording to 1 Mbit per inch density. Speeds are automatically synchronized and selected by pushbutton.

The drive system minimizes skew effect (tilting of the tape as it passes over the heads). Inter-channel timing errors caused by skew effect are cut to less than 1 ms across tape moving at 120 ips. The close head-to-capstan spacing of the drive system improves tape speed accuracy and holds flutter to a minimum. At 60 or 120 ips, flutter is 0.25% p-p over a 10-kHz bandwidth. The spare parts kit provided for maintenance can handle over 90% of the theoretical failures. Access to a resistor stock will increase coverage to 99% of the possible failures. The 34 parts in the kit include a selection of micrologic circuitry, transistors, diodes, trimmer pots, pilot amps and fuses, a relay, an indicator and a capacitor.

Honeywell Inc., 4800 E. Dry Creek Rd., Denver. Phone: (303) 771-4700.

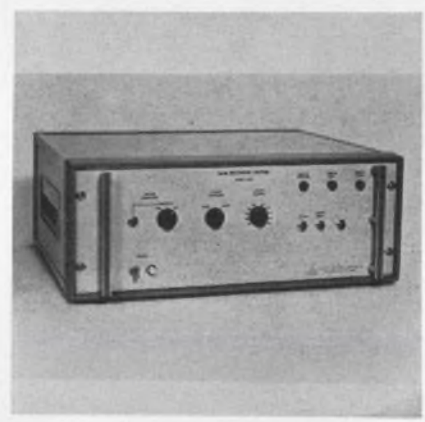
Circle No. 152



Argon gas laser system

Output ratings up to 1 W with major output energies at 4880 and 5145 Å are provided by these argon gas laser systems. Because a tungsten-impregnated material is used, the cathode can be exposed to the atmosphere without oxidation damage. All system components are water cooled and the confocal mirrors have X-Y alignment manipulators at both ends. The 20-kw power supply for the 1-W unit incorporates a power unit for both the 800-gauss magnetic field and the cathode heater filament.

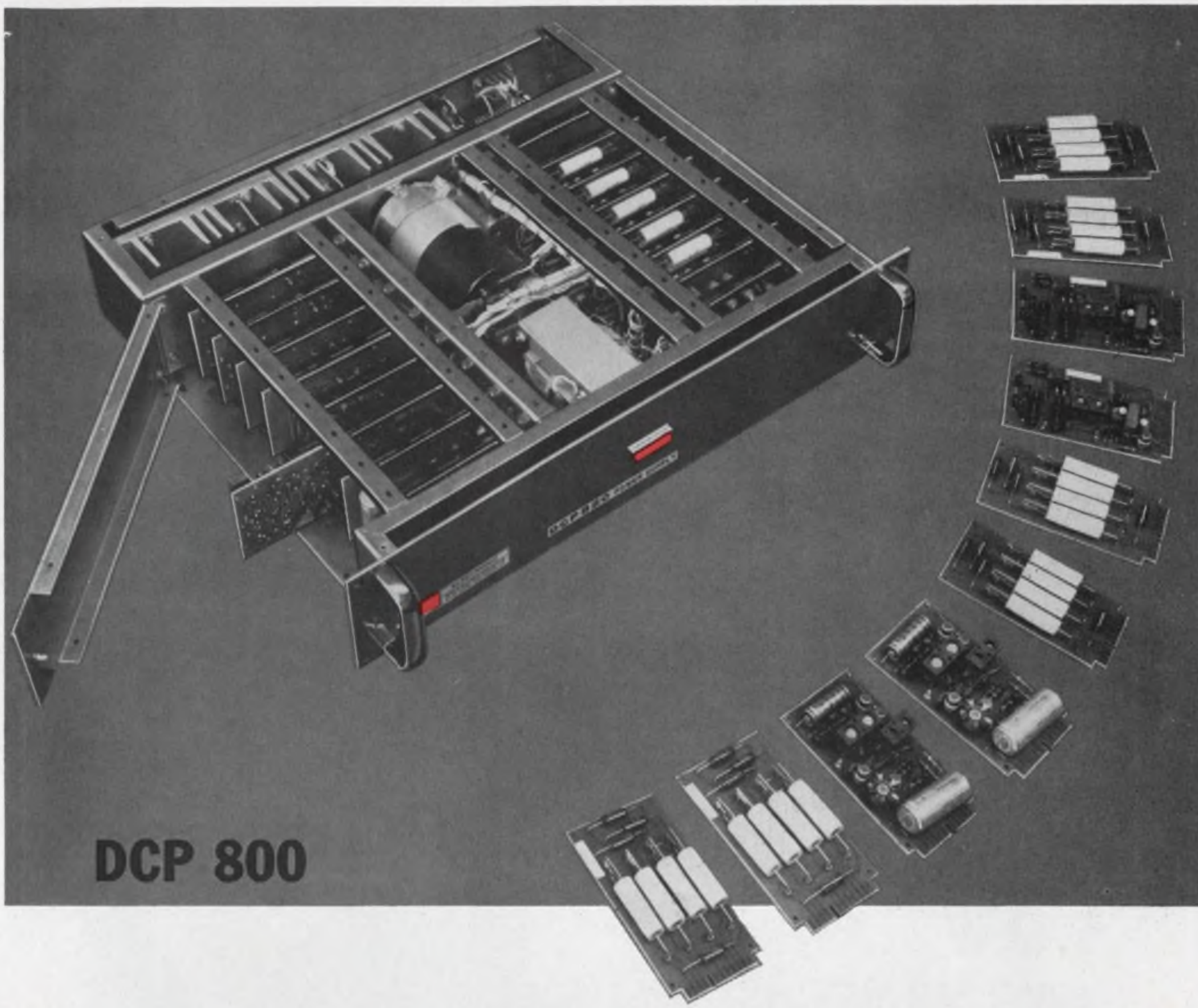
Price: from $12,500. Spacerays, Inc., Applied Lasers Div., 72 Maple St., Stoneham, Mass. Phone: (617) 428-0790. *Circle No. 153*



Tape recorder buffers

This tape recorder buffer translates, formats and transfers data from analog-to-digital converters, counters, registers or digital clocks to standard incremental magnetic tape recorders. The buffer accepts six 4-bit or four 6-bit characters. Any number of additional inputs can be provided. On command, data is sequenced to the tape recorder. The buffers generate IR gap commands and other functions that produce computer-compatible tapes.

P&A: $1200; 60 days. Control Equipment Corp., 19 Kearney Rd., Needham Heights, Mass. Phone: (617) 444-7550. *Circle No. 154*



The DCP 800 Power Supply is a high performance, solid state DC power supply with exceptional versatility. It is a digitally programmed unit suitable for automatic test equipment. It provides automatic crossover from regulated voltage to regulated current.

POWER INPUT:

105-125 Volts — 50-63 cps — single phase.

CONTROL INPUT:

Voltage — Binary Coded Decimal Five Digit Programming in 1 mv steps.
Current — Binary Coded Four Digit Programming in 1 ua steps with 10 to 1 and 100 to 1 range expansion. The DCP-812 only has a 10 to 1 range expansion.
Excitation — Provided by 24 Volts to Reed Relay Input Circuit.

OUTPUT:

	DCP-812	DCP-813	DCP-814	DCP-820	DCP-821
Voltage	0-100V	0-50V	0-100V	0-.50V	0.100V
Current	0-0.1A	0-1A	0-1A	0-0.5A	0-0.5A

ABSOLUTE VOLTAGE ACCURACY: 0.1% or 1.5 mv. Includes:

Line regulation measured for an input voltage step change of 105-125 Volts at 50-63 cps.
Load regulation measured for a no load to full load or full load to no load change within range.
Stability for 8 hours after 30 minutes warm-up.

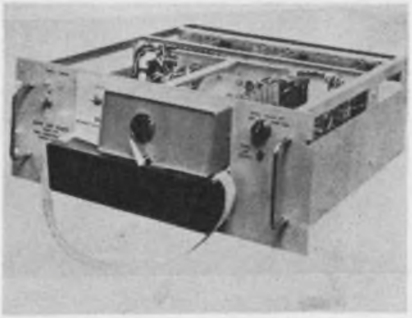
ABSOLUTE CURRENT ACCURACY: 0.35% or 0.25 uamp. Includes:

Line regulation measured for an input voltage step change of 105 to 125 Volts at 50-63 cps.
Load regulation measured for 100 Volt step change increase or decrease.
Stability for 8 hours after 30 minutes warm-up.

Write for more information.

THE ROWAN CONTROLLER COMPANY • ELECTRONIC MEASUREMENTS DIV.
OCEANPORT, NEW JERSEY 07757

ON READER-SERVICE CARD CIRCLE 58



Block tape readers

Available for fixed or variable block lengths from 4 lines up, these programable block tape readers have 20 to 320 or more bits per block. Some configurations will accommodate 40 character blocks in one 7-in. high chassis. The tape reader can be used for any fixed block size from 4 to 40 or more characters or any variable block length using a stop code. Each output bit switches up to 100 mA at up to 30 V. Block stepping rate is 50 blocks/s max for a 4-line block and 7 blocks/s for a 40-line block.

Wang Laboratories, Inc., 836 North St., Tewksbury, Mass. Phone: (617) 851-7047.

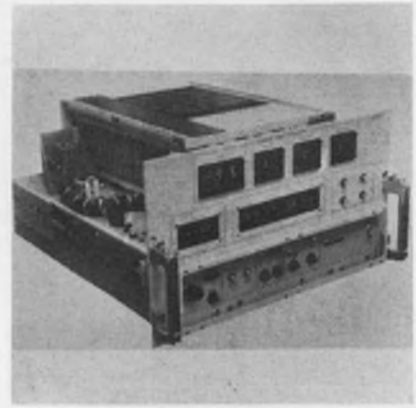
Circle No. 155

AM and pulse receivers

Series 415 AM receivers and series 416 pulse receivers each have four standard tuners covering a 60- to 150-MHz range. Individual receivers provide selection of any of four preset channels within their range. Each unit has a separate 21.4-MHz output. Input impedance is 50 Ω, noise is 6.5 dB max and image IF rejection is 55 and 65 dB respectively. Pulse receivers have a 2-MHz IF bandwidth.

P&A: $995; 60 days. Communication Electronics Inc., 6006 Executive Blvd., Rockville, Md. Phone: (301) 933-2800.

Circle No. 156



Time generator

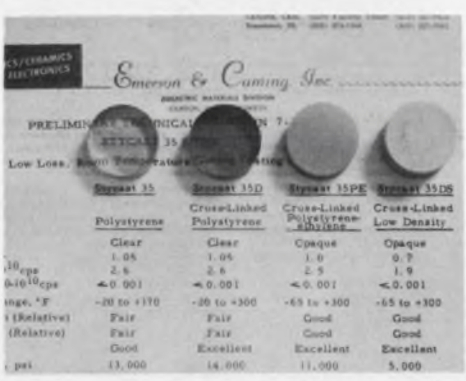
In tracking and data processing systems this time generator time-controls or time-tags phases of an operation. A NASA 1/s binary time code and a NASA serial decimal time code are provided. 30 bits of BCD represents days (10), hours (6), minutes (7) and seconds (7). Coherent pulse rates are from 0.1 to 500,000 pps. An external 1-MHz reference frequency source provides information.

General Dynamics, Electronics Div., 1400 North Goodman St., Rochester, N. Y. Phone: (716) 342-8000.

Circle No. 157

LOW LOSS

CASTING RESINS



FREE CHART

Ten Low Loss systems are offered for both room and elevated temperature cure. Dissipation factors are below 0.001 for minimum effect on circuit operation. Dielectric Constants as low as 1.7. Temperature capability to 400°F.

This valuable Chart is yours.
Write or use Reader Service Card.

Emerson & Cuming, Inc.

- Canton, Massachusetts
- 604 W. 182nd St., Gardena, Calif.
- 3450 Commercial Ave., Northbrook, Ill.

ON READER-SERVICE CARD CIRCLE 59

Ebert Guaranteed* Reliability

NEW EBERT Hi-power® METAL TUBE MERCURY RELAYS ARE GUARANTEED TO PROVIDE LONG, MAINTENANCE-FREE LIFE EVEN IN PROBLEM ENVIRONMENTS

FACT: Ebert *Hi-Power* Mercury Relays are available in 1, 2 and 3-pole units. Load ratings up to 40KW or 100 Amps. Load voltages up to 550 V.A.C. They are *unmatched* for continuous in-use reliability, durability, and ease of installation.

FACT: Their *hermetically sealed, mercury-to-mercury* action eliminates contact problems.

FACT: Their epoxy-clad, *metal tube* construction withstands physical shock or rough handling.

FACT: Once you've tried an Ebert *Hi-Power* Relay you won't be satisfied with any other!

*Guaranteed for one year against defects in materials and workmanship.

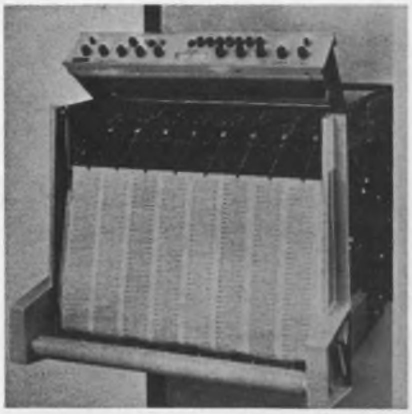
Also available in solid state time delay and solid state hi-sensitive models

WRITE FOR FREE MANUAL AND 30-DAY FREE TEST DETAILS

EBERT ELECTRONICS CORP.

130-10 JERICHO TURNPIKE, FLORAL PARK, N.Y. 11002

ON READER-SERVICE CARD CIRCLE 60



Analog recorder

Thermal rectilinear write-out of input data is provided by this analog recorder. The self-contained multi-channel system offers an 85-Hz full scale response with a 3.5-ms max rise time. The direct-writing oscillograph has high-torque writer units with heat stylus and continuous locking cradle for continuous uniform tracings. The system includes amplifiers, power supply, writer units and paper drive.

Beckman Instruments, Inc., 2500 Harbor Blvd., Fullerton, Calif. Phone: (714) 871-4848.

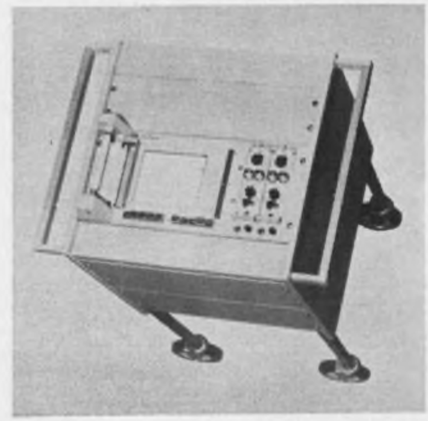
Circle No. 158

Digital computer

This 12-bit core memory computer features an 8-μs 4096-word expandable core memory, an ASR-33 teletype and a software package which includes FORTRAN. The PDP-8/S combines a fully parallel core memory and input/output facility with a serial arithmetic unit.

P&A: under $10,000; 90 days. Digital Equipment Corp., 146 Main St., Maynard, Mass. Phone: (617) 897-8821.

Circle No. 159

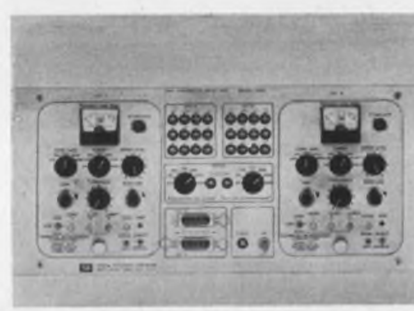


Oscillographic recorder

The two-channel thermal-writing oscillograph operationally controls input signals. The dc preamp has a gain of 100,000. The phase-sensitive demodulator has a calibrated reference phase shift. Carrier pre-amp provides 2400 Hz transducer excitation. The ac/dc converter has 0.5% min resolution and a 10-ms response time. Model 7702A system simultaneously records two variables on 50-mm channels. Resolution is 4 Hz/mm. Chart speeds are 1, 5, 20 and 100 mm/s.

Price: $2475. Hewlett-Packard, Sanborn Div., 175 Wyman St., Waltham, Mass. Phone: (617) 894-6300.

Circle No. 181



Analog/digital converter

Two 20-MHz digitizing clocks allow this dual-input system to operate with a deadtime of 16 µs max for 256-address resolution or 208 µs for 4096-address resolution. Linearity is within ±0.1%, and differential linearity is greater than ±2% over the top 98% of the input range. For on-line data processing, model 217A/242A operates with a general-purpose digital computer or pulse analyzer. The converters may be operated independently or in conjunction.

Technical Measurement Corp., 441 Washington Ave., North Haven, Conn. Phone: (203) 239-2501.

Circle No. 182

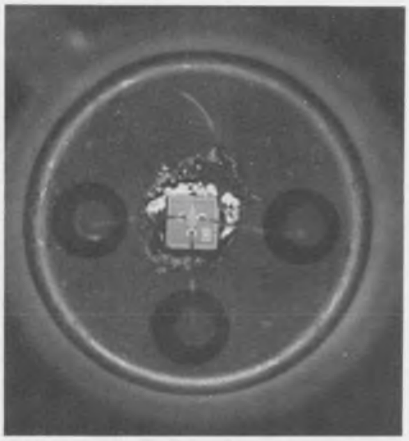
Only Norden offers you 9 new families of reliable encoders ...the variety you need for all your systems—optical, magnetic, or contacting.

• A new Size 31 Gray-code contacting encoder with a 5-million-turn life. First in a new family of Size 31 encoders. • A new high-reliability Size 11 Binary external logic encoder. • A new low-cost optical incremental encoder family with direction sensing, zero reference, and built-in electronic circuit options. • A new Size 23, 360-count single-turn and multi-turn encoder for direct use with integrated circuit logic. • A new low-cost Size 11 Beacon encoder family. • A new low-cost magnetic encoder family. • A new 8-digit-per-turn Size 18 Binary external logic encoder family. • A new 8-digit-per-turn self-selecting Size 18 family with guaranteed life of 7½ million turns. • A new low-cost 100-million-revolution-life encoder.

All these, plus Norden's established product line of more than 50 basic encoders and many modifications, designed to meet your most exacting specifications. Norden encoders are ruggedly built for heavy duty and extreme environments. For detailed information about Norden encoders, write to Norden Division of United Aircraft Corporation, Norwalk, Connecticut, or phone (203) 838-4471.

Norden DIVISION OF UNITED AIRCRAFT CORPORATION
NORWALK, CONNECTICUT

ON READER-SERVICE CARD CIRCLE 63



Ultra-stable MOSFET

A developmental p-channel enhancement-mode insulated-gate field-effect transistor is aimed at solving the problems associated with high-temperature stability of threshold voltages and junction leakage currents. The TXF-200 exhibits a change in gate voltage on the order of 0.5 V at a drain-to-source voltage (V_{DS}) of ±20 V for 24 hours at 200°C. The maximum drain leakage is specified at 5 nA at a drain-to-source voltage of 15 V. The extremely high input impedance ($10^{13}\Omega$) allows amplification with negligible loading of the signal source. Threshold voltage at 10 μA and −10 V ranges from 2 to 5 V. Drain breakdown is 30 V. Input capacitance at 100 kHz is a low 3 pF. The devices are packaged in a TO-18 can and are operable from −65 to 200°C.

Sprague Electric Co., 347 Marshall St., North Adams, Mass.

Circle No. 183

Capacitance diodes

Plastic variable capacitance diodes measure 0.09-in. long with a diameter of 0.075 in. and silver leads. Their abrupt junction silicon epitaxial structure makes high capacitance ratios possible with working voltage to 100 V max and 4-V, 50-MHz Q of up to 450. Capacitance values at 4 V range from 6.8 to 56 pF with ±10% tolerance.

Availability: stock to 2 wks. Somerset Electronics Corp., Box 115, Manville, N. J. Phone: (201) 722-2340.

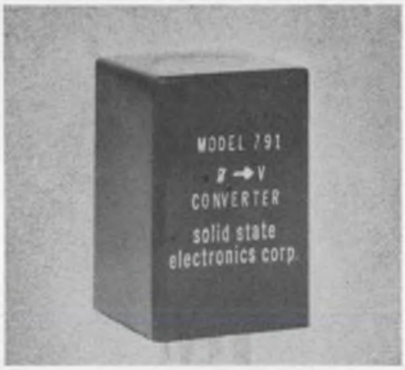
Circle No. 184

90-A transistors

Capable of collector currents to 90 A, these transistors have a BV_{CBO} ranging from 80 to 140 V and a V_{CEO} ranging from 60 to 120 V. The unit can dissipate 280 W at 25°C case. Saturation voltage is 1.5 V max at 50 A. Leakage is 10 μA max at V_{CB} of 60 V. Applications include use in dc to dc converters, dc to ac inverters and switching regulators.

Availability: stock. Solitron Devices, Inc., 1177 Blue Heron Blvd., Riviera Beach, Fla. Phone: (305) 848-4311.

Circle No. 185

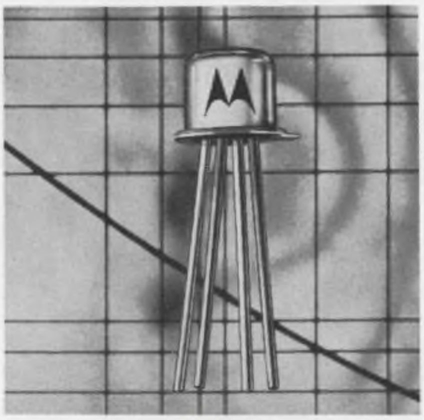


Phase-to-dc converter

A dc output proportional to the absolute difference between two ac signals is produced by this phase-to-voltage converter. Both signals must have equal frequencies or multiple frequencies of each other. This unit is a full-wave bridge phase-sensitive detector with residual voltage suppression. Energized solely by input signals, the unit operates in a pure synchronous switching mode. Applications include phase measurement and control and telemetering.

Solid State Electronics Corp., 15321 Rayen St., Sepulveda, Calif. Phone: (213) 364-2271.

Circle No. 186

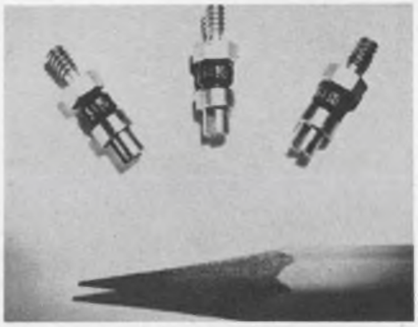


Small-signal RF FET

N-channel junction FETs for small-signal RF applications offer low cross-modulation and intermodulation distortion with a guaranteed 100-MHz max noise figure of 2.5 dB. In addition, drain and source are interchangeable. The low transfer capacitance (2 pF) and input capacitance (6 pF) make the 2N3823 useful in applications as a low-noise uhf amplifier up to 500 MHz. Gate-to-source breakdown voltage ($V_{(BR)GSS}$) is −30 Vdc. Forward transfer admittance (y_{fs}) is 3500 to 6500 μmhos at 1 kHz. Devices are packaged in a TO-72 can.

P&A: $8.60 (over 100); stock. Motorola Semiconductor, P.O. Box 955, Phoenix, Ariz. Phone: (602) 273-6900.

Circle No. 187



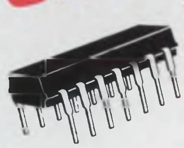
12-A silicon rectifier

Measuring 0.187 x 0.46 in., this stud mount rectifier has controlled avalanche characteristics. PIV ratings to 600 V are available. Hard glass is fused directly to the silicon and terminal pins. A 4-40 stud, which permits mounting to a heat sink, is brazed to one end of the unit and a turret terminal is brazed to the other. Surge ratings are up to 200 A at 1 Hz.

P&A: $5 to $11; stock. Unitrode Corp., 580 Pleasant St., Watertown, Mass. Phone: (617) 926-0404.

Circle No. 188

Now Commercial High Speed TTL I/C's in dual in-line packages 10 ns gates 82¢ per gate function.



Signetics very high speed TTL integrated circuits are now available for as little as 82¢ per gate function in distributor quantity. 10 ns gate delays and 35 MHz flip-flops make SP800 series especially suitable for high speed computers and very high speed counters. Molded dual in-line packages offer lower cost, high performance and easy handling.

SP 800A (+15°C +55°C) Series available from distributor stock
ST 800A (0°C to 70°C) available on factory order only

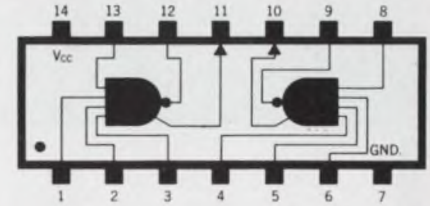
SIGNETICS INTEGRATED CIRCUITS

A subsidiary of Corning Glass Works
811 East Arques Avenue, Sunnyvale, California
Tel.: (408) 739-7700 TWX: (910) 339-9220

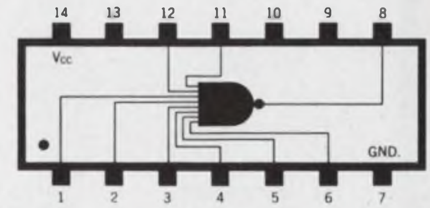
		1000-2499	1 Type 100-999	Mixed 100-999	25-99	1-24
SP806A	Dual 4-Input Gate Expander	2.95	3.10	3.25	3.70	4.65
SP808A	Single 8-Input NAND Gate	2.95	3.10	3.25	3.70	4.65
SP816A	Dual 4-Input NAND Gate	2.95	3.10	3.25	3.70	4.65
SP825A	J-K Binary Element	4.55	4.80	5.05	5.75	7.20
SP826A*	Dual AC Binary Element	8.00	8.40	8.80	10.10	12.60
SP840A	Dual Exclusive-OR Gate	3.30	3.50	3.70	4.20	5.25
SP855A	Dual 4-Input Power Gate	3.30	3.50	3.70	4.20	5.25
SP870A	Triple 3-Input NAND Gate	3.30	3.50	3.70	4.20	5.25
SP880A	Quadruple 2-Input NAND Gate	3.30	3.50	3.70	4.20	5.25

*Available after July 15

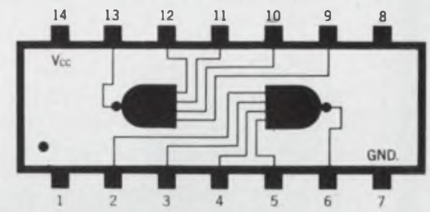
Nine compatible elements



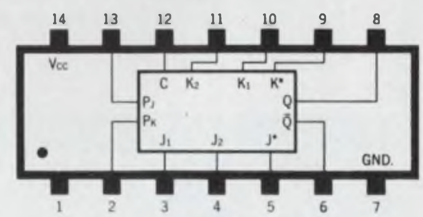
SP806A Dual 4-Input Gate Expander



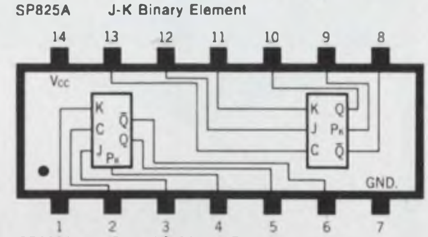
SP808A Single 8-Input NAND Gate



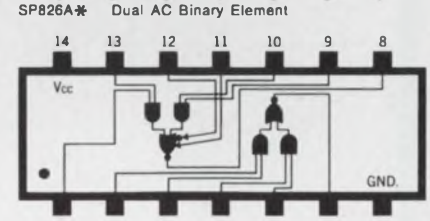
SP816A Dual 4-Input NAND Gate
SP855A Dual 4-Input Power Gate



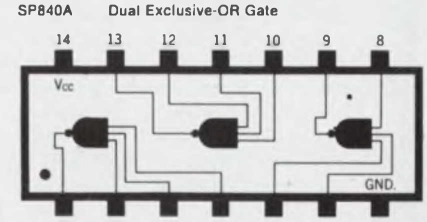
SP825A J-K Binary Element



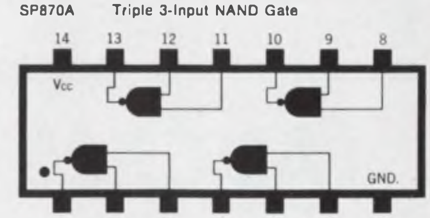
SP826A* Dual AC Binary Element



SP840A Dual Exclusive-OR Gate

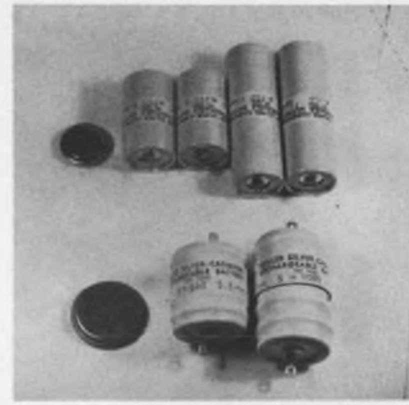


SP870A Triple 3-Input NAND Gate



SP880A Quad 2-Input NAND Gate

ON READER-SERVICE CARD CIRCLE 64

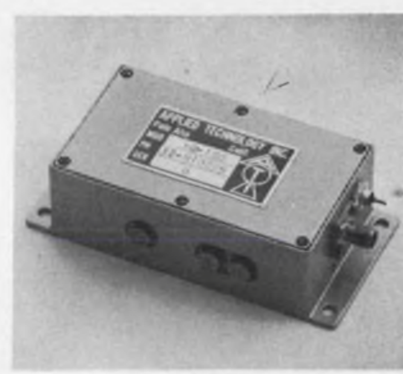


Silver/cadmium battery

Silver/cadmium batteries are offered in small sealed button cases. Advantages over nickel/cadmium cells include: half the size and weight for a given capacity, higher rates of charge and discharge, longer charge retention and long cycle life. With capacities starting at 250 mA-hours, the batteries are designed for microelectronics, communications transceivers, test instruments, medical instruments, alarm systems, telemetry, paging systems and timers.

Electrochimica Corp., 1140 O'-Brien Dr., Menlo Park, Calif. Phone: (415) 323-0283.

Circle No. 189



40-mW crystal oscillator

This single-frequency 40-mW crystal oscillator can be used at any discrete frequency from 90 to 110 MHz. Frequency accuracy and stability are better than 20 ppm over a 0 to 60°C range. Spurious signals are better than 50 dB down. The 4.5-oz unit is housed in a cast aluminum case measuring 1 x 1.75 in.

P&A: $495; 45 days. Applied Technology Inc., 3410 Hillview Ave., Stanford Industrial Park, Palo Alto, Calif. Phone: (415) 321-5135.

Circle No. 190

TECHNO

if you need a 1/4" trimmer... and have only two choices...

what do you do?

Compare. You'll find the Techno Series 10 wire-wound trimmers give you the large size performance you want in the size you need. These humidity-proof multiturn trimmers will perform right up with micro-miniature trimmers many times their size. And pass all military environmental tests.

Check the thin profile — just .156" thick. It lets you stack more units in the same space. They take the tight packaging squeeze without any problems. That's because the diayll phthalate case takes high temperatures and offers greater than 100,000 megohms of insulation resistance to eliminate insulation problems.

But the key to unmatched performance is the "two-half" case design for 100% inspection before and after final sealing. Right there you get reliability insurance.

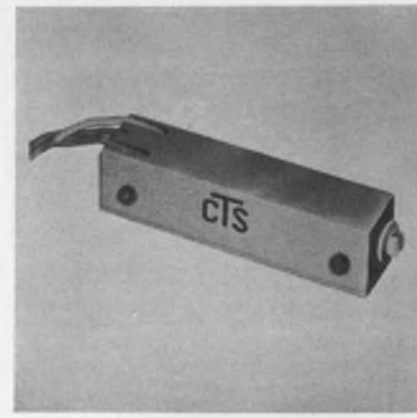
Your Techno sales representative can tell you more about this trimmer series. Contact him. Or write for Bulletin No. 10A. Techno-Components Corp., 7803 Lemona Avenue, Van Nuys, California 91405.

SPECIFICATIONS

Resistance values	100 to 25K ohms
Power rating	0.5 watt at 50°C
Operating temperatures	−65° to 175°C
TC of trimmer	50 PPM/°C max.
Adjustment ratio	25:1

TECHNO

ON READER-SERVICE CARD CIRCLE 65

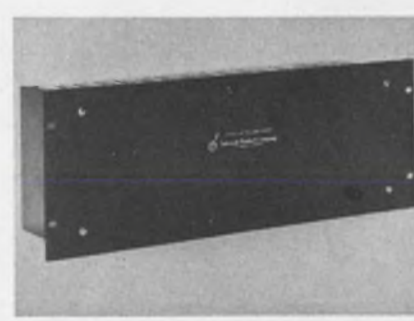


Ultra-stable trimmer

Infinite resolution, 0.01% stability as a ratio divider and 0.0005% settability are offered by this wire-wound trimmer. The unit has a contact which slides along the entire length of the spiral winding instead of from turn to turn so the contactor can not cause shorts. The control has 1-Ω contact resistance. Standard resistance range is 400 Ω to 3 kΩ and power rating is 1/2 W at 125°C. Leads to mounting screws are rated at 1 kVac operating at 500 Vdc max.

P&A: $17.60; 8 wks. CTS Corp., Elkhart, Ind. Phone: (219) 523-0210.

Circle No. 191

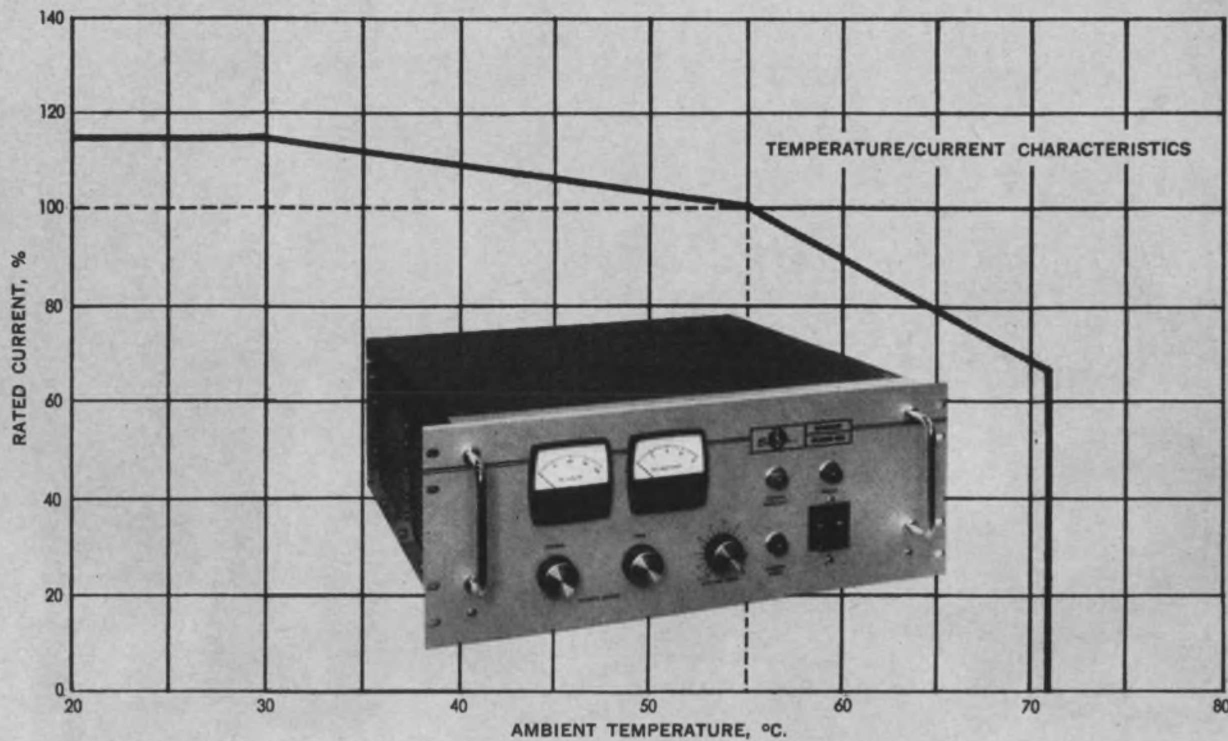


70-dB ac/dc converter

A dynamic range of 70 dB from 5 Hz to 40 kHz and a range of 60 dB from 3 Hz to 200 kHz is provided by this ac to dc converter. Accuracy is 0.5% or better. Input is 1 Vac for an output of 1 Vdc. Noise is 0.2 mV max. The converter contains from 1 to 8 detector channels per 7-in. chassis. A regulated power supply is included.

Availability: 30 days. Technical Products Co., 6670 Lexington Ave., Los Angeles. Phone: (213) 464-8121.

Circle No. 192



Sorensen DCR Series now with temperature capability to 71°C.

Sorensen Wide Range Power Supplies to 20 kW.

Sorensen's wide range DCR Series has been up-dated and improved. What's new about the DCR's? They are now 100% silicon; ambient temperature capability is now to 71°C. • Four 3-phase models have been added extending power capability to 20 kW; 24 models are now available with ranges up to 300 volts. • Multiple mode programming—voltage/current/resistance. • Voltage regulation, line and load combined, is ±.075% for most models • Constant current range 0 to rated current. • DCR's meet MIL-I-26600 and MIL-I-6181 specifications and conform to proposed NEMA standards. • Front panel indicator for voltage/current crossover. These features of the improved DCR (model numbers will have an "A" suffix) are offered at no increase in price. For DCR details, or for data on other standard/custom power supplies, AC line regulators or frequency changers, call your local Sorensen rep, or write: Raytheon Co., Sorensen Operation, Richards Avenue, Norwalk, Connecticut 06856. Tel: 203-838-6571.

MODEL SELECTION CHART

Voltage	Amps.	Model	Price	Amps.	Model	Price	Amps.	Model	Price	Amps.	Model	Price
0- 20	125	DCR 20- 125A	$1055	250	DCR 20- 250A	$1495	—	—	—	—	—	—
0- 40	10	DCR 40- 10A	325	20	DCR 40- 20A	525	35	DCR 40- 35A	$ 710	60	DCR 40-60A	$925
0- 40	125	DCR 40- 125A	1350	125	DCR 40 -125A	1995	500	DCR 40-500A	2950	—	—	—
0- 60	13	DCR 60- 13A	525	25	DCR 60- 25A	710	40	DCR 60- 40A	900	—	—	—
0- 80	5	DCR 80- 5A	325	10	DCR 80- 10A	525	18	DCR 80- 18A	710	30	DCR 80-30A	875
0-150	2.5	DCR 150- 2.5A	325	5	DCR 150- 5A	525	10	DCR 150- 10A	710	15	DCR 150-15A	825
0-300	1.25	DCR 300-1.25A	325	2.5	DCR 300- 2.5A	525	5	DCR 300- 5A	710	8	DCR 300- 8A	825

RAYTHEON

ON READER-SERVICE CARD CIRCLE 206

ON READER-SERVICE CARD CIRCLE 207 ➤

Wrong! Its got GVB*. Even at more than 1500 volts, tests show no breakdown on M.A. bobbin cores with GVB. In addition to guaranteeing the core's ability to withstand at least 500 volts between bare winding and bobbin, GVB finish also seals the bobbin to withstand a ten-inch mercury vacuum.

It seals against potting material, provides a resilient, non-slip base for winding, and its epoxy skin protects the core against wire cuts. Abraded wire problems are eliminated and no prior taping is required.

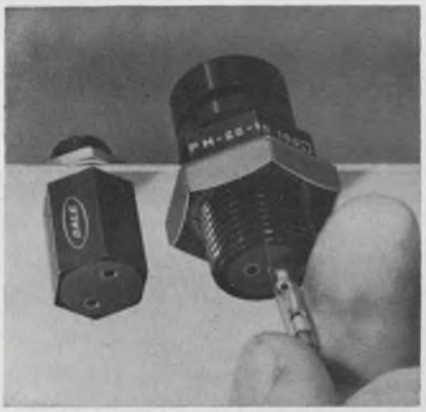
GVB has proven itself on thousands of cores . . . and now Magnetics has applied it to the bobbin core, the miniature workhorse of computers, high frequency counters, timers, oscillators, inverters and magnetic amplifiers.

Made from ultra-thin permalloy 80 and Orthonol® (0.001″ to 0.000125″), Magnetics' bobbin cores are available in tape widths from 0.023″ to 0.250″ or wider on request. Core diameters range down to less than 0.100″ with flux capacities down to several maxwells.

For more information on GVB Bobbin Cores, write Magnetics Inc., Dept. ED-42, Butler, Pa. 16001.

MAGNETICS inc.®

*Guaranteed voltage breakdown



Wirewound resistors

Two power wirewound resistors with plug-in connections are designed to mount through a panel. They come in 10 and 25 W sizes with a resistance range of 0.1 Ω to 95.2 kΩ. Both standard and non-inductive windings are available in tolerances of 3%, 1%, 0.5%, 0.25%, 0.1% and 0.05%. The resistors meet MIL-R-18546. Both can be connected to the circuit by inserting tapered pins into two female receptacles which are connected to the ends of the resistance element.

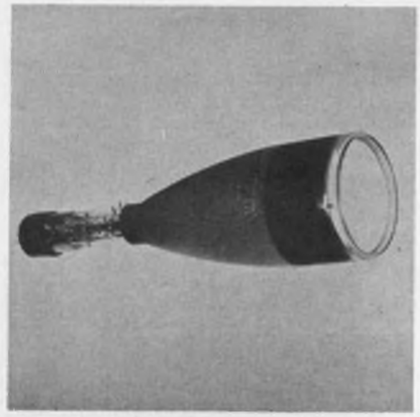
Dale Electronics Inc., P. O. Box 488, Columbus, Neb. Phone: (402) 564-3131. *Circle No. 235*

Trimmer capacitors

Available in panel mount, PC, and sealed vertical PC types, these embedded-band trimmer capacitors have ranges to 16 pF. The smallest sealed panel mount unit is 21/64 in. long and has a range of 1 to 10 pF. These units have a wvdc of 500 Vdc, temperature coefficient of ±50 ppm/°C, and linearity of ±1%. There is no self-resonance below 1200 MHz.

Availability: 4 wks. Voltronics Corp., 296 Route 10, Hanover, N. J. Phone: (201) 887-1517.

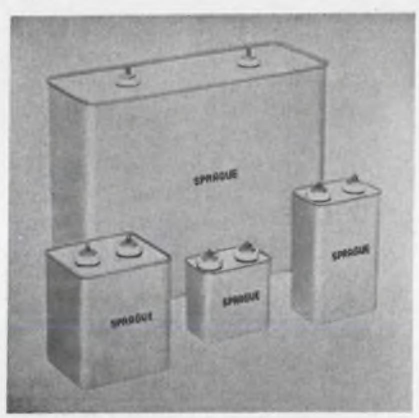
Circle No. 236



Cathode-ray tube

A sharp, bright display in the presence of high ambient light is given by this CRT. Moderate phosphor brightness is required for signal clarity. The aluminized phosphor is deposited on a thin glass sheet mounted within the tube. With electrostatic deflection and small spot size, this CRT has an internally mounted substrate screen.

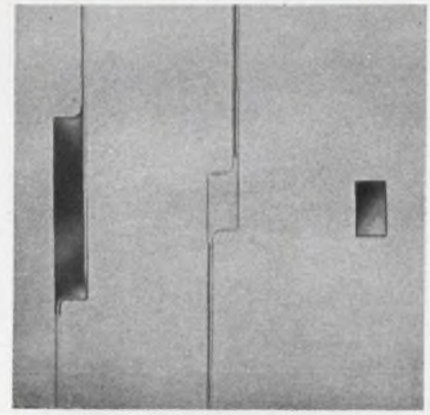
P&A: \$500; 12 to 14 wks. General Atronics Corp., 1200 E. Mermaid La., Philadelphia. Phone: (215) 248-3700. *Circle No. 237*



Storage capacitors

High-voltage dc energy storage capacitors for laser photoflash applications are available in 200 μF at 2500 Vdc, 260 μF at 3000 Vdc, 50 μF and 140 μF at 4000 Vdc and 15 μF at 5000 Vdc. Type 30P design utilizes a castor-oil impregnated paper dielectric. Type 38P units are made with a non-flammable askarel-impregnated paper dielectric. Standard capacitance tolerances are 10 and 20%. Temperature coefficient is 5% from 0 to 40°C.

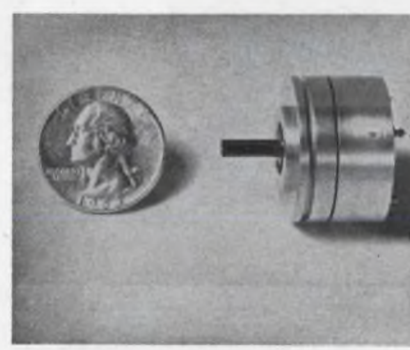
Sprague Electric Co., 347 Marshall St., North Adams, Mass. *Circle No. 238*



Cermet microresistors

Cermet element microresistors cover 10 Ω to 1 MΩ. Model 4205, measuring 0.3- x 0.05- x 0.03-in., has gold-plated nickel leads emerging from an epoxy coated alumina substrate. Model 4201 is a resistor "chip" without leads, measuring 0.1- x 0.05- x 0.03-in. Its sides are grooved and tinned with solder. Resistance tolerances available are ±1, ±2, ±5 and ±10% over a range of 10 Ω to 200 kΩ (4201) and 200 kΩ to 1 MΩ (4205). Power rating is 0.07 W at 100°C and temperature coefficient is 200 ppm/°C over the −65 to 150°C operating range.

Bourns Inc., 1200 Columbia Ave., Riverside, Calif. Phone: (714) 684-1700. *Circle No. 239*



Miniature 28-V switch

Brush design and choice of dielectric keep this 0.9-oz switch noise-free for its lifetime. Designed as a time integrating device in alignment amplifiers, the unit has an operating capacity of 28 Vdc and a current capacity of 100 mA resistive. Starting torque is 0.03 in.-oz max and insulation resistance is 1000 MΩ at 200 Vdc. Life is 10^7 revolutions at 3600 rpm with rated load either direction.

Litton Industries, 1111 N. Main, Blacksburg, Va. Phone: (703) 552-3011. *Circle No. 240*

Fast, convenient direct reading measurements of impedance and phase angle 500 kHz to 108 MHz...

THE 4815A RF VECTOR IMPEDANCE METER

This new Vector Impedance Meter is a versatile instrument that provides fast, direct reading measurements of impedance and phase angle over the frequency range from 500 kHz to 108 MHz. It is continuous tuning over this frequency range, and does not require balancing or data interpretation. Thus, it is an extremely useful tool for the evaluation of the complex impedance of both active circuits and components. The convenience of probe measurement, ease of operation, and direct reading features make the instrument equally useful for laboratory, receiving inspection or production line measurements.

The 4815A is a convenient and powerful measuring tool for any application involving measurements over a band of frequencies or in-circuit measurements. It may be used to determine the self-resonance point of capacitors, the series and parallel resonance points of crystals, or the characteristics of high frequency transformers and transducers. Price: $2650 f.o.b. factory. For complete specifications, contact your local Hewlett-Packard field engineer or write Hewlett-Packard, Rockaway Division, Green Pond Road, Rockaway, N. J. 07866; Europe: 54 Route des Acacias, Geneva.

Advantages:

Fast, continuous tuning from 500 kHz to 108 MHz

Provides data directly in impedance and phase angle, 1 ohm to 100K ohms 0 to 360°

Convenient probe for in-circuit measurements

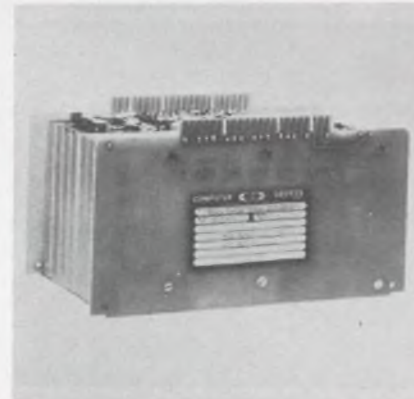
Analog outputs permit permanent data recording

Self calibration check provides measurement confidence

Low-level test signal minimizes circuit disturbance

HEWLETT hp PACKARD
An extra measure of quality

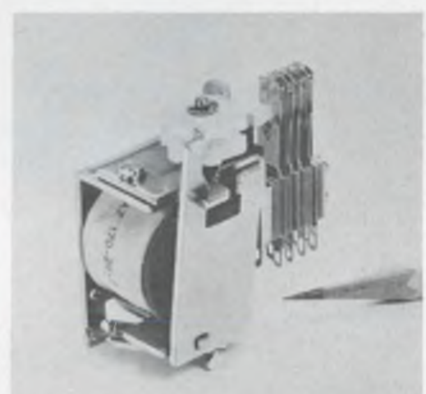
ON READER-SERVICE CARD CIRCLE 70



Delay-line memory

Delay-line computer memory modules can be assembled into a multi-channel memory stack. Each module contains a delay line and read, write and logic circuitry. With delays up to 1000 μs these modules can be used at bit rates of up to 1 MHz in "return to zero" and 2 MHz in "non-return to zero" modes. Each 11-oz module uses 0.3 W and measures 3.5 x 6.37 x 0.5 in.

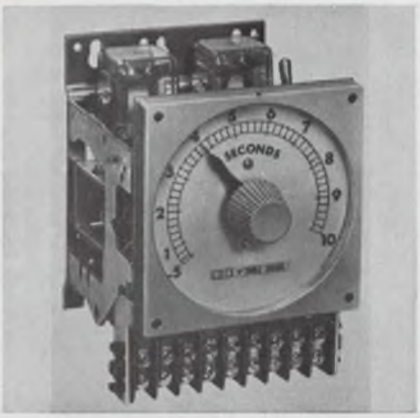
P&A: $350; 4 to 5 wks. Computer Devices Corp., 6 W. 18 St., Huntington Station, N. Y. Phone: (516) 271-0666. *Circle No. 241*



Pulse sequencing relay

Incorporating bifurcated contacts, a molded coil bobbin and two moving parts, this relay provides more than 10^6 mechanical operations. A ratchet and pawl arrangement brings contacts into position by energizing the coil with a pulse of greater than 20 ms duration. The contacts, which remain in position after removal of the energizing voltage, may be switched back to the original position by a second pulse.

Price: $5 (1 to 9). American Zettler, Inc., 697 Randolph Ave., Costa Mesa, Calif. Phone: (714) 540-4190. *Circle No. 242*

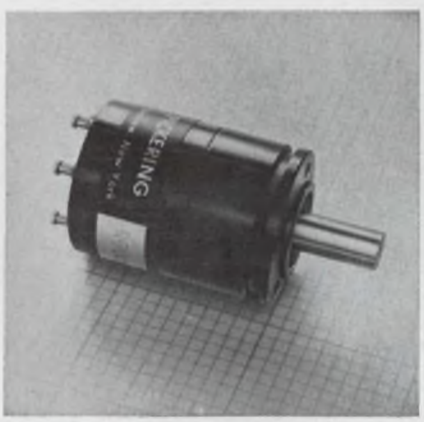


Reset timers

These reset timers consist of a solid-state timing circuit and two plug-in output relays. When the timer is energized, one relay closes. After an adjustable time delay the second relay then closes. Contact rating is 10 A resistive at 120 Vac, 50/60 Hz. The units have 0.02-s accuracy for intervals up to 1 s and 2% accuracy for 1- to 10-s intervals. 1- or 10-s full-scale time ranges are selected by a toggle switch. Reset time is 50 ms.

E. W. Bliss Co., Eagle Signal Div., 736 Federal St., Davenport Iowa. Phone: (319) 324-1361.

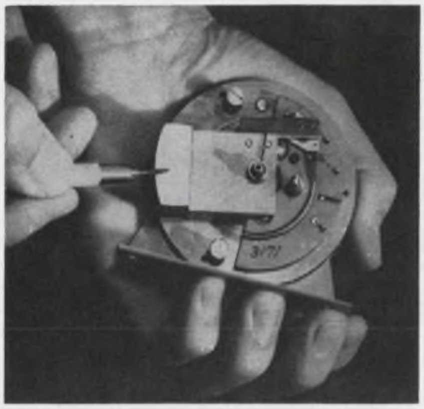
Circle No. 243



Rotary transformer

Up to 1-V/degree output is provided by this differential transformer. Stepless output is proportional to rotary mechanical position. When used as an ac induction pot, the unit changes small rotation into high ac output. Dc converters are available. With an input of 26 V (400 to 2400 Hz), dc output is 0 to ±5 Vdc min at a range of 0 to ±20° of rotary displacement. This noise-free unit has a 40° range (±20° from null) with ±0.35% linearity.

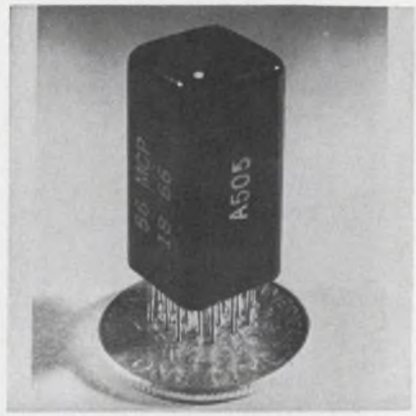
Pickering Co., Inc., 101 Sunnyside Blvd., Plainview, N. Y. Phone: (516) 681-0200. *Circle No. 244*



Pendulum transducer

Either wirewound or conductive plastic, this transducer consists of a vertically suspended pendulum in a low-torque bearing system. An insulated extension of the pendulum arm provides a pick-off system which obtains a voltage signal from the stationary resistive element. Voltage output is a function of the angular displacement of the case from a vertical reference. Infinite resolution is featured in the conductive plastic transducer.

Litton Industries, 226 E. 3 St., Mt. Vernon, N. Y. Phone: (914) 667-6607. *Circle No. 245*

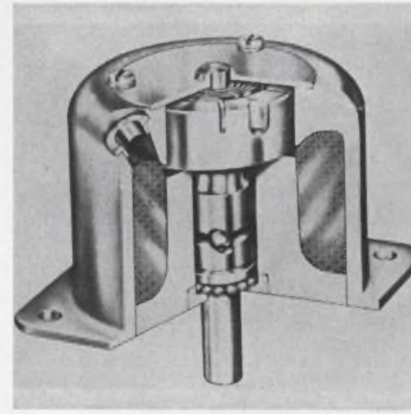


Operational amplifier

Inversion, summation, integration, differentiation, or any combination are performed over a -55 to 125°C range. Model A505 hybrid silicon amplifier has a long term drift of 100 μV max for 60 days. Open loop voltage gain is typically 1,000,000. The differential dc amplifier has a $\pm$10-V input range and a typical unity gain-bandwidth of 1 MHz without external compensation. Output is $\pm$10 V at 5 mA.

P&A: $95; stock to 30 days. United Aircraft Corp., Broad Brook, Conn. Phone: (203) 623-1621.

Circle No. 246



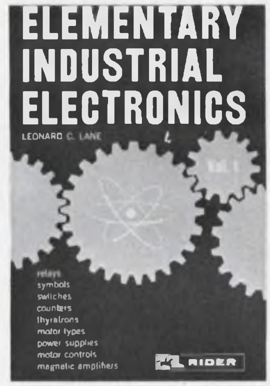
Rotary solenoids

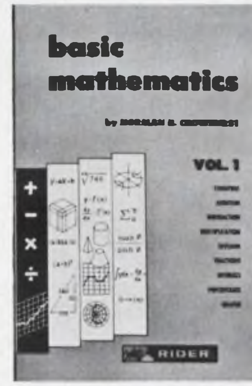
Motion absorbing devices are unnecessary with these rotary dc solenoids. With zero axial shaft movement, these prime energy sources provide an instantaneous snap-action rotary force. Four models have output strokes from 5 to 130°. Torque curves are predominantly flat or have emphasis on the beginning, middle or end of a power stroke. Work available ranges from 30 oz-in.-degrees to 300 lb-in-degrees.

Langevin, Inc., 1801 E. Carnegie Ave., Santa Ana, Calif. Phone: (714) 547-6204.

Circle No. 247

Take a full 30 days to examine why...





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D-C CIRCUIT PRINCIPLES by Training Systems, Inc., and Stanley L. Levine

A complete guide to d-c circuits, the volume presents over 375 carefully prepared frames for a comprehensive and easily understood survey of the field. The course begins with an introduction to electron theory and current flow, and culminates in a clear and easy-to-follow explanation of parallel and series parallel circuits. A Rider Programodule. #0379 $3.95.

SIMPLIFIED TRANSISTOR THEORY by Training Systems, Inc., and Stanley L. Levine

A basic introduction to physical theory and operating principles of transistors and transistor circuits, this programmed text clearly and thoroughly elucidates all the fundamental information necessary to the beginning technician. A Rider Programodule. #0705 $3.95.

ELEMENTARY INDUSTRIAL ELECTRONICS by Leonard C. Lane

A detailed and self-contained course in industrial electronics, the two volumes are amply illustrated with pictures and diagrams for added clarification. Volume I (#0462) covers switches, relays, circuits, and amplifiers. Volume II (#0463) covers many other aspects of industrial electronics application such as welding, computers, and transducers. Each volume, $3.90; #0461 Paperbound Set, $7.80; #0464 Clothbound Set, $9.00.

BASIC TRANSISTORS by Alexander Schure

Presents the fundamentals of transistor theory and practical application. Review questions at the end of each section aid the technician in understanding basic circuit configurations, amplifying systems, and theory of transistors. #0444 Paperbound, $3.95; #0445 Clothbound, $5.50.

BASIC MATHEMATICS by Norman H. Crowhurst

Using the tested and approved "pictured-text" approach, these first two volumes explore the fundamental principles of mathematics. An illustration or diagram appears with each new idea to reinforce the new information presented in the text. Volume I (#0447) covers basic arithmetic: Volume II (#0448) deals with the essentials of algebra, geometry, and trigonometry. Each Volume, $3.90.

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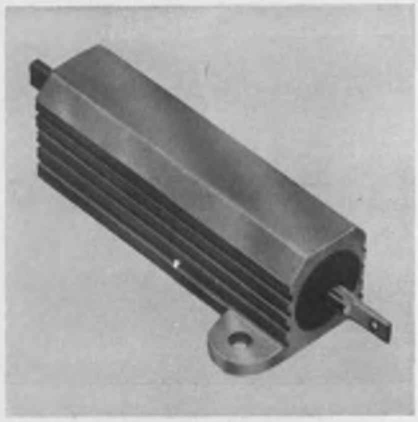
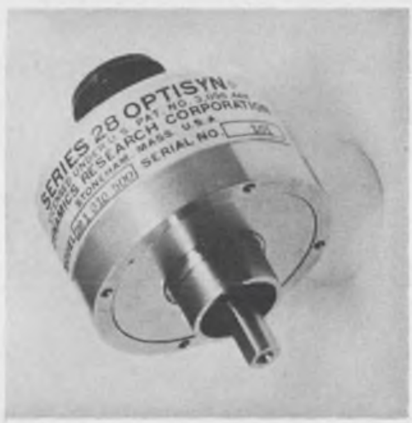


Power resistors

Ranges of 5 to 50 W are available in this line of aluminum-housed power resistors. The heat-sink effect of the aluminum chassis dissipates rated power. Operating temperatures range from −55°C to an internal hotspot temperature of 275°C max. Standard temperature coefficient is ±20 ppm/°C. The units are rated at 24.5 kΩ for 5 W, 47.1 kΩ for 10 W, 95.2 kΩ for 25 W and 273 kΩ for 50 W. Tolerances are 1% to 0.05%.

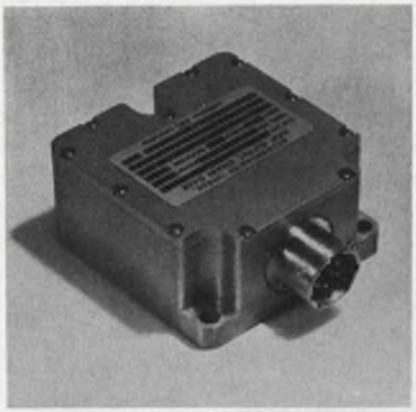
RCL Electronics, Inc., 1 Hixon Pl., Maplewood, N. J. Phone: (201) 763-2820. *Circle No. 250*



Shaft angle encoder

Sine wave, square wave or pulses with outputs up to 2500 Hz/shaft revolution are provided by this shaft angle encoder. Units with rotation direction sensing logic, producing up to 10,000 counts/shaft revolution, can be supplied. Large signals and error-averaging are handled through the use of push-pull sensors. Accuracy is better than ±1 arc-minute and rated life is 5 years.

Availability: 2 wks. Dynamics Research Corp., 38 Montvale Ave., Stoneham, Mass. Phone: (617) 438-3900. *Circle No. 251*

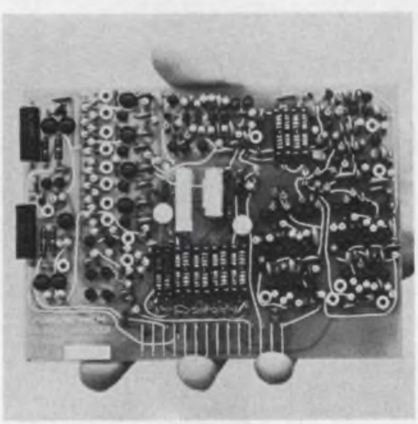


5-Vdc accelerometer

A high-output, bidirectional linear accelerometer has its output amplified by an integral differential dc amplifier to ±5 Vdc. Noise problems associated with low level signals are eliminated. Designed to measure acceleration perpendicular to the mounting surface, model 4-290 covers ±5 to ±500 G. Operable temperature range is −65 to +250°F and weight is less than 7 oz.

P&A: $995; 45 days. Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif. Phone: (213) 796-9381.

Circle No. 252



5-V sine generator

Used in automatic test systems, this voltage-controlled function generator is on a 5 x 7-in. PC card. The unit provides a fixed amplitude sine, square or triangle waveform over a 1-Hz to 1-MHz range. Output is 5 V p-p sine or trangle wave and 1 V p-p square wave. Frequency linearity is 0.1% and stability is 0.05% short tern.

P&A: $395 to $995 (30 days). Wavetek, P. O. Box 651, San Diego, Calif. Phone: (714) 279-2200.

Circle No. 253

Resistance sensing relay

Temperature and voltage stabilized, this relay has a sensitivity range of 5 kΩ to 6 MΩ. Probe voltage is 20 Vdc and probe current is 2.5 mA max. Power consumption is 2.5 VA max. As the amplifier is triggered, it energizes a dpdt control relay, which uses one pole for latching and the other for isolated control of the 1/6-hp, 10-A, 115-Vac or 1/3-hp, 230-Vac load.

Price: $49. Curtis Development & Mfg. Co., 3288 N. 33 St., Milwaukee. Phone: (414) 445-1817.

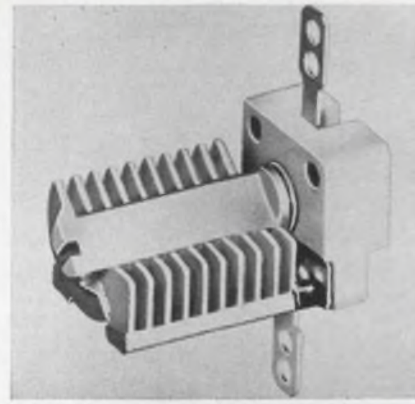
Circle No. 254

Hall-effect multipliers

Field current ranges to 5, 10, 20 and 40 A max are featured in these Hall-effect multipliers. Input of all models is 330 A max and output is 200 mV max. The package consists of a Hall element in the gap of a laminated silicon steel core having two identical field coils. A current flowing through the coils generates a magnetic field in the gap. Voltage is proportional to the product of the magnetic field and current.

P&A: $49.50 to $69.50; stock. F. W. Bell, Inc., 1356 Norton Ave., Columbus. Phone: (614) 294-4906.

Circle No. 255

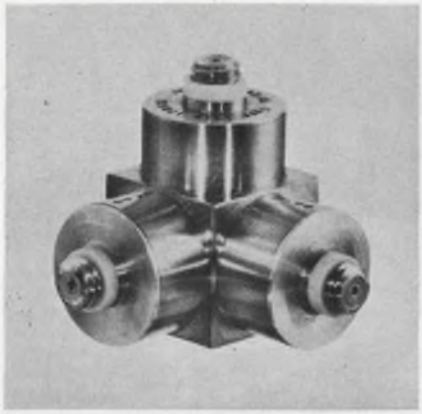


Air variable capacitor

Air variable capacitors offer up to 24.5 pF in single section units that require less than 0.2 in.^{2} for mounting on PC boards or chassis. An acetal fastener provides press-in mounting on PC boards or chassis. ratings are available to 1100 Vdc and Q is greater than 1500 at 1 MHz. Temperature coefficient is 45 ±15 ppm/°C. Type U units are available in two-hole, PC or bushing-mount single section models and in differential and butterfly PC mounting versions.

E. F. Johnson Co., Waseca, Minn. Phone: (507) 835-2050.

Circle No. 256



Tri-axial accelerometer

Simultaneous measurements of vibration are made in three mutually perpendicular axes by this accelerometer. Sensitivity in each axis is 29 mV/G and nominal capacity is 1000 pF. Cross-axis sensitivity is 4% max at 30 Hz and individual cross-axis sensitivity curves are provided up to 5000 Hz. Nominal natural resonance frequency is 45 kHz and true mounted resonance frequency is 23 kHz.

P&A: $390; stock. B&K Instruments, Inc., 5111 W. 164 St., Cleveland. Phone: (216) 267-4800.

Circle No. 257

Low thermal switch

With an operating range from −60 to 180°F, this switch has closed contact thermal voltage with 10 V across the coil of 5 μV nominal and 10 μV max. Open contact resistance, closed contact to coil insulation, insulation between closed contact pairs and closed contact to shield insulation is 10^6 MΩ min. Epoxy encapsulation damps out short-term thermal transients generated externally. The switch is shock tested to 100 G, vibration tested to 30 G, 10 to 2000 Hz.

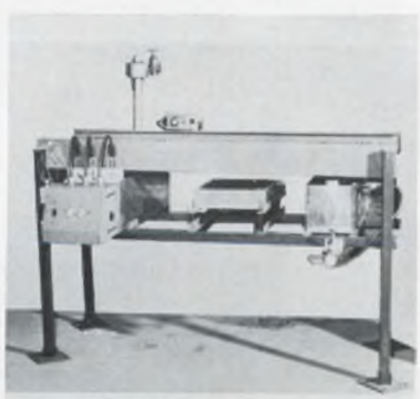
Norfax Corp., 1152 Morena Blvd., San Diego, Calif. Phone: (714) 276-3200. *Circle No. 258*

Terminal installer

Capable of installing solderless terminals on wire at a rate of over 100/hour, the autofeed terminal installation tool operates on 90 to 100 lbs air pressure. A Mylar belt holds the terminals as they are fed into the self-assigning and self-adjusting dies. The tool will not release the terminal until the proper amount of pressure has been applied.

The Thomas & Betts Co., 36 Butler St., Elizabeth, N. J. Phone: (201) 354-4321.

Circle No. 259



Wave-solderer

Wave-soldering systems incorporate a conveyor with Teflon-coated rails with speed variable up to 14 ft/minute, dual infeed foam fluxer, 2-kW radiant preheater and solder fountains with 5-, 10- and 15-in. waves. Solder fountains include air driven pumps which can produce a wave from 0 to 4 in. high. Solder temperature is held to 650°F.

Price: $2495. Wenesco Inc., P. O. Box 303, Northtown Sta., Chicago. Phone: (312) 235-5405.

Circle No. 260

Low resistance tester

Production line tests of connectors, spot welds, printed circuitry or semi-conductor rectifiers can be performed by this low-resistance tester at rates of 1/s. The unit tests over a 0.001- to 0.2-Ω range, determining if a pre-specified limit is exceeded. Requiring only successive positioning of two probes on parts being tested, the semi-automatic device indicates reject parts by sounding an alarm.

P&A: $600; stock. Vari-Tech Co., 546 Leonard St., N.W., Grand Rapids, Mich. Phone: (616) 459-7281.

Circle No. 261

Lead former

Made of cycolac plastic, the lead forming tool forms 1/4- and 1/2-W resistor, diode and jumper leads. Increments of 0.05 inches are on 0.4- to 1.5-inch centers. The edges are radiused. Dimensions are 5-1/2 x 1-1/2 x 1/4-in.

Price: $2.95 (1 to 4). Production Devices, P.O. Box 20175, San Diego, Calif. Phone: (714) 469-0300.

Circle No. 262

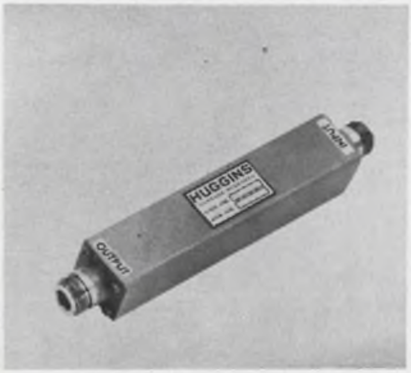
Automatic screen printer

For printed and fired circuits this system has automatic loading and unloading. One or more parts are printed at up to one cycle per second. Oversize micrometers provide X, Y and angular adjustment readable to 0.0001 in. The sapphire locator substrate holding fixtures give positive-pressure work positioning and vacuum hold down. A 6-in. screen comparitor with view stage provides work monitoring.

Precision Systems Co., Inc., 2 W. Main St., Bound Brook, N. J. Phone: (201) 469-1256.

Circle No. 263

Shielded isolators

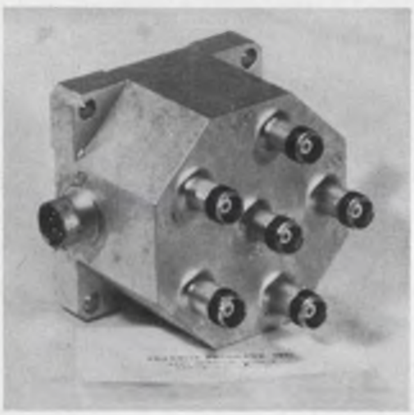


One-third the volume of prior devices, these magnetically-shielded isolators furnish 15-dB max isolation in octave bandwidths from 1 to 8 GHz. The 6- x 1-1/2-in. S-band device has insertion loss of 1 dB min, vswr of 1.25 and 10-kW peak power rating.

P&A: $195; 30 days. Huggins Laboratories, Inc., 999 E. Arques Ave., Sunnyvale, Calif. Phone: (408) 736-9330.

Circle No. 264

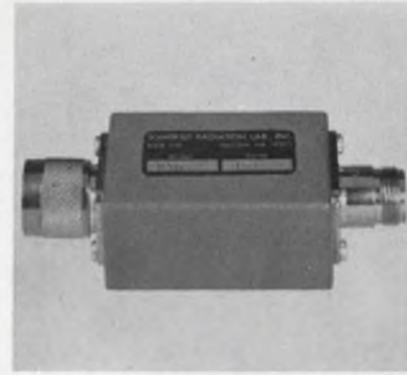
3-in.^{3} coax switch



Designed for space application, this hermetically sealed multi-throw coax switch has individually activated solenoids that can be fail-safe. With TNC connectors, vswr at 0 to 7 GHz is 1.28 nominal, insertion loss is 0.3 dB and isolation is 60 dB or greater. Actuator is 28 Vdc.

Transco Products, Inc., 4241 Glencoe Ave., Venice, Calif. Phone: (213) 391-7291.

Circle No. 265



Frequency multiplier

The usable frequency range of signal generators and frequency synthesizers is extended by this six-octave frequency multiplier with minimum conversion loss. Input up to 400 mW from 50 MHz to 4 GHz produces harmonic energy in the 100-MHz to 12-GHz range at efficiencies approaching 200% divided by the harmonic number. The harmonic-generating device is a 100-ps step-recovery diode.

P&A: $115; 20 days. Somerset Radiation Laboratory, Inc., 2060 N. 14 St., Arlington, Va. Phone: (703) 525-4255.

Circle No. 266

Thermistor bolometer

Used to measure microwave energy, this immersed thermistor bolometer contains a resistive element which changes resistance as it is heated by RF power. The thallium-bromide-iodide immersed component transmits in the 0.5- to 40-micron spectral range. Gain obtained with a given bolometer flake increases with flake size and degradation through noise increases. Because the collecting ability of the lens increases gain, a smaller flake is employed. Specific detectivity of this unit is 5.3×10^8 cm $Hz^{1/2}$ W.

Availability: 4 to 6 wks. Servo Corp. of America, 111 New South Rd., Hicksville, N. Y. Phone: (516) 938-9700.

Circle No. 267

Dual-frequency antenna

This 4-port antenna is used with cross band radio systems operating in the 5.925- to 6.425- and 10.7- to 11.7-GHz common carrier bands. Dual polarization is offered for each band with the separate band feeds combined. The 6-GHz Gregorian design consists of a rectangular to circular transistion, a circular horn and a strut-supported subreflector.

Andrew Corp., Box 807, Chicago. Phone: (312) 349-3300.

Circle No. 268

Klystron oscillators

15-W peak pulse power is delivered by this family of reflex klystron oscillators at any fixed frequency between 26.5 and 35 GHz. Each tube is trimmable ±100 MHz from any specified center frequency. Duty cycle is 0.005 max, beam voltage is 3 kV peak, beam current is 300 mA peak and reflector voltage is −4 to −5.4 kVdc.

Varian, 611 Hansen Way, Palo Alto, Calif. Phone: (415) 326-4000.

Circle No. 269

Gas noise source

Used in 10° E-plane waveguide mounts or coax mounts for pulse operation, this noise source tube operates from 8.2 to 12.4 GHz in waveguide mount and 0.2 to 4 GHz in coax mount. Starting voltage spike is 3.3 kV max. Rated anode current is 175 mA and tube drop is 130 Vdc. The tube-in-mount excess noise ratio is 15.65 dB. This argon-filled cold cathode is made from mandrel-shrunk centerless ground low-loss glass.

Availability: stock. Signalite Inc., 1933 Heck Ave., Neptune, N. J. Phone: (201) 775-2490.

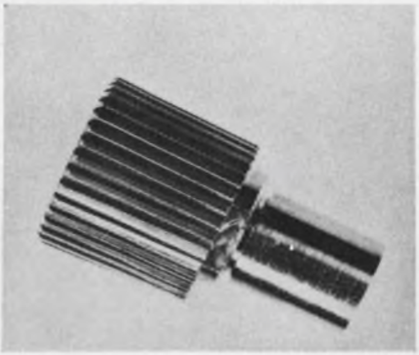
Circle No. 270

12-kW cw TWT

Depressed collector operation raises this TWT's efficiency to 35% over the 7.7- to 8.4-GHz range. A coupled cavity interaction structure provides more than 30-dB gain at saturation. The tube thus matches klystron efficiencies while providing 14 times their instantaneous bandwidth. The liquid-cooled tube has a vacuum envelope providing a direct thermal path between the interaction structure and external cooling ducts.

Microwave Electronics, 3165 Porter Dr., Palo Alto, Calif. Phone: (415) 321-1770.

Circle No. 271



18-GHz terminations

A range of dc to 18 GHz is covered by these terminations. Dc resistance is 50 ±1 Ω at 25°C. Maximum output is 1 W average and 1 kW peak. Type N female, N male, 7 mm Amphenol or 7 mm Rohde & Schwarz connectors are available. The series 1403 terminations are made with film resistors for maximum stability under peak pulse power and can withstand moderate short overloads.

P&A: $85 to $100; 30 days. Weinschel Engineering, Gaithersburg, Md. Phone (301) 948-3434.

Circle No. 272

S-band BWO

50 mW over a 2- to 4-GHz band are delivered by these magnetically shielded BWOs. The oscillator is tuned by adjusting the helix voltage. A nonintercepting negative control grid permits amplitude modulation of the output without drawing current in the modulating circuit. Magnetic field leakage is 10 gauss max 1/2 in. from the tube surface.

Availability: 60 days. Varian, 611 Hansen Way, Palo Alto, Calif. Phone: (415) 326-4000.

Circle No. 273

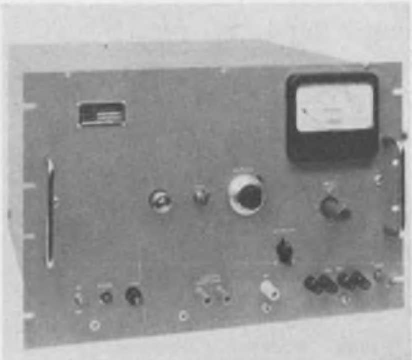
Acoustic delay lines

Delay times from 200 ns to 40 μs are offered with this series of acoustic delay lines. Frequency range is 100 to 5000 MHz and insertion losses are in the 20- to 70-dB range. Bandwidths are one octave. Applications include phased array radar, ranging systems, altimeters, RF checkout systems and very high speed digital scratch pad memories.

Price: $2000 to $6000. Anderson Laboratories, Inc., 501 New Park Ave., West Hartford, Conn. Phone: (203) 522-3101.

Circle No. 274

20-kV supply

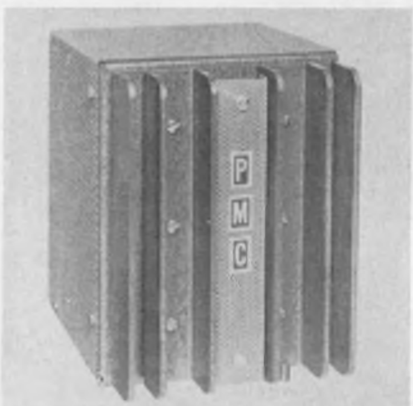


An output range of 5 to 20 kV at 0 to 5 mA is provided by this chopper-stabilized reference power supply. Regulation is 0.1%. An error indicator lights up if the power supply falls out of regulation. The unit is supplied in a rack mount case measuring 19 x 12-5/32 x 15-in.

Beckman Instruments Inc., 89 Commerce Rd., Cedar Grove, N. J. Phone: (201) 239-6200.

Circle No. 275

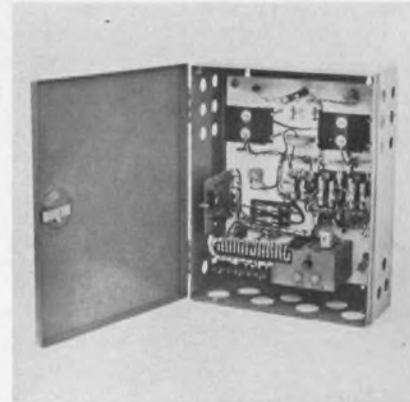
Short-proof modules



Short-proof power supply modules covering 75 to 400 V at up to 6 A are available with either 0.05% or 0.5% line and load regulation. The all-silicon units operate in ambient temperatures of 71°C without derating or external cooling. 288 models in 9 different sizes are offered.

P&A: $70; stock to 3 wks. Power/Mate Corp., 163 Clay St., Hackensack, N. J. Phone: (201) 343-6294.

Circle No. 276

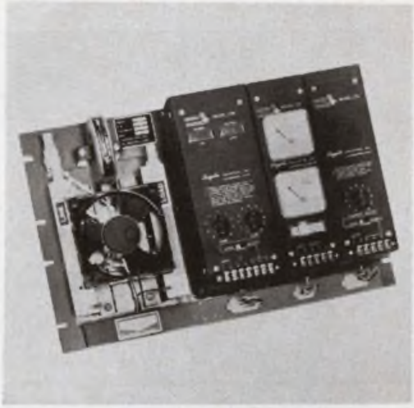


SCR motor controls

Infinitely variable 100 to 1 speed range with full rated torque is available for motors up to 7.5 hp. With these controls, motors accelerate to pre-set speeds gradually. The units have adjustable current limiting, high-overload capacity, full-wave dc power and transient protection. Tach feedback is regulated to ±1% and self-regulation is ±3%.

Vector Dynamics Inc., 127 Toledo St., Farmingdale, N. Y. Phone: (516) 694-5350.

Circle No. 277

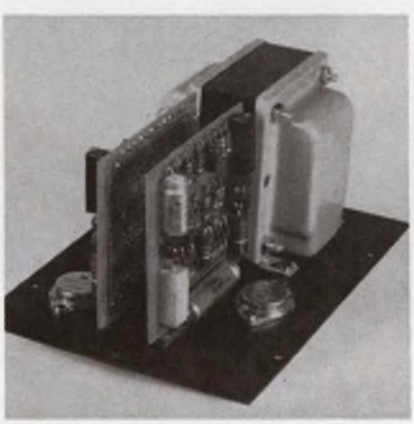


SCR power controllers

Stepless ac or dc control is provided by this controller. Manual or instrumentation control is from room or direct potentiometric thermostats. 3-phase units from 3 to 554 kVA and single-phase units are available. Trigger box and accessories are plug-in. Air- or water-cooled units with electrically isolated heat sinks are supplied for panel or rack mounting.

P&A: $195 (1 kVA), $3830 (554 kVA); 4 to 6 wks. Loyola Industries Inc., 155 Arena St., El Segundo, Calif. Phone: (209) 823-7694.

Circle No. 278



Dual power supply kit

Model 5012 all-silicon dual power supply kit provides two isolated regulated voltage sources. Continuously variable output modes are ±6 to 30 V at 200 mA, ±6 to 30 V at 400 mA and ±12 to 60 V at 200 mA. Regulation is 0.1% and noise and ripple are 0.1 V max. Drift is ±0.1%/°C max. Kit includes all parts required for assembly with regulators on circuit boards.

Availability: stock. Eagle-Picher Industries Inc., American Bldg., Cincinnati. Phone: (417) 623-8000.

Circle No. 279

Dual output power supply

The all-silicon supply provides nine different output combinations from two independent outputs. Each output can be set for either of two ranges and can be operated at either polarity. The two sides can be combined to obtain up to 80 V or 1.2 A. Output A provides 0-20 V at 0-600 mA or 0-40 V at 0-300 mA. Output B provides 0-20 V at 0-600 mA or 0-40 V at 0-600 mA.

Price: $195 to $235. Hewlett-Packard, 100 Locust Ave., Berkeley Heights, N. J. Phone: (201) 464-1234.

Circle No. 280

100-kV supply

Capable of producing 0- to 100-kVdc at 0 to 100 μA, this voltage supply increases the potential of a 10-kV. Output polarity is reversed by turning over the plastic multiplier drum and flipping the meter polarity switch. The built-in regulator maintains output within 1% for line changes from 105 to 130 V.

Beckman Instruments, 89 Commerce Rd., Cedar Grove, N. J. Phone: (201) 239-6200.

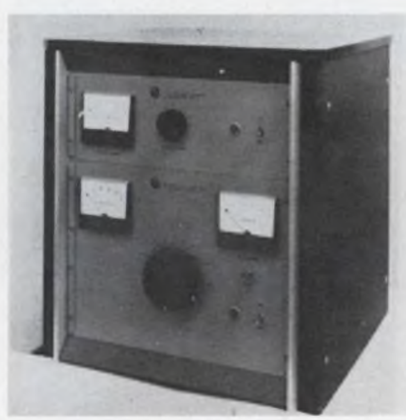
Circle No. 281

Dc to dc converter

Capable of converting 28 Vdc to a 5- to 1040-Vdc output at 5 W, this dc to dc converter sustains full load operation at 100°C. With all-silicon semiconductors, hermetic sealing and full encapsulation, the unit meets MIL-E-5272C. The converter has isolated inputs and outputs and an adjustment range of 12% from the nominal output voltage. Regulation is 0.2% for input variations of 24 to 30 Vdc.

P&A: $355; 4 to 6 wks. Abbott Transistor Labs, 3055 Buckingham Rd., Los Angeles. Phone: (213) 731-9331.

Circle No. 282



High voltage power

An unconditional 3-year warranty is extended on the one high-voltage and four filament transformers incorporated in model 2002. The high-voltage transformer will withstand spikes of 100,000 V. The supply is rated for maximum power at 5000 V, 400 mA. Ratings can be exceeded with maximum outputs of 7500 Vdc and 500 mA.

P&A: $1275 (3002), $1800 (high-voltage and filament combination); stock. Materials Research Corp., Orangeburg, N. Y. Phone: (914) 359-4200.

Circle No. 283

Application Notes

Algebraic circuit analysis

This eight-page discussion is a combination of two papers. In the first half, "Matrix Algebra Simplifies Circuit Analysis," the author's technique is described when applied to any network, whether active, passive, bilateral or unilateral. Emphasis is placed on benefits when several linear systems must be combined. The accompanying discussion, "Matrix Algebra Analyzes Transistor Feedback Amplifiers," develops the theme to actual application of the author's technique to a bilateral two-port network. Theory also is applied to shunt, series and two-stage feedback amplifiers. 3M Co.

Circle No. 284

Solid-state TV

A 4-page application note considers metallized lacquer film capacitors in the horizontal deflection circuit of transistorized TV. Performance curves illustrate characteristics of power factor, capacitance and the results of temperature rise. Loss and capacity vs frequency curves compare metallized lacquer film capacitors with tantalum types. Transistorized TV requires a capacitor in series with the deflection coil to improve horizontal linearity in applications where the diameter of the picture tube is greater than 6 inches. Nucleonic Products Co., Inc.

Circle No. 285

Waveguide field analysis

A method of analysis which provides a solution to the propagated LF, VLF, ELF terrestrial waveguide field is presented in this technical note. With this simple analysis, geometric series terms can be calculated with the zonal harmonic series. The summation of the geometric series, rather than the complex integral method, provides an efficient method for calculating the total field (or waveguide mode sum).

Available for $0.25 from Clearinghouse, U.S. Dept. of Commerce, Springfield, Va.

DTL applications

Design data and applications for 17 DTL circuits are featured in this 24-page brochure. Characteristics of seven NAND gates, two high fan-out gates, two line drivers, three input expanders, two RS/T binary elements and a J-K binary element are given. Characteristic curves, including design limit curves, are presented for all elements. The brochure contains block diagrams of typical subsystem applications, including a switch-bounce eliminator, a full adder, an astable circuit, an economical one-shot, a synchronous decade counter, several types of shift registers, a synchronous binary counter and an up-down counter. Signetics Corp.

Circle No. 286

RTL applications

This 18-page literature package on RTL ICs contains product descriptions, logic diagrams, pin arrangements, schematics and applications information. Complete electrical specifications and data are included for the military, industrial and commercial ranges for 11 types in both TO-5 and flat packages. Sperry Semiconductor.

Circle No. 287

IC design and application

Basic principles in the design and application of linear ICs are given in this 240-page manual. Effects of the silicon monolithic fabrication process on circuit design are discussed. Design equations and performance criteria for IC configurations are derived. Schematic diagrams, operating characteristics and performance data are included.

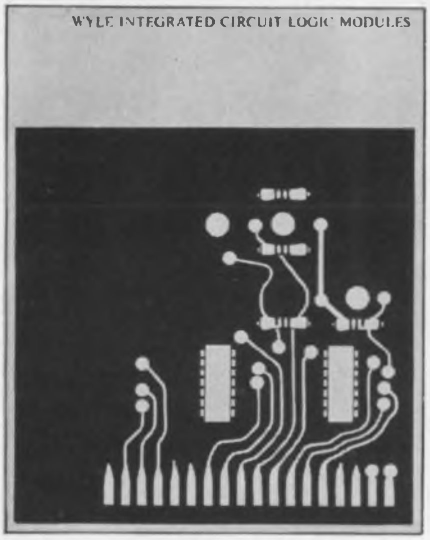
Available for $2 from RCA, Electronic Components and Devices, Route 202, Somerville, N. J.

Op-amp applications

A 4-page application note discusses offset, stability and drift characteristics of operational amplifier inverting and noninverting circuits. The paper shows how to drive large capacitance loads without generating transients. The note includes 12 typical versatile circuits with schematics. Analog Devices.

Circle No. 288

New Literature



IC logic modules

"Series M" IC logic modules are described in this set of specification sheets. Each sheet provides operating and mechanical specs, logic diagrams, and a detailed parts list. Modules described include NAND and AND gates, universal flip-flops, storage flip-flops, counters, buffer drivers, Schmitt triggers, crystal oscillators, multivibrators, decoders and lamp and relay drivers. Accessory cards, mounting hardware and power supplies are also specified. Wyle Laboratories.

Circle No. 289

Ceramic and glass seals

Standard and special ceramic-and glass-to-metal hermetic seals, assemblies and terminals are listed in this catalog. Also included are specialty seals, diode and controlled rectifier housings and metalized ceramics. Photographs, drawings, dimensions and ratings are given. Latronics Corp.

Circle No. 290

Coax installation

A 16-page catalog describes installation procedures for the manufacturer's coaxial cable. In addition, the brochure covers all aspects of maintenance. Contents include sections on cutting tools, reel handling, cable grips and pulling tension, cable cutting and lashing techniques, testing and leak detection. Phelps Dodge Electronic Products Corp.

Circle No. 291

Solid-state components

Reference, application and product information on a line of solid-state components is included in this 20-page bulletin. Varactor diodes and tuning varactors are described with specifications, applications and methods of cut-off frequency, voltage breakdown and capacitance measurements. Similar descriptions are presented for pin diodes, microwave mixer diodes and video diodes. Dimensional drawings for various packages are included. American Electronic Laboratories, Inc.

Circle No. 292

Potentiometer wire

"Data and Properties of L.T.C. Gold Alloy Potentiometer Wire" outlines the manufacturer's potentiometer wire, its corrosion resistance, tensile strength, noise level, life and other tests. Also included are tables showing general characteristics, average temperature coefficient, stress-strain diagram and resistance at various diameters. Sigmund Cohn Corp.

Circle No. 293

Microwave products

Literally thousands of microwave products are described in this 148-page catalog. Included are sections on attenuators, detectors and mixers, directional couplers, filters and preselectors, samplers and separators, slotted lines, mechanical switches and turners. Microlab/-FXR.

Circle No. 294

Telemetry periodical

Published quarterly, this 12-page journal provides telemetry information. Early issues covered basic techniques and advances in data communications. Future issues will describe new technology and special applications. Back issues are available. Electro-Mechanical Research, Inc.

Circle No. 295

Connector check list

A design check list and comparison chart for removable re-entry, miniature crimp-contact connectors lists the features that designers should check when selecting connectors. The comparison chart details fifteen features that are desirable, and then explains how these features are accommodated by the various types of contacts available in the industry. U.S. Components Inc.

Circle No. 296

Video switching

The most commonly used methods of switching video and audio information are described in this 26-page publication. Pictorial diagrams, charts and tables are included. Topics range from a simple single-output monitor switcher to complex dial-controlled solid-state switching systems. Applications and selection of switches are discussed with exact equipment detailed for many systems. Dynair Electronics, Inc.

Circle No. 297

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Input Impedance & Sensitivity

Range	Input Impedance Minimum	Sensitivity
10.000 mV	50 megohms*	1 μV
100.00 mV	500 megohms*	10 μV
1000.0 mV	5000 megohms*	100 μV
10.000/100.00/1000.0 volts	10 megohms	1/10/100 mV

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NEW LITERATURE

Micromin connectors

A general discussion on interconnections, contact termination systems, connector configurations and contacts is given in this handbook. Special interconnection devices are described and data on such designs as a slip ring connector and a 15-contacts is given in this handbook. ITT Cannon Electric.

Circle No. 298

Heat transfer

Mechanical and thermodynamic aspects of heat transfer are illustrated and discussed in this 68-page booklet. Photos, drawings, graphs, charts and tables illustrate the company's heat transfer panels, heat transfer characteristics of the panels, pressure drop data and applications. Other sections describe fittings, proprietary panels, ASME and UL stamped panels, log mean temperature difference charts, load data and typical computations. Dean Products, Inc.

Circle No. 299

Microwave sources

Microwave energy sources are fully covered in a 56-page catalog. It contains specifications, outline drawings and performance curves on microwave oscillators and oscillator/multipliers, both solid-state and triode, in frequencies from L through Ku-band. Also included are amplifiers, frequency multiplier/amplifiers, interdigital filters, special products and assemblies, engineering data and microwave test equipment. Trak Microwave Corp.

Circle No. 300

Inventory management

"Inventory Management for Maximum Profit" describes an approach to added profitability for the electronic parts distributor. Calculation sheets and background data are included in the booklet. Cornell-Dubilier Electronics.

Circle No. 301

Connector handbook

A novel "training manual" is intended to correct the human factors dealing with electrical connectors. The "Connector Hand-Book" is a 24-page cartoon-type booklet subtitled "How Not to Order, Assemble, and Use Connectors." Exaggerated negative psychology is employed in an attempt to call attention to connector-user mistakes before they become actual field service problems. The semi-humorous approach should help highlight errors of omission and commission, such as mistakes in ordering connectors, failure to train assembly personnel, and disregard of product limitations, for people who naturally ignore footnotes in catalogs or instruction sheets. Pyle-National Co.

Circle No. 302

Solid-state control

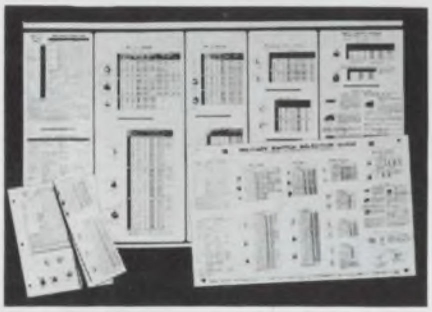
"Electricity and Solid-State for Control," is a 52-page manual for nontechnical people. The booklet is designed to provide an understanding of the basics of electricity and solid-state electronics for control industry "laymen." Ranco Inc.

Circle No. 303

Digital systems

A broad line of advanced digital systems is covered in this condensed catalog. Included are photographs, block diagrams, and functional details on such equipment as a multipoint temperature logging and control system, an integrated digital data printout system, a 3-axis coordinate digitizing system, and a number of others covering a wide range of digital and A-to-D applications. Wang Laboratories, Inc.

Circle No. 304



Military switch reference

These comprehensive selection charts cover one-hole mounted military switches. Featuring cross-reference designations between MS, AN, JAN and the firm's switch order numbers, the tabulations provide reference data for MIL-S-3950B, MIL-S-8834B positive action and MIL-S-8834 miniature positive action switches in single-, double- and four-pole configurations with standard bat and lever lock toggles. Other information covers MIL-S-6807A rotary switches, MIL-S-3950B special service devices, switch guards, complete ratings, general test requirements, specifications and nominal dimensions. Cutler-Hammer.

Circle No. 305

Selenium rectifiers

A 4-page illustrated bulletin describes a line of selenium rectifiers. The bulletin includes photographs, full specs and descriptive text. Standard configurations described are diodes, high-voltage cartridges, arc suppressors/contact protectors, epoxy packages, entertainment rectifiers, multiple circuits, spring-clip assemblies, hermetically sealed packages, encapsulated designs and power rectifiers. Edal Industries, Inc.

Circle No. 306

Manufacturers

vertisements of booklets, brochures, catalogs and data sheets. To order use Reader-ServiceCard.

General Electric Alumalytic® Guide

The Schweber Guide to the selection of General Electric alumalytic® capacitors is another in the series of Schweber capacitor guides. This one lists quality aluminum electrolytics in Schweber's unique numerical-sequence-by-microfarads arrangement so well-liked by engineers and buyers alike. Included are the miniature type, the standard computer grade, and the new "high performance" type which offers for the first time voltage de-rating for higher ambient temperatures up to 105° C.

Schweber Electronics
Westbury, N. Y. 11591
(516) ED 4-7474

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Piezotron® Quartz Accelerometer

Four-page illustrated Bulletin 321466 on Model 818 quartz accelerometer describes Piezotron principle which eliminates need for costly amplifiers and permits use of just one single-wire shielded cable for both power and signal. Bulletin also describes how base strain sensitivity, ground loop, cable noise and insulation resistance problems are prevented. Diagrams of the basic circuit and a typical system show operation. Performance data is graphically displayed. Complete specs and ordering information are included.

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

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Designing Around Tubing

This six-page article details design considerations in determining whether a particular part should be machined from bar stock, formed from sheet or fabricated from tubing. Drawings and photos show how tubular parts have been designed so that they can be fabricated from tubing at considerable savings.

The data provides design criteria for tubular parts with flanges, bends, beads, flares, expanded ends, ultra-thin walls, turned-in ends and ID-radiused ends. Typical parts cited as fabricated best from tubing include spring contacts, cathode support sleeves, tone arms, and fuel cell nozzles to name a few.

Uniform Tubes, Inc.
Collegeville, Pa. 19426

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Dc power supplies

Prices and complete specs for over 200 transistorized portable, modular and rack-mounted power supplies are given in this 8-page catalog. Mounting diagrams, circuit diagrams and application notes are included. Universal Electronics.

Circle No. 307

Laser system

This 8-page illustrated brochure covers all aspects of the manufacturer's "Biolaser" for medical and biological research. Included is a full treatment of all types of applications for the instrument, a description and specifications. TRG Control Data Corp.

Circle No. 308

Semiconductor products

This 26-page product reference list covers zener diodes, reference diodes, high voltage rectifiers and voltage reference modules. The publication lists electrical and mechanical specs for over 1200 basic JEDEC zener and reference diode type numbers and explains the meaning of the basic JEDEC type number suffix letters. General Semiconductors, Inc.

Circle No. 309

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Sept. 15-16
Computer Aided Solid-State Design Institute (Santa Clara, Calif.) Sponsor: University of Santa Clara, Department of Electrical Engineering, Santa Clara, Calif. 95053.

Sept. 20-22
Eighth Annual Conference on Tube Techniques (New York City) Sponsor: IEEE, G-ED; R. J. Bondley, General Electric Company, Schenectady, N. Y.

Sept. 22-24
IEEE Broadcast Symposium (Cedar Rapids, Iowa) Sponsor: IEEE, G-B; Serge Bergen, 10828 Fairchester Drive, Fairfax, Va.

Sept. 26-27
Joint Engineering Management Conference (Wash., D. C.) Sponsor: IEEE, G-EM et al; Homer Sarasohn, IBM, Armonk, N. Y.

September 27-29
13th Annual Air Force Science and Engineering Symposium (Arnold Air Force Sta., Tenn.) Sponsor: Air Force Systems Command and Office of Aerospace Research; Lt. P. Klute, Air Force Systems Command, Andrews AFB, Md.

October 3-5
Aerospace & Electrical Systems Convention (Wash., D.C.) Sponsor: IEEE, G-AES; Harold Schutz, Westinghouse Electric, P. O. Box 746, Baltimore, Md.

October 3-5
National Electronics Conference (Chicago, Ill.) Sponsor: IEEE et al; J. C. Hancock, Purdue University, Lafayette, Ind.

October 18-20
Seventh National Symposium of the Society for Information Display (Boston, Mass.) Sponsor: S.I.D.; Glenn Whitham, Society for Information Display, P. O. Box 413, Wayland, Mass.

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