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JANUARY 6, 1960

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DESIGN IN THE 60's

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COVER STORY: We are literally op[ening] our book to give you a glimpse o[f] Design in the 60's. Bold new conce[pts] will engage engineers in the next dec[]ade; emboldened too is our Art Directo[r] who is brave enough to leave out sev[]eral letters of our otherwise sacred logo.

Selected Topics In This Issue

◄ CIRCLE 1 ON READER-SERVICE CARD

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Design in the Sixties

From the viewpoint of challenges to electronic design engineers, the sixties promise a most exciting decade. Though no one can accurately predict the course of electronic achievements in the next ten years, Design in the Sixties, in this issue, offers the educated guesses of dozens of authoritative industry spokesmen.

ELECTRONIC DESIGN has opened these pages for the blue-sky predictions of the experts—their attempts to outguess the next 10 years—as well as for their down-to-earth technical challenges for today.

A New Editorial Service— Price and Availability Data . . .

To answer the engineer's questions, "But is it really available?" and "What Does it Cost?", *ELECTRONIC DESIGN* is instituting a special service in its New Products Department. Beginning this issue, price and availability will be provided whenever possible.

Our New Products Editor asks each manufacturer who submits a new product, over a dozen questions regarding price and availability such as: Is it available from stock? In sample quantities only? Built to customers specifications? Cost per unit?

ELECTRONIC DESIGN is proud to provide this service which we believe is a necessary function of a responsible press.

Selected Topics In This Issue (Cont.)

CIRCLE 2 ON READER-SERVICE CARD ➤

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ELECTRONIC DESIGN photo

Session on kilomegacycle computers was one of the highlights of the Eastern Joint Computer Conference in Boston. Speaker is Dr. J. P. Eckert, of Sperry Rand.

Tomorrow's Computers, Today's Hardware Share Attention at Eastern Joint Conference

"BLUE-SKY" kilomegacycle computers and down-to-earth hardware shared the spotlight at the ninth annual Eastern Joint Computer Conference in Boston.

Among the predictions of an International Business Machines Corp. representative were these:

- Microminiaturization in computers, batch-bulk processing, automated logic synthesis and equation-controlled manufacturing.
- Computers with interconnections, and active devices made in a continuous process from bulk raw material to finished product.
- The merger of device, circuit and interconnecting technology.

These forecasts were by IBM's Dr. Rex Rice, who also noted the need for increased logic capabilities, vast amounts of storage, improved input-output techniques and higher speed.

"With the advent of microminiaturization," he said, "servicing will be accomplished by replacing the whole computer."

Dr. Rice's paper, "Computers of the Future," was the first presented at the conference. More than 2500 computer men crowded the Statler-Hilton Hotel to hear 27 papers, participate in panel sessions and view the exhibits of 60 manufacturers.

Microwave Circuits Shown

A preview of tomorrow's digital-microwave circuits was presented to the second session by Dr. Jan Rajchman, laboratory specialist of the Radio Corp. of America, Princeton, N.J. He showed the results of using microwave techniques with tunnel diodes and variable-capacity diodes in phase-locked oscillators (PLO's).

Specially developed tunnel diodes, with time constants as low as 50 micromicroseconds, provided switching times of less than one millimicrosecond. Dr. Rajchman described three types of tunnel-diode elements that were investigated:

- Bi-stable elements with a single diode.
- Bi-stable elments with two diodes.
- Monostable elements with inductive coupling.

He showed how switching was accomplished by interconnecting simple elements, each made of one or two tunnel diodes serving as bit-store, amplifier and threshold majority gate.

In describing experiments with phase-locked oscillators, Dr. Rajchman showed ways of arraying the PLO's to provide logic functions. The PLO, he explained, is a circuit that can sustain oscillations in either of two opposite phases. It includes a fixed inductance and a voltage-variable capacitance excited by a frequency twice that of the oscillation.

Dr. Rajchman showed examples of microwave techniques in a full binary adder with two PLO's and four hybrid rings operated at pulse repetition rates of 100 mc. He indicated that computers with PLO's could take advantage of well-developed microwave strip-line-transmission techniques.

Kilomegacycle Units Possible, But—

Few will deny the possibility of kilomegacycle operation in tomorrow's computers. But most authorities are quick to point to the obstacles—and there are many.

At each of the four evening panel sessions, participants pointed to a host of problems that

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"They [the Russians] are behind—but not by far." —Dr. Willis Ware.

ELECTRONIC DESIGN photo

"We can no longer assume that the speed of light is infinite."—Dr. Ralph Meagher.

would have to be surmounted before kilomegacycle computers could become a reality.

Dr. Ralph Meagher of the University of Illinois cited a formidable limitation—the speed of light—about a foot per millimicrosecond. Though engineers may develop millimicrosecond switching elements, he indicated, it may require many times that interval to transmit the information to other parts of a machine.

"We can no longer assume," Dr. Meagher said, "that the speed of light is infinite." He cited the need for tiny components as solutions to many problems. Transmission lengths, resonant frequencies of basic components and phase shifts at microwave frequencies all demand ultra-small components, circuits and subassemblies.

Dr. Meagher and other panelists suggested asynchronous circuitry as a possible approach to the kilomegacycle pinch. In asynchronous machines, a circuit would operate at a time determined by the completion of operation of a previous circuit.

Denser Circuits Needed

With all signs pointing to the need for microminiaturization, component densities must rise sharply. This will cause power-dissipation problems.

Densities of 109 components per cubic foot may be needed. This means that power dissipation exceeding 10^{-7} watt per element would be intolerable. "We're not quite ready for this," Dr. Meagher said. "We can cope with 100 watts per cubic foot—maybe 1000 watts per cubic foot—but 10 kw is a bit difficult." *(cont. on page 6)*

NEWS

Dr. Stanley Frankel, a noted consultant, quipped: "The future looks rosy—according to gossip. We hear of components like thin films whose dimensions are measured in Angstroms. And there's no law of physics that says we can't reduce dissipation to 10^{-7} watts per component."

But Dr. Frankel noted, too, the magnitude of the problem. He was joined by Dr. M. Clayton Andrews, of IBM, who defined a system as "a connection of things we know a great deal about which form something we know very little about."

Property Reproducibility a Problem

Dr. Andrews raised the problem of reproducibility of the properties of the elements required for kilomegacycle computers.

"With magnetic elements," he commented, "the only heat loss is in the energy stored in the field when it is discharged. In kilomegacycle machines, we would discharge 10^{-10} joule per switch. Hence we could switch 10^{10} of these switches per second—if we could make them."

Sperry Rand's Dr. J. Presper Eckert, pointing to one of the most promising components, the tunnel diode, indicated that the tunneling time was only 10^{-14} second. The RC time constant, 10^{-11} second, is still 10 times better than what engineers are looking for, he said.

Dodging the technical problems entirely, Douglas Hogan of the Defense Department indicated that the Government expected future machines to cut the cost per computation and keep the same program reliability found in today's machines.

"We'll want faster internal work," he said, "Not necessarily faster output. Hence you won't

have to rush off and build thousand-times-faster printers."

Mr. Hogan commented in conclusion: "We bought relay machines when you made them. We used them and liked them. Then we bought your vacuum-tube and transistor machines. We used them and liked them. Regarding kilomegacycle machines—you make them, we'll buy them."

An Expert Look at Soviet Computers

The three-day conference ended Dec. 3 with an after-dinner address on computer developments in the Soviet Union. This followed a $300 award to Mr. Harold Skramstad of the National Bureau of Standards for the best presentation of a technical paper during the sessions.

Dr. Willis Ware of the Rand Corp., who recently returned from a tour of Soviet computer installations, briefly described a dozen Russian computers, then offered these observations on the units:

- They have no large ferrite stores.
- They have no sophisticated or very large magnetic drums.
- They have no drums with floating or moving heads.
- They have no large files, like disk files of the Ramac type.
- They have no miniaturization.

Dr. Ware saw no printed-circuit work, but he was told that production models of Besm II would use printed circuitry. In the computer art, the U.S. definitely leads the Soviet, according to Dr. Ware. He said the Russians had no alphanumeric facilities in any input-output equipment. Their printers are about as fast as those in this country, but their card handlers are somewhat slower, he added. And they don't have as many machines as we have.

Despite the U.S. lead, Dr. Ware warned against complacency. "They are behind," he said, "but not by far. They are definitely not five years behind—perhaps two years."

He said the Soviet had transistors with 20-millimicrosecond switching times and also thin films. Their workmanship, even in the universities, was described as good—neat. Their uncompleted M20 seemed most impressive. In many respects, Dr. Ware said, it can be a real competitor of our own advanced machines.

He saw flip-flops with 20-millimicrosecond rise times. He saw their most common production transistor, a pnp with a 120-mc cutoff. He saw excellent test equipment—scopes with 80-mc passbands. He was told of 200-mc scopes.

"Finally," Dr. Ware stressed, "They know all the ideas we have. They know our literature. They know it better than we do."

Two Memory Devices Unveiled at Show

Among the attention-getting items on display at the computer conference were two memory devices shown for the first time: a high-speed magnetic tape drive and a new type of single-disk tape memory.

Magnetic-Tape System Uses Vacuum Drive

Minneapolis-Honeywell's Datamatic Div. reports that its new high-speed magnetic tape drive is the most efficient tape-handling system yet devised. Using an all-vacuum rather than a mechanical drive, the system can reportedly read or write 96,000 decimal digits per second.

The drive uses a vacuum capstan (pneumatic clutch) to replace conventional pinch-roller mechanisms. In addition, suction is used to attach special tape reels to the drive mechanism and to attach the end of the tape to the reel hub. This eliminates perforations in the reel flanges and helps keep dust off the tape.

It is hoped that the new tape mechanism, to be used with the new Honeywell 800 computer, will eliminate damage to tape, extend the efficiency with which tapes are handled and increase their life expectancy.

Developmental Memory Rotates Paper-Thin Disk

A new, single-disc tape memory, representing a novel approach to the fast-access, large-storage problem, was shown by the Laboratory for Electronics, Inc. Named the LFE Bernoulli Disk, the device was developed to overcome some of the problems with conventional drums.

The device uses a two-mil-thick mylar magnetic tape disk that is rotated close to a stabilizing backplate in which read-write heads are imbedded flush with the smooth surface. An electric motor drives the tape disk, while a small orifice in the center of the backplate allows air to flow between the rotating disk and the stabilizing plate.

At high speeds—up to about 15,000 rpm for a seven-inch disk—centrifugal force flattens the limp tape disk, and air is pumped through the orifice and out at the disk periphery. The hydrodynamic forces of the air between the disk and the plate, together with dynamic and elastic forces of the revolving disk, cause the disk to rotate at a controllable, small separation from the heads.

LFE engineers hope that the Bernoulli Disk will eliminate costly close-tolerance head mounting.

Production models of the disk, due in about six months, should cost about 20 to 25 per cent less than equivalent drum storage units, LFE reports. ■ ■

ELECTRONIC DESIGN photo

"Thanks." Harold Skramstad of the National Bureau of Standards receives $300 award from Jean Felker, program chairman for the ninth annual Eastern Joint Computer Conference. The award was for the best presentation of a technical paper at the sessions. Mr. Felker is with A T & T.

ELECTRONIC DESIGN photo

Dr. Ware, speaking on Soviet computer technology, drew a packed house, even though the dinner was held on the last evening of the conference.

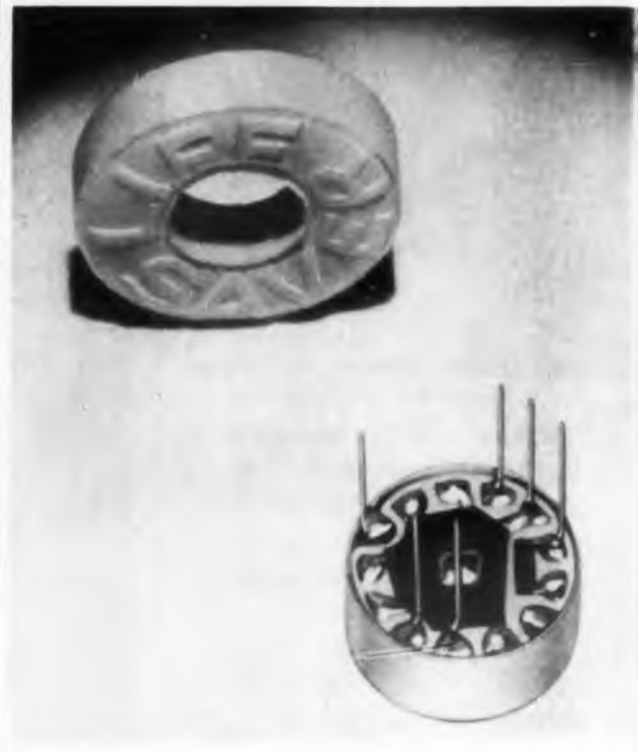
The latest on computers . . .

For an overall look at current computer activity see p. 36 of this issue of ELECTRONIC DESIGN. Discussed in this roundup are the efforts to develop both tomorrow's high-speed computers and the microwave computers of the day after tomorrow.

CIRCLE 8 ON READER-SERVICE CARD ➤

NEWS

Four-Stage Production Amplifier Weighs 1/16 Oz.



Microminiature 4-stage amplifier contains 12 fixed resistors, 5 capacitors and 4 transistors and weighs one-sixteenth of an ounce. The amplifier, designed by Centralab, has a component density in excess of half a million components per cubic foot. The unit, now in production, reportedly has a gain of 73 to 78 db at 1 kc with 1000-ohm load. Its nominal input impedance is 2000 ohms. Signal-to-noise ratio is 42 db below 1 volt. Current drain from a 1.3-volt cell is 2.1 miliamperes maximum.

Scientist Bids U.S. Spend More for Civilian Space

Hot in the midst of the military-civilian space controversy, the director of Cal Tech's Jet Propulsion Lab, Dr. William Pickering, called for more federal dollars for "civilian space" and for single-agency, non-military control of the U.S. space program. He spoke at the EIA Winter Conference in Los Angeles last month.

"The 1961 space budget must be significantly bigger than the last budget," he said, "to accomplish enough technological advances to make us successful in the 'cold war'."

Dr. Pickering advocated a reorganized space setup to "achieve dramatic results" and to "sometime start achieving them first." While arguing that the U.S. had launched more successful satellites than the Soviet Union, he emphasized that "each of the Russian launchings has been carefully calculated to produce a time impact on peoples' minds, while ours have been more in the nature of scientific consolidations."

Since the mark of a successful civilization is now its technological achievements, Dr. Pickering said, advances in the electronics industry are an important factor in the cold war. He called on the industry to progress in research, in the quality of its members and in the education of the high school and college students who will one day become industry members.

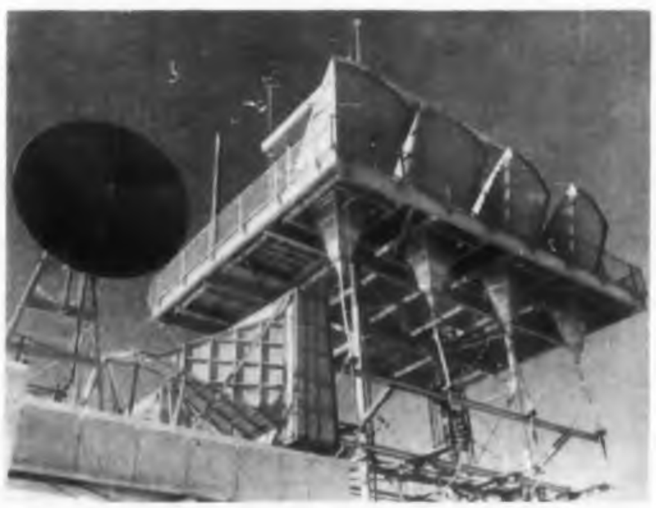
Computer Data Now Transmitted Without Direct Wire Link

For the first time, computers can "talk" to each other on microwave relay links. A newly installed pulse-code modulation system links six large IBM computers. Some of these are at North American Aviation's Los Angeles plant, others at a Rocketdyne Div. facility 39 miles away.

The system uses seven parallel channels. Each can carry 15,000 bits per second, and two 12-kilocycle controlling channels. Transmitted information is either stored on tape or transmitted directly to the computer.

International Business Machines Corp. and Pacific Telephone and Telegraph Co. developed the system for North American. They report it is the first time information has been transmitted from one computer to another without a direct wire link. With the microwave system, North American claims a combined commercial capability greater than any now existing at any location.

According to Pacific Tel and Tel most of the problems in developing the system were routine, with the exception of channel precision. Extremely accurate timing and delay had to be achieved to make seven channels appear as one to the computer.



Dish receives microwave signals carrying computer data from Rocketdyne, nine miles away, and beams them 30 miles to the Los Angeles plant of North American. The newly installed pulse-code modulation system is the first to transmit information from one computer to another without a direct wire link.

NEWS

IR Detector Sees Farther, Faster

BY DOPING germanium with copper, Dr. Robert Talley, manager of the Hughes Research Center at Santa Barbara, Calif., has obtained an infrared detector about six times as sensitive as other detectors in the 8-to-23-micron range.

Still in the prototype stage, the new detector reportedly responds out to about 29 microns, with peak sensitivity at 24 microns.

Because the spectral range to 25 microns includes some 84 per cent of the energy radiated by the human body, which is a 300 K blackbody, the new detector is expected to have substantial military possibilities.

The time constant of the detector is short. Lab tests show that the new infrared detector responds in microseconds to very small temperature changes.

"Makes it possible to detect targets at extreme distances," Dr. Talley said. "Its short time-constant recommends the detector for use in high-speed surveillance systems."

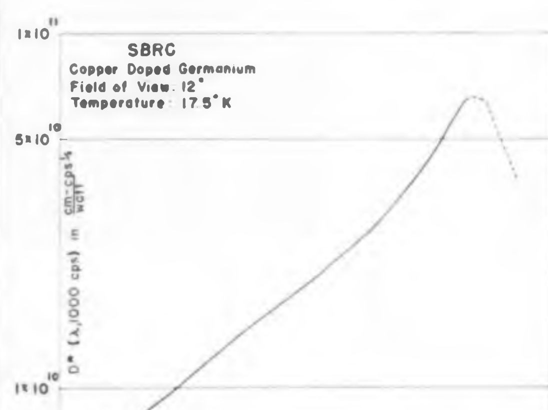
The designers of the detector, Dr. Talley and his assistants, Dr. Donald Bode and Walter Konkel, have devised a cooling unit that they consider practical for military use. It is an experimental Dewar flask about 10 inches long and 3 inches in diameter. The upper chamber contains liquid nitrogen for cooling the radiation shield.

A two-stage minicooler is placed in the inner tube of the Dewar. Hydrogen gas expansion in the upper part of the tube precools helium gas, which in turn expands in the lower end to cool the detector to about 17.5 K.

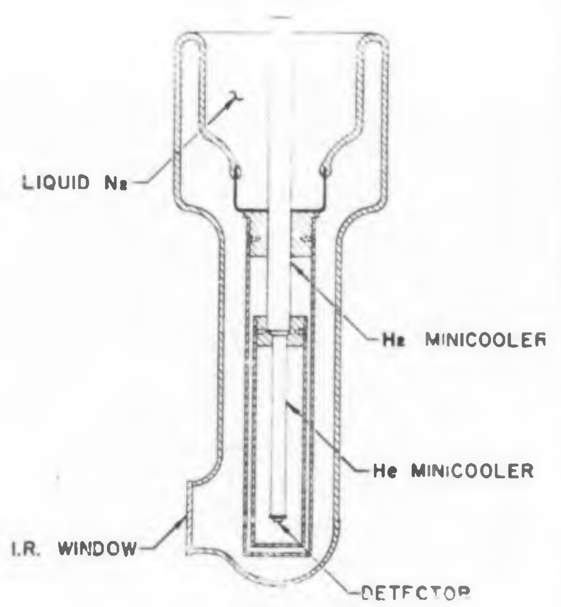
"This cooling technique," says Dr. Talley, "makes it possible to design simpler and more rugged equipment than can be done with the current practice of using liquid helium cooling in a double vacuum container."

If the hydrogen is used alone, a detector temperature of 21 K can be obtained without pumping—or 18 K with vacuum pumping. A typical H_2 flow rate is five 1/m STP at 400 psig.

Best detectivity, of course, is at the 17.5-K temperature. When measurements were made (1000 cps because of low-frequency noise partially caused by the minicooler), the results were: resistance 2.8 meg; bias current 20 μa; noise level 0.7 μv for f = 5 cps at 1 kc; detectivity, $D^*(500, 1000, 1)$ 1.3 x 10^{10}



With peak sensitivity at 24 microns, new sensor can detect 84 per cent of 300 K (body temperature) radiated energy. Detectivity is 1.3 x 10^{10} cm/w.



H_2 and H_e Joule-Thomson cryostat, made of Dewar flask and incorporating a copper-doped germanium cell, makes possible simpler, more rugged infrared detection equipment. Detector is kept at 17.5 K.

cm/w, not corrected for window transmission. Volume was 2 x 2 x 2 mm and field of view 12 deg.

The curve shows spectral detectivity. The absolute values above were obtained from integration of the curve and the 500 K detectivity values. Sensitivity is highest at 24 microns (λ_{max} at 120 K), and is about one third of the theoretical maximum for a 25-micron detector with a 12-degree view of the 300 K background. It is also about six times better than the best published detectivity for other detectors in the 8-to-23-μ range, like zinc-doped Ge.

To make the detector, copper was diffused into high-purity germanium at various temperatures from 650 to 900 C. The sample was then quenched in air. Since the stability of copper is strongly dependent on temperature, the concentration of copper ranged from 10^{15} to 2×10^{16} per cc. All samples were sensitive, though the higher concentrations produced greater detectivity. ■ ■

PRICES AND AVAILABILITY . . .

Traveling-wave-tube Amplifiers have been cut in price by Huggins Labs, Inc. Eleven forward-wave types with HA and PA catalog numbers can now be bought at prices ranging from $1125 for type HA-28 to $2475 for type PA-8.

High-Purity Indium has been reduced in price by Consolidated Mining and Smelting Co. of Canada Ltd. Consolidated's research-grade indium has been cut to $16 per small-lot troy ounce from $22 per tray ounce. High Purity Metals, Inc., is now offering three grades of indium ingots with purities ranging from 99.9+ to 99.999+ per cent.

Microminiature lamps 0.045 in. in diameter and 0.125 in. long (not including lead length) are available from Sylvania Electric Products, Inc.

Is your company making changes in prices or availability of its products? Send the details to ELECTRONIC DESIGN, 830 Third Ave., New York 22, N.Y.

CIRCLE 12 ON READER-SERVICE CARD ➤

NEWS

RFI Problems Plague Mobile Radio Engineers

Worried about a serious deterioration of mobile communication services because of frequency interference (RFI), engineers at the IRE Professional Group on Vehicular Communications Conference explored remedies. None of the 300 attendees were optimistic about the trend being revised.

Impulse noise, was singled out as a particularly tough problem. Picked up at the antenna of a mobile system, high-level impulse noise generated by auto ignition systems, high-voltage power lines and neon lights is well-nigh impossible to eliminate, many registrants agreed.

Even fm systems, supposedly "noise-free," suffer degradation as high as 30 to 40 db when installed in a "non-suppressed" vehicle. The present narrow-band sharp-cutoff filters are prone to "ringing" when triggered by sharp impulse noise bursts. Various methods of gates or blanker stages have been suggested, including one scheme described by Dr. F. W. Chow of the General Electric Co. However, due in part to the additional expense and complexity imposed on mobile equipment as well as increased IM distortion, blanking techniques are not seen as the immediate solution to noise reduction.

Auto Industry Aiding RFI Reduction

The auto industry is working together with electronic groups to reduce mobile RFI. But, the current trend to higher-compression engines requires higher firing voltages, which produces higher spurious radiation. Complete engine shielding is economically impossible and engine performance, if shielding were practical, would suffer because of the increased capacitance in the ignition circuitry.

Another serious problem, discussed by Brooks Short, of General Motors' Delco-Remy Division, is

◄ CIRCLE 13 ON READER-SERVICE CARD

the need to standardize the suppression specifications for vehicles in countries throughout the world. Presently, specs vary widely from one country to the next in terms of methods of setup, units of measurement and permissible levels.

In the meantime, final work is being completed on test standards in this country for IRE approval. J. T. Chappell, Army Signal Research and Development Labs and W. S. Shipman, Columbia Gas System Service Corp., discussed the proposed IRE test methods and briefly compared them with the auto industry's S.A.E. test procedures.

One point seemed widely accepted—interference problems will become more acute before improvements will be seen. For system evaluation, approved test methods must be established and agreed upon as soon as possible.

New Mobile Devices Described

Other papers presented at the Dec. 3-4 meeting, held at the Colonial Inn, St. Petersburg, Fla., were devoted to descriptions of new devices in mobile work. R. A. Beers described RCA's hybrid mobile transceiver, G. M. Dewire discussed and demonstrated a GE miniature, personal-paging receiver and Stuart Myer of Dumont Labs presented details on a portable, self-contained frequency meter with an accuracy of 0.00025 per cent for split-channel check and alignment.

NEWS BRIEFS . . .

. . . **MULTIPLE-BEAM** "Pincushion" radar, slated for the Advanced Research Project Agency's advanced anti-missile Project Defender, is scheduled for delivery in late 1961. "Pincushion" will be used first in mid-Pacific ballistic-missile test firings, where it will enable trackers to compile a billion bits of data on each ICBM run. Raytheon Co., which is developing the unit under a $15-million contract, describes it as "one of the nation's longest-range precision" radars.

MEETINGS

Calendar of Events

January

11-13 6th National Symposium on Reliability and Quality Control, Statler-Hilton Hotel, Washington, D.C.

*12-15 Society of Plastics Engineers' 16th Annual Technical Conference, Conrad Hilton Hotel, Chicago, Ill.

25-29 Stress Measurement Symposium, Arizona State University, Tempe, Ariz.

February

*1-4 ISA Winter Instrument-Automation Conference & Exhibit, Rice Hotel and Sam Houston Coliseum, Houston, Tex.

2-4 15th SPI Reinforced Plastics Division Conference, Edgewater Beach Hotel, Chicago, Ill.

*3-5 1960 Winter Convention on Military Electronics, PGME, Ambassador Hotel, Los Angeles, Calif.

10-12 7th Annual Cleveland Electronics Conference, IRE, AIEE, Philadelphia, Pa.

11-12 7th Annual Cleveland Electronics Conference, IRE, ISA, AIEE, Engineering and Scientific Center, Cleveland, Ohio.

11-13 1st Annual Electronics Representatives Association, Drake Hotel, Chicago, Ill.

16-18 1st National Symposium on Nondestructive Testing of Aircraft & Missile Components, SRI, Hilton Hotel, San Antonio, Tex.

*19-23 3rd International Electronic Parts Show, Paris, France.

25-26 Scintillation Counter Symposium, PGNS, AIEE, AEC, NBS, Washington, D. C.

*Includes meetings described herewith

16th Annual Society of Plastic Engineers Technical Conference, January 12-15

The theme of the 16th Annual Society of Plastic Engineers Technical Conference will be the professional achievements and approaching opportunities in the growth of plastic engineering. Several symposia based on the interests of the Professional Activities Groups of the Society will include plastics in building, injection molding, polymer structure and properties, reinforced plastics, standards for reporting properties, fabricating, finishing, plastics in electrical insulation, casting and plastic tooling, forming, extrusion, thermosetting molding, metals for plastic molds, and vinyl plastics. Conference Chairman is Mr. Charles M. Wasugh of E. I. DuPont de Nemours & Co., Inc., 7250 N. Cicero Ave., Lincolnwood, Ill.

Instrument-Automation Conference and Exhibit ISA, Houston, Tex., February 1-4

The theme of the winter Instrument-Automation Conference and Exhibit will be "Process Control in the Electronic Era."

Technical sessions of the Conference will be devoted to the concepts, techniques and applications of the scientific equipment and methods utilized by various industries, with special attention being paid to the petroleum, chemical, aeronautical, missiles and electronics, and of process industries.

Papers scheduled for the technical sessions cover instrumentation progress and utilizing electronic principles for flow measurement, control and feedback in the chemical and petroleum industries. Reliability, testing and standards in the aeronautical and missile industry will be covered in other papers, while presentations will be made on the development and economic justification of control systems in the Management and Economic sessions.

The Exhibit will include computers, measuring devices, transmission and telemetering instruments, data processing and information display equipment, control instruments and other elements and components of the newest products and services in instrumentation and automatic control.

The Conference Sessions will be held Feb. 1-4 at the Rice Hotel, while the Exhibit will be staged in the Sam Houston Coliseum, Feb. 2-4. For additional information write to: Instrument Society of America, 313 Sixth Ave., Pittsburgh 22, Pa.

1960 Winter Convention on Military Electronics, PGME, February 3-5

Tours to the Pacific Missile Range and Naval Ordnance Laboratories, Corona, are among the many field trips offered to visitors at the 1960 Winter Convention on Military Electronics. The field trips are expected to offer a cross section view of the missile, defense and electronic industries in Southern California.

A visit to Space Technology Labs, Inc., will be held Wednesday, Feb. 3. Visitors will be shown a film on current space probe activities and the company's Space Communications and Navigation Network (SpaN Net), headquarters for a vast intercontinental tracking station network.

Feb. 3, from 7:30 to 10:00, an evening trip to the System Development Corp. of Santa Monica will be featured. Two tours will be offered Feb. 5 to include a visit to the Pacific Missile Range, Point Mugu, Calif., to view a Regulus test launch and a tour to Consolidated Electrodynamics Corp.

The convention to be held at the Biltmore Hotel, Los Angeles, Calif., is sponsored by the Institute of Radio Engineers Professional Group of Military Electronics. Chairman: Dr. Lester C. Van Atta, Hughes Aircraft Co., Los Angeles, Calif.

WASHINGTON REPORT

Ephraim Kahn

. . . **COST DATA** rules in the Armed Services Procurement Regulation may be expanded. The General Accounting Office wants military buying procedures to give guidance to contracting officers when insufficient information is supplied by contractors.

. . . **U.S.-RUSSIAN COOPERATION** in peaceful space projects is being emphasized. The U.S. has offered to let the Russians use the American tracking network for their man-in-space program. Next move is likely to be made through the United Nations.

. . . **PATENT POLICY** battle lines are becoming clearer. Congress, sparked by its small-business committees, will probably line up behind the view (supported by studies made for the Attorney General) that patents obtained under federal R & D contracts should belong to the Government. Operating agencies—defense, space administration, and atomic energy—will take a more flexible view. They have to work with industry and try to understand its problems.

. . . **RELIABILITY PROGRAM** for electronic parts and tubes will be expanded by the Defense Department. Preliminary recommendations of a Pentagon committee will be studied by industry, which will be asked for recommendations. Object is to set reliability levels for equipment and components that both industry and the military can live with. Under consideration is the granting of financial incentives to electronics concerns to develop highly reliable components. When adopted, the new reliability standards may force electronics companies to meet new criteria for inclusion on the Qualified Products List.

. . . **PARALLEL PRICING**, an approach to antitrust action considered very promising by the Justice Department, has apparently been knocked out of court. Government efforts to show that "conscious parallelism" of prices—with all companies in an industry following the price for a specific item set by a market leader—were rejected as proof of conspiracy to restrain trade or fix prices. Chances are, however, that such pricing will be cited in the future as secondary evidence to back up charges of collusion that can be proved in other ways.

. . . **GOVERNMENT SERVICES** to industry and trade groups are under critical scrutiny by the Budget Bureau. As part of a drive for fiscal balance, pressure is being put on agencies to impose realistic costs for special services. At present, for example, some special statistical surveys are made for industry—but most of the cost is borne by the Government, while the industry involved merely picks up publication costs, or a little more.

. . . **R & D PROFIT** and cost allowances seem headed upward, says Maj. Gen. W. T. Thurman, assistant for production programing of the Air Materiel Command. But, he asserts, there will have to be restraints "to insure that companies whose work is practically all in the defense field don't indulge this to the extreme and run up tremendous bills at the direct expense of the taxpayer."

. . . **CRACKDOWN ON R & D**—and subsequent production orders—has been hinted by high officers of all three military services. The Chief of Bureau of Naval Weapons would like R & D to get maximum support, since it is "not very expensive, relatively speaking." But tighter management should cut off less fruitful projects at the earliest possible stage and limit parallel approaches.

. . . **MORE SELECTIVITY** in both R & D and in choice of items to be put into production is urged by the Army's Chief of Ordnance. Lt. Gen. J. H. Hinrichs says that this country cannot afford both "today's weapons and tomorrow's." The answer, he believes, is to "adjust to realities, continue our R & D work and only go for those major improvements on which there can be no question." Ordnance is convinced that "maintenance of 'in-house' know-how and scientific and technical talent, from a long-range viewpoint, is a must," the general said.

. . . **WEAPONS SYSTEMS** will be fewer in the future, the Air Force Deputy Chief of Staff for Development predicts. The chief, Lt. Gen. R. C. Wilson, says that "the very richness of our technology" presents hard choices. New developments "appear continually and so close together that it is nearly impossible to select a system and develop it fully," he asserts.

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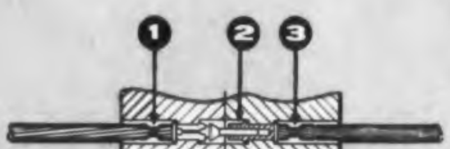

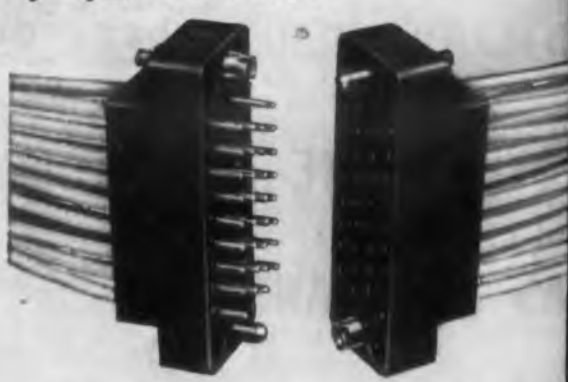

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EDITORIAL

Goals for the 60's

"Design in the 60's" in this issue points up the fact that by 1970 the electronics industry may be radically different not only in size but in character from the one of today. It's hard to predict the many problems that will arise to plague the industry and still harder to say which of these will be the greatest.

We would like to hazard a guess and say that adapting to technical obsolescence, using technical manpower effectively and obtaining proper recognition for the electronics industry are three major problems that will have to be coped with successfully if the industry is to enjoy healthy growth.

The industry must develop a flexibility of operation great enough to absorb the shocks of increasing technical breakthroughs. This means that it will have to learn how to capitalize quickly on research findings on the one hand, and on the other, to phase out obsolete projects or methods as rapidly and efficiently as possible. If it masters this "art," the industry can thrive on rapid change and use this skill to meet and beat foreign competition.

The industry must learn to make much more effective use of its technical manpower. There is no sign of meeting the shortage of competent technical manpower in the forseeable future. Furthermore, as technical problems become more complex and sophisticated, manpower problems will increase. The best way to meet this need is to make better use of the technical people now employed.

The industry must work hard to achieve recognition as an industry. Under the present Federal Standard Industrial Classification of business categories, there is no "Electronics Industry." And no group of headings now used can adequately encompass the various activities of electronics. The result is that when a business census is taken, the electronics industry, now reported to be the fifth largest in the country, completely disappears in a few manufacturing groups under a general heading "Electrical Machinery & Supplies." This means that the Government is very poorly informed through its usual channels about the statistics of this growing industry. The electronics industry also is poorer because of a lack of marketing information that normally flows from the Government.

There are other electronics industry problems that may seem more important, but we can't think of any that are more basic and whose solutions represent for the industry truly worthy goals for the 60's.

Edward E. Grazda

DESIGN IN THE 60's

What will you as an engineer be doing during the next 10 years? Our answer to that question is compiled from predictions by men in the industry and our editorial staff. This report should be read carefully, for these are the directions in which you will be moving in the coming decade.

As Goes Solid State So Will Go Electronics

ELECTRONIC progress in the next 10 years is going to revolve around the solid-state art. Packaging, computers, communications, production, navigation and guidance will be affected. In fact, every area of electronics will owe to the researchers in solid state a good share of credit for their own advances.

In components, for example, microresistors and microcapacitors were developed because of pressure exerted by the advent of transistors. An average-size resistor was usually the smallest component on a chassis containing electrolytic capacitors, vacuum tubes and transformers. Now that vacuum tubes are a thing of the past in many applications, designers have had to concentrate efforts on miniaturizing or even eliminating some of the other components. Otherwise the size advantage gained by using transistors is lost.

Smaller and Smaller Components

Thus relay makers are developing smaller, lighter relays. Wire manufacturers are investigating thinner, lighter insulation materials. Miniature light bulbs are under development to take advantage of this space reduction. Transformer engineers are investigating new form factors, new core materials and various winding methods in an effort to reduce size. And capacitor and resistor makers are in process of checking every promising new material and technique to make these units smaller.

But size advantage isn't all. New techniques, new circuits and new applications for old components will result from advances in the semiconductor art.

New high-speed switching systems in telephone circuitry have been developed around semiconductors. Work will progress toward more portable, more efficient systems. Here the military will benefit. Transistors have also opened the way for development of push-button dialing systems. Several transistorized tone oscillators easily fit into the standard telephone set.

Improvements for Computers

Computers also will undergo many changes because of semiconductors. Magnetic cores are more compatible with transistors; therefore they are coming into their own.

Transistorized computer circuits already have eliminated the banks of vacuum tubes and their huge power and cooling requirements. By making computers smaller, more functions can be crowded into the same space. Thus they become more versatile.

Already many lightweight versions of computers have been developed for aircraft and missile use. As work moves ahead, more sophisticated circuits will evolve.

High-speed computer memories will require development of suitable input and output devices. And as higher computer speeds are demanded, the trend is toward utilization of microwaves. Computers operating at kilomegacycle speeds will require as much plumbing as wiring. Again, space-saving in other areas will be necessary. Micromodules will certainly be required.

Systems Designers in Race

In systems design, the problem of keeping up with the industry will be acute. The goals involve larger objectives with smaller components. To build systems to implement certain objectives, the basic components must be developed first. Systems designers cannot work very far ahead of component designers. And to take advantage of semiconductors and microminiature developments, these designers must keep in close touch with many other areas of electronics design. Their powers of prediction must be kept sharp.

Progress in the materials area, combined with production techniques now under development, promise new packaging concepts. Automatic packaging of assemblies is expected to become practical and economical. Micromodules are a start in this direction. Their impact probably will not be felt for a few years. Although design engineers have practical assembly methods for micromodules in mind, economists will make the decision to go ahead. Some devices cannot be assembled economically for short production runs. Cost studies will be important in this area.

Molecular Research Pressed

Molecular electronics, or solid circuits are an exciting new development growing out of semiconductor physics. To date these units are still in the laboratory. Work is in progress—and will continue at a good rate—to convert solid circuits into production items. Experts agree success won't result overnight. The problems in achieving uniformity of materials and reproducibility of the devices are great. More understanding of the basic functions of matter is going to be required.

Semiconductor materials research has given infrared (IR) systems designers a lift. New types of windows and new combinations of materials for IR detectors will continue to be developed.

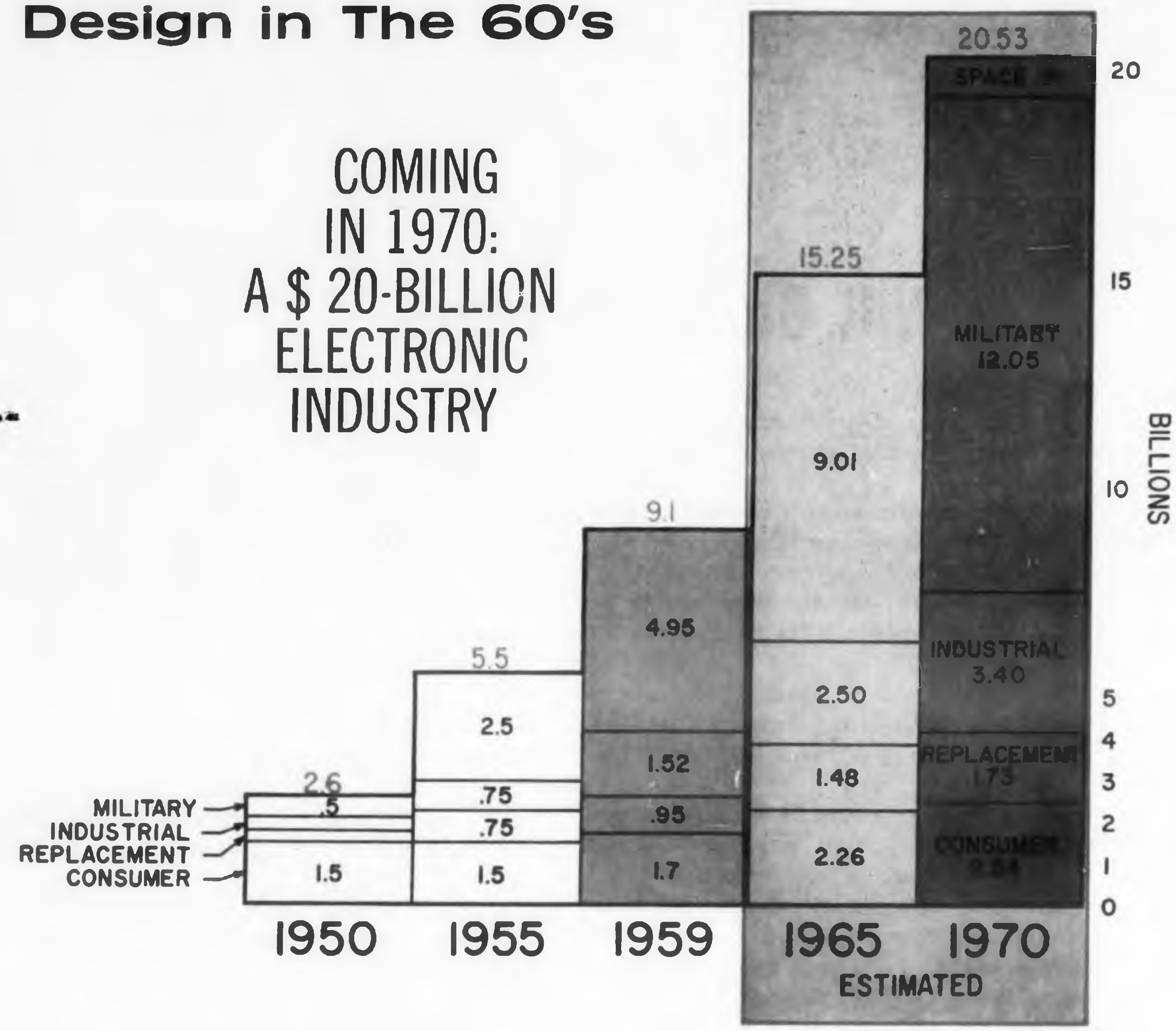
Materials research in many areas will be required to keep pace with the demands of space flight. Environmental requirements for components will become more severe. Superimposed upon these severe conditions will be the specifications of systems designers, calling for higher frequency and higher speed of operation for some equipment.

Air Traffic Controls Needed

An almost alarming increase in air traffic has demanded more sophisticated airways control. The burden has been placed chiefly on electronics designers. Fortunately the trend toward miniaturization has given the designer the help he needs. Semiconductors will provide the means for eliminating much accessory equipment and saving space.

Looking forward then, it appears certain that the industry will continue to advance rapidly. The new frontier provided by semiconductors will continue to challenge designers. Many will be spending a good share of their time catching up with semiconductor developments in their own areas.

There is little doubt that the electronics industry will be able to keep up with new space advances, more aircraft flying at higher speeds, and the demands from business for devices to assume more complex functions. ■ ■



Sales of $20 Billion, Seen by 1970

FACTORY sales of the electronics industry will more than double in the 1960's, the Electronic Industries Association forecasts. This increase would be at a slower rate than the spectacular tripling of sales during the decade of the 50's.

By 1970 factory sales of electronic equipment will pass $20 billion, the EIA predicts. Sales in 1959 were $9.2 billion.

Most of the $11 billion in added sales will be registered in the military market. Expenditures for military electronics equipment are expected to rise from 1959's $5 billion to $9 billion by 1965 and to $12 billion by 1970. By then, 60 per cent of the total dollar value of equipment produced by the domestic electronic industry will be going to the armed services, the EIA anticipates.

Expenditures for this equipment in turn will represent 20 to 25 per cent of the total estimated military budget of $60 billion. This budget is expected to include by 1970 some $2.7 billion for electronics R & D—nearly 3 per cent of the country's entire anticipated 1970 spending for technical research.

In 1959, the EIA started keeping figures on a new category of industry expenditures: non-military space electronics. This spending totaled slightly less than $100 million in 1959. By 1970, spending for non-military space electronics should reach $800 million.

Population of the United States in 1970 is expected to reach 220,000. The 1970 Gross National Product has been forecast at $725 billion, up from about $475 in 1959. And manufacturing capacity is expected to grow by about 50 per cent during the 60's. ■ ■

Will Marketing Dominate Electronics Industry in 60's

THE DECADE now beginning may eventually be remembered as the one in which marketing considerations became dominant in the electronics industry. If this trend develops, the 60's will be the third consecutive decade of profound change for the industry.

In the 40's, black-box thinking dominated electronics. Resources then were concentrated on developing equipment to solve narrow-gage problems.

A staggering number of technical advances brought changes in the 50's. These developments supported a three-fold increase in the size of the industry, which changed character under the influence of systems thinking.

But late in the last decade, particularly in 1959, new currents were felt in the industry. Leaders warned that "our greatest need in electronics, as an industry, is to build our marketing capability up to the level of our technical capability." Some companies, recognizing this, reorganized to give their marketing men more scope. Other companies went further and redefined their goals.

Jack G. Anderson, vice president for marketing at Hoffman Electronics, told members of the American Management Assoc. that in many production programs for the military, "the value of the supporting services is considerably in excess of the procurement cost of the prime equipment. We, therefore, believe it is consistent with the requirements of our market to consider that the supporting services we can provide are in fact the dominant characteristics of our performance."

In the 60's then, while some companies will be selling electronic products, others will be selling electronically based services. Another group will be offering something still more general: solutions to customer problems, with the final form of the solution undetermined at the time of negotiation. ■ ■

A Confident Look at the Next Ten Years

by
the Head of Electronic Industries Assoc.

Following is a statement by David R. Hull, president of the Electronic Industries Assoc., on what the future holds for electronics:

"Our marketing data department recently completed studies projecting sales of more than 20.5 billion dollars for the electronics industry in 1970. This is more than twice the 1959 business.

"An upsurge was forecast for industrial electronics of nearly two and a quarter times present levels. Growth of more than 100 per cent was predicted for consumer products. Replacement sales are expected to rise more than 80 per cent, despite greater reliability of original equipment.

"Such growth prospects in an industry which has just completed a decade of phenomenal expansion would warrant unalloyed optimism but for the sobering fact of our industry's great dependence upon Government business. I wish it were possible for us to look forward during the next ten years to a time when we could begin to base over-all future prospects, much more substantially than in the past, upon civilian markets.

"But I believe we must expect a resurgence of Communist aggression, rather than a lessening of tensions, which will leave future administrations in Washington with no choice but to maintain high levels of defense spending for the next decade or longer. Defense sales will have risen from about 50 to 60 per cent of the industry's total business by 1970.

Industrial Sales to Soar

"Meanwhile, however, the industry can anticipate substantial growth in a number of civilian lines.

"It is possible, for example, that the gain in

Design in The 60's

A Look at Next 10 Years

industrial electronics may be greater than the 225 per cent forecast by the EIA marketing data department. In any event, we have just begun to scratch the surface of market potentials in that portion of the industrial field represented by electronic computation and data processing.

"A few months ago one of the leading instrumentation periodicals published a survey of more than 30 applications of computers for process control. Prominent on a list, which included the chemical, power, railroad, and cement industries, were computer utilizations in the petroleum industry, where it would be possible with equipment available today to automate processing from the well to the automobile gasoline tank.

"Such equipment, in the almost immediate future, will make far greater use than now of semiconductors to attain higher reliability standards. This development, among others, foreshadows adoption of computer controls for processing units and, indeed, complete plants in vastly more industries than thus far have chosen this route to higher operating efficiencies.

"I also am confident that in the next ten years we shall see computers used by business management both for the making and execution of decisions—and to an extent undreamed of today.

Industrial TV Expanding

"Market potentials are promising for other types of industrial electronic equipment. These include industrial television, the use of which is certain to increase with growing needs for remote control, particularly as a result of nuclear industrial expansion.

"I believe we shall see a great increase in the use of closed-circuit television in education. Experience at Hagerstown, Md., and in schools and colleges in other parts of the country has demonstrated, among other advantages, that teachers do a much better job when they have to present courses on television. TV promises both higher education standards and conservation of teaching manpower.

"A very considerable expansion can be anticipated, I believe, in the use of semiconductors in the power industry. Semiconductor rectifiers are being greatly improved and, in terms of simplification, size reduction and other respects, will represent a substantial advance over rectification by comparatively cumbersome rotary machinery or banks of electron tubes.

"Sometime within the next decade, the electronics industry will have to find solutions for a problem which is related not only to its future growth but which very directly concerns what can be described as conservation of a major national resource. The problem concerns efficient utilization of the radio-frequency spectrum.

"It is hoped that in a relatively short time Congress will establish a single authority in Washington responsible for determining which frequencies should be reserved for the Government and which may be assigned to civilian users. If this occurs, the first step will have been taken in the direction of sensible spectrum utilization by ending the present practice of allocation by compromise among Government agencies, rather than upon the basis of sound technical considerations.

"But the most important step toward spectrum conservation will remain to be taken, and it is here that the electronics industry will have a major responsibility. It will be up to our industry to supply much of the technical skills and provide much of the long-range planning necessary in evolving concepts which will make possible efficient use of the spectrum. Bands must be found for radiation equipment, mobile communication, space exploration and other uses.

"The spectrum can be expanded, in effect, for these purposes and opportunities thereby created for the industry's growth. But the job will call for more than the application of existing know-how and the development of new technical principles. It will call also for the exercise of wisdom and consideration for all concerned to avoid solutions which may bring severe dislocations to certain sectors of the industry.

Great Opportunities for Small Business

"The electronics industry has another problem which, unless given special attention, can become acute during the next ten years. This is the problem of small business in which, as we all realize, there is a large element of political sensitivity. Actually few industries offer greater opportunities for small companies than ours. Furthermore I am confident that more small electronics companies will become established during the next decade than in the one now ending.

"But also we shall see, I believe, a trend toward mergers and the absorption of some existing companies by larger ones, as members of the industry seek to balance product lines and make their businesses sounder through diversification. We can be certain that these moves will attract far more attention in Congress than increases in the rates at which small companies will be forming."

"The EIA has taken a number of steps to advance the position of small business. It recently created a Small Business Committee, which is planning a series of regional conferences for developing programs to aid small enterprises in solution of their problems. The association also, as a matter of policy, has been careful to ensure small business an effective voice in the organization's affairs, including representation on committees on military management and relations between prime and subcontractors.

"Taking the long view, one cannot help but be optimistic about the future of the electronics industry. Its problems are grave but far from insoluble. Much more important, our industry can look from a history of spectacular development to years of opportunity literally as boundless as the universe."

(Semiconductors on next page)

Design in The 60's

Manufacturers of Semiconductors Look for Components With Life Spans of 40 Years at Competitive Low Cost

HIGH RELIABILITY and low-cost automated production represent key goals for semiconductors in the coming decade. With greater knowledge of basic materials and parameter failures, life spans reaching 40 years are anticipated.

Scientists at Bell Labs, offering "blue sky" predictions based on down-to-earth development activity, envision drastic modifications of current packaging techniques to include integrated circuitry and molecular electronics.

HF Range to Be Extended

Parametric devices, such as the pn junction and the maser, will find widespread application in very-high-speed computers. With a better understanding of noise sources in semiconductors, the diode parametric amplifier will be useful to frequencies exceeding 50 kmc. Silicon transistors are expected to become more widely used, with operation reaching the kmc range. Pnpn devices will become more popular in equipment requiring switching speeds up to 10^{-9} per second.

Semiconductor materials will make serious industrial inroads in thermoelectronics and electroluminescence. During the coming decade power and light generation by these materials should become a reality.

Tunnel Diodes Hold Promise

In the next several years, the Esaki, or "tunnel" diode, should be sufficiently advanced in production and reliability to be considered a valuable device in applications ranging from computers (its theoretical switching speed is 10^{-12} per second) to entertainment devices. Application engineers are busily engaged in the development of practical schemes and circuits for the two-terminal semiconductors. Methods of cascading several stages, operation within the two-terminal unit's low-voltage range and basic design approaches must be made available to the design engineer before widespread use can be achieved.

Power Potentials Predicted

Transistors with power levels as high as 1500 watts in the frequency range of 10 mc are predicted by Dr. Harper Q. North, president of Pacific Semiconductors, Inc. The displacement of power transmitter tubes in the megacycle region should ultimately follow. Mr. North emphasizes that control problems in solid-circuits are formidable: low yields will result as circuit complexity increases until a realistic production status is reached.

Nick DeWolfe, head of Transitron's engineering department, predicts that transistor reliability will reach a point within ten years where the solder joints used to connect devices will be less reliable than the transistor component. He is confident that two-terminal AND-OR storage elements will be available to bring about drastic changes in computer size and design techniques. The basic incompatibility of reliability and miniaturization will, he feels, delay the success of the much-heralded microminiaturization program.

Immediate Projects Listed

During 1960 miniaturization will proceed on such available components as micro-diodes, micro-transistors and extremely small resistors and capacitors. The control-rectifier, in spite of its turn-off difficulties, will find increased applications in industrial and military equipment.

The influence of foreign competition has spurred the efforts of major manufacturers to further improve reliability as a sales wedge. Similarly the pressure of large missile systems underscores the need for high reliability.

Germanium and silicon mesa transistors are expected to reach a price level suitable for application in large-scale, high-frequency entertainment and industrial equipment. ■ ■

Heavy Research Due in Materials

MATERIALS for semiconductors, molecular electronics, components and insulation will undergo much research in the 1960's.

"During the next decade,"—said a representative of Minnesota Mining and Manufacturing Co.,— "there will certainly be a great extension along the line of progress in the last decade. The chemist can be counted on to develop an increasing variety of polymers for films, fibers, resins, wire enamels, etc."

In the solid-state field, engineers and scientists will be working to contrive a circuit function in a block of material with semiconductor junctions and electrical fields. Their efforts will require an understanding of the basic properties of matter.

Keeping Apace A Problem

The designer's big problem is keeping up with all the progress in materials. This year, for instance, he is facing a rare problem in the insulation field: too much of a good thing, according to a representative of Rogers Corp., insulation manufacturer. The wealth of materials born in the 1950's "will now demand intelligent application," he said.

He added that in the next decade, the non-organic polymers would come into play and might be the biggest area of progress in new electronic insulation materials.

Along with the new materials, old ones are being examined for new applications. "Glasses themselves are being investigated as semiconductor devices," a spokesman for Corning Glass Works said. "It is quite apparent to us that glass is going to become even more important in the electronics of the immediate future."

Present Shortcomings Noted

Other areas requiring further work were outlined by a representative of Ohio Semiconductors, Inc. He said that:

In the infrared field the continuing problem is to find better ways to get controlled transmission edge for windows and sensors, larger cross-section materials for windows, new combinations

Design in The 60's

Heavy Research Due in Materials

of materials for special applications and a greater homogeneity of materials for uniform index of refraction.

In thermoelectrics one of the most significant problems is to develop materials that will make these devices practical for large-scale domestic applications. New combinations of materials, more abundantly available in nature and yet competitive in performance, must be made. For generative applications, improved high-temperature materials and bonding techniques are needed.

In the development of solar cells and their application, the problem is to obtain improved materials for greater efficiency.

In transistors and diodes better materials are needed for higher operating temperatures and higher frequencies.

In magnetoresistance and Hall-effect devices new materials are needed for improving such characteristics as voltage output, power dissipation and temperature coefficients.

New Applications Envisioned

More predictions on electronic materials were offered by Dr. Leslie Taylor of Dow Corning Corp. He said that "new materials that will find application in the near future" included solventless resins that possess better heat stability and radiation resistance; room-temperature vulcanizing rubbery materials with improved thermal stability; oil-resistant, high-temperature rubbers and resins, and faster curing, tougher Class H impregnating varnishes.

This is but a sampling of likely progress and problems. The work to be done in electronic materials is tremendous, almost overwhelming. Two ways of meeting the challenge were outlined in a paper delivered at the IRE convention last year by Allan M. Hadley, deputy secretary of the Advisory Group On Electronic Parts.

The first approach, he said, involves "accelerating to the maximum degree possible those current and proposed material programs which are on the books of government and industry." Careful coordination is necessary here, Mr. Hadley indicated.

The second approach, he said—it seemed more logical and offered more chance of success, he thought—is "in pooling and exchanging materials information from all sources."

"The big question," he said, "is whether such an action . . . would advance the materials situation to a degree sufficient to offset the value of proprietary interest. Only management can answer this question."

He cautioned against the "hasty rejection" of this approach. ■ ■

Communications Designers, With Eyes on Space, Facing Challenge of Developing Smaller, More Reliable Equipment

EXPERTS agree that the full impact of semiconductor technology is still to be felt in communications—both wire and wireless. In the next 10 years the advances will include not only transmission of intelligence but auxiliary switching systems, control devices and the like. In these areas, both efficiency of operation and size of equipment will undergo surveillance.

Progress in space technology will require the communications equipment designer to meet the challenge of smaller, more sophisticated equipment. As in the past, reliability will occupy a good share of the designer's efforts. And an often overlooked problem—cost—is coming into prominence.

New materials and techniques will contribute to the day-by-day advances in communications. But experts feel that progress will be paced by advances in the technology as a whole.

Key Developments Foreseen

Developments forecast for the next 10 years include:

■ Space communications systems. These will include voice, television and control signals for swift, reliable data transmission, control and message handling between space vehicles and the earth. There is a good possibility that devices will enable satellites to communicate with one another. Systems of relaying data from satellite to satellite are a certainty.

■ World-wide communications system. The Air Force's 480L and the Army's UNICOM are examples of developments now under way. These systems and perhaps others will enable anyone to call anywhere in the world in the time it now takes to make a local call.

■ Data-handling equipment for remote process control. Equipment to control automatic processes in remote locations. Included here is high-speed control of transportation facilities, such as air-traffic control. Use of telephone circuits for transmitting business data—payrolls, sales information, etc., will increase.

■ World-wide television networks. Relay satellites with controlled directional antennas will be utilized for this service. Nonentertainment functions will include high-speed facsimile-type communications.

■ Radio comumnications between individuals. Selective calling techniques will be improved to provide private radio systems in the same manner as the telephone does today.

■ Wall display devices. Experimental models of flat-screen TV tubes have already been demonstrated.

■ Simpler telephone terminal equipment. A system will be developed to extract the information from voice and send it "dehydrated." Voice transmission is inefficient. Cordless telephones and all-electric switching systems are likely.

Shrinking Spectrum Studied

In general, communicaitons experts are concerned with the shrinking frequency spectrum. Some feel that some means other than electromagnetic must be found to transmit intelligence. We seem to have exhausted, the experts say, all that electromagnetic radiation has to offer. Spin-wave propagation bears more investigation. Here the usual laws of radiation and propagation do not apply.

Several communications areas are going to get considerable attention in 1960. The most important is data transmission. A scheme must be developed for assuring errorless transmission. For example, it may be necessary to use an error-correcting code or planned redundancy. A suggested plan uses a slow-speed transmission system, with error correction where extreme accuracy is required. A high-speed system can be used when that degree of accuracy is not necessary.

Reliability in communications presents a difficult problem. Although equipment reliability may be 100 per cent, nature does not always cooperate in permitting 100 per cent transmission of a message. Therefore some systems of planned redundancy must be found. Designers in 1960 will be trying to devise methods of obtaining redundancy, using parallel facilities at a cost of slightly more than a single facility.

Tropo Scatter Work Pressed

Tropo scatter systems are due to become even more important communications links in 1960. Work is under way to push the operating distance to over 600 miles. Frequency of operation in the 10,000 mc range is being investigated. There is one tropo link now operating at 8000 mc.

Ionized meteor trails, artificial and otherwise, have been investigated and will become even more important in 1960. Work is being carried on to determine many of the unusual phenomena associated with meteor trail transmission. For example, the maximum signal does not always come from the same direction. Odd phase relationships between transmitted frequencies close to each other have been discovered. Engineers will spend a good deal of time analyzing experimental data in an effort to answer these questions.

A need exists for a transmission system for 400 to 2400 miles or greater. It must be capable of carrying multi-channel information. One solution is the relay satellite. Limited experiments have been performed, but 1960 promises much activity in this area.

Another possible solution lies in the high-altitude manned relay station. A series of aircraft flying at very high altitudes can be equipped as radio relays. Although the concept is not new, many experts believe it will receive a serious tryout in 1960.

Wire Improvements Sought

Work toward improving wire communications is going to continue in 1960. In wire, progress is inherently slow because of compatibility problems. Innovations must be compatible with what is already in existence. Therefore telephone engineers are faced with an interesting challenge.

Pushbutton dialing will be expanded. An all-number director system to replace the present two-letter, five-number system is expected to be started in 1960.

Electronic switching will receive considerable attention this year. Telephone system designers are looking at Bell System's Morris, Ill., switching system with considerable interest. This all-electronic unit is computer controlled with its various features programmed into it. The system may be the key to making electronic switching less expensive than electromechanical. ■ ■

(Components on next page)

Design in The 60's

Standard Components To Stress Operation In Tough Environments

MORE RELIABLE and generally smaller standard components can be expected in the next decade. Paralleling these improvements will be a surge toward functional solid-state devices. Behind these anticipated developments will be both the need—primarily military—and the normal, competitive drive to make components better.

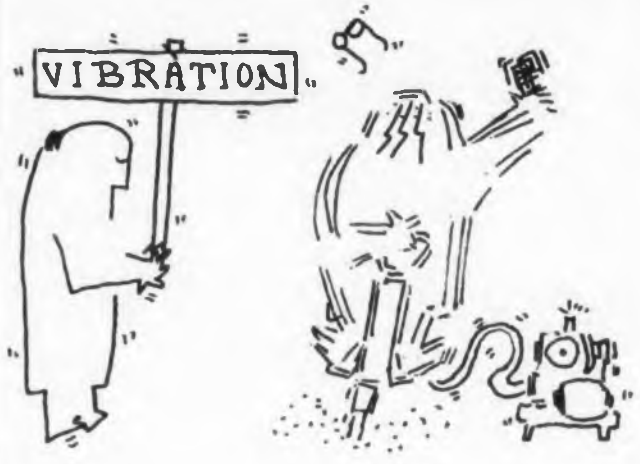
Minor improvements in standard components will continue as new, adaptable materials are developed. In the immediate future designers will have to solve their problems with these standard components. This means that the question of component reliability will still be important.

In time, however, integrated circuits and solid-state circuits will become more attractive as systems become more and more complex. The trend toward more complex equipment seems to be growing without limit.

Density Advances Due

Improvements in component density can certainly be expected. Today's component densities are about 50,000 to 60,000 per cubic foot. But new techniques of component fabrication, interconnection and function promise a tenfold increase, said Dr. J. Morton of Bell Telephone Labs. The variety of new techniques provides exciting opportunities for great improvement in performance, size, cost and reliability, he said.

The movement toward solid-state electronics will require system and component designers to change their basic viewpoints. They must ask different questions, Dr. Morton said. The system designer must specify his needs only in terms of basic system functions, with properly weighted objectives. In turn, the component designer must not only look for new and better ways of making and interconnecting elements into functional mod-



ules: he must go directly to the physics of the electronics, atoms, phonons and photons in seeking basic functions.

During the 1960's the design engineer will have his hands filled with economic matters, too. "A prime concern," said a spokesman for Vitramon, Inc., "will be the economic conversion of components of essentially military inspiration to commercial and industrial use without loss or impairment of the reliability and efficiency levels already achieved."

Stress on Reliability

An interesting aspect of the steadily increasing demands for reliability is the effect it will have on size. A spokesman for Allied Control Co., Inc., said: "The major trend in this new era will be toward greater reliability—even if this requires an increase in size or weight over present subminiature and miniature relays."

He also predicted that contaminant-free, sealed electromagnetic relays would be expected to operate under adverse conditions through hundreds of thousands or millions of cycles without a miss. These relays will also be called upon to work without fail the first time after storage under adverse conditions for five years, he said.

As for connections, "the immediate problems will include further miniaturization, subminiaturization and reliable performance in high-temperature applications and in dry-circuit conditions," an official of Burndy Corp. explained. At present there are too many special connectors, and this will result in a drive for standardization. With standardization will come increased reliability in increasingly miniaturized and environmentally demanding applications.

(Components continued on next page)

Design in The 60's

Standard Components

Versatile Components Sought

How components are designed will be important, too. "More attention will be given to the design of components that will be able to be accommodated in a wider variety of system conditions," a representative of Perkin-Elmer Co. said.

As components improve so will the associated equipment. For instance, Photocircuits, Inc., is working on printed-circuit boards that operate in the temperature range of 500 to 600 C. The boards are designed to stand the same severe environmental conditions the components must withstand.

Also in the works are unclad laminates. The lines of the board are placed where needed; thus etching is eliminated.

Summing up, Dr. Morton said: "We must move to new levels of technical sophistication. We must develop more competence in the system-engineering method, while at the same time we enhance our abilities to apply the basic physical sciences. . . . The challenge of Space Age electronics is not only technical but exciting and personal to each of us." ■ ■

Receiving Tube Manufacturers Buoyed By Space Applications and Automation

FREEDOM from nuclear radiation damage is a top requisite for equipment designed for space vehicles and missiles. For this reason, the military is placing high faith in the use of receiving tubes rather than semiconductors for these applications. Top tube manufacturers are busily developing automated lines with automatic test facilities to insure maximum uniformity of characteristics and highest yield.

Ralph P. Clausen, chief engineer of receiving tubes for Sylvania Electron Tubes, predicts:

"Relative uniformity of products, which has been characteristic of tubes for a long time, will be increased by several orders of magnitude in the next decade. Furthermore reliability will be enhanced, so that tube survival rate, of better than 99.9 per cent per 1000 hours for 20,000-hour duration should be commonplace."

Lower Power Consumption

Mr. Clausen also is convinced that in the near future tubes will be available with power consumption in the order of less than 25 per cent of today's requirements. These accomplishments will result from continual improvement in component materials, new design concepts and progress in automation techniques.

Throughout the industry, functional design integration of electrical, mechanical and thermal areas will be intensified. The trend to "hybridization" will be further extended to take advantage of the best properties of material, together with the most improved characteristics of components. Functional sophistication will deepen, with reliability of much more import than miniaturization.

These forecasts were offered by A. F. Dickerson and A. P. Haase of the receiving-tube department of General Electric Co., Owensboro, Ky. They further envision as a major trend extension of the receiving tube from a component to a modular or functional level. G.E.'s TIMM (thermionic integrated micro-modules) program exemplifies an integration effort in which material developed for ceramic receiving tubes is being used to fabricate resistors, capacitors and thermionic elements, resulting in complete functional modules. ■ ■

Makers and Users Call for Improved Testing of Equipment In Accelerated Campaign to Cut Operational Failure

THIS YEAR, and throughout the 60's a major problem will be designing and producing electronic equipment that is reliable. The men saddled with the problem will be burdened with the development of more complex equipment and the appearance of new and unproved components. In addition components and equipment will be called on to operate in more severe environments.

A clue to what can be done to achieve more reliable equipment in the coming years was given by C. R. Knight, director of Arinc Research Corp. He said:

"If the customer can curb his previously unbridled tastes for new electronic marvels, equipment reliability improvement should be very evident in the future."

Figure-Rate Problem Cited

"One of the most important problems" a designer will face, Mr. Knight said, "will be a shortage of well-documented, dependable information on the failure rates of parts which he proposes to use, and information on the effect his application will have on these failure rates."

There will be many claims and counterclaims as to whose failure-rate information is correct and the most dependable, the research head said.

Looking at reliability problems in the far future, Sydney R. Scott, an engineering staff assistant at Arinc, said:

"I see more and more use of packaged circuitry, micromodules, and the like—provided that they can be reproduced with consistent characteristics and satisfactory reliability. The latter point is debatable."

Mr. Scott explained that maintenance concepts for these items must be drastically revised and that cost problems would probably not allow their discard, although that would be the ideal answer.

More use of semiconductors will be made. But it is possible, he said, that the reliability problems with such items will be as bad as with tubes in the 1950's. More use of built-in, automatic test equipment will relieve the reliability and maintenance problems associated with increasingly complex equipment, he said.

Reliability a Contract Term

In 1960 both industry and the military will be demanding more reliability. The mean time to failure and failure rates will be spelled out in more and more contracts and specifications. Reliability will be an operating characteristic that will have to be met.

A worthwhile point to consider when trying to meet this demand is that reliability is not independent of human factors. The designer must take into consideration that the equipment and systems are not always operated and maintained by engineers.

"Operation," Mr. Scott said, "should be foolproof to the greatest extent possible, and maintenance should be reduced to a 'go, no-go' proposition. There are many cases where poorer reliability can be accepted—provided that troubles can be isolated and corrected extremely rapidly, possibly automatically."

Material Control Stressed

Reliability in molecular electronics will become a material control function, explained R. F. Hahn of United States Testing Co. He sees some good resulting from the use of these components. Reliability problems associated with connection, loose parts, wire harnesses and the like will be minimized, he said.

He also predicted that several statistical tools would be developed and perfected to aid in the determination of reliability figures.

Another forecast: failure analysis techniques using infrared, isotopes and radioactive tracers will be perfected, aiding in the evaluation of modes of failure and suggesting solution.

Test Equipment Foreseen

Test and production equipment will play an important part in achieving reliability. Some future equipment was pictured by Charles F. Conrad, Inc. He said:

"We expect to see test chambers capable of simulating zero gravity electronically. We expect to see vacuum systems which attain the desired condition through electronic means, by converting the air to a solid rather than pumping it out of the chamber."

A representative of Rotron Manufacturing Co. said: "Significant advances in reliability will have to go hand-in-hand with greater cooperation in the design stages between the prime contractor and the cooling device manufacture. The prime contractor will have to make a deliberate effort to create and maintain an atmosphere of 'we are in this thing together to the good of the ultimate result'" ■ ■

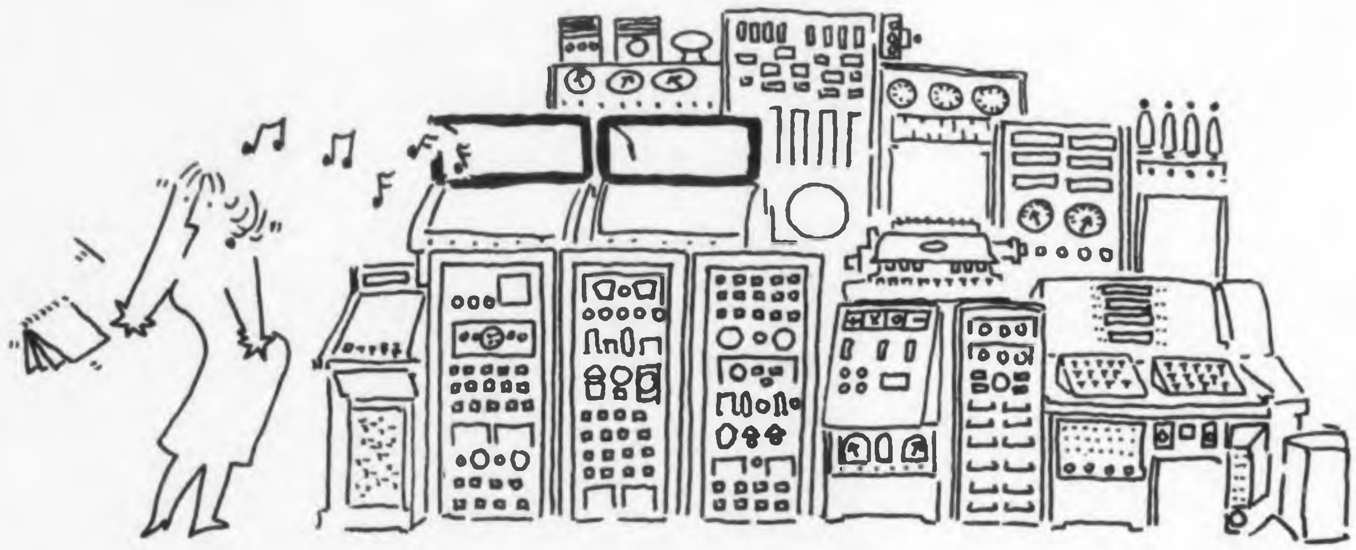
(Packaging on next page)

Basic Research to Give Packaging a Lift

PACKAGING of electronic components promises to be one of the most interesting developments of the next 10 years. Solid circuits—also called molecular electronics—made their appearance less than a year ago. The micromodule concept has just begun to make an impression upon designers.

Important advances are expected as a result of basic research on materials and techniques. New sealing methods, vacuum deposition techniques, fine-line etched wiring techniques will all contribute to these advances. Materials are being developed—and will be developed—as substrates and components to be compatible with these new techniques. More precise processing will be possible, resulting in precision ultraminiature components.

Components will become so small that component manufacturers will be producing the complete subassemblies. The high skills needed to handle the tiny components can be utilized to



Microwaves Studied To Speed Computers, But Obstacles Loom

IF MICROWAVE computers are not here yet, it's not because people aren't trying. Many companies—among them Radio Corp. of America, General Electric, Sperry Gyroscope, International Business Machines, Lockheed and Bell Telephone Labs—as well as university laboratories, are studying techniques for speeding up computers.

Super-Fast Techniques in Labs

Cryogenic and electron spin techniques are being studied, as well as phase modulation schemes in which two stable phases (modulating a high-frequency carrier) are the binary states, rather than two discrete voltages.

Components under investigation include magnetic thin films, varactors, parametric amplifiers and, of course, tunnel diodes.

A few laboratory successes with these approaches have yielded operating speeds of 10 kmc. Though they all show promise for nanosecond computers, they all pose real problems.

Not the least of these problems is that of personnel. Where, for example, does one find accomplished computer designers who are also microwave experts? The average computer man knows practically nothing about plumbing.

Just which technique will dominate tomorrow's computers is not too clear. However, on at least one point all computer authorities agree: tomorrow's computers will do more—much more.

One of the most interesting possibilities, says Sherman Boyd of Stromberg-Carlson, San Diego, is the construction of computers in which a large number of circuits are electroluminescent-photoconductor combinations. Logic circuits and control elements could be built very inexpensively—15 or 20 cents for a flip-flop, or a photoconductor switch for a nickel. No wiring would be needed between the units, just a beam of light.

Communications A Roadblock

There are many barriers to be overcome. A make the entire subassembly. Then when a unit large enough to be handled is made, it will probably be assembled into a piece of equipment by semi-skilled labor.

Experts predict no startling advances in microminiaturization in 1960. Rather it will be a year of catching up. Designers will be busy learning how to apply the rush of new developments that descended upon them in the past year.

Companies in micromodule programs will be developing the production techniques for which the wafers were designed. On some of these wafer components, a sealing problem remains. A good method of sealing the transistor wafer is still to be found. Designers will be working toward making inductors and transformers fit this flat-form factor.

Designers working in molecular electronics will be striving toward reproducibility. Solid circuits are barely out of the research laboratory, and much work remains to make them practical.

Meanwhile, as components become smaller, designers will be cramming more of them into less space. By using standard components, they will be making practical circuits, capable of being reproduced. This, they feel, is much closer to reality than solid circuits. ■ ■

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major one, according to Remington Rand's manager of product design and development, Andrew T. Fischer, is that of communication between human and computer.

Mr. Fischer points out:

"Current computers use mechanical languages of programs, involving instructions and addresses, each having unique meaning. Humans, on the other hand, communicate in informal languages, in which words can have multiple interpretations. The intended meaning depends on chronological, spatial and other associations."

The language barrier, Mr. Fischer feels, will be hurdled in steps. As a first step, he sees the elimination of the need to address information in communicating with a computer. The computer itself may perform the addressing, he says.

Another possibility here is that of replacing the addressable type of memory with an associative memory. In such a memory, data would be stored and retrieved by chronological, spatial and other associations, as in humans.

Human, Machine and Pseudo Languages

Mr. Fischer sees as a second step the use of pseudo languages—intermediate between human and machine languages. It should be easier thus to translate first from human to pseudo language and then to have the computer translate the pseudo language into its own. This method of automatic programming is used with Remington Rand Uni-

Design in The 60's

Faster Computers Studied

vac computers.

As a final development of the 60's, Mr. Fischer pictures computers using search stimulating programs resembling steps of human thought.

To demonstrate the intelligence that can be designed into computers, Mr. Fischer points to the use of novel input devices by which computers can "read" handwriting or "listen" to dictation and type well-edited copy. These functions have already been demonstrated in the Spac (Bell Telephone Labs) and Perceptron (Cornell Aeronautical Labs) machines.

Perhaps more dramatic is Mr. Fischer's prediction that tomorrow's computers will perform management functions. "Artificial intelligence" that helps some of today's machines play chess or solve problems in Euclidian geometry may help computers solve some of management's problems.

Computers To Cost Less

Mr. Fischer's greatest challenge to tomorrow's computer men may well lie in his prediction that computers in the 60's will cost less and be smaller, in spite of their expanded performance.

Reduced size and cost will result, he asserts, from changes in logical design and system organization. New electronic techniques and new components will help. Mr. Fischer points to parametric amplifiers, films and elements that resemble neurons in the human brain, and he cites their ability to perform complex logical functions at a surprisingly low cost for components.

He sees great hope in microminiaturization, in molecular engineering, in magnetic and cryogenic films. He sees savings exceeding 50 per cent possible through mechanization and mass production, even in present-day equipment.

Confident of the changes that computer innovations will bring, Mr. Fischer comments:

"The potential hidden in computer development is bound to bring philosophical and social changes. The hope of having either a more efficient model shop, a better industrial organization or a better society lies largely in the advancement of computers in the next decade."

Better Use of Computers Asked

In a similar vein, Dr. Charles R. DeCarlo, assistant general manager of IBM's data system division, voices the optimism of many industry leaders when he says:

"From now on, the big job is not making machines more powerful—but putting them to work. In the 60's we must apply the power of these systems to tasks that fully merit their potential.'

Lest anyone misinterpret these remarks, Dr. DeCarlo is quick to add that he does not mean the electronics industry is finished with technological developments.

"There will be many exciting refinements and improvements," he says. "Memory capacity, speed and flexibility will increase fifty-fold during the next few years. Circuitry will be improved. Switching speeds will rise considerably. Memory devices may be changed or modified."

Integrated Functions Stressed

Shifting to a broader, philosophical question, Dr. DeCarlo expresses his opposition to the phrase "data-processing systems." In its place, he prefers "integrated communications systems" as more truly reflecting a systems concept. He amplified:

"Computers will be exploited to achieve less cost, better return and greater operating efficiency for users, if we can parallel our so-far successful efforts in machine technology with as great or greater emphasis on systems concepts.

"To put it bluntly, we in this industry must undertake a fresh, long look at the organization of the machines we have now or foresee. We can no longer be satisfied with a systems philosophy that does little more than automate existing business or scientific procedures.

"Instead of superimposing data-processing devices on old systems, let's go back to the systems themselves. Could we not better organize a bank or a design department to capitalize on appropriate data-processing technologies? Is this not the place to begin to organize a data-processing system?"

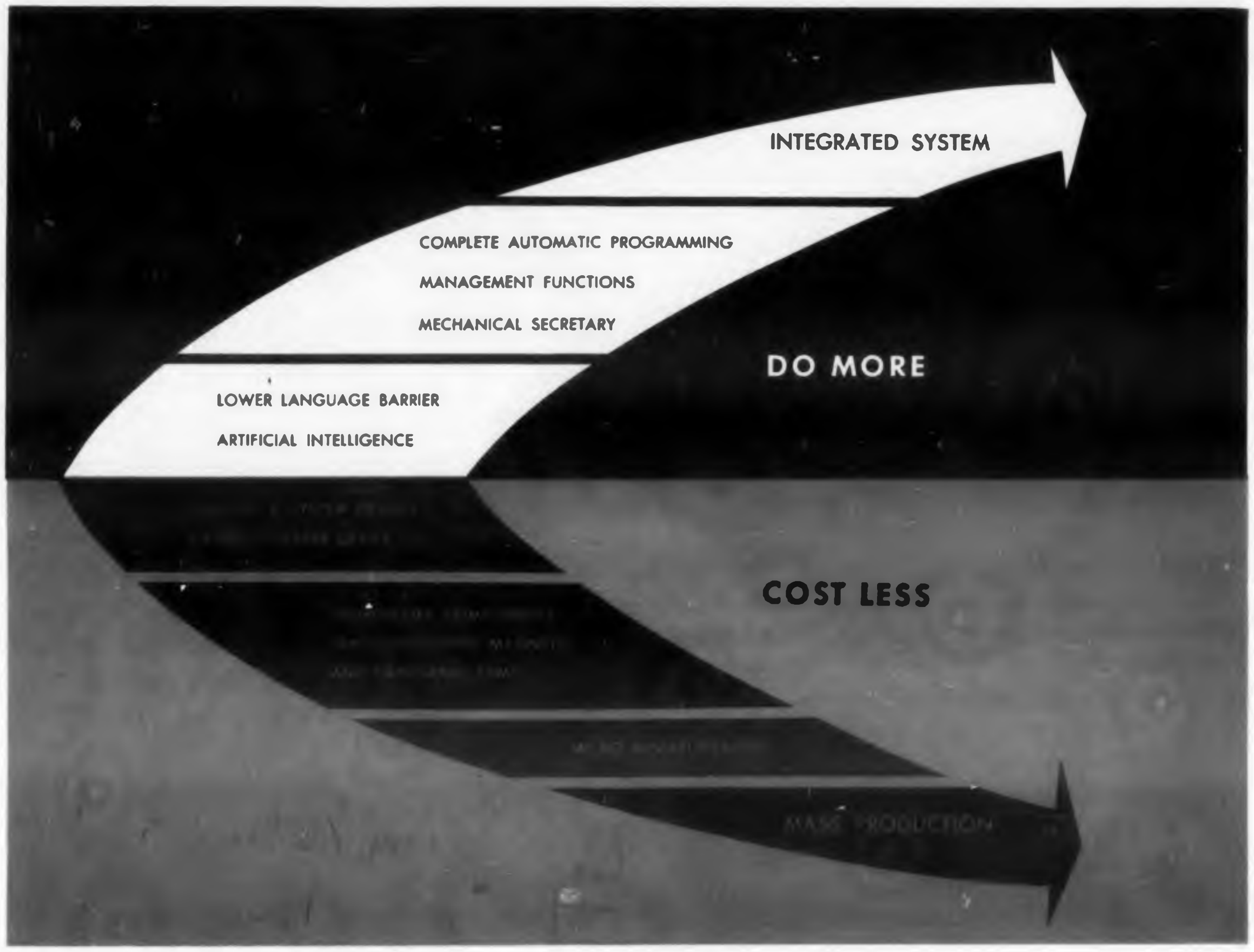
Voice Input and Output

Citing an application of the high-speed IBM 7090, Dr. DeCarlo comments:

"This is faster and more direct than anything we've had before, but it is far from the ultimate. Eventually a system will feature direct voice input and output. You just pick up a phone, tell the computer what information you need and receive a verbal result."

Other areas in which Dr. DeCarlo sees progress in the 60's are in data acquisition and display.

"In information retrieval systems," he says, "a company will be able to maintain a large amount of information in a central computer file. This information will be tapped via long-distance lines and immediately displayed on a screen rather



Computers in the 1960's will do more and cost less, according to Remington Rand's manager of product design and development, Andrew T. Fischer.

than indicated through various printouts."

Through centralized computers, he sees higher speed and reduced operating costs. "It is far more economical," he says, "to transmit data over long-distance lines to one central computer than to maintain several parallel or overlapping systems. Cost per calculation—even if you feed in two plus two—goes down as the volume of work goes up."

Computer To Aid Doctors

Dr. DeCarlo sees many completely new areas where computer-communications networks will yield outstanding results. He sees, for example, medical diagnosis with a computer as a possibility in the 60's.

Many hospitals in many cities would be linked to such computers. As an adjunct to standard diagnosis procedures, symptoms would be fed into a computer for comparision with human diagnosis.

Another medical application would be in complete operating room control. All pertinent factors —blood pressure, respiration, basal metabolism, heart functions and other measurable patient welfare criteria—would be fed into a computer. The machine would sense trends or developments—possibly well before attending physicians who are concentrating on other tasks.

"This is all in the future," says Dr. DeCarlo, "but the potential is here right now ready to be tapped.

"We've learned how to build, use and control the tool. Now we must put it to really practical use. From 1960 on, we will see computers becoming more and more a part of our daily lives. ■ ■

Ultrasonics: Everything

From Gages to Cleaners

APPLICATIONS of ultrasonics are expected to increase to an unprecedented number in the next ten years. Already ultrasonics has invaded the metal working, optical, instrument, jewelry, chemical, medical and food processing industries. In the next few years ultrasonic cleaners will become common household items.

According to Robert L. Rod, president of Ac-

Design in The 60's

Ultrasonics Racing Ahead

coustica, ultrasonic equipment will be used in the home for thawing frozen foods, tenderizing meats and processing coffee beans. In industry, he sees extension of ultrasonic techniques to processing, gaging systems, and the acceleration of chemical reactions. Rocket thrust will be controlled by sonics, and nuclear reactors may be controlled by some form of sonic modulating energy.

But before all this comes into being, some down-to-earth problems have to be solved. Paul Platzman, vice president of Narda Ultrasonics, points out that there is a need for better transducer material. Ferrites, he says, will eventually replace both barium titanate and magnetostrictive transducers.

Barium titanate is fragile and tends to depolarize at the extremes of cleaning temperatures. Ultrasonics equipment workers also pay a premium for uniformity of barium titanate. Servicemen are required to adjust a generator to a tank, since all tanks do not have the same frequency or impedance.

Ferrites Have Advantages

Ferrites are much less expensive and much easier to produce. Because they will not polarize, it is possible to obtain much greater power densities from a ferrite transducer. There is no reliability problem with ferrites.

But the problem with ferrites is obtaining them in large enough quantity. Equipment manufacturers are reluctant to redesign their units to accommodate ferrite transducers until they are assured of an adequate supply. Ferrite transducers are now being manufactured by Phillips of the Netherlands, but the problem is to get them produced in the U.S.

Mr. Platzman feels that inexpensive transducers plus transistorized ultrasonic generators will bring the price of ultrasonic cleaners below $50. Home ultrasonic dishwashers will become common, as will small devices to clean jewelry, silver and contact lenses in the home.

Industry will also benefit from inexpensive, miniaturized cleaners. New markets will be opened. For example, cleaners that can be carried to a field installation will save disassembly and travel to bring the item back into the shop.

Designers of ultrasonic equipment will therefore be concentrating on development of transistorized assemblies in the coming year. With the trend toward miniaturization, packaging will also have an important role.

Cleaning of Components Aided

The cleaning of printed-wiring boards with ultrasonics is gaining more attention. Ultrasonics provides the only way of cleaning an assembled board. Other promising applications include cleaning of dirty magnetic computer tape—without erasing the signal; ultrasonic welding of plastic films for sealing; cleaning engravings; cleaning used motion picture film, and fast cleaning of very delicate instruments.

Another interesting application is the use of the Levavasseur whistle to control burning of solid-fuel rocket propellants. This device utilizes the sonic sound made as the rocket fuel burns. A transducer feeds back a signal to a controlling valve, which in turn regulates the burning rate. ■ ■

Instruments to Accent Digital Techniques, Automatic Measurement

TO PROVIDE the best service, the instrumentation engineer must often anticipate industry's needs. He is often more interested in what industry will need in five or ten years than in what it needs now. As a result, his predictions, rarely fanciful, can provide a good clue to where industry is going.

One can take, for example, the predictions of Ivan G. Easton, engineering manager of General Radio Co. He sees future instruments operating much faster than those of today, with greater stability and accuracy. He pictures recorders with vertical writing rates of six inches per millisecond, and phase-stable oscillators as standard-frequency sources beyond 1000 megacycles per second.

More Accuracy, Stability Needed

Mr. Easton expects continued tightening of the accuracy and stability requirements for inductance and capacitance, and he foresees improvement by a factor of five in the next ten years.

Viewing another side of the future, Hewlett-Packard's director of development, John Cage, sees a rapid increase in the number of semiconductor devices in instruments. He sees not only transistors, diodes and photoconductors in use but tunnel diodes, photoluminescent devices and semiconductor devices that do not now exist.

He foresees more emphasis on instrument styling and functional design, as well as greater consideration for designing instruments to fit more easily and conveniently into systems.

Automatic Measurement Due

In two important areas, Mr. Cage and Mr. Easton appear to be gazing into the same crystal ball. Both see an accelerated trend toward digital techniques, digital readouts and more automatic measurement.

By 1965, Mr. Easton predicts, there will be automatic impedance plotters, which will operate over a wide range of frequencies. And Mr. Cage sees automatic ranging voltmeters and impedance bridges that will automatically read resistive and reactive components simultaneously without requiring an operator to make critical adjustments.

In the more immediate future, Mr. Cage sees an important problem: inadequate knowledge of the capabilities and economics of electronic instruments on the part of industrial users.

Mr. Cage says, "The instrumentation industry must learn how to get the soap manufacturer to use electronic instruments as effectively and intelligently as does the guided-missile expert. ■ ■

Microwave Devices To Step Up Power

THE COMING decade will fall heir to many new classes of microwave devices unknown 10 years ago. The results of developing and cross-breeding these devices, and the totally unpredictable mutants of the process will determine the future of microwave development.

One prominent trend that will continue is toward devices capable of generating more microwave power, both average and peak. A tenfold increase in peak power (up to the 100-megawatt region) and an even greater increase in average power (beyond one megawatt is probable. New, higher-efficiency tubes will probably have to be developed to handle the level of power safely.

According to William C. Brown, manager of Raytheon's Advance Development Lab.:

"In the case of Amplitron, a great increase in power has been made possible because of both the high efficiency of the device and a breakthrough in cooling techniques.

"Twenty kw per square centimeter may eventually be realized. Since a typical S-band pulsed Amplitron may have 20 square centimeters of area, it it immediately evident that we are on the verge of a major breakthrough in economic power generation in the S-band region."

Broader Use of Spectrum Set

Expansion of microwave techniques to the millimetric regions will continue. Some method of generating reasonably high power in the millmetric bands will soon become a must for space communication and ranging systems.

"The 1960's will see gas plasma become a major factor in the development of new

Design in The 60's

Microwave Power to Rise

microwave circuitry and for the development of extremely high power at very short wavelength," according to V. R. Learned, director of R & D of Sperry's electron tube division.

In addition a microwave source in any band will be provided with broader electronic tuning range to combat countermeasures and spectrum-crowding. The coming decade will see more use of computer-assistance in obtaining optimum microwave source design.

Toward the Very Quiet

Conflicts between the lowest possible noise and the smallest and simplest device will be compromised or resolved. For example, the lowest noise by far in an input device is attained through the use of cryogenic maser devices. But solid-state parametric amplifiers, while considerably more noisy, have the great advantages of simplicity and small size. Either a non-cryogenic solid-state maser or a quieter solid-state parametric amplifier would resolve the conflict of advantages. Until this occurs, masers will continue to be used when noise is of paramount importance, while parametric devices will be used for lightweight applications.

"The next ten years in microwaves belong to the physicist and to the researcher in basic materials," says R. E. Henning, technical director of Sperry Microwave Electronics Co.

Although the tunnel diode is still too new to evaluate as a factor in microwave design, it is sure to find many applications not previously thought possible. Ferrites have come to be accepted for an assortment of switching and modulating roles.

Solid-State Advances Forecast

According to Dr. Colin Bowners, technical director of the Special Microwave Devices Group of Raytheon:

"The next few years should see the introduction of high-power, low-frequency circulators and isolators for use at the new 'super-power' levels from X-band downwards. Practical microwave limiters should also be expected, capable of protecting crystals and parametric amplifier diodes against burn-out from stray high-power radiation. Frequency, phase and amplitude modulators, having modulation frequencies up to a few megacycles per second, will enable many new systems to be evolved."

The possibility of developing a ferrite solid-state oscillator may be a fundamental step in the years ahead. Such a device could significantly affect the present competition among the many electron-stream microwave sources.

David B. Smith, vice president of technical planning for Philco Corp. says:

"For the next decade the great opportunity lies in the possibilities for discovery of rather basic new building blocks, through advances in the physics of materials, to improve our ability to handle, manipulate and communicate information and data of all kinds."

Other solid-state contributions to the microwave art are sure to occur and are as impossible to predict as the "wiggle" in a characteristic that led to the tunnel diode.

Microwave Systems to Improve

For some time to come, brute-force radar power will be central to ICBM and bomber detection. From antenna arrays far too large to be scanned mechanically, microwave power of tens and hundreds of megawatt power will be radiated in new antenna patterns and recognizable pulse shapes. New detection and correlation schemes will be pressed into use in an attempt to solve the almost unbelieveable range and sensitivity requirements of the ground-based systems.

Transmission of power by microwave link has been proposed by Raytheon as a feasible application for its Amplitron. The multitude of applications for such a development, including a hovering radar platform proposed by the company, may be tested in the 1960's. Component advances into higher power will be welcomed by these system designers.

Satellite Sensors Planned

In further attempts to get every possible second of advance warning of an ICBM attack, several different satellite-borne sensors will be sent into orbit. Two such projects have already been designated. Project MIDAS attempts to detect the heat of ICBM's early in the launching phase, while SAMOS aims at spotting the build-up preparatory to an attack. These are but two of many applications where miniature microwave data links will be valuable.

Because attenuation of microwaves in space is geometric only, lightweight millimetric ranging and Doppler systems stand a good chance of being employed as interplanetary navigation aids. The simple press for more spectrum will force the development of millimetric telemetry and communication systems. Study of the causes of telemetry blackout during ICBM atmospheric exit and entry exposed the need for millimetric telemetry to overcome the problem. All these systems are look-

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Design in The 60's

Microwave Power to Rise

ing forward to a millimetric source of reasonable power.

Microwave 'Marriages' in Offing

Interesting sources of new microwave systems are forthcoming "marriages" of microwave developments to several other techniques. The application of solid-state and printed circuitry to microwave has just begun. Radio astronomy systems will be built around masers that theoretically can "see" for tens of billions of light-years.

What promises to be a most fruitful marriage is one of microwaves and computer techniques. Arthur A. Hauser, director of technical planning for Sperry Gyroscope, feels this union has a better than even chance of taking place in the next decade. At a symposium last year several manufacturers, including Radio Corp. of America, International Business Machines and Bell Lab., reported progress in this field. The group at Sperry has some small sub-units in operation now and envisions a communication system capable of handling data at the rate of 30 million words per second.

Microwaves are finding use in such diverse areas as microwave spectroscopy, solid-propellant detonations and industrial control. Low-loss millimetric circular waveguides may be used for thousand-channel transmission lines. The variety of uses bounded only by the imagination of the microwave systems engineers. ■ ■

Slow but Steady Is the Byword In Nuclear Instrumentation Race

CONTINUED steady, conservative development of nuclear instrumentation is looked for in the 1960's. Specialists hesitate to predict any radically new advances, though they report faster speeds and greater reliability will have to be designed into nuclear instruments.

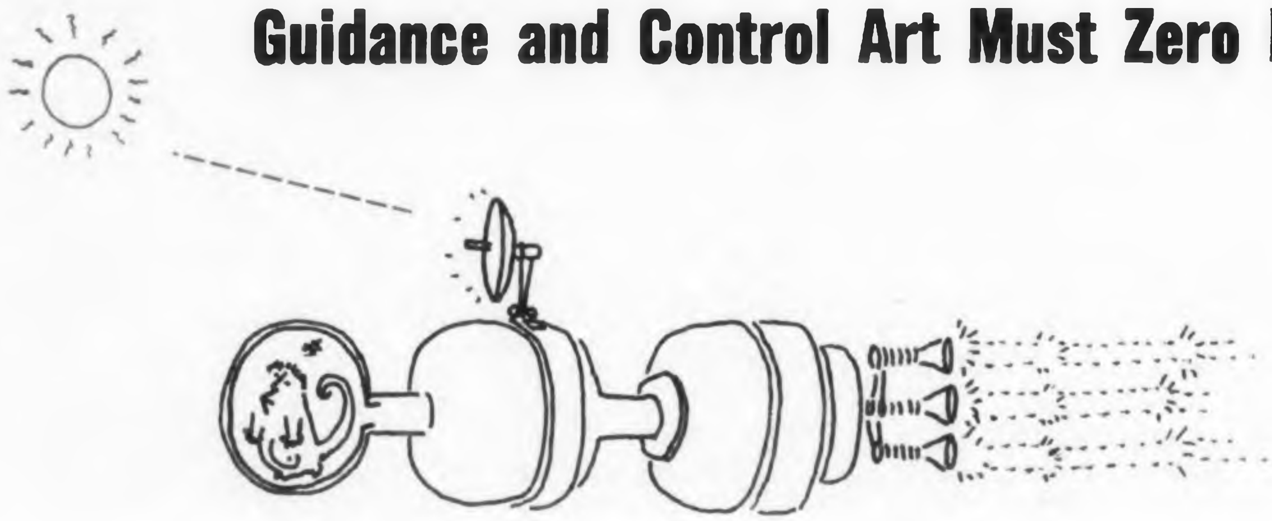
Portable equipment, especially, will be made more reliable—and smaller. Until now tubes for this gear were considered by many designers to be reliable enough, generally more reliable than transistors. Therefore the size of portable nuclear instruments remained roughly unchanged during the 1950's. As transistorization becomes complete, nuclear instruments will finally be made smaller.

Semiconductor detectors will be put in general use. The recent appearance of the gold-on-germanium, alpha-particle detector in Canada and the gold-on-silicon cryogenic detector in the U.S. are the first steps in this development.

The 60's will also bring:

- Wide application of automatic data-processing techniques to measurement, recording and analysis of nuclear data.
- A switch from analog to digital reactor control.
- Circuits and equipment to handle fractional-millimicrosecond pulse rates routinely; traveling-wave-tube amplifiers and fast sampling scopes are only a beginning.
- Extended use of single crystal detectors. ■ ■

Guidance and Control Art Must Zero In on Man-in-Space Needs



THE ART of guidance and control is turning a corner that will set the direction of developments for the next 10 years. To the categories of air-to-air, surface-to-air, surface-to-surface and so forth, a new category of vehicle must be added —earth-to-space.

Of the many developments that contribute to this new direction, the most significant by far is this: man is about to leave his planet and head for trackless space. The job of putting tracks and signposts in this void is the lot of guidance for the next 10 years.

What this development means to guidance is a new order of technical requirements affecting environmental range, duration of flight time, accuracy, and complexities of the geometrical problem to be solved. And the man aboard the vehicle will be called on to master new limits of reliability and safety, acceleration and thrust, and, in the case of inertial guidance, unprecedented drift rates.

Inertial Guidance Faces Test

To fulfill these staggering requirements, inertial guidance, which will probably continue as the mainstay of guidance in space, must also turn a corner in thinking and philosophy of design. The best bearings and flotation and air support for gimbals on earth will not be good enough in space.

Already work has started on air-supported rotors, electrostatically supported and electromagnetically supported rotors. These would spin in a vacuum and be completely free of bearing errors. These approaches to rotor support will compete with one another and with improved versions of the current flotation and air-supported gimbaled gyroscopes.

Minneapolis-Honeywell recently announced a model of an electrostatically supported beryllium sphere rotor as its entry toward this advance. Several other companies and universities are conducting work, both analytical and experimental, along similar lines. During the next few years, the electronics industry can look for announcements of designs like these—and even more radical ones, such as superconductivity and molecular gyroscopes.

Revolution in Accelerometers

In the field of accelerometers, a similar revolution is taking place. The feeling is that the drift-rate gyroscopic type of accelerometer has been pushed near to its limits. The desirability of digital outputs from accelerometers plus the pressing need for a new approach to greater accuracy has led to the study and development of such devices as a rotating mass accelerometer at Ford Instrument Co., a vibrating string accelerometer at Arma and a vibrating mass accelerometer at Bell Telephone Labs.

As in the case of the gyroscope itself, the future work in accelerometers for space application will involve the development of entire new operating principles for a device rather than an extension or refinement of old methods.

In computers, the trend coincides with the trends elsewhere—that is, toward replacing the

Design in The 60's

Guidance and Control Art Must Meet Space Needs

analog computer with the digital. Not only is the digital technique being considered for handling the converted output from analog sensing devices, but several developments are now in process to replace the mechanical analog of space, the gimbal, with a mathematical analog in a digital computer. The development of such gimbal-less gyroscopes has been announced both by Ford Instrument and Chance Vought Electronics.

Optical Guidance Favored

In the free fall of space flight, gravity is no longer available as a correction source for the inertial device. This makes some optical or active radiating type of sensor mandatory as a monitor.

Present thinking favors the optical approach, since it requires very little power and conditions are ideal for optics in space. Such a system would sight on distant fixed stars and some one or more planetary bodies in the solar system to solve the geometry of a planet-to-planet trajectory.

Some thinking divides the trip from earth to another planet into three phases: the near-earth phase, using more conventional types of radio guidance or present types of inertial-radio or inertial-celestial guidance; a mid-course guidance scheme that would call for an optical-inertial device, using the sun as the "down" reference in a heliocentric trajectory; and a final, or homing, phase that would probably rely on some active radar or infrared guidance.

It appears that a radar or radio assist during the launch phase will be necessary in the immediate future. The availability of highly accurate measurements and calculations in such a ground based auxiliary system gives it advantages not easily replaced in a self-contained system.

Component Changes Due

In the servo-control systems accompanying space or other guidance applications of the next ten years, environmental conditions and accuracy requirements will change sufficiently to bring about some dramatic changes in several components. According to Joseph Carlstein, chief engineer of the Ketay Dept., Norden Division of United Aircraft Corp.:

"By the end of the 1960's, rotating servo components, as we know them, will probably no longer be sufficiently sophisticated to satisfy the requirements of these systems. Basic research is now in progress to replace the analog electromagnetic principle with some superior principle for data transmission in the servo."

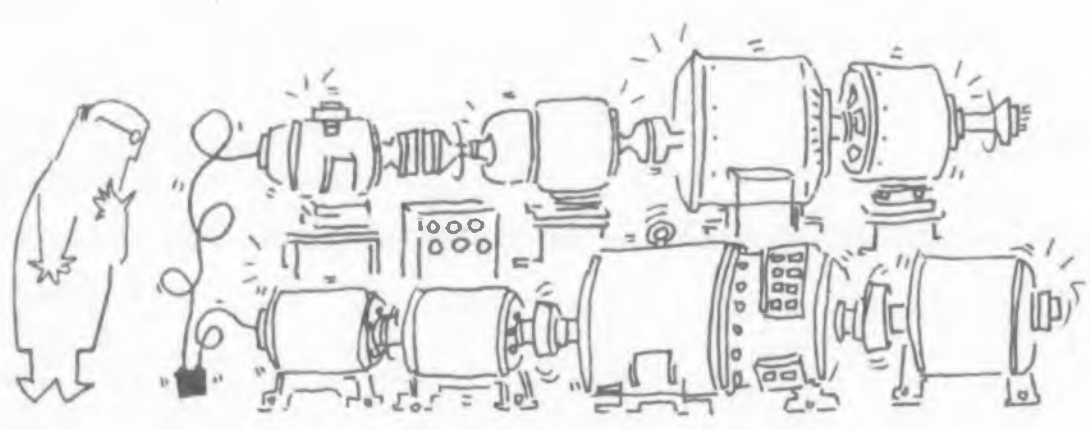
Back on earth, guidance will be going through considerable change as well. Inertial guidance will be in use for submarines and aircraft during the 1960's; already it is under development for both applications. Doppler systems promise to continue their gains in accuracy and reliability. The prospect of many supersonic and very-high-altitude aircraft in the coming decade and the resulting strain on radio ground-base navigation systems promises to spur the development of self-contained inertial or Doppler-inertial guidance schemes for both civilian and military aircraft.

Precision Units Sought

The immediate problems facing guidance-design engineers are on the component level. R. L. Bishop, head of advanced research and planning, Arma Division of American Bosch Corp., reports: "Today increased emphasis is being given to greater reliability as a prime requisite in missiles and to more accuracy in inertial instrumentation. A more versatile digital computer, with a greater degree of flexibility in programing and use, is needed and is under active development at Arma. Weight and size reductions are being carried out concurrently."

Speaking of trends in servo-control design, Mr. Carlstein says: "The development of control components will proceed along three lines: toward the very precise, toward the very small and toward surviving more tortuous environments. Every step in development will involve a compromise in these three." ■ ■

Power Supply Sizes And Costs to Shrink; New Sources Are on the Way



DURING the next decade power supplies can be expected to become smaller, cheaper, more reliable and lighter. Major efforts will be in the use of solid-state devices for power conversion, regulation and control.

In the military field, explained a spokesman for Leach Corp., "it can be expected that new forms of energy conversion for the generation and application of electric power will come out of the laboratories and become operational." He added:

"Such techniques as fuel cells, solar cells with improved efficiency, nuclear-energy power converters, thermal power converters, and perhaps still other devices not yet announced will form the majority of power conversion devices."

In the industrial area the next decade will probably see the silicon diode, with magnetic amplifier control, and the silicon-controlled rectifier become primary conversion units, the spokesman said. No one expects the vacuum tube to be entirely eliminated. Power sources with tubes designed into the circuits will still be specified and procured.

Static Power Rise Seen

Another prediction, from Microwave Associates, Inc., is that static power supplies should be available in the next 10 years with ratings up to 75—or even 100—kva.

Progress in power supplies during 1960 seems dependent on what component manufacturers accomplish. A representative of Mid-Eastern said that if power transistors could be raised from their present 105-volt limit to say 150 or 200 volts, designers could eliminate regulators and expensive electrolytic capacitors. In place of capacitors they could use transistorized hum filters. Then, too, if the price of silicon transistors can be reduced, higher temperature operation can be achieved at little increase in cost.

This year practical experience will be gained with the micromodular and molecular electronic approaches to miniaturization of components and functioning circuits, the Leach spokesman said. He added that much effort would be spent in determining the average failure rates for today's electronic components. With this data, reliability calculations for complete weapons systems can be made more realistically. Then new efforts can be made to improve the performance of weak components in the system's reliability chain.

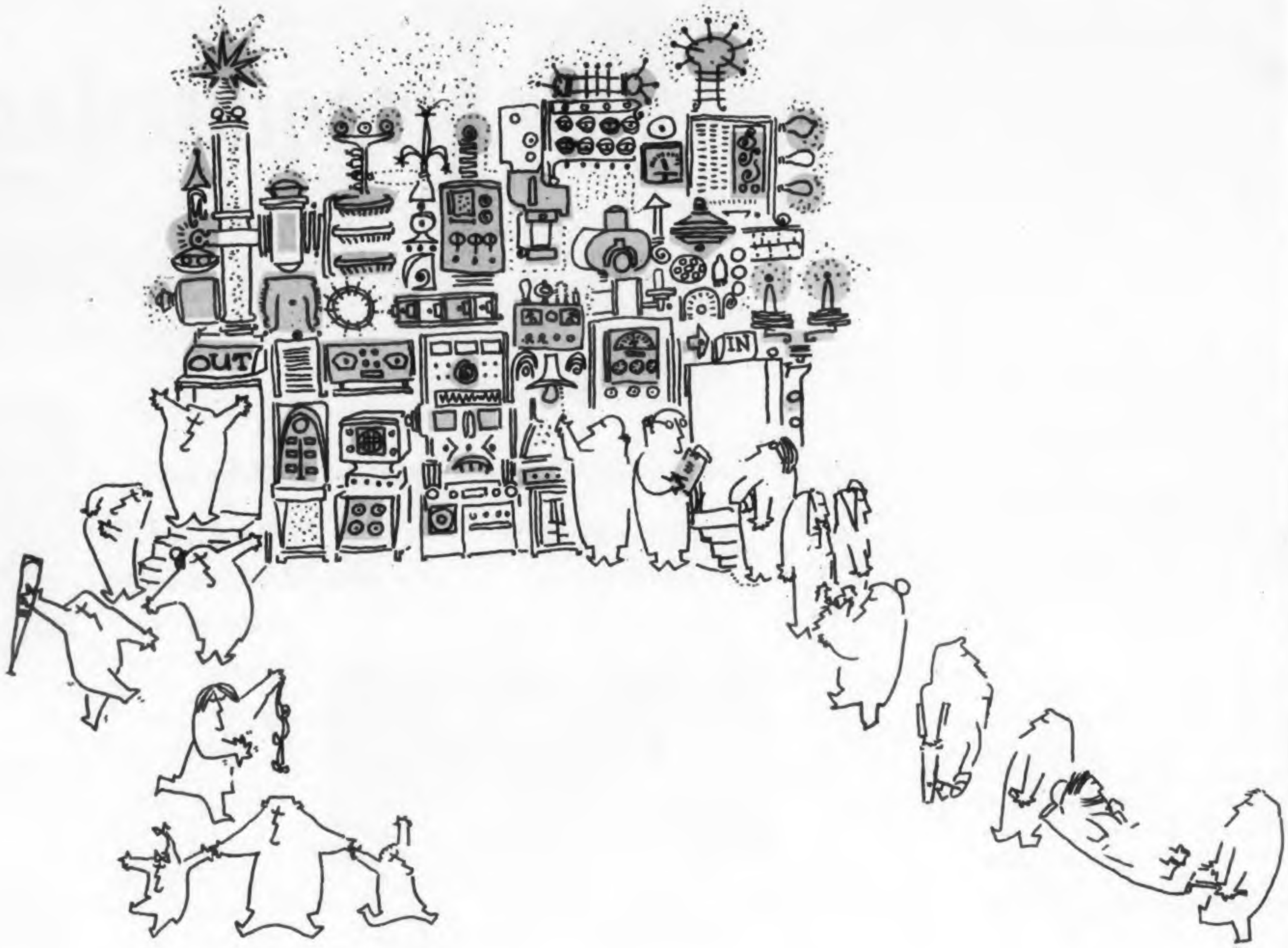
Smaller Batteries Expected

The next ten years will bring "further decreases in battery size and weight—in terms of energy, complete self-sufficiency, complete freedom from maintenance and highly extended life," a representative of Yardney Electric Corp. said.

"We see John Doe in 1969 adopting as part of his everyday language the names of battery systems that in 1950 he never heard of and in 1960 only saw mentioned in isolated technical articles," the representative said.

This year, it is predicted, more storage batteries will be used in conjunctions with energy converters, both thermal and solar types. These battery-converter combinations will be used in both solar radios and satellites. The Yardney representative said that this particular development was leading the way to a self-sufficient and regenerative power system that would provide what might well be called perpetual power. ■ ■

(Medical on next page)



Medical Electronics: Automation Prescribed For Hospital and Patient

AUTOMATION will figure heavily in medical electronic advances of the next decade. Those working in the field—most of whom prefer to remain anonymous—predict that medical electronic equipment will be developed to:

Automate hospitals.

Automate diagnosis.

Automate the writing of prescriptions.

Reduce medical expenses.

Also predicted—by Birtcher Corp. which deals in medical electronics—is a trend toward making electronic instruments portable.

Disease Detector Forecast

David Sarnoff, chairman of the board of Radio Corp. of America, sees the day when an electronic device can be used by people in their homes to detect diseases in their earliest stages. He also forecasts miniature electronic devices that would replace defective human organs.

A semielectronic hospital, though it may sound like something yet to come, is possible today. A 100-bed hospital could be equipped with sensors and associated equipment for $20,000 to $30,000, said a spokesman for Gulton Industries, Inc. The sensors would be attached to each patient and transmit vital data to some central piece of equipment. Thus each patient would be continually monitored.

The spokesman also said that hospitals would be equipped with devices that would give "less data and more information."

Monitoring Instruments Predicted

Also envisioned by Gulton are small instruments—the size of a hearing aid—that a person could use to keep his physician informed of his condition. They would be used only in serious cases. The instruments would transmit over radio

channels heartbeats, for example, and notify the doctor when an unusual condition was developing.

Industry spokesmen see two great needs today:

(1) Educational courses in medical engineering. These would help physicians and engineers understand each other's problems.

(2) Selling physicians on the value of medical electronics.

Though there is some disagreement on the degree of resentment, physicians feel electronics is encroaching on their prerogatives the industry believes. Some doctors, it is said, think electronic equipment might make them unnecessary. Not so, say those working in the field: the industry is only providing more accurate tools for the physician and is not interested in pre-empting his traditional duties and responsibilities. ■ ■

(Systems on next page)

Design In The 60's

Systems Engineering

SYSTEMS engineering in the 1960's will be called on to bridge the gap between national policy makers and component designers.

The last decade saw the birth of the weapon system concept. While single systems, such as SAGE, Atlas and Polaris, have grown to nation-wide proportions, components have shrunk to near-microscopic size. If the gulf is to be bridged, the area of responsibility of systems engineering must be extended at each end.

Some costly lessons in developmental planning were learned in the late 1950's. Programs that were engineering successes were aborted as functional failures. Increasing international scientific competition in the 1960's will force government and industry to face the fact that technology is one continuous effort, that this effort must be coordinated toward a single purpose in order to be effective.

Speaking of the national space program, Dr. William H. Pickering, director of the Government's Jet Propulsion Lab, said he thought there was a lack of broad governmental understanding of objectives.

Public Education Urged

"The question of the relative priority of military and civilian programs is not clear," he said, "and indeed inter-service and inter-agency rivalry for scarce funds, facilities and manpower is certainly occurring.

"As professional engineers and scientists, it appears to me that our task is to

To Be Asked to Span Policy-Component Gap

educate the public and Congress to the realities and the needs of a national space program—not only to the technical realities of space but also the realities of the time and money required to accomplish results."

Necessity will force such education in the coming decade. There will also be more communication between Government leaders, who must decide what must be done, and technical leaders, who must help them decide how it is to be accomplished.

The need was understood by Dr. John R. Dunning, dean of the faculty of engineering, Columbia University, who pointed out that the U.S. Senate, House of Representatives and Executive Branch were almost all made up of career politicians with legal background. In contrast, Dr. Dunning noted, half the members of the Soviet ruling body, the Presidium, are scientists and engineers.

Super Computers Expected

The techniques of operations research will probably be mechanized by super computers of the 1960's, in some sort of super SAGE system.

The decisions to be made will encompass a broader scope than ever. Not only must the nation decide the optimum weapon system but basically how best to employ technology to implement national aims. Decisions proportioning funds between strategic vs. tactical weapons, defensive vs. offensive weapons, will be replaced by military vs. scientific technical programs, conquest of space vs. the winning of men's minds on earth. This is indeed to be a decade of fundamentals.

At the other end of the span, the system engineer must look more realistically at the plight of the component and material designer. M. A. Lowy, chief systems engineer of Data-Control Systems, Inc., recalled that two years ago a telemetry system was financed and built, but it could not fulfill its intended objective. This was simple because no source tube of sufficient power was available.

State of Art Work Supported

Archibald Surlock of Atlantic Research Corp. sees a pressing need for recognizing "state of art" programs, similar to the inertial navigation development program of Dr. Charles S. Draper of the Massachusetts Institute of Technology. Such programs are as necessary to the success of the system engineer as are the specific vehicle development programs.

Building systems to implement objectives is impossible unless the basic building blocks have been developed in time. When it was decided to develop a revolutionary, integrated cockpit presentation for the Army-Navy Instrumentation program, it was found necessary first to develop a transparent flat-plate presentation screen, micro-miniature electronic components and other basic elements.

Such planned development and the anticipation of component needs will be more and more the concern of the system engineer in the 1960's. ■ ■

Some Basic Rules

Handling Nodes And Loops

Interpretations And Examples

Visual Engineering Mathematics

A Self-Contained Course

T. R. Nisbet and W. W. Happ
Lockheed Missile System Div.
Palo Alto, Calif.

This is the third of four parts on flow graph analysis, a visual form of engineering mathematics. Two-port networks and the topology equation are described and illustrated here. Reference is made to material which appeared in the December 9th issue of *ELECTRONIC DESIGN*.

A FLOW GRAPH can have more than one pair of dependent and independent variables; the two-port network is a good example of the kind of technique used.

A schematic representation of a two-port network described by its h-parameters is shown in Fig. 1. The equivalent circuit of a transistor is shown in Fig. 2. It corresponds to the two-port network of Fig. 1.

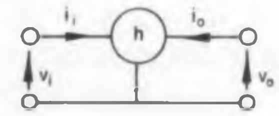


Fig. I

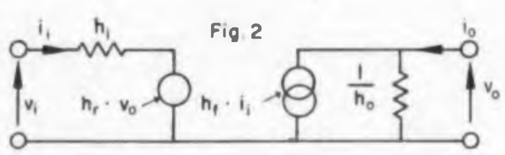


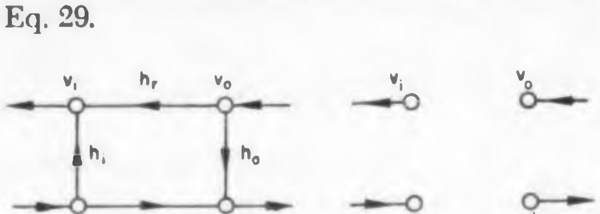
Fig 2

The equations which describe Fig. 2 are:

$$v_i = i_i\, h_i + v_o\, h_r \tag{27}$$

$$i_o = i_i\, h_f + v_o\, h_o \tag{28}$$

To construct a flow graph from this system of equations, begin by drawing in the input nodes and the output nodes, with arrows to indicate the dependent and independent variables. The result is shown on the left of Eq. 29. Into this pattern of nodes, the equations of the system (27 and 28) are fitted, resulting in the complete flow graph, Eq. 29.



(29)

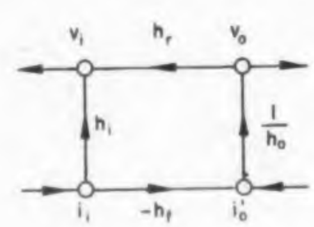
There are a number of points to be noted about this flow graph, in addition to the fact that it expresses Eq. 27 and 28. To describe the transmittance h_i, for example, the unused independent variable of the system, v_o, must be made zero. Similarly, to describe h_r, the only available independent variable that can be made 0 is i_i, so that

$$h_r = \left.\frac{v_i}{v_o}\right|_{i_i = 0} \tag{30}$$

The flow graph therefore offers a ready reference for the definition of the h-parameters which are used.

From this example, too, can be seen the general concept of "flow." No signal, in the conventional sense of the word, flows between i_i and v_i. But when we use the h-parameters we are by definition thinking of the input in terms of current. The input voltage is, as it were, an incidental by-product of the fact that there is an input current. The "signal flow" thus becomes a flow of information, or influence, which makes v_i behave in accordance with the conditions set by i_i.

To know the input impedance with the output current instead of the output voltage held constant, the flow graph 29 must be manipulated so that it conforms with this requirement; the output current must be an independent variable. By inverting the output path, we have



(31)

Note the change of sign which has occurred at the contributive node. The change in value from i_o to i_o' merely shows that a different value of current is involved; it is still the output current of the system. Using the addition formula (Table 1) for the two paths (h_i) and ($-h_f$, $1/h_o$, h_r), we can write the required relationship, thus:

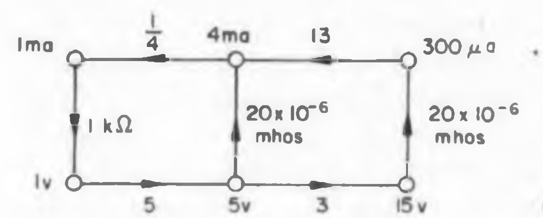
$$\left.\frac{v_i}{i_i}\right|_{i_o = 0} = h_i - \frac{h_f \cdot h_r}{h_o} \tag{32}$$

This will be recognized as the expression for z_i in terms of the h-parameters—an elegant solution by comparison with its counterpart using matrices.

The Topology Equation

Though the fundamental meaning of the topology equation is simple, its implications are profound. From it stem the remaining rules, which enable us to make adjustments to a flow graph when it is being constructed, or to evaluate any nodes or transmittances from a completed flow graph.

The topology equation itself can be applied only to a closed flow graph: Eq. 2 is an example, and it will be recalled that the product of the transmittances around the loop was unity. If the system included two loops, the sum of the loop transmittances would again be unity; e.g.,



(33)

Loop 1: $1\ \mathrm{K} \times 5 \times 20 \times 10^{-6}\ \mathrm{mhos} \times \frac{1}{4} = \frac{1}{40}$

Loop 2: $1\ \mathrm{K} \times 5 \times 3 \times 20 \times 10^{-6}\ \mathrm{mhos} \times 13 \times \frac{1}{4} = \frac{39}{40}$

Topology Equation: Loop 1 + Loop 2 $= \frac{1}{40} + \frac{39}{40} = 1$

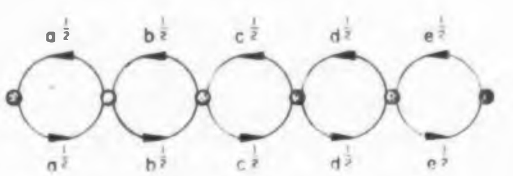
It is an interesting exercise to invert one of the loops of Eq. 33. The other loop then changes shape, and a negative sign is introduced, but the sum of the loops remains 1.

It is convenient to refer to this "1" as a loop transmittance to the power zero, so that a path with no loops becomes a "zero-order loop." A first-order loop, defined below, is given a negative sign; a second-order loop, a positive sign; a third-order, negative; and so on. A first-order loop is what has hitherto been described merely as a "loop." It consists of a consecutive path of arrows leading from a node and returning to the same node. A second-order loop is the product of two loops which do not touch each other, and a third-order loop is the product of three loops which do not touch each other. (See example, Eq. 35.)

The topology equation therefore takes the general form that the sum of the loops in a closed flow graph is always zero, i.e.,

$$\Sigma \text{ loops} = 1 - \Sigma L_1 + \Sigma L_2 - \Sigma L_3 + \Sigma L_4 \ldots . = 0 \quad (34)$$

where the subscripts denote the order of the loops.



(35)

In the above example of a closed flow graph, Eq. 35, there are a number of first-, second-, and third-order loops, and the topology equation is:

$$1 - [a+b+c+d+e] + [ac+ad+ae+bd+be+ce] - [a \cdot c \cdot e] = 0 \quad (36)$$

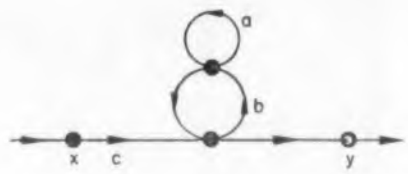
It was mentioned earlier that an open flow graph can be closed by a fictitious transmittance $1/T$, and the resultant topology equation solved for T, giving the transmittance of the open flow graph. However, in the majority of problems the flow graph need not be closed, for the topology equation itself can be adapted to yield a rule for evaluating the ratio of any two nodes in an open flow graph, i.e., the overall transmittance from one independent variable to one dependent variable, assuming that any other independent variables in the system are held constant.

The formula and the rules for this operation are: In an open flow graph, the overall transmittance between any two nodes, one of which is a dependent and the other an independent variable, is:

$$T = \frac{\Sigma\,[\text{path} \times \Sigma \text{ nontouching loops}]}{\Sigma \text{ loops}}$$

Rules. Write down the product of the transmittances along each path from the independent to the dependent variable. Modify each path by multiplying its transmittance by the sum of the loops which it does not touch (remembering to begin with a zero-order loop). Add the modified path transmittances together and divide the result by the sum of all the loops in the open flow graph.

Example.



Path $x \rightarrow y$, transmittance $= c$

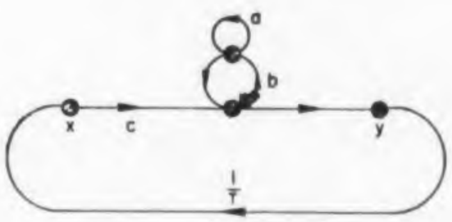
Modify by Σ nontouching loops $(1-a)$

There is only one path in this case, so Σ (path $\times \Sigma$ nontouching loops) $= c(1-a)$

Σ loops $= 1 - a - b$

Overall transmittance $x \rightarrow y = T - y/x = \dfrac{c(1-a)}{1-a-b}$

The same result can be obtained by closing the flow graph by a fictitious transmittance of $1/T$ and using the topology equation, thus:



Topology equation: Σ loops $= 0$

Zero-order loop $= 1$

First-order loops: *(i)* a; *(ii)* b, *(iii)* c/T

Second-order loop: *(a)* $\left(\dfrac{c}{T}\right)$

$$\therefore 1 - a - b - \frac{c}{T} + \frac{ac}{T} = 0$$

which reduces to $T = \dfrac{c(1-a)}{1-a-b}$

Part four of this series will follow. ■ ■

"Hairpin" Triggers High Speed Shutter

A CLEVER, high speed electromechanical shutter has been developed which is triggered through an electromagnetic field set up by a high current surge. Designed by Paul A. Kendall, an electronic scientist at the U. S. Naval Ordnance Laboratory, Washington, D. C., the shutter can be easily adapted for a range of shutter open times from 20 to 500 microseconds.

Mr. Kendall's requirement was for a shutter which would be triggered, by a sub-millisecond transient, to open and close a slit 0.001 in. by 0.3 in. Also, the nature of his equipment required that the shutter operate wholly in an air medium.

The electro-optical shutters such as the Kerr cell, image converter tube, and those using the Faraday effect, although capable of high speed synchronization, were unacceptable because they do not employ an air medium. A mechanical shutter would not respond fast enough to be triggered by the rapid transient.

High Current Surge Actuates "Hairpin"

In attempting the design of the shutter, a cross between the electrical and mechanical seemed a good approach, since electrical energy is capable of high speed control and the mechanical design offers total energy transmission and complete gating action. Thus, an electromagnetic field set up by a high current surge through a conductor was mechanically harnessed to produce a controlled high speed shutter action, Fig. 1. By bending part of a single copper wire into a "hairpin" configuration, the electromagnetic fields set up along the parallel segments of the

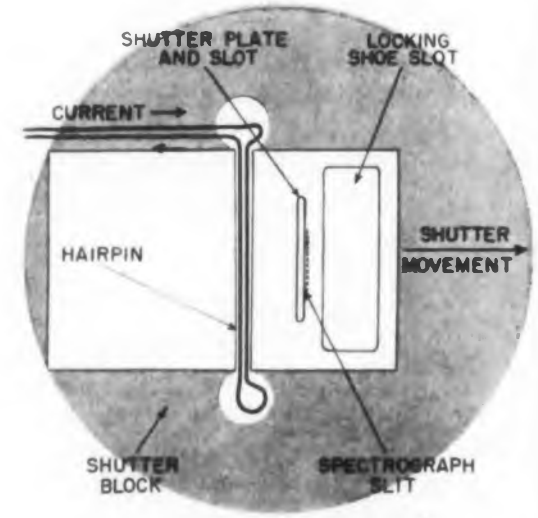


Fig. 1. A high current surge produces an electromagnetic field which causes the hairpin to spring open, pushing the shutter plate, and exposing the shutter slot.

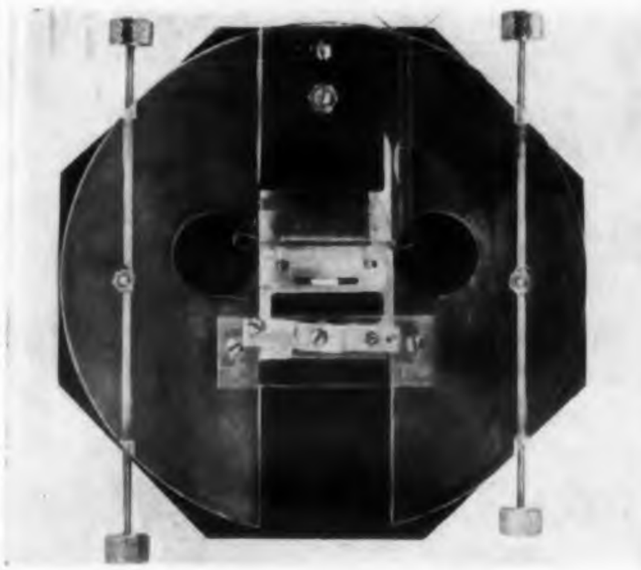


Fig. 2. Photograph shows the physical construction of the high speed shutter.

"hairpin" will oppose each other. The wire was ordinary No. 22 insulated type which had been flattened to improve the operation of the shutter. A high voltage discharge circuit supplies the current surge.

This new circuit consists of a special low inductance energy storage capacitor, an ignitron for switching the energy from the capacitor to the "hairpin," and a medium power thyratron. By varying the maximum voltage on the storage capacitor, the lengths of shutter open times can be controlled.

Shutter Operation

During the high current surge, the "hairpin" is rapidly thrust apart by the opposing electromagnetic fields. The part of the "hairpin" in contact with the back stop remains stationary while its opposite parallel segment in contact with the shutter plate moves only a short distance.

The movement of the wire is limited due to its spring action and the force exerted on it by the seating block. The shutter plate after receiving the impulse from the hairpin is a free body except for the friction between it and the shutter block. Upon completion of the gating operation, the shutter plate, because of its light-weight construction, is gently decelerated by the locking shoe. The shutter is then locked in place with the shoe in the locking shoe slot. The force on the shutter plate is proportional to the current squared. For example, in Mr. Kendall's set-up, the maximum force on the shutter plate and maximum current through the "hairpin" (for 170 microseconds open time) were about 2000 pounds and 15,000 amp, respectively. ■ ■

Density Switch Monitors Gas-Vapor Leaks

Used in High-Density Electronic Packages

LIQUID-GAS coolants for high-density electronic packages can now be positively monitored for leakage by a new gas density switch. This unit can sense the density of the atmosphere inside the electronic unit even though the pressure varies nonlinearly with temperature.

Manufactured by Newark Controls Co., 15 Ward St., Bloomfield, N. J., the type SN-98, Fig. 1, uses a gas-plus-liquid reference. This reference density is sealed within an internal bellows, and reacts to temperature changes in the same way as the gas and liquid coolant. The exterior of the bellows is exposed to the gas-vapor environment in the electronic package.

The switch operates on the differential of pressure between the trapped reference density and the cooling medium. In this way, the pressure effect of temperature variations is cancelled. Hence, the switch will react only to an actual leak in the electronic package.

The gas-plus-vapor density switch is an important protective monitor for use with fluorochemically-cooled high-density units, which have recently been the subject of considerable interest. A session of the National Aeronautical Electronics Conference (May 4-6, 1959, Dayton, Ohio), devoted to thermal design methods, described fluorochemical liquid-gas cooling of high-density electronic units.

The pressure-temperature curve of SN-98 type switches can be tailored to match the characteristics of whatever liquid-gas coolant is used in the unit. A typical curve is shown in Fig. 2. Previous density switches have been able to match only the straight-line characteristics of pure gas coolants.

These switches are designed to actuate

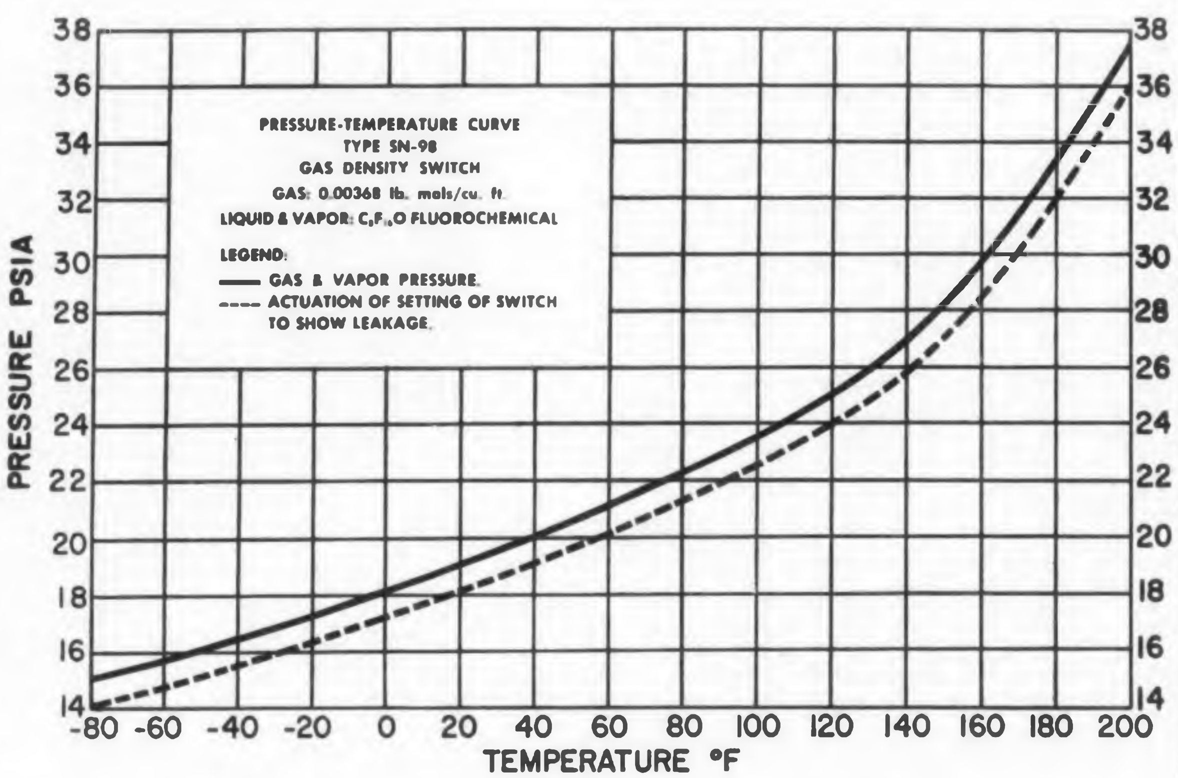


Fig. 2. Pressure-temperature curve of the switch can be tailored to match the nonlinear characteristic of the liquid-gas coolants.

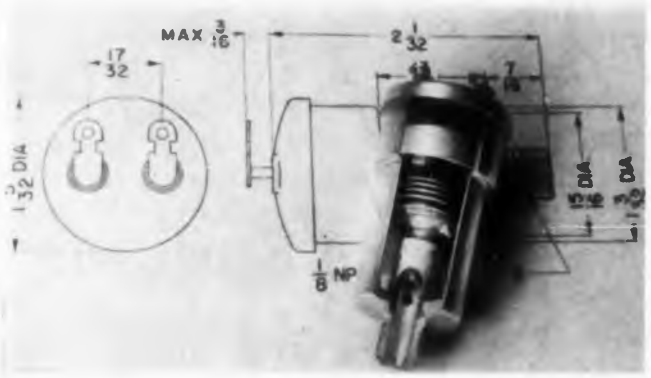


Fig. 1. Sample of gas or gas-vapor inside bellows cancels temperature effect on pressure of monitored coolant.

on a characteristic pressure-temperature line or to actuate a specified number of psi above or below this line. The latter is used when the switch must anticipate critical conditions, or when the switch must actuate only after some definite drop in normal system pressure.

Gas density switches can now be used in the following situations where the gases and vapor follow a characteristic pressure-temperature line:

1) When gases alone are present
2) When gases are soluble in liquids
3) When liquids are miscible
4) When the gas law is subject to deviations
5) When there is association or dissociation of molecules due to arcing
6) When the vapors become supersaturated

The SN-98 can operate on a differential pressure between the actuate and deactuate points of 1 to 3 $\pm 1/2$ psi. The gas density switch has a 45 psi proof pressure above system pressure and performs with an accuracy of ± 1.0 psi over a temperature range of -85 to $+200$ F.

Miniature in size, these switches measure 2-1/32 in. in length and have a diameter of 1-5/32 in. Because of its compactness, the SN-98 can be easily installed in the usually small gaseous-vapor portion of the system. In addition, the switch meets the exacting operating environmental specifications which include MIL-E-5272, ± 20g shock, and 55-1000 cps at 10g. Employing a snap-action switch, the unit has glass-to-metal hermetically sealed electrical terminals and is available as spst or spdt. The units are rated at 28 vdc, 110 vac, and 5 ampere noninductive.

For further information on this gas density switch, turn to the Reader-Service Card and circle **101**.

Increase Sensitivity Ten-Fold With New Image Orthicon

SURPASSING the 350-line broadcast resolution standard, a new image orthicon can operate with one-tenth the illumination needed by present commercial camera tubes. To make the new device even more impressive, probable tube life has been increased through the elimination of many of the reasons for the tube failure.

Manufactured by General Electric Power Tube Dept. in Schenectady, N. Y., the GL-7629 is also being considered in several military surveillance and optical tracking systems.

Sensitivity, Depth of Focus Improved

The new tube can produce pictures of usable black-and-white quality at one foot-candle of scene illumination or less, compared to the ten foot-candles required by standard image orthicons at the same camera lens setting. Color broadcasts can be achieved with 40 foot-candles instead of the 400 now required. Removal of the extremely high lighting requirements for color will make possible colorcasts from sports arenas, auditoriums and light-equipped ballparks without the addition of special lighting.

Increased sensitivity is apparent in this comparison of results using standard 58201.0 (left) and new GL-7629 (right).

Conversely, normal or near-normal light levels can be taken advantage of to increase depth of focus. This is achieved by stopping down the lens aperture in the usual way.

Electron Conduction Yields Long Life

The new G-E target uses electron conduction rather than ion conduction employed in conventional image orthicons. Electron conduction is a reversible process, and the life of such a tube is not limited by the exhaustion of charged carriers. Because of this, the problems of "stickiness" (image of a previous scene smeared over a new one) and "burn-in" (permanent damage caused by overbright stationary high lights) are virtually eliminated.

Early models have been operated for several thousand hours, with no burn-outs at this writing. Until a sufficient number of test hours have elapsed, no firm estimate of tube life can be made. Because the main cause of failure has been corrected, probable life promises to be substantially increased.

Resolution Improved

The extreme thinness of the new target inhibits sideways leakage, thus giving the GL-7629 from 25 to 50 per cent more resolution than present tubes under normal studio lighting.

An equivalent resolution of 1300 lines has actually been achieved under test. While network transmission, with a bandwidth of 325-350 lines, cannot take advantage of this extra resolution, special-purpose camera designs for military and industrial applications can benefit directly.

For further information on the GL-7629 image orthicon, turn to the Reader-Service card and circle **100**.

NEW PRODUCTS

Covering all new products that might generally be specified by an electronics engineer engaged in the design of original equipment.

Price And Availability

PRICE AND AVAILABILITY data is now being added, whenever possible, to the New Product descriptions that appear in *ELECTRONIC DESIGN*. This data will help you to:

—Evaluate the products more intelligently.

—Decide which products to buy now and which to wait for.

—Schedule your orders wisely.

—Get an insight into prices and savings for similar products.

Most manufacturers have been very cooperative in providing us with *Price and Availability* data. Since some of the data arrived after our deadlines, it was impossible to add it to all of the products. The data represents the latest information at the time of publication.

Gold Plated Connectors Designed For Micromodules 468

This line of gold plated connectors is designed for micromodules and other miniaturized circuitry. The insertion force is less than 0.5 lb and the withdrawal force is less than 0.25 lb per contact. Connecting devices in the line include: module header, module receptacle, straight through connector, and right angle connector. Contact resistance is less than 0.005 ohms per contact. Designed for 0.05 in. printed circuit grid, the line conforms to SCL-6250.

Molded Insulation Co., Dept. ED, 335 East Price St., Philadelphia 44, Pa.

***Price & Availability:** Price range for 7 to 23 contacts is $2.50 to $8.50. Delivery is 60 days after order is received.*

Frequency Standard Uses Solid State Temperature Control 471

The model F frequency standard has a solid state temperature-regulating device and is designed for missile and airborne use. It has five outputs, single and three-phase. The unit is accurate to $\pm 0.001\%$ with phase accuracy of 1 deg in missile environment. Dip potted, the standard weighs 11 oz and is contained in a 5 x 3 x 1 package. Printed circuitry and silicon transistors are used throughout and output frequencies are: 9.6 kc square wave, single phase; 4.8 kc square wave, single phase; and 400 cps square wave, three phase. It stands 15 g shock (three blows each in 3 planes), and 15 g vibration from 30 to 2000 cps.

Designers for Industry, Inc., Dept. ED, 4241 Fulton Parkway, Cleveland 9, Ohio.

***Price & Availability:** Price is $1950 per unit for 1 to 9 units, $1600 for 10 to 49 units, and $1400 for 50 to 99 units. Sample quantities available and it can be delivered 120 days after order received.*

Slip Ring And Brush Assembly Measures 0.982 x 0.624 in. 469

This capsule slip ring and brush assembly is 0.982 in. in length and has an outside diameter of 0.624 in. The drive flange is 0.75 in. in diameter. The assembly has 56 isolated circuits and the rotor is bearing-mounted at both ends. Leakage resistance is more than 20,000 meg at 500 v dc between all circuits and between each circuit and ground. Current ratings are 0.5 amp on 12 circuits and 0.25 amp on the other 44 circuits. Lead wires are No. 28 and 30 AWG. Torque required is 65 gm-cm for reliability at 25 g between 0 and 2000 cps.

Electro-Miniatures Corp., Dept. ED, 600 Huyler St., South Hackensack, N.J.

Price & Availability: *Prices vary according to design needs. Prompt deliveries available.*

Rectifier Bridge Assembly Rated at 155 v rms max 470

This selenium rectifier bridge assembly is designed to operate off line voltage and rated at 155 v rms max at 90 ma dc. The rectifier combines four selenium elements in a package measuring 13/16 x 7/8 x 15/32 in. A twist-on locating or mounting lug, part of the integral assembly, is used for solid and simple mounting.

Radio Receptor Co., Inc., Selenium Div., Dept. ED, 240 Wythe Ave., Brooklyn, N.Y.

Price & Availability: *Prices range from 63 cents per unit for 1000 units and over to $1.40 each in sample lots. It is available from stock.*

Footswitch 441

Comes in five different ratings

Model Y 15A footswitch comes in five different standard switch ratings. Cord-sets and special paint are available for individual requirements. The footswitch has a cast iron housing in black wrinkle finish measures 4-3/4 x 2-3/4 x 7/8 in. and weighs 1 lb.

Vemaline Manufacturing Co., Dept. ED, 388 N. 11th St., Prospect Park, N.J.

***Price & Availability:** Price range is $7.85 to $8.15. Delivery is within 10 days.*

Anemometer System 447

Two-channel type

This two-channel hot wire anemometer system measures the intensity and scale of longitudinal and transverse turbulence components for airstream turbulence analysis. The system includes a hot wire anemometer, a sum and difference control unit and a random signal meter, all packaged in a single cabinet. Each of the two wires has a separate constant current supply and controls plus separate dc bridge circuits. The compensated amplifier covers from 2 to 100 kc and has a noise signal of 0.25 μv. The unit has square wave calibration, cross correlation circuits, and true rms readout with long averaging time and high peak factor. It weighs about 100 lb and measures 23 x 21 x 16 in.

Flow Corp., Dept. ED, 85 Mystic St., Arlington, Mass.

***Price & Availability:** Price is $3970. Delivery is 30 days after order is received.*

Soldering Gun 440

Has prefocused spotlight

Model 8100B soldering gun is a single heat gun rated at 100 w and equipped with a prefocused spotlight. The tip utilizes copper for heat transfer and iron plating for strength and durability.

Weller Electric Corp., Dept. ED, 601 Stone's Crossing Road, Easton, Pa.

Price & Availability: *Units will be available from stock after January 15th. List price is $6.44.*

Decade Selector Tube 439

Counting speed is 1 mc

Type ET-51/6700 thermionic decade selector tube has a counting speed of 1 mc. It consists of a thermionic cathode and 30 other electrodes which are divided into 10 groups. Each group is made up of a target electrode, a spade electrode, and a grid electrode. The target and spade electrodes are brought out individually to the tube base. Alternate grid electrodes are connected to form a set of odd number grids and a set of even number grids. The heater is rated at 6.3 v at 300 ma.

International Electronics Corp., Dept. ED, 81 Spring St., New York 12, N.Y.

Price & Availability: *For up to 50 tubes, the price is $44.20 ea; for more than 50, the price is $31 ea. Delivery time is 8 weeks.*

Magnetic Amplifier 432

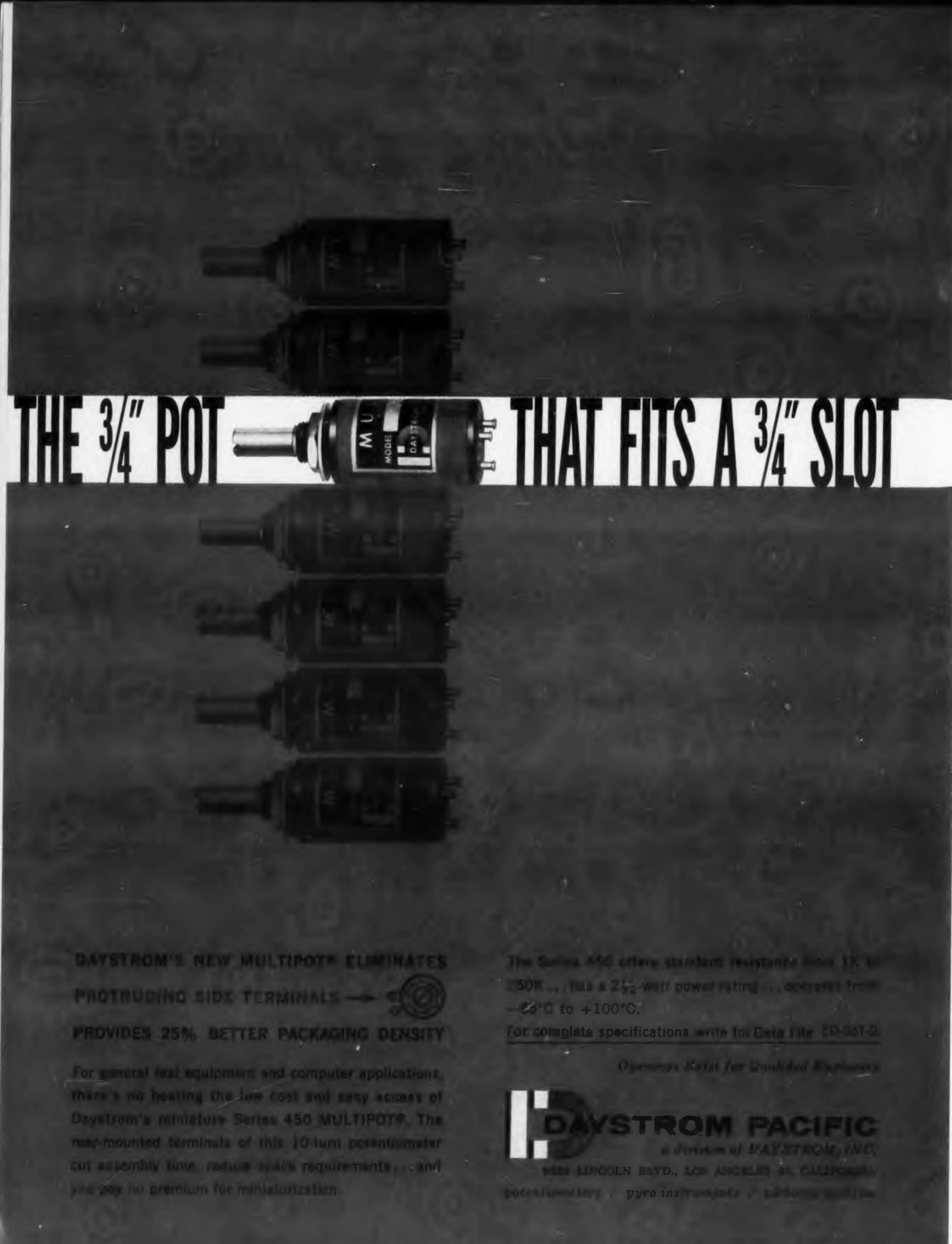
Provides gate signal to SCR's

Type MA 1 magnetic amplifier provides the necessary phase angle firing control for the GE C35, or equivalent silicon controlled rectifier. Designed for 120 v, 50 to 400 cps, the amplifier supplies gate signal to SCR's to give full-wave ac or dc output. The unit is hermetically sealed, has a solder turret, and measures 3 x 2-1/2 x 3 in.

Magnetico, Inc., Dept. ED, 6 Richter Court, E. Northport, L.I., N.Y.

Price & Availability: *Available in stock. Prices on request.*

CIRCLE 48 ON READER-SERVICE CARD ➤



NEW PRODUCTS

Differential Amplifier 431

Has power gain of 250,000

Model AR 108 amplifier has a power gain of 250,000 and a total volume of 3 cu in. It is a direct-coupled unit with silicon transistors used throughout. At maximum sensitivity, an input of 5 mv will provide a constant current output of 0.5 ma into a load of 0 to 5000 ohms. With a load of 100,000 ohms, maximum output is 5 v. Differential input impedance is 5000 ohms and frequency response is flat from dc to 5 kc.

Leach Corp., Dept. ED, Compton, Calif.

Price & Availability: *Unit is immediately available. Price is $450.*

Profile Monitor 443

Handles up to 90 inputs

Model 201 profile monitor provides a visual display of pressure, strain, velocity, or any phenomena measurable electrically. Having accommodations for up to 90 inputs, it can display one of these phenomena or any combination having comparable electrical outputs. The accuracy is ±2% of full scale, the resolution is 40 lines per in., and the maximum scanning rate is 3000 cps. The sensitivity is from between 0 and 10 mv, peak-to-peak, full scale, to between 0 and 150 v, peak-to-peak, full scale.

Advanced Technology Labs, Div. of American-Standard, Dept. ED, 369 Whisman Road, Mountain View, Calif.

Price & Availability: *Price is $2895 fob Mountain View, Calif. Delivery time is 60 days.*

◄ CIRCLE 49 ON READER-SERVICE CARD

Silicon Mesa Transistors 444

Have output of 500 mw at 70 mc

Types 2N715 and 2N716 silicon mesa transistors have an output of 500 mw at 70 mc and will deliver 50 mw at 200 mc. They have a beta spread of 10 to 50 and a collector reverse voltage of 50, for the 2N715, and 70, for the 2N716. Collector reverse current at 25 C is 1 μa max and 100 μa max at 150 C. The temperature limits are −65 and +175 C.

Texas Instruments, Inc., Semiconductor-Components Div., Dept. ED, P.O. Box 312, Dallas, Texas.

Price & Availability: *Type 2N715 is priced at $48.70 ea in quantities of 1 to 99, and $32.50 ea in quantities of 100 to 999. Type 2N716 is priced at $63.75 ea in quantities of 1 to 99, and $42.25 ea in quantities of 100 to 999. They are immediately available through the sales office and distributors.*

Pressure Gage 438

Range is 0 to 0.01 in. of water

This pressure gage has a range of 0 to 0.01 in. of water and is able to detect pressure differences as small as 0.0001 in. Other models have a full scale range from 0 to 0.03, 0.1, 1, 3, 10, 20, 50, and 100 in. of water. Made to operate on 115 v ac at 60 cps, these instruments use a noble metal thermopile installed in a flow tube as the sensing device. The flow tubes can be installed directly in a line for use as draft gages or for controlling differential pressure, or they can be installed to operate as a remote electrical flow meter. The sensitivity is increased in the lower part of the range.

Hastings-Raydist, Inc., Dept. ED, Hampton, Va.

Price & Availability: *Price is $250. Delivery is about two weeks after receipt of order.*

CIRCLE 50 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Vacuum Relay 458

Rated at 4 kv, 60 cps and 2.5 kv at 16 mc

Contact vacuum relay model RB7B measures 1-9/16 in. over-all and has a rated operating voltage of 4 kv at 60 cps and 2.5 kv at 16 mc. The dpdt relay has a continuous current rating of 6 amp at 60 cps and 3 amp at 16 mc. Sealed rocker contacts provide heavy contact pressure and resistance to vibration and shock. Contact resistance remains low due to the absence of contact contamination.

Jennings Radio Manufacturing Corp., Dept. ED, Box 1278, San Jose, Calif.

Price & Availability: *Units available 4 to 6 weeks after order received. Price $130 each for 1 to 9 units.*

Power Transformer 460

Power to weight ratio is 140 w per lb

Operating over a temperature range of —55 to +130 C, series 883 power transformer weighs 2.3 lb and provides a power-to-weight ratio of 140 w per lb. It occupies a chassis mounting space of 1-9/16 x 3 in. and is 3-5/16 in. high. A primary voltage of 115 v, 400 cps is standard, with secondary voltages available from 5 to 2000 v. It conforms to MIL-T-27A.

Arnold Magnetics Corp., Dept. ED, 4613 W. Jefferson Blvd., Los Angeles, Calif.

Price & Availability: *Delivery 3 weeks after reception of order. Price varies according to user specifications.*

Revolution Counter 464

Counts shaft revolutions up to 1000 rpm

Requiring 1-1/4 oz in. torque for electrical control of a machine or system operation, series 307 revolution counter counts shaft revolutions up to 1000 rpm. The unit is available for ac or dc operation, with 11 dial ranges from 0-12 to 240,000 revolutions, and in various circuit arrangements. Applications may be achieved with overtravel of the input shaft within 1-1/4% of dial range and without damage to the counter.

Automatic Timing & Controls, Inc., Dept. ED, King of Prussia, Pa.

Price & Availability: *3-week delivery. Price is $66 fob Philadelphia. Quantity discounts.*

Waveguide Components 465

Cover range from 5.85 to 90 kmc

Three types of these cylindrical components are available in a range of sizes to cover the 5.85 to 90 kmc range. They are: a rectangular to cylindrical transition used to launch a TE_{11} mode; a circular polarization phase shifter used to transform a linearly polarized TE_{11} mode to either left or right hand circular polarization; and a conical horn which radiates or receives either a linear or circularly polarized wave for antenna testing.

DeMornay-Bonardi, Dept. ED, 780 S. Arroyo Parkway, Pasadena, Calif.

Price & Availability: *Made on order only. Delivery 2 weeks to 30 days after order is received. Prices range from $176 to $261 (depending on waveguide size) when 1 to 9 units ordered.*

NEW PRODUCTS

Pulse Mixer 466

Mixes and amplifies pulse rates

Two pulse rates can be mixed and amplified in this unit which consists of two gating transistors with a common output pulse transformer. Specifications of the mixer are: input/output, —4 v, 1/10 μsec pulses; supply voltages and currents, —15 v, 30 ma and 10 v, 0.3 ma; and clamp voltage —4 v at 20 ma.

Harvey-Wells Electronics, Inc., Dept. ED, East Natick Industrial Park, E. Natick, Mass.

***Price & Availability:** Units are in stock. Prices up to $52.20.*

Memory Stack 456

Withstand 2000 cps of vibration

This magnetic core memory stack, designated Mil-Stak, is unaffected by acceleration up to 10 g and vibration up to 2000 cps. The cores are wired to form an array on a molded plastic frame. The wired arrays are interconnected by a locked link method and the entire stack is encapsulated in polyurethane. This rugged construction makes the unit suitable for military applications.

Telemeter Magnetics, Inc., Dept. ED, 2245 Pontius Ave., Los Angeles 64, Calif.

***Price & Availability:** Units are made to customer specifications and price varies accordingly. Delivery time, which also depends on the individual requirements, is four to seven weeks.*

Panel Meters 434

Available in 61 models

Built in accordance with MIL-M-10304A, these 3-1/2 in. panel meters are available in 61 standard models. Voltmeters, ammeters, microammeters, and milliammeters are included in the line.

Beckman Instruments, Helipot Div., Dept. ED, 2500 Fullerton Rd., Fullerton, Calif.

Price & Availability: *Standard models are available from stock. Price ranges from $18 to $25.*

DC Amplifier 445

Delivers 100 ma at an impedance of less than 1 ohm

Model 93 solid state dc amplifier has a maximum current output of 100 ma at an output impedance of less than 1 ohm. The input impedance is higher than 50 K, isolated by at least 100 meg from the cabinet. The recovery time from overloads is a maximum of 100 msec. The unit features a unique combination of differential input and wide bandwidth. It can drive any of the recently developed hf galvanometers. This model comes with a regulated power supply. For rack mounting, an adapter panel for 19-in. racks can be furnished.

Video Instruments Co., Inc., Dept. ED, 3002 Pennsylvania Ave., Santa Monica, Calif.

Price & Availability: *Price is $485 fob Santa Monica, Calif. There is no discount for up to 9 units, but there is a discount of 3% for 10 to 24, 5% for 25 to 49, and 10% for 50 to 99 units. Up to 20 units can be delivered in 30 days; for more than 20 units, allow 45 days delivery.*

CIRCLE 55 ON READER-SERVICE CARD ➤

Digital Tape Reader 43?

Processes up to 180 in. of tape per sec

Model 300 servo-transport digital-tape reader processes magnetic tapes at speeds from 10 in. per sec to 180 in. per sec. It provides 1 msec start or stop time at 100 in. per sec. At a density of 50 bits per in., it will read one digit at a time on command. Read commands are accepted one at a time with repetition rates to 200 individual read pps. The unit packs 128 or more bits per in. on any number of tracks. The tape-tension control permits steel and plastic tapes to be used interchangeably.

Shepard Labs., Inc., Dept. ED, Summit, N.J.

Price & Availability: *Priced at \$15,000, the unit is available on order only. Delivery is 120 days after order is received. Price reductions are made when units are bought in quantities.*

Trimming Potentiometer 453

Has temperature range of −55 to +200 C

The ceramic metal construction of this series 50 trimming potentiometer makes it possible to use the unit in an ambient temperature range of −55 to +200 C. It can ride out 100 g shock. Standard resistance range is from 100 to 20,000 ohms with 2 ohms maximum end resistance at either end.

Helipot Div. of Beckman Instruments, Inc., Dept. ED, 2500 Fullerton Road, Fullerton, Calif.

Price & Availability: *Standard units available from stock. Standard price is \$8.00 with quantity discounts.*

Digital to Analog Converter Indicator 451

Read-in is binary information

Consisting of a relay matrix, a 2^9 analog to digital converter, and a 400 cps, 115 v motor, the model T8613-14 servo package has a read-in of binary information. Accuracy is ± 0.5 deg, and output rate is 8 rpm maximum. Designed for military applications in aircraft or ground installations, the unit is adaptable to industrial uses.

Kearfott Co., Inc., Dept. ED, Little Falls, N.J.

Price & Availability: Available 90 days after order is received. Price on request.

Dynamic Rectifier Analyzer 457

Forward current range is 1 to 5 amp dc

For in-coming inspection, on-line testing, and laboratory use, model 138A dynamic rectifier analyzer has a forward current range of 1 to 5 amp dc and a piv of 0 to 1000 v. The controls for forward current and reverse voltage are independently adjustable. The forward drop range of 0 to 0.2 v and reverse currents of 0, 0.05, 0.5, 5, and 50 ma can be measured. The unit has permanent provisions for monitoring all four parameters with an external oscilloscope. No auxiliary equipment is needed. Required input is 120 v, 60 cps, 250 w. The over-all size is 21.25 x 16 x 16 in. and the weight is 60 lb.

Wallson Associates, Inc., Dept. ED, 912-914 Westfield Ave., Elizabeth, N.J.

Price & Availability: Price is $945 fob Elizabeth, N.J. Units are usually available from stock; if not, delivery is within three weeks.

NEW PRODUCTS

Digital Process Controllers 449

For bi-directional measurements

Developed for bi-directional measurement and control applications, this series of transistorized add-subtract digital process controllers provides direct reading numerical display of the measurement, and has provision to actuate various control functions when a preset number or series of numbers are reached. The units operate at rates up to 20,000 counts per sec and higher. Input sensitivity is 1 v rms at 1 ma.

Dynapar Corp., Dept. ED, 7312 N. Ridgeway Ave., Skokie, Ill.

Price & Availability: *1 to 3 and 1 to 4 digit units are in stock and cost approximately $950 and $1150 respectively. Higher units are built from stock parts.*

DC Amplifier 463

Handles signals up to 250 mv

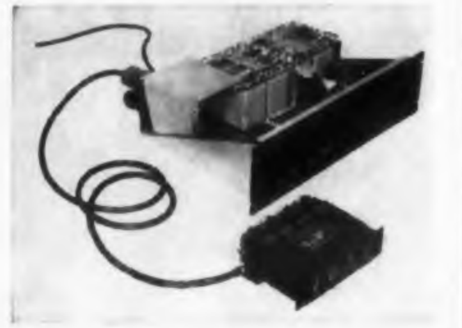
Designated the DA-11, this transistorized dc amplifier handles signals as low as 0 to 10 mv and as high as 250 mv. Under conditions of maximum gain, an input of ±10 mv will produce an output of ±5 v. Carrier rejection is 60 db or greater below max output. The unit withstands a shock of 100 g and operates from +32 to +150 F. It measures 3 x 1.87 x 2.62 in., and weighs 11 oz. Humidity requirements of MIL-E-5272B Procedure III are met.

United ElectroDynamics, Dept. ED, 200 Allendale Road, Pasadena, Calif.

Price & Availability: *30 to 45 day delivery. Price is $695 when ordered in quantities of 1 to 9.*

Digital Clock 595

For process control systems



For use in process control systems, this standard digital clock may be operated in the presence of explosive gases. Oil-filled step switches and mercury-wetted relays are used. The display, composed of single plane in-line lamp banks, may be mounted remotely. Pushbutton switches allow for resetting. The digital output contacts can be either decimal or binary coded decimal form. Switching circuitry that transfers power input to the clock to a dc source in case of an ac power failure is optional.

Parabam, Inc., Dept. ED, 13000 Yukon Ave., Hawthorne, Calif.

Portable Scope Dolly 393

Made of heavy gage steel

Made of heavy gage steel, this portable scope dolly is offered with either sloping or flat top. By adjustment of brackets on the top shelf, it can carry almost any standard type laboratory scope. Full-swivel, 3-in. rubber casters are included.

Wyco Metal Products, Dept. ED, 6918 Beck Ave., N. Hollywood, Calif.

Rare Earth Metals 398

For electronic components

For electronic tubes as well as for solid state devices, these rare earth metals are offered in purities of 99.5% to 99.9%. They are offered in the form of finely divided powders and in ingots, rods, pellets, and turnings. The powders are offered in any size down to —325 mesh.

Cerium Metals and Alloys Div. of Ronson Metals Corp., Dept. ED, Newark, N.J.

◄ CIRCLE 61 ON READER-SERVICE CARD

NEW PRODUCTS

Quartz Crystal 574

Frequency range is 4 to 150 mc

Type KC-43A quartz crystal has a frequency range of 4 to 150 mc with a frequency shift of less than ±0.0025% over a temperature range of −55 to +105 C. The dimensions are: pin diameter, 0.017 in.; pin spacing, 0.192 in.; body height 0.53 in.; body width 0.402 in.; and body thickness, 0.15 in. On the plug-in unit, the pin diameter is 0.04 in. Type Sm-43 quartz crystals are for use with high shock, vibration and other extreme environmental conditions.

The Keystone Electronics Co., Dept. ED, 65 Seventh Ave., Newark 4, N.J.

Transistor Mounting Kits 369

For transistors in TO-3 and TO-5 line

These power transistor mounting kits provide the necessary hardware to mount all power transistors in standard TO-3 and TO-5 package. With the kits—types MK-10, MK-15 and MK-20—electrical isolation from a chassis or heat sink is possible. Hardware includes a transistor socket, front and back mounting templates for hole drilling guides, two No. 6 mounting screws, an insulating washer and complete mounting instructions.

Motorola Inc., Semiconductor Products Div., Dept. ED, 5005 E. McDowell Rd., Phoenix, Ariz.

Tape Transport 383

Speed is 0.3 to 60 in. per sec

Series 3167 tape transport has tape speeds from 0.3 to 60 in. per sec, governed by a hysteresis synchronous capstan drive motor. Able to accommodate tape widths from 0.25 to 1 in. on reels up to 10.5 in. in diam, the unit is a one-piece casting with its own power supply and controls. It has plug-in heads for 2 to 20 tracks and automatic stop for tape break or end of tape. Its applications are in data recording and playback, voice monitor systems, and general industrial uses.

Minneapolis-Honeywell Regulator Co., Dept. ED, 10721 Hanna St., Beltsville, Md.

Time Code Generator 585

For airborne use

This all-transistor airborne time code generator weighs 20 lb and occupies 1/2 cu ft. Time code is supplied as 14-bit Point Mugu code modulating a 1 kc carrier, and in dc shift form. Outputs include 1, 5, and 10 pps, and 100, 1000, and 2000 cps. All outputs are suitable for recording on magnetic tape. Accuracy of the unit is one part in 10^5. Power requirements are 77 w at 115 v, 400 cps.

Electronic Engineering Co. of Calif., Dept. ED, 1601 E. Chestnut Ave., Santa Ana, Calif.

Electrolytic Capacitors 411

Can sizes are 3/16 x 1/2 to 3/8 x 1-1/2 in.

Called Electromite, these electrolytic capacitors have can sizes from 3/16 x 1/2 to 3/8 x 1-1/2 in. They have welded terminal connections. No pressure contacts are used. Their low-leakage characteristics minimize drain and conserve battery life when used across a battery in by-pass applications. They operate over the temperature range of −20 to +85 C, from 3 to 150 wvdc. An elastomer hermetic seal is used.

Cornell-Dubilier Electric Corp., Dept. ED, South Plainfield, N.J.

Differential Voltmeter 414

Has a standard cell reference

Model 803R dc-ac differential voltmeter is a rack-mounting version of the model 803. Having a standard cell reference, the unit provides an accuracy of 0.05% of any dc input from 0.1 to 500 v, and 0.1% from 0 to 0.1 v. For ac measurements over the range of 30 to 5000 cps from 0.5 to 500 v, the accuracy is 0.2% of the input. The accuracy is not changed when voltages other than full scale are measured. The instrument can be used on ac to 5 mv.

John Fluke Manufacturing Co., Inc., Dept. ED, P.O. Box 7161, Seattle 33, Wash.

CIRCLE 65 ON READER-SERVICE CARD >

NEW PRODUCTS

Delay Lines 381

Delay time is 0.3 μsec ±5%

Type CLN-150-30 lumped constant delay line has a delay time of 0.3 μsec ±5%. Operating over the temperature range of −55 to +85 C, the delay line has an impedance of 150 ohms, a maximum rise time of 0.08 μsec, and pulse attenuation of 1 db max. Packaged in a hermetically-sealed metal case measuring 2-3/8 x 5/8 x 1-11/32 in., the unit has threaded mounting studs.

Technitrol Engineering Co., Dept. ED, 1952 E. Allegheny Ave., Philadelphia, Pa.

Silicon Rectifier 511

Is rated at 100 amp

Designed for easy installation on many battery charging applications, this silicon rectifier is rated at 100 amp. A center-tap unit, it consists of two silicon junctions mounted on a 4 x 6-in. nickel-plated copper cooling fin. Mounting holes are spaced to facilitate mounting to practically any battery charger. All junctions use successive layers of humidity-resistant insulating resins and sealants to assure reliable operation over the temperature range of −20 to +130 F.

International Rectifier Corp., Dept. ED, 1521 E. Grand Ave., El Segundo, Calif.

Ceramic Permanent Magnet 380

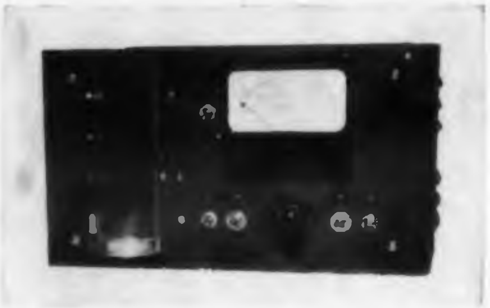
Has high energy-to-weight ratio

Type M-1 isotropic ceramic permanent magnets are made of a light weight, high energy material that provides increased flexibility in magnet design. They can be used for beam focusing or deflection in cathode ray tubes, ion traps, and in speakers. They are able to reproduce the original flux after being subjected to a strong demagnetizing influence. Having a high resistivity, they can be situated in electrical circuits without producing a conducting path.

Allen-Bradley Co., Dept. ED, 136 W. Greenfield Ave., Milwaukee 4, Wis.

Dielectric Test Set 596

Test voltage is 0 to 5000 v rms



Designed for testing samples of magnetic wire, model P5 dielectric test set has a continuously adjustable testing voltage from 0 to 5000 v rms. A transparent test cage is mounted on the front panel to receive the pieces of wire. The unit has a dual scale kv meter for accurate setting of test voltage, a pushbutton high voltage ON control which actuates a holding type contactor, plus safety controls. The unit can also be used as a standard hipot tester by plugging test leads into high voltage jacks at the rear of the unit.

Peschel Electronics, Inc., Dept. ED, Towners, Patterson, N.Y.

Comparators 589

Digital

The 2120 series digital comparators are designed to compare the output data from digital counters, voltmeters, and time interval meters with preset limits. The upper and lower rejection limits can be set from the front panel or by external devices such as tape readers or stepping switch banks. For use in missile checkout equipment, automatic test equipment, and digital data systems, the instruments perform the comparison after the counting or digitizing operation is complete and have no effect on the accuracy, frequency limits, or voltage limits of the system in which they are used. Separate comparison circuits for the two limits and voltage weighing rather than time sequenced comparison decreases comparison time.

Dicon Labs, Dept. ED, P. O. Box 2242, Orlando, Fla.

Microphone 421

For such uses as missile launching operations, it can be used in a sound range rated on the noise scale at 150 db.

Chance Vought Aircraft, Inc., Dept. ED, Dallas, Tex.

Unit Indicator 575

For use with T-PAC modules, model U1-10 displays the output of model LE-10 logical element package or model FS-10 static flip-flop. Power requirements are −90 v at 1 to 2.3 ma.

Computer Control Co., Inc., Dept. ED, 983 Concord St., Framingham, Mass.

Solderless Connectors 576

For solderless connections between wires and component leads, this junction cell consists of a gold-plated eyelet and a rubber core.

Plastic Associates, Dept. ED, 185 Mountain Rd., Laguna Beach, Calif.

Modular Writing Surface 577

Needing 1-3/4 in. panel space, this retractable modular writing surface mounts in standard EIA slots on front and rear rails. Made of steel, Formica, or aluminum, it comes in widths of 16, 21, and 27 in. and in lengths of 16 to 36 in.

Western Devices, Inc., Dept. ED, 600 W. Florence Ave., Inglewood 1, Calif.

Rocker-Actuated Switches 578

For flush or offset two-hole mounting, the switches have these ratings: 20 amp, 125 v ac, 1.5 hp; 10 amp, 250 v ac, 2 hp. Made of molded phenolic, units are 1.2 in. long and 0.762 in. wide.

McGill Manufacturing Co., Inc., Dept. ED, Valparaiso, Ind.

Storage Cabinet 579

For housing small parts, standard models have 18 or 24 drawers. Each drawer can be sub-divided into compartments by adjustable cross dividers. Cabinets are 34 x 11 in., with a depth of 11 or 17 in.

Bay Products, Dept. ED, 1835 W. Cambria St., Philadelphia 32, Pa.

Adaptor Plate 580

The octagon witch box adaptor plate, for Mark-Time switches, converts toggle switch operation to time switch operation for control of plating equipment, battery charges and other operations.

M. H. Rhodes, Inc., Dept. ED, 30 Bartholomew Ave., Hartford 6, Conn.

NEW PRODUCTS

Connector — 598

Non reversing hermaphrodite type

This non-reversing hermaphrodite connector can be used as a plug or as a socket. Having a power rating of 100 amp, 440 v ac, the connectors are suitable for 2, 3, and 4-wire cables. Only one solder connection is needed for each conductor. Measuring 2.75 in. in diam, the connector has an anodized-aluminum housing and weighs 1.25 lb.

Specialty Electronics Development Corp., Dept. ED, Syosset, N.Y.

DC Amplifier — 604

Gains to 5000 available in five steps

This differential dc amplifier offers gains up to 5000 in as many as five fixed steps. The bandwidth may be up to 300 cps on standard models, and to 1000 cps on special models. For units having a bandwidth of 80 cps and a gain of 50, the gain accuracy is 0.02% at dc, the noise is 3.3 μv, and the common mode rejection is 114 db at 60 cps.

Beckman Instruments, Inc., Systems Div., Dept. ED, Anaheim, Calif.

Electrical Tapes — 607

Have fluorocarbon backings

No. X-1111 electrical tape has a 0.002-in. extruded TFE-fluorocarbon film backing coated on one side with a pressure-sensitive adhesive. The adhesive offers maximum resistance to jet fuels and hydraulic fluids. A thermosetting tape, it is recommended for use at 155 C. No. 1112 electrical tape has a TFE-fluorocarbon impregnated cloth backing which is coated with a thermosetting silicone adhesive. It is recommended for use at 180 C and is especially designed for uses where the cold flow of Teflon film is a problem. It provides good holding power for heavy-duty functions while giving improved cut-through resistance.

Minnesota Mining and Manufacturing Co., Dept. ED, 900 Bush Ave., St. Paul 6, Minn.

Remote Indicating Accelerometer 485

Accuracy is 0.1 g

For automatic aircraft and missile control systems and remote visual indication, model 0013-5100 accelerometer offers a range to ±7 g, a natural frequency of 5.5 cps, and an accuracy of 0.1 g. The damping ratio is 0.65. The output can be synchro or potentiometer type. The unit operates over the temperature range of −55 to +85 C and at altitudes to 100,000 ft.

M. Ten Bosch, Inc., Dept. ED, Pleasantville, N.Y.

AC Motors 569

From 1/12 to 1/4 hp

These 400-cps ac motors, designed for aircraft use, range from 1/12 to 1/4 hp. Made to conform to MIL-M-7969, these 115 to 200 v motors have a high starting torque, a large horsepower reserve, and low weight per horsepower output. They are fully enclosed for protection against moisture, dust, and salt spray and can be used in ambient temperatures to 120 C.

Lundy Manufacturing Corp., Dept. ED, Glen Head, N.Y.

Oscilloscope Camera 384

Distortion is less than 0.5%

Model 12650 oscilloscope camera reduces distortion to less than 0.5%. It has a f/1.9 77 mm lens and can be furnished with a large Polaroid Land back. A binocular viewing hood permits direct viewing of the cathode ray tube. The camera swings back providing access to lens and shutter, or can be lifted off completely. For remote operation, an electric shutter actuator can be supplied.

Beattie-Coleman, Inc., Dept. ED, 1000 N. Olive St., Anaheim, Calif.

Washer Nuts 385

Light weight

Type H19320 captive washer nut is a light weight device designed for electronic assemblies. The service temperature is 800 F. An identical configuration, type H19343, is made for service to 500 F. Offered in thread sizes 2-56 through 10-32, both fasteners meet the requirements of MIL-N-25027.

Kaynar Manufacturing Co., Inc., Dept. ED, Box 2001, Terminal Annex, Los Angeles 54, Calif.

Air Conditioner 370

Operates from −65 to +125 F ambient

Designed for mobile or stationary use, this air conditioner, model MAC-7-1/2, operates at ambient temperatures of −65 to +125 F. It has permanently lubricated bearings, automatic temperature control, cycling or noncycling operation, built-in electric heaters, and humidity controls and accessories. The cabinet is all welded. Several standard configurations are available.

Airflow Co., Dept. ED, 400 S. Stonestreet Ave., Rockville, Md.

Hipot Tester 377

Output voltage fixed at 900 v rms

Designed with a fixed output voltage of 900 v rms, model P1AC-S hipot tester gives both buzzer and panel light indication of breakdown, grounds and shorts when testing during manufacture of components. Maximum short circuit current is 19 ma, and output voltage drops to zero when the output is shorted. The unit measures 5 x 6 x 4 in, weighs 6 lb, and operates from any 115 v lighting circuit.

Peschel Electronics, Inc., Dept. ED, Patterson, N.Y.

Prepared by Bonfield Associates, Inc. *for Electronic Design and Electronics.*

Electrical Brushes 551

These brushes feature three-section construction, with a hammerplate riveted to the long section and passing over all three sections. For use on large motors or generators, they offer improved communication and long life.

Speer Carbon Co., Dept. ED, St. Marys, Pa.

Transistor Mounting Pads 552

Made of injection-molded plastic, they provide stable mounting for all JETEC 12 and 30 transistor cases. The pads are elevated on four integrally molded feet, allowing insulating air space. Soldering is simplified, since no jig is needed for component spacing.

Regan Plastics Corp., Dept. ED, 532 W. Windsor Rd., Glendale 1, Calif.

High-Voltage Filter 553

For military use, it keeps caps from shaking loose because of vibration. It is designed for 4000 v operation and has silver plating. All parts have a tolerance of 0.001 in.

Filtron Co., Inc., Dept. ED, 10023 W. Jefferson Blvd., Culver City, Calif.

Magnetic Core Alloy 555

For use in manufacturing magnetic amplifiers, the Super Squaremu 79 maintains uniform characteristics from unit to unit. It has high gain, long linear range, high saturation flux density, and good thermal stability.

Magnetic Metals Co., Dept. ED, Hayes Ave. at 21st St., Camden, N.J.

Teflon Terminal 556

Type RFT-SM-2 TUR-C4 is for installation in chassis to 0.125 in. thick. Having the one-piece Press-Fit construction, the terminal needs no washers, nuts, or lockwashers.

Sealectro Corp., Dept. ED, 139 Hoyt St., Mamaroneck, N.Y.

Stop Nuts 557

Called Brilok, they are one-piece, washer-faced, resilient hexagons made of Zytel 101 nylon resin. For use in aircraft and electronic equipment, they are light weight, stable at high temperatures, and resistant to abrasion and corrosion.

Pheoll Mfg. Co., Inc., Dept. ED, Chicago, Ill.

Infrared Detector Test Console 568

Type 301 infrared detector test package is for use with photoconductors, photovoltaic detectors, bolometers, and thermocouples. It tests detectors in production quantities at a rate of 500 to 1000 detectors per day measuring signal, noise, and resistance.

Infrared Standards Labs., Dept. ED, 10555 Magnolia Ave., Riverside, Calif.

NEW PRODUCTS

Insulation Tape 584

Has high tensile strength

High voltage splicing tape No. 30 has high tensile strength, a high degree of surface tack and fusion, good cold weather handling characteristics, and good storage stability. It meets ASTM D-1373 requirements for ozone and corona-resistant insulating tapes. Maximum operating temperatures are 90 C up to 5 kv and 85 C up to 17 kv. This tape is available in standard widths, with special sizes on request.

Bishop Manufacturing Corp., Dept. ED, 16 Canfield Road, Cedar Grove, N.J.

High Vacuum Equipment 397

Offers 5 x 10^{-7} mm Hg pressure

Type VS-400 high vacuum pumping station has a pump-down speed of 5 x 10^{-6} mm Hg in 45 sec and an ultimate pressure of less than 5 x 10^{-7} mm Hg. Offered with a choice of forepumps and gages, the unit is of modular design. It measures 38 x 37 x 30-1/4 in., weighs a maximum of 500 lb, and requires 2000 w at 110 or 220 v ac.

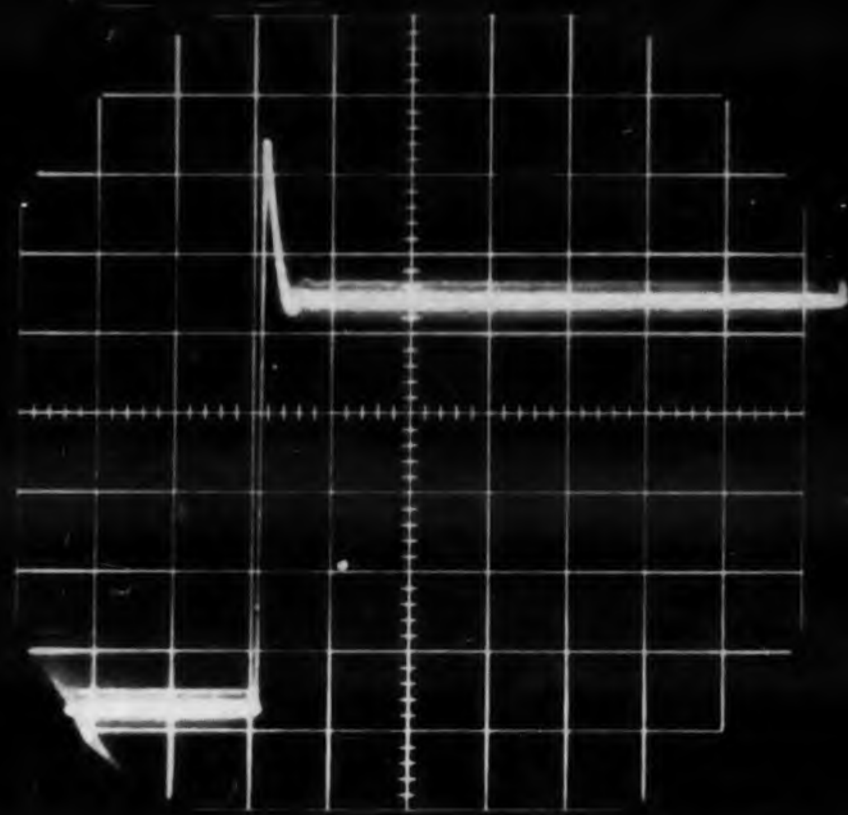
Veeco Vacuum Corp., Dept. ED, 86-P Denton Ave., New Hyde Park, L.I., N.Y.

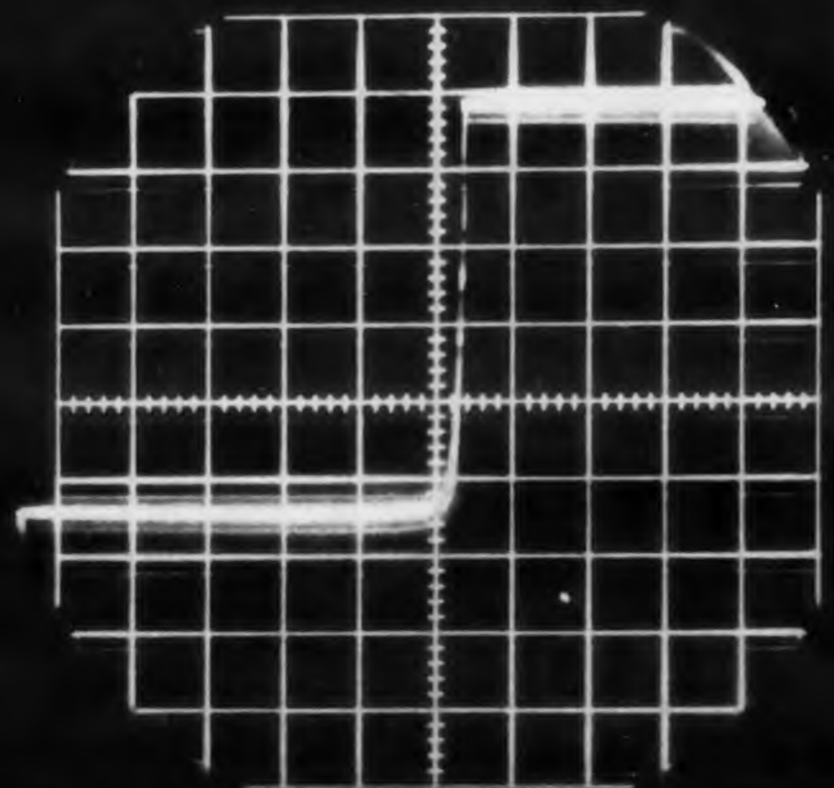
PC Laminates 390

Have high dielectric strength

The KOP-R-KLAD printed circuit laminates can be used at high temperatures, have a high dielectric strength, and are claimed to eliminate circuit failure due to leaking. Available in sheets and continuous rolls, the 12 types offered include copper bonded to Teflon, Teflon-glass, Kel-F, and FEP fluorocarbon. The method of bonding uses no third material as an adhesive and does not require the copper to be oxidized.

W. S. Shamban & Co., Dept. ED, 11617 W. Jefferson Blvd., Culver City, Calif.





Molding Compound 581

Withstands temperatures to 6000 F

Resistotemp is a high-temperature insulation that will withstand temperatures to 6000 F for limited periods, and sustained temperatures to 1000 F. The material is made of refined fibrous potassium titanate and phenolic resin. It has a density of 1.6. It may be molded in conventional matched metal dies and cured in conventional ovens.

Resisto Chemical, Inc., Dept. ED, Wilmington, Del.

Vinyl Tubing 372

Contracts to form skin-tight insulation

Available in 25 standard sizes to cover objects 5/64 in. to 5 in. in diam, this heat reactive vinyl tubing contracts at temperatures over 275 F to form skin-tight electrical insulation for symmetrical rods, tubes or contoured shapes. It shrinks up to 30% in diam and 15% in length. Some of its applications are the insulation and protection of harness cables, condenser coils, ground straps, transformer leads, high voltage leads, and flexible conduit.

Minnesota Mining and Manufacturing Co., Dept. ED, 900 Bush Ave., St. Paul 6, Minn.

Electronic Alarm 396

Is self-powered

Type R2A self-powered electronic alarm is a null-balance device that can be used for one or two point alarm. The basic components for a single alarm point are mounted on two printed circuit cards. Each unit has slots for two sets of cards to allow for both high and low limit alarms. Conversion from one to two-point is by adding a set of printed circuit cards. Operating from a common 0 to 0.5 v ac signal, the instrument compares the process signal with the adjustable alarm point signal in a difference amplifier.

Swartout Co., Dept. ED, 18511 Euclid Ave., Cleveland 12, Ohio.

◄ CIRCLE 72 ON READER-SERVICE CARD

Digital Readout Modules 573

Operate on 1 to 30 v dc

These digital readout modules operate on any dc voltage from 1 to 30 v and have a response time of less than 0.1 sec. Measuring 1-15/16 x 1-7/8 x 1-3/4 in., they can be energized to display any number from 0 through 9. In-plane digital display is by means of seven miniature electromagnetic indicating segments operated in any combination. Not subject to burn-out, these indicators provide readability in strong incident light. Digit size is 1-1/2 x 1 in. Type 201 provides momentary operation and type 202 is designed for pulse controlled latching or memory operation.

Allard Instrument Corp., Dept. ED, 146 E. Second St., Mineola, L.I., N.Y.

Molybdenum Stampings 386

For semiconductor devices

These gold-clad molybdenum stampings are for base tabs for silicon transistors and diodes. Other uses include high temperature applications in oxidizing atmospheres. The stampings are available in diameters from 0.03 to 0.25 in. OD, in thicknesses down to 0.002 in., and with tolerances as close as ±0.0001 in. in thickness.

Accurate Specialties Co., Inc., Dept. ED, 37-11 57th St., Woodside 77, N.Y.

Scope Carrier 375

Has a plug-in amplifier cabinet

Model OC-5 scope carrier has a cabinet for plug-in amplifiers, a linoleum writing desk, and a bottom felt-lined tool drawer. The frame is chrome plated 7/8 in. steel tubing and the cabinet is 16 gage, blue-grey crackle finished sheet metal. All makes of scopes can be accommodated on the 15 deg angle top. The carrier weighs 70 lb and measures 37 x 17-3/4 x 27 in.

Technibilt Corp., Dept. ED, 905 Air Way, Glendale 1, Calif.

Closed-Circuit TV 583

Provides 600-line resolution

Designed for heavy-duty industrial and general use, Model 70-A closed-circuit camera features a transistorized video amplifier which eliminates microphonics and provides 600-line resolution. The cast aluminum case is 7-5/8 x 5-15/16 x 11-13/16 in. The unit requires 45 w at 115 v, 60 cps.

Dage TV Division, Dept. ED, Thompson Ramo Wooldridge, Inc., Michigan City, Ind.

Silicon Rectifiers 388

Are rated at 40 and 22 amp

These silicon rectifiers are rated at 40 and 22 amp for continuous duty at ambient temperatures to 150 C. The maximum reverse current is 5 ma at maximum rated temperature and piv. The 22-amp units, models 1N1191A through 1N1193A have piv ratings of 50 to 200 v in 50-v steps and a maximum forward drop of 1.2 v. The 40-amp units, models 1N1183A through 1N1186A, also having piv ratings from 50 to 200 v, have a maximum forward drop of 1.1 v. The units are designed to withstand extreme temperatures, humidity, and mechanical shock.

Delco Radio Div., General Motors Corp., Dept. ED, Kokomo, Ind.

Time Delay Switch 415

Has no moving parts

Designed to close after a delay has elapsed, this static time delay switch operates without moving parts. The time delay range is 0.05 to 180 sec, ±5%. Life of the unit is 1000 hr. The contacts are spst, 5 amp to 200 v dc at 25 C. The temperature range is −55 to +85 C, or as high as +125 C by special design. The unit withstands vibration of 39 g to 2000 cps. Operation is at 24 to 31 v dc for the standard unit, or 18 to 50 v, if specified.

Hydro-Aire Co., Dept. ED, 3000 Winona Ave., Dept. ED, Burbank, Calif.

CIRCLE 75 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Data Transmitter 373

Transmits through regular telephones

In addition to transmitting through the telephone, this instrument permits data and alphabetical information to be transmitted between typewriters, digital voltmeters, magnetic tape, punched paper tape, core storage units and magnetic drums. The transmission of alpha-numeric information at high speeds is also possible over telemeter or microwave linkages. Power requirement is 110 v at 60 cps at less than 10 w. The unit weighs 25 lb and measures 8-3/4 x 19 x 13 in.

Franklin Electronics Inc., Communications and Control Div., Dept. ED, 5901 Noble Ave., Van Nuys, Calif.

FM Telemetering Transmitter 599

Measures 1.64 x 2.75 x 4 in.

Model 1483-A1 true fm telemetering transmitter is a completely modularized missile transmitter with all circuits mounted on individual bulkheads and measuring 1.64 x 2.75 x 4 in. The output is 2 to 6 w at 215 to 260 mc. The unit uses silicon transistors, has the AFC loop crystal controlled for $\pm 0.005\%$ carrier stability, and withstands extreme vibration as well as heat above 100 C.

Telechrome Manufacturing Corp., Dept. ED, 28 Ranick Dr., Amityville, L.I., N.Y.

Ceramic Coil Forms 430

Available in various sizes and heights

Available in sizes of 0.206, 0.260, 0.312, 0.375, and 0.5 in., these ceramic coil forms are designed to withstand severe shock, wide temperature variations and extreme humidity. Mounted heights are 19/32, 27/32, 1-1/16, and 1-11/16 in. Collars, lugs, tuning cores and hardware are also available. The coil forms may be obtained either completely assembled or in part.

United Products, Dept. ED, 165 Franklin Ave., Nutley, N.J.

Time Base and DC Amplifier 593

For use with X-Y plotters

Type HRT-1 time base and dc amplifier provides seven sweep rates, from 0.5 to 50 mv per sec, for use with X-Y plotters. Accuracy is 2%. By resetting the recorder attenuator, sweep rates may be reduced to 1000 sec with some loss in linearity. Starting and resetting is with a panel switch or a single remote contact. By rotating the panel selector, the unit becomes a multi-purpose chopper-stabilized dc amplifier.

Houston Instrument Corp., Dept. ED, 1717 Clay Ave., Houston 3, Tex.

Current Limiter 374

For use in all types of electronic circuits

Engineered to operate in all types of electronic circuits, this solid state current limiter is a one-shot device which will fire in less than 1 msec at 316% rated value or 1/10 sec at 150% rated value. It is available in ratings from 1/32 to 5 amp in two models. Model 100, 1/4 x 1 in., fits a standard fuse holder; model 200, 1/4 x 1/8 x 1/16 in., is a pigtail type for printed circuits.

Microelectron, Inc., Dept. ED, Box 24174, Los Angeles 24, Calif.

◄ CIRCLE 76 ON READER-SERVICE CARD

NEW PRODUCTS

Networks 570

For analog operational amplifiers

Designed for ac or dc analog operational amplifiers in computers and guidance systems, series NAC networks are held to total summing accuracies as high as ±0.005% without trimming potentiometers or capacitors. Individual resistors are wound to tolerances as close as ±0.003% with stabilities of ±0.003% per yr and time constants as low as 10^{-8} sec. The networks are mounted on epoxy-glass printed boards with turret lug terminations or male plugs.

Julie Research Labs., Inc., Dept. ED, 556 W. 158th St., New York 32, N.Y.

Molded Screws 367

Come in short lengths

For use in subminiature assemblies and components, these molded black nylon screws in fillister head style measure 4-40 x 1/2, 6-32 x 1/4, 3/8 and 1/2; 8-32 x 3/8, 1/2 and 1-1/2; 10-32 x 3/8, 1/2, 5/8 and 1-1/2. Round head screws measure 1/4 in. and 1/8 in. in length with 2-56 thread sizes. The screws are light-weight, nonconducting, nonmagnetic, and are resistant to corrosion and fungus.

Weckesser Co., Dept. ED, 5701 Northwest Highway, Chicago 46, Ill.

Fluorocarbon Bondings 376

For microwave systems

This modified fluorocarbon bonding material permits hermetic sealing of microwave systems at temperatures down to −100 F. It is unaffected by hydraulic fluids, fuels, fuming nitric acid, alkalies, time, moisture, dirt and solvents. Applied to Teflon or Kel-F, the bonds are flexible, pressure tight, and retain all of the electrical characteristics of the original.

Radiation Applications, Inc., and Schenley Industries, Inc., Dept. ED, 800 Second Ave., New York 17, N.Y.

High-Intensity Microphones 561

Types NM 125 and NM 135 have a linear dynamic measurement range of 95 to 200 db. Made for use in adverse environments, they use self-generating ceramic sensors with an operating temperature range of −60 to +260 C.

B & K Instruments, Inc., Dept. ED, 3044 W. 106th St., Cleveland 11, Ohio.

Silicon Fluid 562

This liquid glass coats or is packed around electrical connections to prevent arcing, flash-over, or short circuits. Effective over the range of −90 to +250 C, it is useful in preventing shorts caused by moisture.

Dow-Corning Corp., Dept. ED, Midland, Mich.

Video Monitor 563

For closed-circuit TV in industrial and military use, this monitor has a horizontal resolution of 650 lines and a linearity withn 2% of picture height. This compact unit has an aluminized 90-deg magnetic deflection picture tube plus a polaroid screen.

Cetec Electronics Co., Dept. ED, 1400 Industrial Way, Redwood City, Calif.

Remote Microphone 564

Model M-60 combines a one-channel remote amplifier and a microphone in a 12-oz unit. The amplifier output is +12 dbm at 2% or less distortion and the frequency response is ±1.5 db from 60 to 15,000 cps.

Collins Radio Co., Dept. ED, P.O. Box 1891, Dallas 21, Texas.

Mobile Amplifier 565

Measuring 2-1/8 x 3-1/2 x 3 in., it packs to 8 w using 11 active circuit elements. Input is provided for carbon microphone. It has output taps for 4, 8, or 16-ohm speaker.

Digitrols, Dept. ED, P.O. Box 985, Baltimore 3, Md.

Quick-Disconnect Terminals 566

Having many switch and control uses, these terminals give push-on high-pressure spring loaded connections. Including insulated and non-insulated, straight and flag types, they come in wire sizes 18 to 14 AWG.

ETC Inc., Dept. ED, 990 E. 67th St., Cleveland 3, Ohio.

Ceramic Terminal Strips 567

Made to withstand shock and vibration, the strips have nylon yoke chassis fittings. Pre-timed for instant soldering, they may be mounted over tube sockets. They come in three sleeve heights and in seven standard sizes with 1 to 11 silvered notches.

Tektronix, Inc., ED, P.O. Box 831, Portland 7, Ore.

NEW PRODUCTS

Silicon Diodes 601

Recovery time is 0.8 usec

Designed for operation from −65 to +150 C, types 1N690 through 1N693 silicon diodes have a maximum recovery time of 0.8 μsec to return to 10 K when switched from a forward current of a 2-μsec pulse of 500 ma to a reverse voltage of −50 v. They switch from a 5-ma forward pulse to −40 v and recover to 100 ohms in 0.5 μsec. Forward conductance is 400 ma at 1 v and leakage is 50 μa at 150 C. These diodes meet the requirements of high current pulse circuits for high speed computer switching, pulse clamping, gating, blocking, and diode logic circuits.

Sperry Semiconductor Div., Sperry Rand Corp., Dept. ED, S. Norwalk, Conn.

Counter-Timer 588

Has three input channels

Model 727A solid state universal counter-timer consists of three input channels, a special decade count-down base, and plug-in decade counting units. The output information operates digital printers, punches, in-line readouts, and other data processing equipment. Readout can be in vertical numeral panels or in the in-line Nixie version. The measurement ranges are: frequency, dc to 10 mc; time interval, 0.1 μsec to 10^7 sec; and period, 0.1 μsec. Accuracy is ±1 count, plus or minus oscillator stability. The sensitivity is 0.25 v rms and the input impedance is 25 K per v. Also available for use in the same frequency range are model 707A transistor frequency-period counter and model 757A transistor time interval meter.

Computer-Measurements Co., Dept. ED, Sylmar, Calif.

Nickel Ferrites 389

For microwave devices

Developed for use in microwave devices, these alumina-substituted nickel ferrites operate in the low loss region above resonance. Their typical applications are in resonance isolators where broad-band characteristics are needed, X-band devices involving continuous wave powers, and other devices where high Curie temperatures and low losses are necessary. Designated types AN-20-MW, AN-25-MW, AN-30-MW, and AN-35-MW, they have a saturation magnetization of 1300, 750, 650, and 300 gausses, respectively, a remanent magnetization of 700, 350, 325, and 115 gausses, and a coercive force of 6, 16, 12, and 25 oersteds.

Kearfott Co., Inc., Dept. ED, 1500 Main Ave., Clinton, N.J.

Communications Towers 392

Are 10 to 500 ft tall

These tubular alloy steel communications towers are from 10 to 500 ft tall. Having a three-sided sectional design, the towers come in sections 10 or 20 ft long and in four weights. The heaviest towers can be raised to 500 ft with windloading of 30 lb per sq ft, or up to 360 ft with windloading of 40 lb per sq ft. Guys are specified for the heavier models that are more than 100 ft tall, and for the shorter, lighter models. All parts are hot dip galvanized steel to insure protection against weather conditions. The welds are sprayed with molten zinc.

Motorola Communications and Electronics, Inc., Dept. ED, 4501 W. Augusta Blvd., Chicago 51, Ill.

Correction Notice

Specification for the dc modulator, described on page 120 of the November 25th issue, should read: "Each unit has less than 1-μv dc offset, and less than 1 μv drift over long service periods." Inquiries will be received by Millivac Instruments, Box 997, Schenectady, N.Y.

CIRCLE 80 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Fasteners 368

Are self-aligning

Suited for hard-to-reach places, these stainless steel fasteners, called Synclamps, are self-aligning, self-locking and withstand extreme environmental conditions. Self-alignment is accomplished because of a nylon insert. When the screw is tightened, the insert is stripped allowing the clamp to self-align. The more the screw is turned the tighter the clamp seats.

Timber-Top, Inc., Dept. ED, 36 Brooklyn Ave., Freeport 8, L.I., N.Y.

Electronic Counter 371

Serves as a materials handling instrument

This counter serves as a complete materials handling instrument, suitable for batch counting, machine cycling and packaging operations. Warning presets, footage-yardage counters, and photoelectric amplifiers and sensing units may be used with the Tally-Count. Operating advantages include remote control operation, counting capacity to 100,000, and an automatic zero set.

Standard Instrument Corp., Dept. ED, 657 Broadway, New York, N.Y.

Voltage Regulating Transformer 378

Keeps voltage within ±3% of rated output

This voltage regulating transformer keeps voltage within ±3% of rated output with line variations from 100 to 130 v. The average dc input to filter for type PF-50 is 275 v dc at 50 ma; for type PF-110, 385 v dc at 110 ma; and for type PF-250, 380 v dc at 250 ma. Other units can be made to customer specifications.

Raytheon Co., Industrial Apparatus Div., Dept. ED, Manchester, N.H.

Solder 379

Rosin type

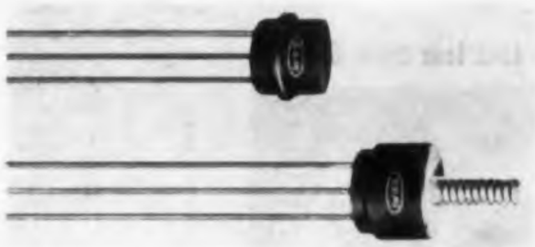
Series AR activated rosin type paste solder is for electronic component soldering where completely neutral rosin type fluxes are inactive, but where nonconductive, noncorrosive residues are required. Slightly active before soldering, this solder paste tests neutral after soldering. It can be used with steel, cadmium plate, tin plate, silver plate, and other metals which are often difficult to solder.

Fusion Engineering, Dept. ED, 17921 Roseland Ave., Cleveland 12, Ohio.

CIRCLE 260 ON READER-SERVICE CARD ➤

Silicon Controlled Rectifiers 365

Have low losses with loads up to 300 w



At 100 C, these miniature silicon controlled rectifiers control up to 1 amp, continuous, per cell with an input signal level of 2 ma. Switching efficiency is about 98%. At 2 amp, the maximum drop is 2.5 v. Low heat sink requirements with peak recurrent ratings to 30 amp are afforded over a temperature range of −65 to +150 C. Applications include ac and dc static switching, proportioning control, dc to dc converters, servo motor driving, and protection circuits.

Solid State Products, Inc., Dept. ED, One Pingree St., Salem, Mass.

Silicon Computer Diodes 382

Has low capacitance

Types 1N925 through 1N928 silicon computer diodes have a maximum inverse capacitance of 4 μμf at zero voltage and a typical inverse capacitance of 1.1 μμf at −10 v. The maximum recovery time at 20 K is 0.15 μsec, switching from 5 ma to −10 v. These diodes are furnished in a PSI package having a maximum diameter of 0.125 in.

Pacific Semiconductors, Inc., Dept. ED, Culver City, Calif.

Transistor Transformers 366

Measure 1/2 in. in diam, 1/2 in. in height

Engineered to operate in af transistor circuits, these units measure 1/2 in. in diam, and 1/2 in. in height. A choice of four standard lead terminations provide lead spacing on 0.1 in. grid for mounting on circuit boards without using clamps. Minimum lead length is 1 in. Built to meet MIL-T-27A, class R, grade 5 requirements, these transformers may be used reversed, input to secondary.

Hermetic Seal Transformer Co., Dept. ED, 555 N. Fifth St., Box 978, Garland, Tex.

NEW PRODUCTS

Band-Pass Filters 359

Insertion loss less than 6 db

All channels (23) from 400 cps to 70 kc are available in the Series F-185 miniature telemetering band-pass filters. Insertion loss is less than 6 db. Relative attenuation is less than 3 db in pass-band, greater than 15 db at adjacent channel edges. For channels 1 through 6, the filters measure 3/4 x 1-1/2 x 2-1/4 in. Channels 7 through 18 and A through E measure 3/4 x 3/4 x 1-3/8 in. Specifications of MIL-T-27A are met.

Kelvin Electronic Co., Dept. ED, 5907 Noble Ave., Van Nuys, Calif.

Servo Actuators 424

Have mechanical feedback

These compact, lightweight servo actuators employ mechanical feedback which eliminates the electrical feedback transducer and the associated amplifier ordinarily used to close the servo loop. The feedback of piston position to the armature of the input force motor is by means of springs and a precision motion reductive device. Any error or difference between the input force and the spring feedback force is amplified by a variable orifice hydraulic amplifier. The units offer excellent linearity and resolution. A wide range of design parameters is available, including piston areas to 3 sq in. and strokes to 4 in. Open loop gains to 120 sec^{-1} can be obtained.

MOOG Servocontrols, Inc., Dept. ED., E. Aurora, N.Y.

Chart Recorder 360

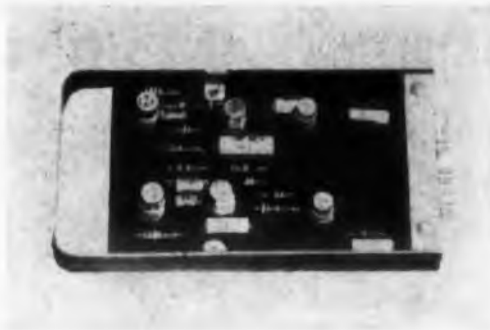
Plots 12 variables on a 5-in. chart

The plotting of 12 variables on a five-inch calibrated chart by scanning and sampling is possible with model M5 miniature multipoint recorder. Each variable is identified at its position by means of a number and a point, printing with multiple or single colors. The instrument is available with 12 points and a standard printing rate of 5 sec per point. Spans are available with thermocouple or linear mv calibrations over a wide range. Standardization is accomplished by the use of a Zener reference power supply.

Westronics, Inc., Dept. ED, 3605 McCart St., Fort Worth, Tex.

Modulator Amplifier 632

Gain is about 12



Model S-40001-PB modulator amplifier converts low level dc voltages of less than 0.5 mv to 1 v into a 10-kc square wave ac output. The over-all gain of the dc input to the ac output, peak-to-peak, is about 12. An internal 10-kc frequency source is included for driving the transistor chopper and to provide signal power for an amplifier demodulator. The plug-in circuit used requires 27 ma at 24 v dc and has a flat frequency response from dc to about 20% of carrier frequency. The unit is transistorized. The design shown is for guide rail mounting; another style has feet for individual mounting.

Plug-In Instruments, Inc., Dept. ED, 1416 Lebanon Road, Nashville, Tenn.

NEW LITERATURE

Capacitors 93

Bulletin 3700D, 10 pages, provides complete data on the type 109D tubular sintered-anode Tantalex capacitors. The units may be operated at temperatures up to 85 C at rated dc working voltage, or up to 105 C with a voltage derating of 15%. The capacitors' design will meet the 2000 cycle military missile vibration requirement. Capacitors are now available in ratings ranging from 560 μf, 6 v to 43 μf, 100 v in Group 2, ±20% units. They are also available with ratings from 330 μf, 6 v to 30 μf, 100 v in the Group 1 units. The bulletin contains photographs, many graphs, and gives the data in tabular form. Sprague Electric Co., North Adams, Mass.

Wiring And Connections

Entitled "The Systems Approach to Electronic Wiring and Connections," this 28-page book is divided into three parts. The first section is on case histories on printed circuit and wiring device applications, designed to stimulate new application ideas from the material presented. The second has check lists to assist in specifying, designing and integrating multiple wiring device components, tolerances on printed circuits, connectors and sockets, and multi-conductor cable and flexible harness. The third is on the firm's design, tooling, manufacturing, and inspection facilities. The book also offers engineering analysis, designed to assist in packaging and interconnecting high density electronic assemblies. The check list for printed circuit design is a typical one.

It reads:

1. Does the circuit layout employ free-flowing and rounded corners on conductors and pads?
2. Are conductor lengths as short as possible?
3. Are dc conductors maintained as near to edges as possible?
4. Are heat sinks employed where necessary to avoid hot spots?
5. Are boards supported at intervals of not more than 4 in. (for 1/16 to 3/32 in. board thickness)?
6. Are component leads spaced at least 1.5 times stock thickness and placed at least twice stock thickness from the edge of the board?
7. Do conductor lines which run near the edge of the board allow a 1/16 in. margin from the outer blank?
8. Is there a minimum spacing of 1/32 in. between pads except where impossible?
9. Is there a minimum of 1/32 in. and preferably 1/16 in. copper land around holes?
10. Does the design provide 1/16 in. minimum conductor width to fullest extent possible, with a 1/32 in. minimum?

11. Are large unrelieved expanses of copper (which can blister more readily during dip solder) avoided?
12. Does the design employ single sided boards wherever possible (except where redundant circuitry for maximum reliability is utilized)?
13. Are fungus resistant coatings specified, if required?
14. Are any special or unusual tolerances carefully and prominently defined?
15. Does the design adhere to proven design standards and tolerances?
16. Is the material selected compatible with the electrical and mechanical requirements of the unit?

For copies of the book, write on company letterhead to Methode Manufacturing Corp., Dept. ED, 7447 W. Wilson Ave., Chicago 31, Ill.

Microwave Diodes 94

This 12-page booklet contains complete electrical and mechanical data on all microwave diodes manufactured by the firm as well as a replacement guide to nearly 200 widely-used diode types. Information on the company's recently announced Micro-Min line is contained in the booklet. These microwave diodes can be used for applications up to 150 C. Sylvania Electric Products Inc., 1100 Main St., Buffalo 9, N.Y.

Data Recording System 95

Bulletin No. 350-8 describes an Automatic Multipoint Digital Data Recording System that is designed to handle 200 input variables. General description, system components, typical system operation, and specifications are given in this two-page data sheet. Datex Corp., 1307 S. Myrtle Ave., Monrovia, Calif.

Digital Calendar 96

Bulletin No. 2800 describes the firm's digital calendar which produces a decimal representation of the date in months and days. Typical wiring diagrams and specifications are included in this two-page bulletin. Chrono-log Corp., Box 4587, Philadelphia, Pa.

Wiring System 97

This six-page brochure details the types, sizes, and costs of the firm's Cradleclip wiring system. Designed for retaining cable runs or mounting components from 1/8 to 2 in. in diam., the system includes cradles for supported mountings and binders for control or unsupported wire or cable runs. Specifications of MIL-STD-202A are met. Electrovert Inc., 124 E. 40th St., New York 16, N.Y.

NEW LITERATURE

Semiconductor Handbook 103

This 24-page handbook includes two listings of the semiconductors of nine manufacturers: (1) in sequence by parameter and function, and (2) by transistor and type number. The handbook contains a section of dimensioned mounting diagrams. I & G Div., Radio Shack Corp., Boston 17, Mass.

Power Transistor 104

This four-page booklet describes the 2N297A power transistor. High current switching, audio amplification, and small motor and servo drivers are typical applications. The maximum collector-emitter rating is 50 v, and collector current rating is 5 amp. Absolute maximum ratings, and electrical and environmental test data are arranged in tabular form. Characteristic and analysis curves are included. Specification MIL-T-19500/36A (SigC) is met. Semiconductor Products, Bendix Aviation Corp., Red Bank Div., Long Branch, N.J.

Rate Turntables 105

Catalog No. 152, 16 pages, describes rate turntables and lists model numbers for inertial guidance test equipment and components. The turntables may be used for testing rate gyros, antennas, seekers, accelerometers, and guidance assemblies. General description and specifications for all units are included. Sterling Precision Corp., 17 Matinecock Ave., Port Washington, L.I., N.Y.

Magnetic Tape Transports 106

Instrumentation-grade transports for memory, monitoring, programming, time delay, data repetition and wave analysis applications are described in this illustrated booklet, DS 3191, four pages. Electrical and mechanical specifications of three transport models include loop lengths, tape speeds, controls, and power and mounting requirements. Minneapolis-Honeywell Regulator Co., 10721 Hanna St., Beltsville, Md.

Terminal Boxes 107

Detailed specifications of the firm's line of weatherproof multi-junction terminal boxes are given in this four-page bulletin, No. 28. They have cellular, neoprene gasketed covers that provide protection for the termination against the effects of oil, dust, dirt, humidity, or other contaminating environment. Drawings give arrangements of terminal strips, and number, size, and placement of hubs. Thermo Electric Co., Inc., Saddle Brook, N.J.

Coils 112

This one-page data sheet describes the qualities of relay coils, chokes, and toroids manufactured by the firm. Information is provided on inspection of materials, production, and engineering service. Preferred Coils, Inc., Box 14, Highland Sta., Springfield 9, Mass.

Encoders 113

Bulletin No. 300-5 is a four-page booklet describing the characteristics of eight series of shaft position encoders. Linear and non-linear calibration is included for series C-100. All data is tabulated under rotation, readout, code, model number, and special feature headings. Datex Corp., 1307 S. Myrtle Ave., Monrovia, Calif.

Time Programmer 114

The model 301 time programmer, designed for missile and satellite application, is described in this one-page data sheet. It has an analog-to-digital converter and a timing accuracy that is equal to the frequency regulation of the 400 cps power supply used to drive the synchronous motor. Physical and electrical characteristics are given. Aztec Research Laboratories, Inc., Bay Area Facility, 2324 Lafayette St., Santa Clara, Calif.

Impedance Bridge 115

The type 250 series universal impedance bridges are described in this four-page catalog sheet, No. C-16. Accuracy ratings of the instruments are 0.1% for resistance, 0.2% for capacitance, and 0.3% for inductance. They have seven ranges and 12,005 divisions of dial resolution. Specifications and circuit diagrams for two models are provided. Information about an accessory generator-detector is included. Electro-Measurements Inc., 7524 S.W. Macadam Ave., Portland 19, Ore.

Phototransistors 116

Brochure G-190, eight pages, describes the firm's complete line of pnp germanium alloy junction phototransistors which combine high speed response with high sensitivity. The illustrated brochure includes such data as: maximum ratings; cut-off and small signal characteristics; mechanical data; light sensitivity; chopped light frequency response; photo spectral response; and noise considerations. Typical circuit applications and response curves are shown, and design considerations discussed. Small size, lower power consuming types covered in the brochure include 2N1392, 2N469A, 2N1393, and 2N1394. General Transistor Corp., 91-27 138th Place, Jamaica 35, N.Y.

NEW LITERATURE

Mechanical Differentials 119

This 24-page technical booklet describes mechanical differentials and their applications to precision instrument and servo control work. Typical applications and design advantages are also covered. The booklet contains photographs and sketches, and lists the firm's stock items. Pic Design Corp., 477 Atlantic Ave., E. Rockaway, Long Island, N.Y.

Failure Data 120

The development of equations to determine the physical basis of failure is the subject of this booklet. Containing 22 diagrams, it establishes the mathematical basis for predicting the point of failure. The data in the booklet, No. PIB 12, has applications to problems of missile reliability. General Electric Co., 3198 Chestnut St., Philadelphia 4, Pa.

Transistors 121

Brochure G-210, eight pages, presents the firm's line of high voltage npn and pnp germanium alloy junction transistors. Type numbers covered are 2N1310, 2N1311, 2N1312, and 2N1408. Included are a complete list of specifications, application circuitry, and characteristic curves and graphs. The transistors are recommended for use where large dynamic range is desired and large voltage swings are required. General Transistor Corp., 91-27 138th Place, Jamaica 35, N.Y.

Transistorized Relays 122

Transistorized relays for high speed signalling or data control are covered in this two-page, illustrated bulletin, No. 65. Advantages of semiconductor relays over mechanical vacuum tube relays for high speed signalling applications are discussed. The bulletin describes the theory of operation and the mechanical arrangement of the firm's units. Rixon Electronics, Inc., 2414 Reedie Drive, Silver Springs, Md.

Rotary Solenoids 123

This four-page brochure describes rotary solenoid products and systems. The text and illustrations cover a complete line of standard and special solenoids, packaged switch assemblies, and 360 deg drive stepping units. Engineering specifications, advantages of these products, and their applications are given. Illinois Tool Works, Pacsol Div., 3155 El Segundo Blvd., Hawthorne, Calif.

Magnetic Tape Recorder 126

This 20-page brochure contains information on the firm's magnetic tape recorder, type FR-100B. The instrument has up to 32 recording tracks, six tape speeds, plug-in interchangeable heads, and low flutter. Components described include the tape transport, amplifier modules and power supplies. Graphs are provided for cumulative flutter and frequency response at speeds ranging from 1-7/8 to 60 ips. Performance data is given for direct, fm, PDM, and NRZ digital record/reproduce systems, and include input and output impedances for all systems. Sections of the brochure describe modifications for specialized needs and accessories that go with the unit. Photographs and tables are included. Ampex Corp., Instrumentation Div., 934 Charter St., Redwood City, Calif.

Servomotors 127

The entire line of size 8 servomotor components, including velocity and inertia-damp units, is presented in this 16-page catalog. Included are 115 v, 400 cps, and 26 v, 400 cps versions. Requirements of MIL-E-5272A are met. Complete electrical and mechanical specifications, outline drawings, schematics and torque-speed curves are given. All units in this series withstand 100 g shock, 30 g vibration to 2000 cps, and can operate at temperatures up to 200 C. Beckman Instruments, Helipot Div., 2500 Fullerton Road, Fullerton, Calif.

Insulation Materials 128

Application and engineering data on laminated plastics and vulcanized fiber is given in this eight-page catalog. General information includes a tabulated column that gives suggested applications for particular materials. All other information is also tabulated. The general data provides NEMA grades, military specifications, color, forms, and sizes in which the materials are furnished. Physical, mechanical, and electrical properties are included. Taylor Fibre Co., Norristown, Pa.

Logic Switches 129

Designed for use in large and small data systems and computers, several types of logic switches are described in this eight-page booklet. Applications include: storage and memory, tape data assembly and translation, code conversion, programming, preset unit counting, format conversion, and numerical control. The booklet contains photographs and diagrams. Tally Register Corp., 5300 14th Ave. N.W., Seattle 7, Wash.

NEW LITERATURE

Coaxial Transmission Lines 132

Catalog No. 598 shows the entire Series "800" rigid copper and rigid aluminum coaxial transmission lines and accessories. The new catalog format eliminates cross reference reading from section to section and shows all pertinent data on each item adjacent to its photograph and dimensioned line drawing. Dimensions are given for the Spir-O-lok and EIA connectors in all sizes. Also presented, are six pages of engineering data and performance curves. Prodeling, Inc., Dept. GE-7, 307 Bergen Ave., Kearny, N.J.

Temperature Conversion Chart 133

This chart converts fahrenheit to centigrade and centigrade to fahrenheit. It also gives interpolation factors for fractional readings. The reverse side of the chart gives differences between wet and dry bulb temperatures for determination of relative humidity. Electric Hotpack Co., Inc., Dept. ED, Cottman Ave. at Melrose St., Philadelphia 35, Pa.

Nickel-Cadmium Batteries 134

The 19-page bulletin No. 8 provides information on rectangular, cylindrical and button type Eveready nickel-cadmium rechargeable batteries. Included is information on physical and electrical characteristics, presented in tabular form, and charging and discharging curves for several representative types. Also given are several simple circuits using the batteries. Supplemental data are available on request. Battery Engineering Dept., Union Carbide Consumer Products Co., 30 E. 42nd St., New York 17, N.Y.

Transistor 135

A driver transistor designated 2N1176, A, B, is covered in this two-page data sheet. Absolute maximum ratings, small signal parameters, electrical test data, and dimensional data on the germanium pnp audio signal transistor are given. Bendix Aviation Corp., Semiconductor Products, Red Bank Div., Long Branch, N.J.

Instruments Catalog 137

A wide range of scientific measurement, recording, and testing instruments are described in a 48-page, condensed catalog. A brief description, typical illustration, salient specifications, and reference for additional information are given for each family of instruments. Included are DC Amplifiers, Data Handling Systems, Laboratory and Calibration Instruments, Magnetic Tape Instrumentation, Nuclear Instrumentation, Oscillographs, Recorders and Indicators, Servo Components, Temperature Controllers, and Transducers. Catalog G-10, Minneapolis-Honeywell Regulator Co., Station M-321, Wayne and Windrim Aves., Philadelphia 44, Pa.

Analog Computor 138

Four-page bulletin K5-U gives a description, specifications, and applications for the firm's linear operator—a building block of analog computing systems. Photographs and block diagrams illustrate the unit. George A. Philbrick Researches, Inc., 285 Columbus Ave., Boston 16, Mass.

Coil Winding Machines 139

This two-color, eight-page catalog illustrates and gives complete technical data on five coil winding machines for heavy duty transformers and field coils. Two new models are included. Three heavy duty tensions are also described. Geo. Stevens Manufacturing Co., Inc., Pulaski Road at Peterson, Chicago 46, Ill.

Metals and Alloys 140

This eight-page publication, entitled "Metals and Alloys for use in Conjunction with Semi-Conductor Products," outlines the products made for firms in the semiconductor industry. It discusses new alloys of gold, platinum, and other metals in the form of wire, sheet, or stamped products, as well as electroplated wire and strip, rhodium and gold plating solutions. Included are sections on new products made by special techniques developed so that the requirements of high purity and close control of physical characteristics are maintained. Sigmund Cohn Corp., 121 S. Columbus Ave., Mount Vernon, N.Y.

NEW LITERATURE

Switching Transistors 144

A 24-page booklet, "Medium and High Speed Switching Transistors," lists maximum ratings and electrical characteristics for all pnp and npn medium and high speed types in the firms switching transistor line. It also contains nine transistor switching time measurement circuits, diagrams illustrating mechanical specifications and connections, and a section on transistor switching time requirements. Sylvania Electric Products Inc., 1100 Main St., Buffalo 9, N.Y.

Resistors

Technical data on precision wire wound and composition variable resistors is presented in a new 24-page engineering catalog. In the precision wirewound sections such subjects as: characteristics of resistance wire, temperature coefficient interpretation, "E" temperature coefficient, MIL-R-93B and MIL-R-9444 nomenclature, are discussed. The subject matter of the composition variable resistor section includes: MIL-R-94B nomenclature, resistor interchangeability, summary of test results on the firms variable resistors. The catalog contains charts, diagrams and data of interest to engineers concerned with the application of resistors. *It can be secured by writing directly to the Reon Resistor Corp., Dept. ED, 155 Saw Mill River Road, Yonkers, N.Y.*

RF Cables and Connectors 145

A 28-page reference manual, listing rf cables and connectors, offers cross references between military and commercial code numbers, a guide for selecting rf coaxial cable connectors, as well as descriptions and technical data on most types of commonly used connectors. Some information on wave guides, waveguide flanges, and waveguide adaptors is also included. Data is presented in tabular form with typical component illustrations. Western International Co., 45 Vesey St., New York 7, N.Y.

Shaft Position Encoders 147

Four-page bulletin 312-A illustrates and describes typical shaft position encoders. Basic design features, mechanical and electrical design considerations, scanning rates, and coding are covered. A high rate scanning circuit is shown. Datex Corp., 1307 S. Myrtle Ave., Monrovia, Calif.

Insulating Materials 148

The selection and application of electrical insulating varnishes with complete details on all electrical and mechanical properties and operating temperature limitations are covered in this catalog. Included in the 35-page catalog are charts, graphs and illustrations on temperature conversion, solvents, specific gravity, viscosity and other categories pertinent to selection of insulating systems from Class A to Class F at the lowest production cost. Other sections provide data on the selection of the proper varnish, impregnation methods, baking and curing procedures, and storing and handling suggestions. Minnesota Mining and Manufacturing Co., Irvington Div., 900 Bush Ave., St. Paul 6, Minn.

Testing Facilities 149

Environmental, qualification and reliability testing facilities are described in detail in this four-page, two-color, illustrated brochure. The testing division is equipped to test electronic and electromechanical components. Testing to commercial, aircraft and military specifications is possible in a variety of natural, induced or combined environments. Environments which can be supplied or induced include high altitude, vibration, temperature, pressure, and humidity, singly or in combination. Ballistically operated devices can be fired for production reliability or qualification testing. Horkey-Moore Assoc., 24660 Crenshaw Blvd., Torrance, Calif.

Automatic Test Equipment 150

This 15-page booklet describes automatic go/no-go component test equipment for high-volume testing of fixed and variable resistors, fixed and variable capacitors, and transistors and diodes. Schematic diagrams illustrate the test sets. Kearfott Co., Inc., 1500 Main Ave., Clifton, N.J.

Ready-Made Oscillator for Frequencies Between 5 & 50 Mc

THE OSCILLATOR shown in Fig. 1 is a negative-resistance emitter follower oscillator with a tank in the base circuit.

This circuit has good driving ability and is adequately stable for many oscillator requirements. The voltages and load resistor are not critical, but care should be taken not to exceed the rating of the transistor selected.

Although the circuit works best with only an inductor, as shown, a small variable capacitor may be used in parallel with the inductor as a convenient means of varying the frequency. It was found that the oscillator was adequate for frequencies between 5 and 50 mc. Fig. 2 may be used as a guide in selecting an inductance to obtain a desired frequency.

All high frequency transistors tried have worked successfully; those tried were: 2N504, 2N501, 2N393, 2N345 and 2N240. Different types of transistors give slight changes in frequency as indicated in Fig. 2.

Forrest Salter, Electronics Div., Argonne National Laboratory, operated by the University of Chicago, Box 299, Lemont, Ill.

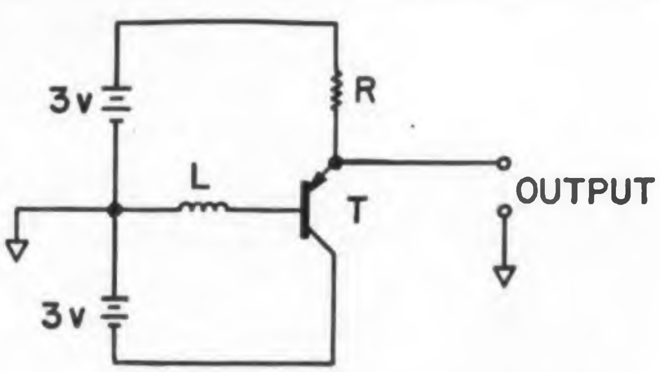


Fig. 1. A simple, emitter follower oscillator with a tank in the base circuit.

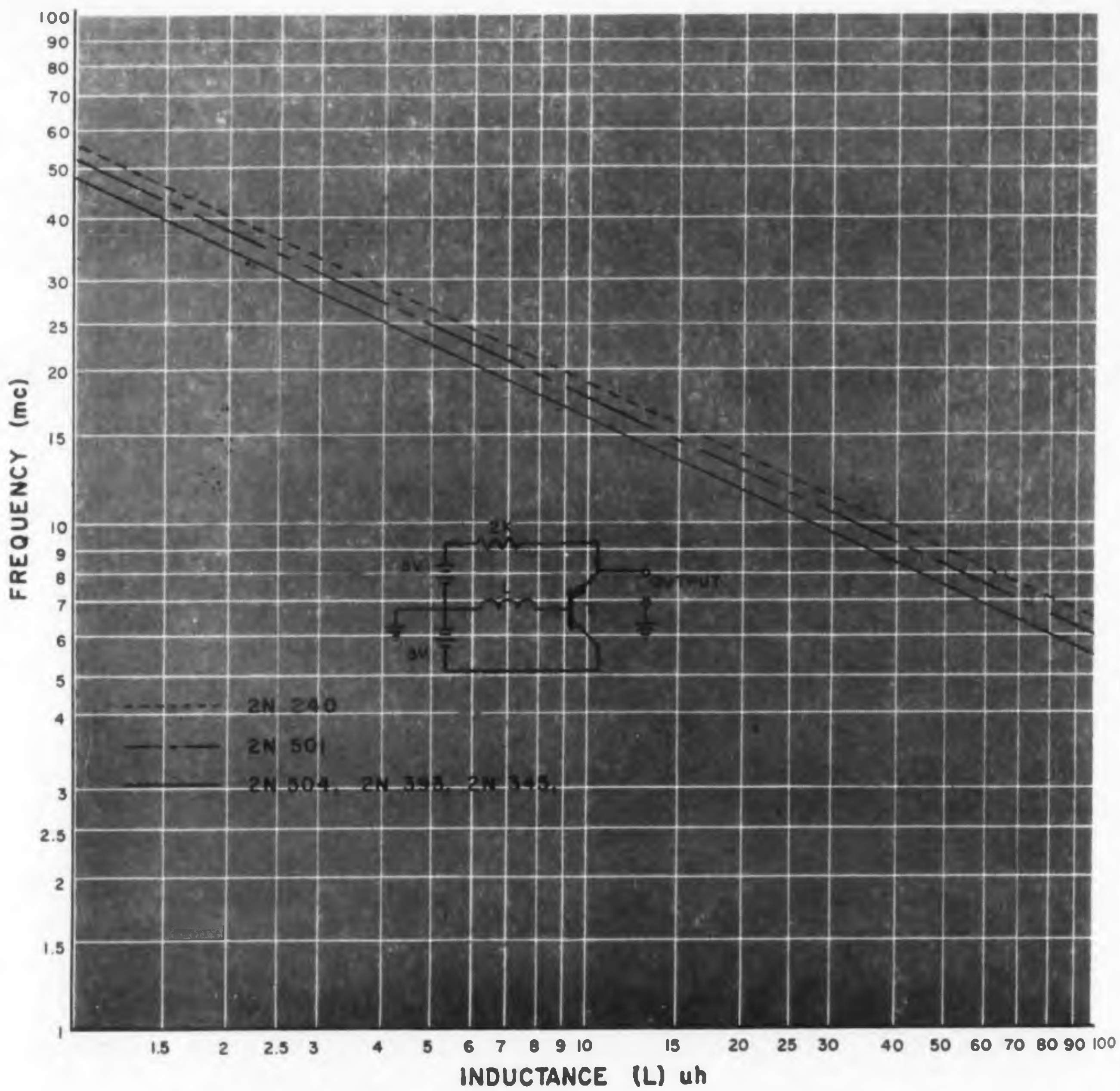


Fig. 2. This design chart can be used in selecting an inductance to obain a desired frequency. The curves have been experimentally determined for five different transistor types.

IDEAS FOR DESIGN

Lamp And Receptacle Provide Stand-by Power And Appliance Checker

A useful accessory for bench work is illustrated. It consists simply of a 150 w lamp in series with the line and a two-receptacle electrical fitting which serves two purposes. First, when the 200 w soldering iron is plugged into one of these receptacles, it is in series with the 150 w lamp. This keeps the iron on "half heat," sufficient for small jobs but prevents the tip from burning up due to overheating. When maximum heat is required, iron is then plugged into a regular outlet and attains full heat almost immediately.

The second function of this device is that the second outlet becomes a handy checker for shorts and continuity on electrical appliances and equipment. When unit to be tested has a dead or partial short, the lamp lights up fully, indicating that it should be checked before using. If the appliance is OK, the bulb (which glows dull red with soldering iron in series) will show more light, and if appliance has an open circuit, there will be no change in light.

This tester has prevented many a blown fuse and is well worth the installation, since its cost is very small.

John B. Powell, Radio & "Victrola" Engineering, Radio Corp. of America, Camden 2, N.J.

Handy bench accessory does double duty as soldering iron standby circuit and appliance power circuit checker.

Figures Switched

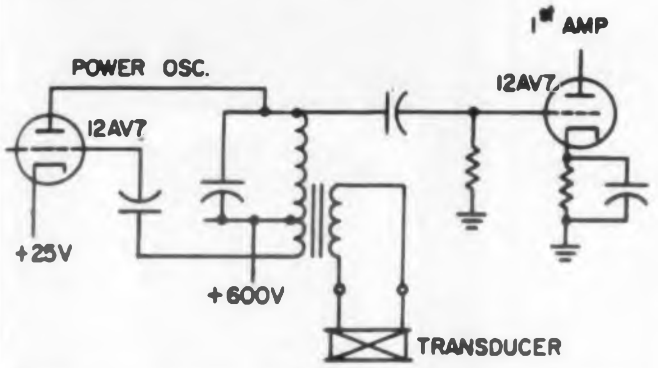
The two figures were switched in the Idea for Design on increasing input impedance of emitter followers (*ED* Nov. 11, 1959, p176). The modified circuit proposed by Mr. Barr is the upper one.

Oscillator Coil Doubles As Step-Up Transformer

By incorporating an output winding on the oscillator coil of a depth-sounder unit to serve as the coupling device between the transducer and first amplifier, improved circuit performance at low cost is achieved.

Rather than couple the return signal from the transducer to the first stage directly, the signal is fed through the oscillator transformer having a step-up ratio of 3:1. Thus, a 10 db increase in signal level is obtained with no further parts other than a dc blocking capacitor between the coil and first amplifier grid.

Herbert C. Single, Marine Sonics Section, Raytheon Co., Waltham, Mass.



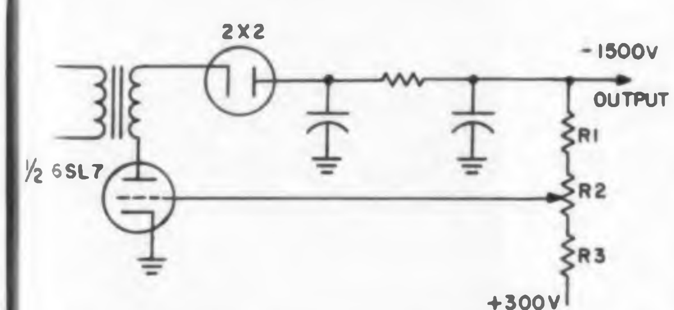
Transducer output gets boost of 10db by coupling to amplifier through oscillator coil.

Simple Make-Do CRT-Supply Regulation

A high voltage negative supply for a CRT had to be regulated to $\pm 2\%$. The regulating device was limited to 1/2 6SL7 which was available in the set and was to be as inexpensive as possible. The simple solution illustrated more than satisfied these requirements.

The plate of the 6SL7 was connected to the end of the transformer secondary that is normally grounded. A potentiometer was inserted in the supply bleeder. The design required only the addition of this inexpensive potentiometer. The results exceeded the specifications.

Sol Abrams, Design Engineer, Polarad Electronics Corp., Long Island City 1, N.Y.



CRT Supply was regulated with an available 1/2 6SL7 and a pot.

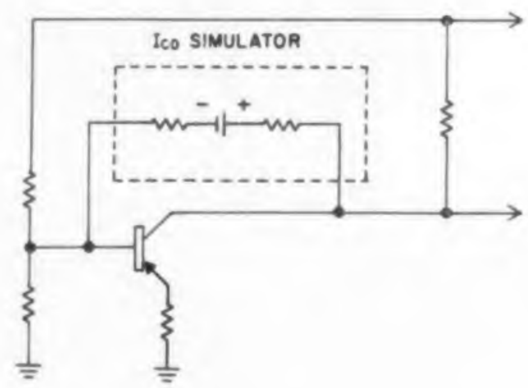
Simulated Oven for Transistor Testing

Transistor circuit behavior at elevated temperatures may often be simulated so that tedious oven testing may not be necessary. The most severe effect of temperature is to increase I_{co}. By using a high voltage battery in series with resistors, any value of I_{co} can be readily simulated. The impedance of the simulator should be high compared to that of the circuit under test to avoid resistive loading problems. For example, a 45 v battery and two 220 K resistors provide 100 μa of simulated I_{co} at an impedance which is high enough not to disturb most transistor circuits.

The circuit stability factor may be found by measuring emitter current and the ac behavior under various temperature conditions may be readily checked.

Other transistor parameters, notably current gain and base-emitter conductance, are also a function of temperature, so that this technique is certainly no substitute for oven testing. However, the simulator has proved invaluable for rapid breadboard work.

William D. Roehr, Application Engineer, Motorola Inc., 5005 E. McDowell Road, Phoenix, Ariz.

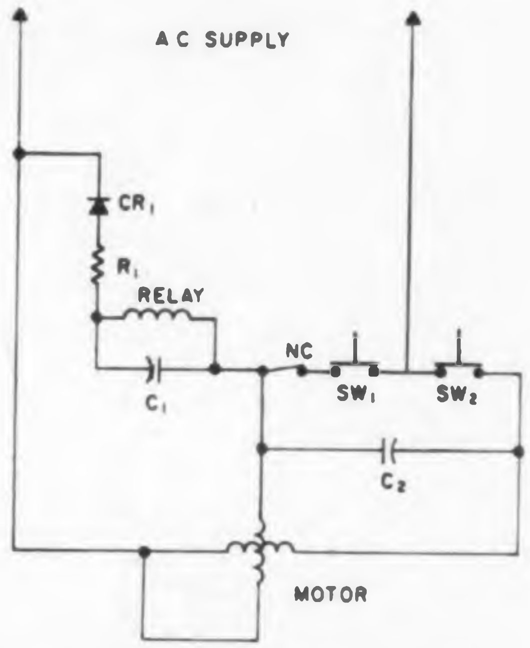


Typical circuit shows oven simulator in place.

Dual-Speed Motor Drive

Two speed operation is often required from capacitor type small motors. A common requirement is for a slower speed driving in one direction than in the other. This can be accomplished, without using extra gears and a clutch, by inserting a pulsing circuit into the motor feed, during operation in the slow direction.

The circuit shown runs at its rated speed in one direction when SW_2 is closed. When SW_1 is closed, however, the NC contact of the relay carries the power necessary to run the motor in the



Pulsing circuit provides dual-speed motor drive.

opposite direction. The relay, by virtue of CR_1, R_1, C_1, and its *NC* contact, oscillates.

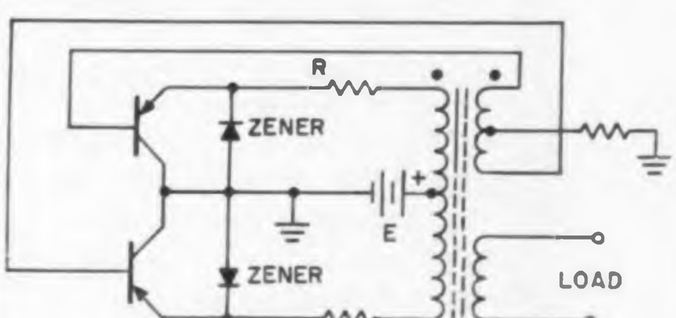
The contact, therefore, is not constantly closed but is open for a percentage of time which is determined by the component values in the oscillating network. The fact that the contact is closed only part of the time results in a slower output speed for the motor without a loss in torque. An additional switch can be used to override the feature if desired.

Louis E. Owen, Supervisor Spectrochemistry Department, Goodyear Atomic Corp., P.O. Box 628, Portsmouth, Ohio.

One of Our Figures Was Missing

The figure which should have appeared with an Idea for Design by Robert A. Durand entitled "Zener Diodes Avert Transistor Derating" (*ED*, Dec. 9, 1959, p153) was inadvertently not included with the article. The figure is shown below.

Our apologies to Mr. Durand and readers.



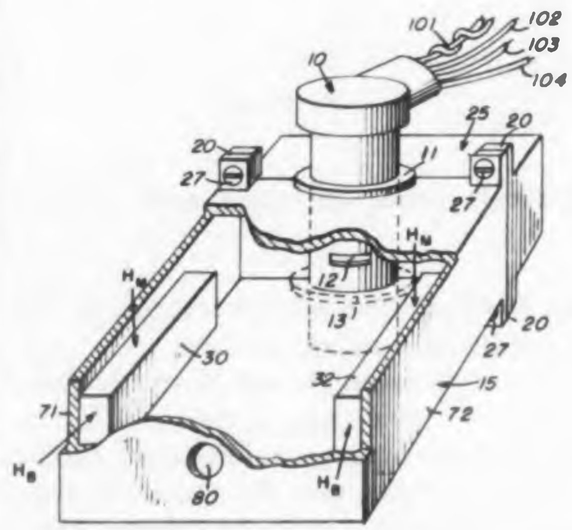
Mr. Durand's circuit showing how Zener diodes may be placed in saturating-core-type transistorized power supplies to avert the necessity for transistor derating.

PATENTS

Magnetically Tuned Klystron

Patent No. 2,897,455. George R. Jones, John C. Cacheris and Clyde A. Morrison. (Assigned to USA.)

An X-band reflex klystron may be linearly frequency-modulated to 400 megacycles with less than ±5 per cent amplitude modulation by simultaneously ferrite loading the output cavity and voltage control of the repeller.

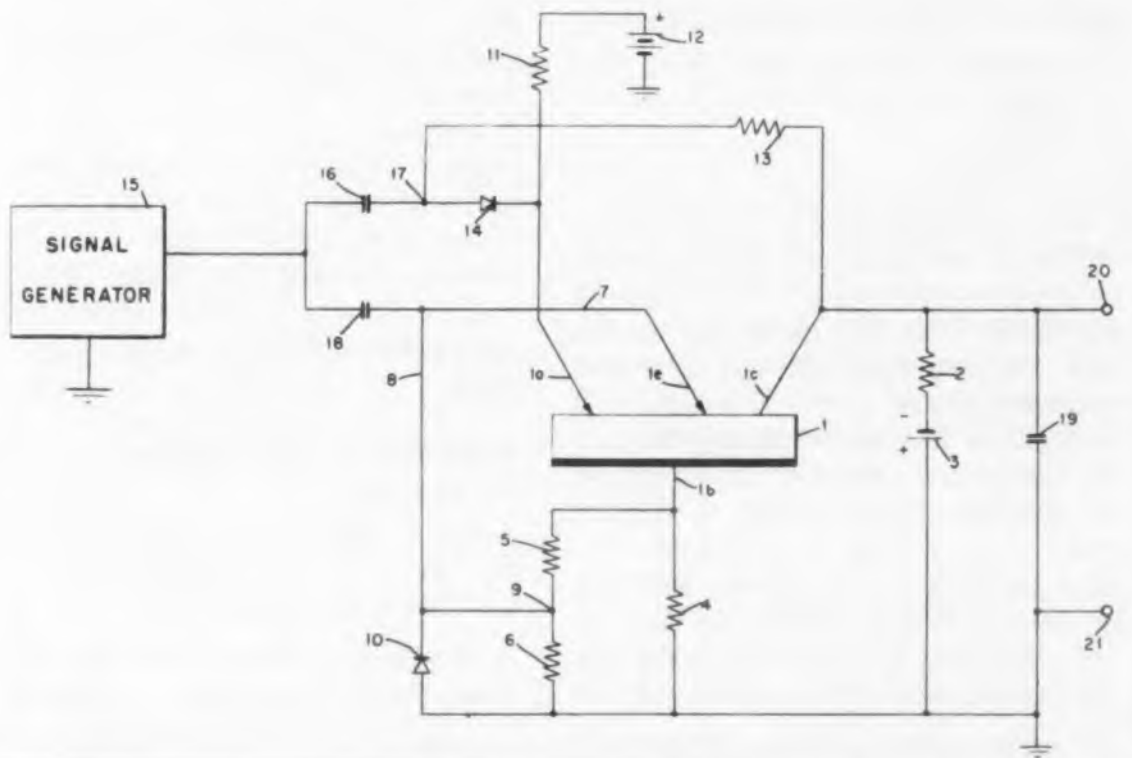


An iris, *12*, couples klystron, *10*, to a rectangular TE_{101} cavity containing ferrite slabs, *30* to *32*, adjacent the short sides. With the longitudinal biasing magnetic field H_B about 300 oersteds, the modulation develops the magnetic field H_M, about 100 to 300 oersteds, and controls the repeller voltage to frequency-modulate the klystron over the very wide range.

Binary Trigger Circuit Employing A Single Transistor

Patent No. 2,906,889. Raymond M. Emery and Robert A. Henle. (Assigned to IBM Corp.)

An auxiliary emitter transistor is applicable to a stable single-stage binary counter device. The successive responses of the circuit to positive-going pulses may be explained as follows: Initially, emitter *1e* is cut off by reason of conduction between auxiliary *1a* and the base; diode *14* is also nonconducting. A positive pulse couples through capacitor *18* to drive the emitter conducting; collector *1c* conducts to remove the bias on diode *14*. The next positive pulse passes through capacitor *16* and diode *14* to drive auxiliary *1a* harder and the base-emitter voltage increases until the transistor is restored to cutoff. Terminals *20* and *21* meter the single change in the collector in response to double change in the circuit input.



BOOKS

Handbook of Electronic Control Circuits
John Markus, McGraw-Hill Book Co., 330 West 42nd Street, N. Y. 36, N. Y., 347 pp, $8.50

This volume presents a compilation of significant industrial electronic circuits published in *Electronics* during the period 1956-1959. Over 250 electronic circuits, each complete with values of important components, are given. Included with each circuit is a concise description giving the general nature of the circuit, its performance characteristics, a detailed explanation of how it works, practical data on critical components, and suggested applications. Following each circuit description is a reference to the original source, where the engineer may obtain more details on related mechanical problems or examine graphs of performance characteristics.

The circuits are logically grouped in chapters arranged alphabetically according to function. These circuit types include: alarm, audio control, computer control, counting, magnetic amplifier, multivibrator, nucleonic, oscillator, servomechanism, and telemetering control circuits.

Pinpoint Transistor Troubles in 12 Minutes
Louis E. Garner, Jr., Coyne Electrical School, 1501 W. Congress Parkway, Chicago 7, Ill., 478 pp, $5.95

Designed specifically for the serviceman, this book presents servicing techiques for trouble-shooting various types f transistorized equipment. The princi- al chapters discuss basic test procedures, reamplifiers and hearing aids, audio mplifiers, hybrid portable, receivers, ransistorized portable and audio receiv- rs, transistorized TV sets, transmitters, verters, control and alarm systems, test nstruments, atomic radiation reactors, tc. Also included is a 50-page reference lata section, covering wave-form analysis, parameter symbols, reference tables, char- acteristic charts covering over 500 types of transistors, and an interchangeability di- rectory with over 600 transistor changes.

Connecting Induction Motors: Operation and Practice

A. M. Dudley and S. F. Henderson, Mc-Graw-Hill Book Co., 327 W. 41st St., New York 36, N. Y., 425 pp, $13.50.

This revised edition of a standard book presents an up-to-date treatment of the operation and repair of single and poly-phase induction motors.

The book covers such jobs as motor changing, winding, and connecting. It explains the principles involved in the operation and performance of the induction motor—how the input as electrical power is converted to output at the shaft in the form of mechanical power—and gives a clear picture of the rotating magnetic field. The influence of various changes in the electrical input on motor performance is described. These include voltage, phases and frequency, as well as such variations in the winding as turns per coil, coil throw, winding distribution, and type of connection. Connection diagrams for the commonly used single and two-speed windings are shown, and the 1955 standardized terminal identifications are given for single and polyphase motors.

New in the fourth edition are chapters on part-winding starting connections, single-phase connections, multispeed polyphase motors, and the use of performance characteristics information on the name plate for maximum potential use of the motor. The book includes tables of voltages showing how connections may be changed for any combination of phases and voltages, and over 400 illustrations and diagrams.

J. George Adashko

The Junction Transistor as a Current Divider
A Simple Equivalent Circuit

P. A. Popov

THIS ARTICLE develops and explains a new low-frequency transistor equivalent circuit, and derives clear, easy-to-use design formulas.

The theory of four-terminal networks, used with matrix methods, is a universal and flexible tool for designing junction transistor circuits. But from the point of view of practicing engineers, it has the shortcoming of lacking clarity. This shortcoming is shared by the transistor equivalent circuit in which one or two current or voltage generators and two or three resistors are used.

The problem of developing a simple and clear equivalent transistor circuit is far from completely solved. True, specialists, well versed in the theory and practice of semiconductor electronics, may not need such a circuit, but others do.

Current Divider Equivalent Circuit

The proposed equivalent circuit is shown in Fig. 1 for a grounded-base junction transistor. The resistances r_o, r_e, and r_c in the circuit are the base, emitter, and collector resistors. They are connected in a current-divider node.

We define a "current-divider node" as a network in which the current entering one or several branches is distributed among the remaining branches, not in inverse proportion to the resistances, but in accordance with some other definite ratio which is independent of the magnitude of the resistances.

In our case, the distribution depends on the construction of the transistor, and in the final analysis, on the laws of diffusion of the carriers in the semiconductor layers that make up the transistor.

For such a current divider node, we use the symbol enclosed in the circles on the diagrams. The arrows on the branches connected to the current divider indicate the direction of the currents, and the coefficients marked along these branches represent the fractions of the distributed current.

Naturally, the divider must obey Kirchhoff's first law: the sum of the currents entering a node equals the sum of the currents leaving the node. The second Kirchhoff law may or may not hold for circuits that include a current divider.

To show a circuit in which Kirchhoff's second law cannot be used, we can break the collector branch of the current divider in Fig. 1. We emphasize that the break in the circuit inside the circle does not mean that no current flows in that branch, but merely that Kirchhoff's second law does not hold for the loop containing this branch.

To simplify the analysis of the equivalent transistor circuit, let us determine the h parameters that characterize this circuit. The system of equation with h parameters is of the form

$$U_1 = h_{11} I_1 + h_{12} U_2$$
$$I_2 = h_2 I_1 - h_{22} U_2 \qquad (1)$$

The parameter h_{11} is obviously the input resistance of the circuit when the output terminals are short circuited. (We recall that we deal with the ac components of currents and voltages at the input and output of the circuit.)

At the same time, by applying Kirchhoff's second law to the input of the equivalent circuit (Fig. 2) at $R_L = 0$ and $r_c \gg r_o$, we can write

$$U_1 = I_1 r_e + I_1 (1-\alpha) r_o$$

from which we get for the input resistance of the transistor

$$R_{in} = \frac{U_{in}}{I_{in}} = \frac{U_1}{I_1} = r_e + r_o (1-\alpha)$$

Consequently

$$h_{11} = R_{in} = r_e + r_o (1-\alpha) \qquad (2)$$

The parameter h_{12} characterizes the influence

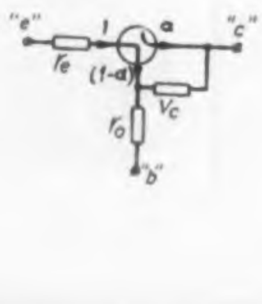


Fig. 1. A grounded-base transistor shown in its current divider equivalent circuit.

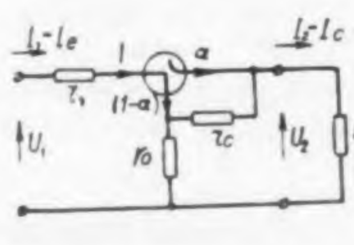


Fig. 2. The grounded-base circuit with a load.

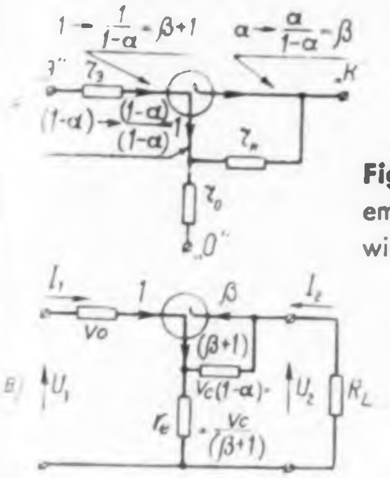


Fig. 3. The grounded-emitter circuit with and without a load.

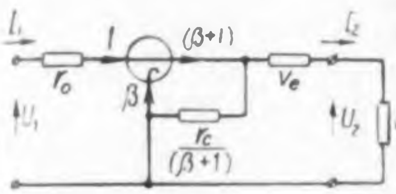


Fig. 4. The grounded-collector circuit with load.

of the output voltage on the input circuit of the transistor.

$$h_{12} = \left(\frac{U_1}{U_2}\right)_{I_1=0} = \frac{r_o}{r_e + r_c} \qquad (3)$$

The parameter h_{21} characterizes the distribution of the emitter current between the collector and the base.

$$h_{21} = \left(\frac{I_2}{I_1}\right)_{U_2=0} = -\alpha. \qquad (4)$$

[The minus sign in front of α is due to the choice of the direction of the current I_2 in the system of Eq. (1)].

Finally

$$h_{22} = \left(\frac{I_2}{U_2}\right)_{I_1=0} = \frac{1}{r_e + r_c} = \frac{1}{r_{out}}. \qquad (5)$$

is the output conductance of the transistor for open-circuited input loop.

Similar arguments can be used to express the h parameters in terms of the elements of equivalent circuits for grounded-emitter and grounded-collector circuits (Figs. 3 and 4).

Operation With Small Load Resistance

If the load resistance R_L is chosen to be many times smaller than the output resistance of the transistor ($R_L \leqq r_{out\,o} = r_o + r_c$), we can neglect the shunting effect of r_o and r_k and assume that the entire collector-branch current of the divider flows through the load resistance R_L. Taking this into account, we can readily derive an expression for the current gain (K_I), the voltage gain (K_U) and the power gain (K_P) of the circuit shown in Fig. 2:

$$K_I = \frac{I_e}{I_e} = \alpha \qquad (5a)$$

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$$K_U = \left|\frac{U_2}{U_1}\right| = \left|\frac{I_c R_L}{I_e R_{in}}\right| = \left|\alpha \frac{R_L}{R_{in}}\right| \quad (6)$$

$$K_P = K_I K_U = \alpha^2 \frac{R_L}{R_{in}} \quad (7)$$

The quantity R_{in} in Eq. (6) is the input resistance of the stage.

$$R_{in} = r_e + r_b (1-\alpha). \quad (8)$$

The current-division coefficients remain the same if the transistors are connected in a grounded-emitter circuit (Fig. 3). (These coefficients are invariants of the connection circuit, i.e., they are independent of which transistor electrode is grounded.)

In a grounded-emitter circuit the base current I_b is the control current, and should be taken as unity. For this purpose, one should divide each coefficient at the electrodes by $(1 - \alpha)$ (Fig. 3a). After this is done, and after putting

$$\frac{\alpha}{1-\alpha} = \beta \quad (9)$$

[hence, $1/(1 - \alpha) = \beta + 1$], we can obtain the fundamental relations for a grounded-emitter circuit:

$$R_{in} = r_b + r_e (\beta+1) \quad (10)$$

$$K_I = \beta \quad (11)$$

$$K_U = \left|\beta \frac{R_L}{R_{in}}\right| \quad (12)$$

$$K_P = \beta^2 \frac{R_L}{R_{in}}. \quad (13)$$

For a grounded-collector circuit (Fig. 4) we have

$$R_{in} = r_b + (r_e+R_L)(\beta+1) \quad (14)$$

$$K_I = (\beta+1) \quad (15)$$

$$K_U = (\beta+1) \frac{R_L}{R_{in}} \quad (16)$$

$$K_P = (\beta+1)^2 \frac{R_L}{R_{in}} \quad (17)$$

The simple relations in Eqs. (5) to (17) are very clear, convenient for analysis, and easy to remember. But their range of application is quite limited. They hold only when $R_L \approx 0$.

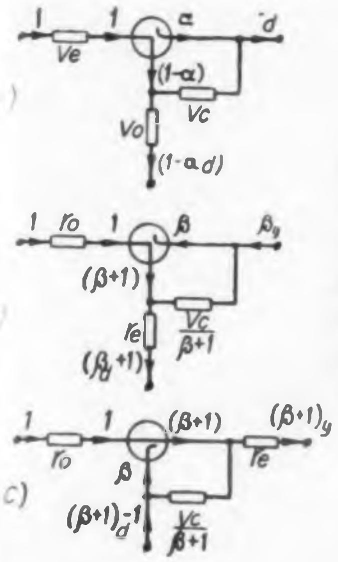

Fig. 5. Dynamic representations of the grounded-base (a), grounded-emitter (b), and grounded-collector (c) circuits as current dividers.

Operation with Arbitrary Load Resistance

As the load resistance is increased and approaches the output resistance of the transistor, the shunting action of the latter begins to manifest itself: a considerable portion of the collector-branch current is diverted into the resistances of the equivalent circuit of the transistor. This reduces the load current and changes the input resistance of the circuit.

The conventional design formulas become quite complicated in this case. However, by using an equivalent circuit with a current divider, one can simplify the design formulas for all loads, and reduce them to a form similar to Eqs. (5a) to (8) or (10) to (17).

We illustrate this with a grounded-base circuit.

Substituting the values of the h parameters, Eqs. (2) to (5), into the formula for the current gain of an active four-terminal network, expressed in terms of the h parameters, we obtain, after simple algebraic manipulations

$$K_I = \left| \frac{h_{21} Y_L}{h_{22} + Y_L} \right| = \alpha \frac{r_{out\,e}}{r_{out\,e} + R_L} \quad (18)$$

Analogously

$$R_{in} = \frac{h_{11} h_{21} - h_{12} h_{21} + h_{11} Y_L}{h_{22} + Y_L}$$

$$= r_e + r_e \left(1 - \alpha \frac{r_{out\,e}}{r_{out\,e} + R_L}\right). \quad (19)$$

$$K_U = \left| \frac{h_{21} R_L}{h_{11} + (h_{11} h_{22} - h_{12} h_{21}) R_L} \right| = \quad (20)$$

$$\left| \alpha \frac{r_{out\,e}}{r_{out\,e} + R_L} \cdot \frac{R_L}{r_e + r_e\left(1 - \alpha \frac{r_{out\,e}}{r_{out\,e} + R_L}\right)} \right|$$

where Y_L is the load admittance.

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Eqs. (18) to (20) differ from the corresponding Eqs. (5a) to (8) only in the presence of a factor $r_{out\,o}/(r_{out\,o} + R_L < 1$ in front of the coefficient α.

This circumstance makes it possible, in analogy with the dynamic parameters of vacuum tubes, to introduce the concept of the dynamic current gain α_d of a transistor.

The junction transistor as a whole can be considered as a current divider for all values of the load resistance R_L. In this case the distribution of the current among the electrodes of the transistor will be characterized, not by a static coefficient α, but by a dynamic coefficient α_d (Fig. 5).

The dynamic coefficient is always smaller than the static coefficient, and in the limit (when $R_L = 0$) the two become equal.

$$\alpha_d = K_{do}\,\alpha = \frac{r_{out\,o}}{r_{out\,o} + R_L}\,\alpha \qquad (21)$$

$$K_{do} = \frac{r_{out\,o}}{r_{out\,o} + R_L}$$

where K_{do} is the conversion factor for the grounded-base circuit.

It is important that, under this treatment, the current-division coefficients of the current-divider node remain unchanged and equal to the static values for all values of the load. At the same time, the entire transistor (looked upon from the output terminals of the emitter, collector, and base), also behaves as a current divider and at $R_L \approx 0$, the division coefficients of the entire transistor agree in magnitude with the coefficients of the divider node, and turn into the dynamic coefficients when $R_L \neq 0$.

If Eq. (21) is taken into account, Eqs. (18) to (20) become

$$K_I = \alpha_d \qquad (22)$$

$$R_{in} = r_e + r_e\,(1-\alpha_d) \qquad (23)$$

$$KU = \left| \alpha_d \frac{R_L}{R_{in}} \right| \qquad (24)$$

From Eqs. (22) and (24) we get

$$K_P = \alpha^2{}_d \frac{R_L}{R_{in}} \qquad (25)$$

Recalling that the dynamic coefficient α_d decreases as the load resistance is increased, we can readily visualize the dependence of the quantities K_I, R_{in} and K_U on the load resistance R_L, as well as their possible limiting values.

Investigating the properties of a grounded-emitter stage, we obtain

$$K_I = \beta_d \tag{26}$$

$$R_{in} = r_o + r_e\,(\beta_d + 1) \tag{27}$$

$$K_U = \left| \beta_d \frac{R_L}{R_{in}} \right| \tag{28}$$

$$K_P = \beta^2_d \frac{R_L}{R_{in}} \tag{29}$$

$$\beta_d = K_{de}\,\beta \tag{30}$$

$$K_{de} = \frac{r_{out\ e}}{r_{out\ e} + R_L} \tag{31}$$

where $r_{out\ e}$ is the output resistance of the transistor with the base circuit open (i.e., the resistance between the emitter and the collector of the transistor is infinite). It follows from the equivalent circuit (Fig. 3) that

$$r_{out\ e} = r_e + r_c\,(1-\alpha) = r_e + \frac{r_c}{\beta + 1} \tag{32}$$

It can be shown that for a grounded-collector stage the following relations are true

$$K_I = (\beta + 1)_d \tag{33}$$

$$R_{in} = r_o + (r_e + R_L)\,(\beta+1)_d \tag{34}$$

$$K_U = (\beta+1)_d \frac{R_L}{R_{in}} \tag{35}$$

and

$$K_P = (\beta+1)^2_d \frac{R_L}{R_{in}}. \tag{36}$$

The symbol $(\beta + 1)_d$ will be called the dynamic gain of the stage, to distinguish it from the static gain $(\beta + 1)$. Here

$$(\beta+1)_d = K_{dc}\,(\beta+1) \tag{37}$$

$$K_{dc} = \frac{r_{out\ e}}{r_{out\ e} + R_L} = K_{de} \tag{38}$$

Determining the Parameters

At the beginning of the article we determined the h parameters from the equivalent circuit of the transistor.

In practice, obviously, the inverse problem is to be solved: determine the parameters of the equivalent circuit with the current divider from the known h parameters of the transistor. This can be done as follows: From Eqs. (3) and (5) we get

$$r_e = \frac{h_{12}}{h_{22}} \tag{39}$$

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from (4)

$$\alpha = -h_{21}, \tag{40}$$

from (5)

$$r_{out\,e} = \frac{1}{h_{22}} \tag{41}$$

from (2)

$$r_b = h_{11} - r_e\,(1-\alpha). \tag{42}$$

In using the given formulas for circuit design, it must be borne in mind that the parameters of the equivalent circuit with current divider are subject to the same limitations as the h parameters: the measured (or calculated) values of the parameters hold only for a specified position of the operating point (U_{ce} and I_c) of the junction transistor.

The equivalent circuit with current-divider can be used also to determine the dc operating conditions of the stage. It is merely necessary to put $r_c = \infty$, and to take into account the inverse collector current.

Typical Calculation

Let us calculate the voltage gain of the circuit shown in Fig. 6, in which transistors type P6A are used.

The parameters of each transistor are

$$h_{11} = 40 \text{ ohms}; \; h_{12} = 4 \times 10^{-4};$$

$$h_{21} = 0.92; \; h_{22} = 2 \times 10^{-6} \text{ mho}.$$

1. We determine the parameters of the equivalent circuit with current divider

$$r_e = \frac{h_{12}}{h_{22}} = \frac{4\,(10)^{-4}}{2\,(10)^{-6}} = 200 \text{ ohms}$$

$$r_{out\,e} = \frac{1}{h_{22}} = \frac{1}{2\,(10)^{-6}} = 500 \text{ K}$$

$$\alpha = -h_{21} = 0.92$$

$$\beta = \frac{\alpha}{1-\alpha} = \frac{0.92}{1-0.92} = 11.5$$

$$r_b = h_{11} - r_e\,(1-\alpha) = 40 - 200\,(1-0.92)$$
$$= 24 \text{ ohms}$$

$$r_{out\,c} = r_b + \frac{r_c}{\beta+1} = 24 + \frac{500\,(10)^3}{11.5+1}$$
$$\approx 40\,(10)^3 \text{ ohms}$$

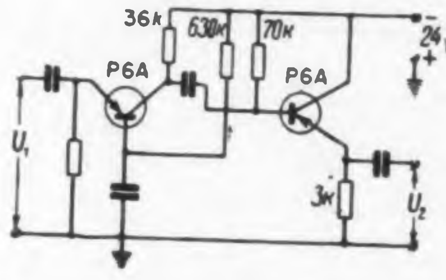


Fig. 6. A two-stage amplifier used for the typical calculations.

2. $$K_{dc\,2} = \frac{r_{out\,e}}{r_{out\,e} + R_L} = \frac{40(10)^3}{40(10)^3 + 3(10)^3} = 0.93$$

$$(\beta+1)_d = K_{dc}\,(\beta+1) = 0.93\,(11.5+1) = 11.6$$

$$R_{in\,2} = r_b + (r_e + R_L)\,(\beta+1)_d = 200 + [24 + 3\,(10)^3]\,(11.6) = 35.2\text{ K}$$

3. $$R_{L1} = \frac{R_{c1}\,R_{e2}\,R_{in\,2}}{R_{c1}\,R_{e2} + R_{c1}\,R_{in\,2} + R_{e2}\,R_{in\,2}} = \frac{36(70)\,(35.2)}{36(70) + 36(35.2) + 70(35.2)} = 14.2\text{ K}$$

$$K_{de\,1} = \frac{r_{out\,e}}{r_{out\,e} + R_L} = \frac{500(10)^3}{500(10)^3 + 14.2(10)^3} \approx 0.975$$

$$\alpha_d = K_{de\,1}\,\alpha = 0.975\,(0.92) = 0.895$$

$$R_{in\,1} = r_e + r_b\,(1-\alpha_d) = 24 + 200\,(1-0.895) = 45\text{ ohms}$$

$$KU = \frac{U_2}{U_1} = \alpha_d\,\frac{R_{L\,1}}{R_{in\,2}}\,(\beta+1)_d\,\frac{R_{L\,2}}{R_{in\,1}} = 0.895\left(\frac{14.2}{35.2}\right)\left(11.6\right)\left(\frac{3(10)^3}{45}\right) = 276.$$

In the last equation, the factor R_{L1}/R_{in2} defines the distribution of the collector current of the first transistor among the resistances R_{c1}, R_{e2}, R_{in2}, in inverse proportion to the magnitudes of the latter.

It follows from the example that the computation labor is less than that required by the matrix method. At the same time, the simplicity and clarity of the formulas, as well as the close relationship between them and the physical processes in the transistor, are advantages of the proposed method.

(*Translated from Junction Transistor as a Current Divider, in the September 1959 issue of* Elektrosvyaz).

GERMAN ABSTRACTS

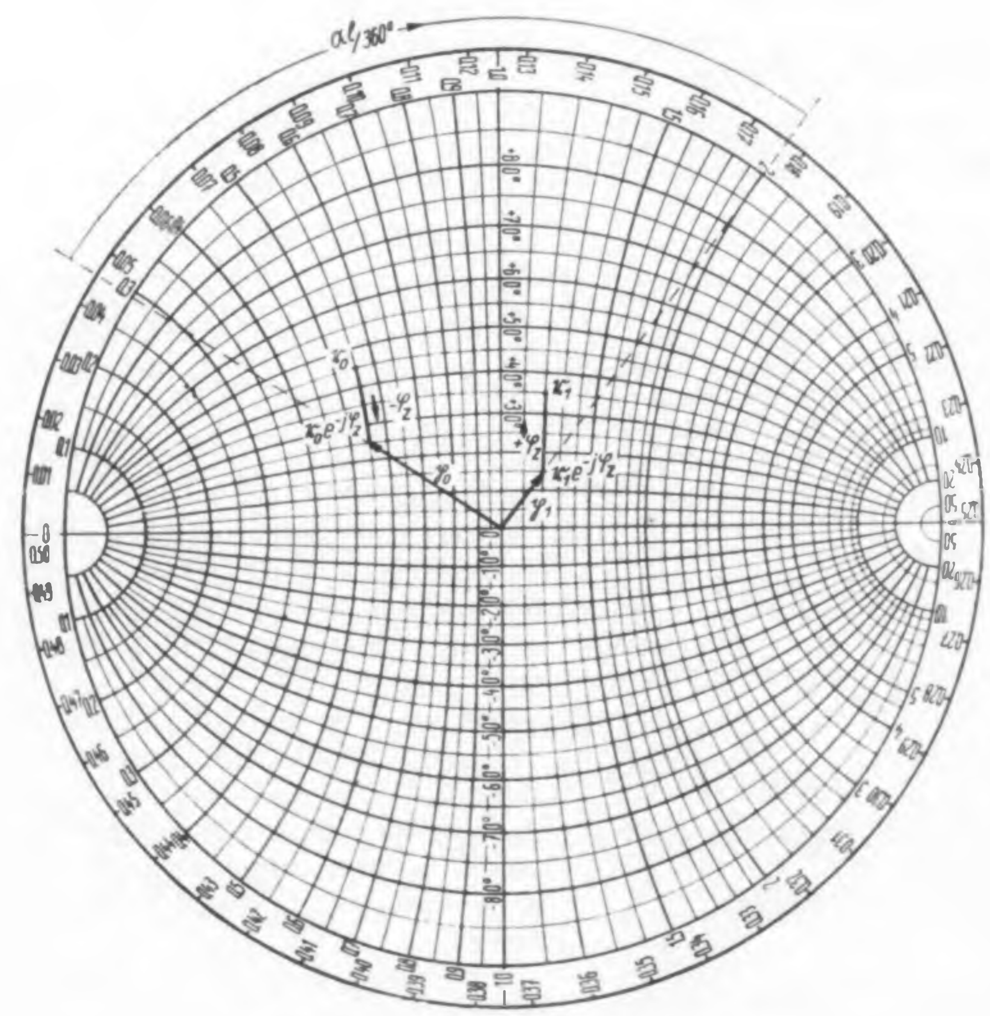
E. Brenner

Graphical Calculations with Lo

LOSSY transmission lines are defined through a complex characteristic impedance Z_o and a complex propagation constant $\gamma = \alpha + j\beta$. For a line of length d terminated in an impedance Z_R, the reflection coefficient at the load terminals is

$$\Gamma_R = \frac{Z_R\, e^{-j\,\phi_Z} - 1}{Z_R\, e^{-j\,\phi_Z} + 1}$$

where Z_R is the complex impedance of the termination, normalized with respect to the magni-



Example of use of Smith chart for lossy line.

...ith Lossy Lines

...ude of the characteristic line impedance and ϕ_Z ...s the angle of the characteristic impedance.

The reflection factor at the input terminals, Γ_1 ...s given by

$$\Gamma_1 = \Gamma_R \, e^{-2(\alpha + j\beta)\, d}$$

...o that the driving point impedance of the line Z_i is defined through

$$\Gamma_1 = \frac{Z_1 \, e^{-j} \, \phi_Z - 1}{Z_1 \, e^{-j} \, \phi_Z + 1}$$

...where Z_i is the complex point impedance, ...normalized with respect to the magnitude of Z_o.

Manipulations involving the above equations ...an be carried out graphically with the aid of the ...mith chart (Γ-plane) if the chart is drawn with ...he magnitude (Z)—angle(Z) circles (rather than ...$Re(Z)$, $Im(Z)$ circles as is usual). On the chart, ...ig. 1, the concentric $|\Gamma|$ circles are omitted as ...s usual.

The chart may be used as follows: Given the ...omplex Z_R, normalize with respect to the magni...ude of Z_o and locate this point on the chart. Now ...move on a $Z =$ *constant circle by* $-\phi_Z$. The vector ...rom the origin to this point is the receiving end ...eflection coefficient. The magnitude of Γ_1 is now ...ound from

$$|\Gamma_1| = |\Gamma_R| \; e^{-2\alpha d}$$

...nd the vector Γ_R, reduced to the magnitude of Γ_1 is rotated clockwise through the angle which ...orresponds to d (in wavelengths). The value of Z_i is now found by adding the angle ϕ_Z (moving ...n a $Z =$ constant circle). When the magnitude ...f the reflection coefficient exceeds unity (as may ...e the case for lossy lines) the chart is used with ...he reciprocal value, $1/\Gamma$.

Abstracted from an article by K. E. Mueller, Ho...hfrequenztechnik und Elektroakustik, *Vol. 68, No. 2, July 1959, pp 61-64.*

(Continued on following page)

Echostant Matching

ECHOSTANT matching is a new method for matching image parameter filters to a resistive load. The match achieved is superior to that obtained with simple m-derived termination and requires fewer circuit components than does the double m-derived termination. The term "echostant" is a contraction of the phrase "echo constant" and is used because the method requires minimizing an image reflection factor over the passband.

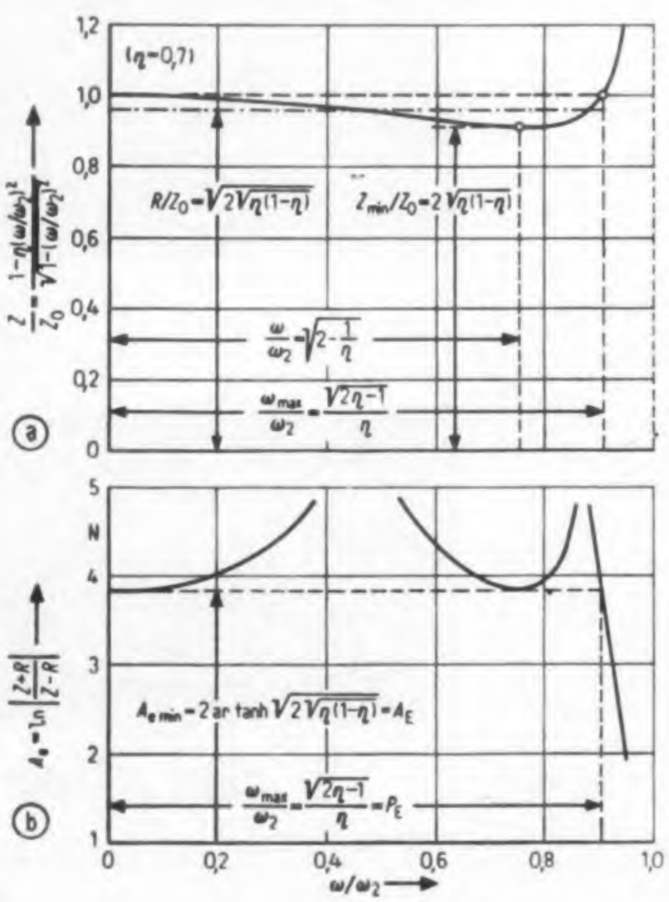


Fig. 1. Image impedance and image reflection function for a low pass m-derived image parameter filter.

In view of frequency inversion and low-pass bandbass translation methods, the discussion of the low pass design is sufficient. For a simple m-derived low-pass filter, the image impedance as a function of frequency is given by

$$\frac{Z}{Z_0} = \frac{1 - \eta\,(\omega/\omega_2)^2}{[1 - (\omega/\omega_2)^2]^{1/2}}$$

where ω_2 is the angular cut-off frequency and η i a parameter. A typical graph ($\eta = 0.7$) is shown i Fig. 1. When terminated in a resistance whose n merical value is the geometric mean of Z_{min} a d $Z(0)$, the effective passband is defined as P_E, so that the absolute deviation (Z-R) is the s me as at $Z = Z(0)$ and $Z = Z_{min}$.

The image reflection function A_e is defined through the equation

$$A_e = \ln \left| \frac{Z + R}{Z - R} \right|$$

so that the quality of the match improves as $A_{emin} = A_E$ increases if P_E has the largest possible values.

The principle of the echostant match is indicated in Fig. 2. The filter to the left of I is reflection-free and the "displaced" image matched sections are added. If Z_{in} is approximately the same as Z_o, then the image reflection function A_e is approximated by

$$A_e \approx ln \left| \frac{2}{ln\,(Z_{in}/Z_o) + \alpha} \right|$$

The impedance Z_{in} is given for

$$Z_{in}/Z_o \approx 1;\ \Delta \ll 1;\ \delta \ll 1;\ \epsilon \ll 1$$

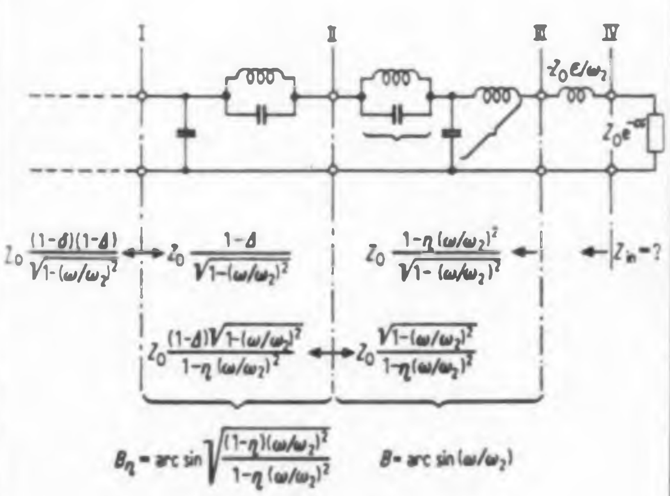


Fig. 2. Echostant matching.

approximately by

$$ln\,(Z_{in}/Z_o) + \alpha \approx \left[\alpha + ln\left(\frac{1-\eta}{\cos B} + \eta \cos B\right)\right]$$

$$- \Delta \cos 2B - \delta \cos 2(B_\eta + B$$

$$+ j\,[\Delta \sin 2B + \delta \sin 2(B_\eta + B) - \epsilon \sin B]$$

where B is defined as shown in Fig. 2. The method of least mean squared error is used to maximize A_E and P_E.

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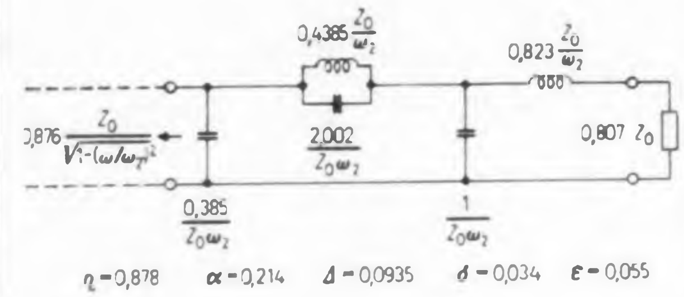


Fig. 3. Complete design of Echostant matched low pass filter.

Optimum match is obtained for $\eta = 0.878$ corresponding to $P_E = 98.25$ per cent and $A_E = 3$ nepers. A filter designed in this manner is shown in Fig. 3. In the final design, the two tank circuits in series and the two inductances in series have been combined into single branches.

In the original paper the attenuation in the stop band, the simulation of Tchbycheff behavior by means of double ended echostant matching, as well as compensation of losses are discussed.

Abstracted from an article by T. Laurent, Archiv der Elektrischen Uebertragung, *Vol. 13, No. 3, March 1959, pp 132-140.*

A Flat Beam Electron Gun

TO ACHIEVE a flat electron beam of maximum thickness $2b$ (Fig. 1) and maximum possible length L, the beam entering the field free region must have a certain convergence angle γ. Because of the lens action of the anode slit, the convergence angle Θ within the electron gun always exceeds γ.

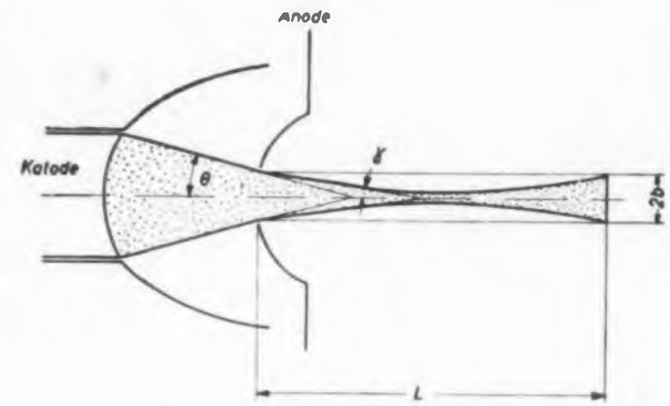


Fig. 1. "The flat beam gun"

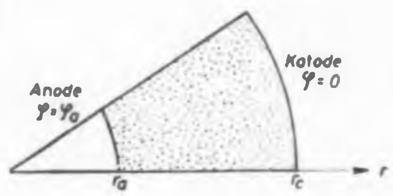


Fig. 2. Sector of cylindrical diode

The geometry of the focusing electrode is calculated by using the solution of Poisson's equation for a sector of a cylindrical diode (Fig. 2) under space charge conditions and matching the solution to a solution of Laplace's equation in the charge free region. The calculated result as well as a shortened design obtained by electrolytic trough is shown in Fig. 3.

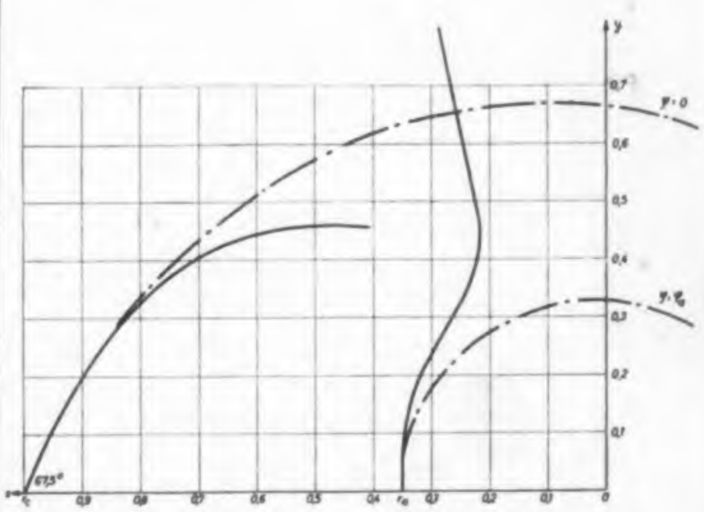


Fig. 3. Foaming electrode. The dashed curve is obtained by analytic solution, the solid line represents the shortened form obtained from the electrolytic trough.

Using certain simplifying approximations (e.g., $\tan\gamma = \gamma$), the optimum design is obtained for

$$\Theta = 2.4\gamma;\ r_c = 2.84\ r_a$$

resulting in

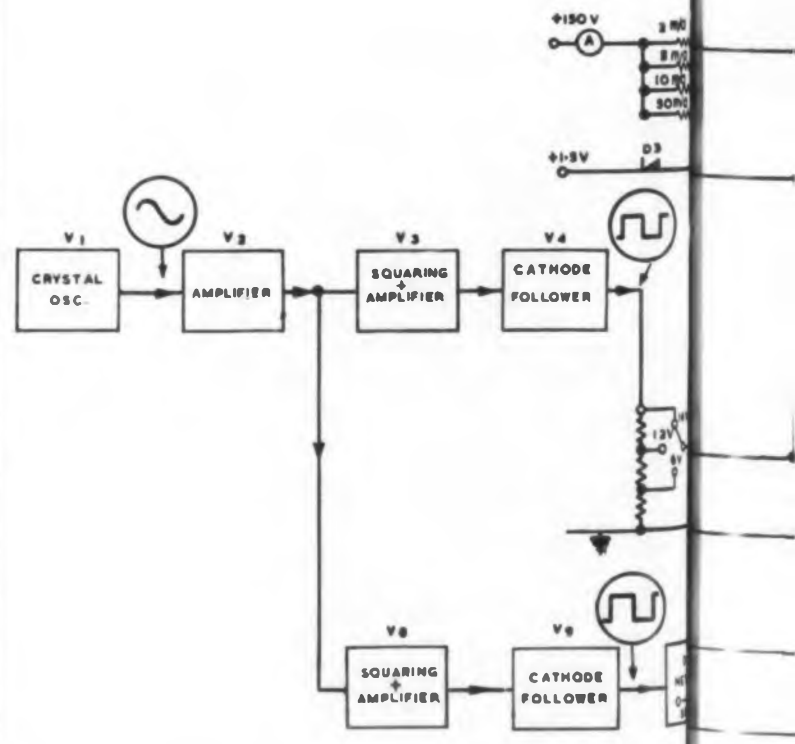
$$\Theta^2 = 0.55 \times 10^{-6}\ b\ I/LV^{3/2} \text{ mks units}$$

Abstracted from an article by G. Bolz, Nachrichtentechnische Zeitschrift, *Vol. 12, No. 9, September 1959, pp 464-466.*

Circuit Measures Effect of Diode Recovery Time

TO THE CIRCUIT designer, the effect of hole storage is that it implies a finite time for a diode to recover to an acceptable value of reverse resistance after being switched from the on to the off state. This can be troublesome in a number of applications, but is particularly so when considering the design of high-speed pulse systems. If such pulses are themselves modulated, the problem becomes more acute since the diode switching characteristics can introduce unwanted crosstalk into the system. The effect of hole storage on cross-talk depends on the circuit conditions, i.e., the magnitudes of current and voltage

Fig. 1. Block schematic diagram of the test equipment, including relevant waveforms and details of the test diode circuit.

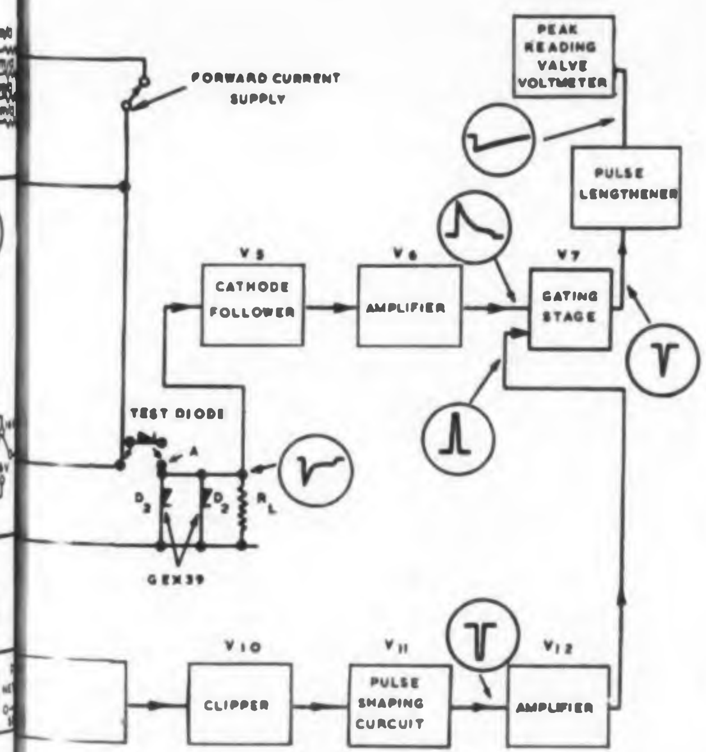


used, and on the pulse spacing. Therefore it is important to know the state of a diode at some predetermined time after switch-off. A measuring equipment has therefore been designed which will provide the required information for a number of preselected values of diode mean forward current and applied reverse voltage.

A diagram of the equipment, showing relevant waveforms and details of the test diode circuit, is shown in Fig. 1.

After passing a known forward current, the diode under test is reverse biased by the application of a voltage pulse of preselected amplitude which has a fall time not exceeding 50 mμsec. This is produced in the form of a square wave having a period of approximately 3 μsec. The diode is then allowed to recover to its steady-state reverse current. The resultant reverse current waveform is amplified by stages V_5 and V_6 and then sampled at periods from 0.1 μsec to 1 μsec in 50-mμsec steps by the use of a gating stage V_7. The sampled waveform is finally applied to a peak reading instrument which is calibrated as follows.

The recovery waveform of the test diode is examined with the aid of a Tektronix type 545 oscilloscope connected between point A and ground. By measuring the magnitude of the reverse voltage at the test point A at the time corresponding to the position of the sampling pulse, the reading on the output valve voltmeter may be calibrated in units of reverse resistance. A typical



DIGEST

calibration curve obtained for the equipment is shown in Fig. 2.

The most important design features of the equipment may be summarized as follows. The sampling pulse is produced by means of a ringing choke circuit in the anode of the tube V_{11}, the unwanted half-cycle of oscillation being damped-out by means of a shunt diode. The timing is varied by passing the square wave from which the sampling pulse is derived through a tapped delay line between stages V_9 and V_{10}.

The recovery waveform depends not only on the

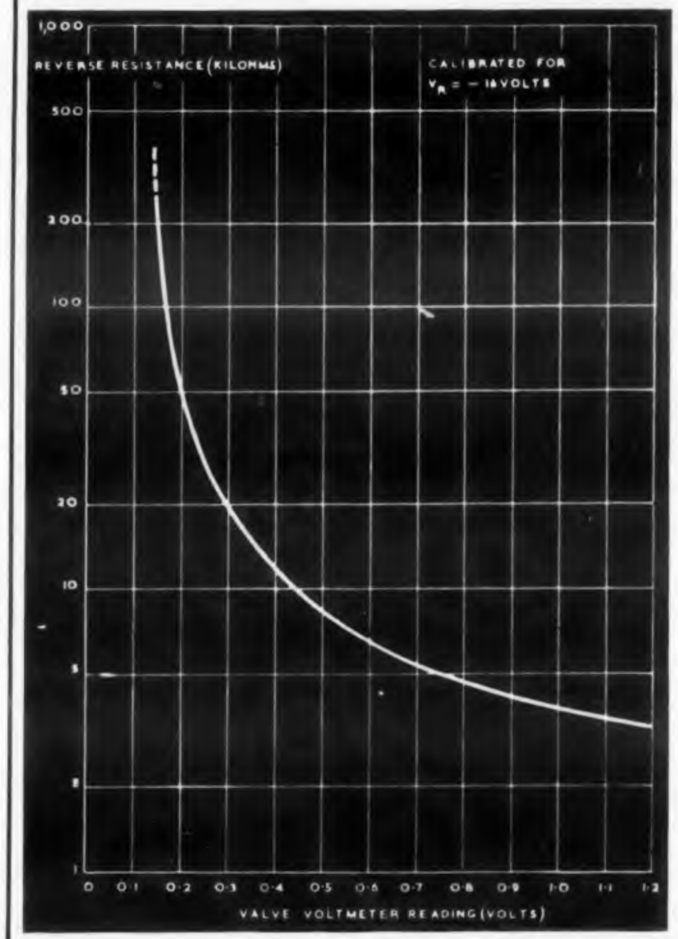


Fig. 2. A typical calibration curve obtained for the measuring equipment.

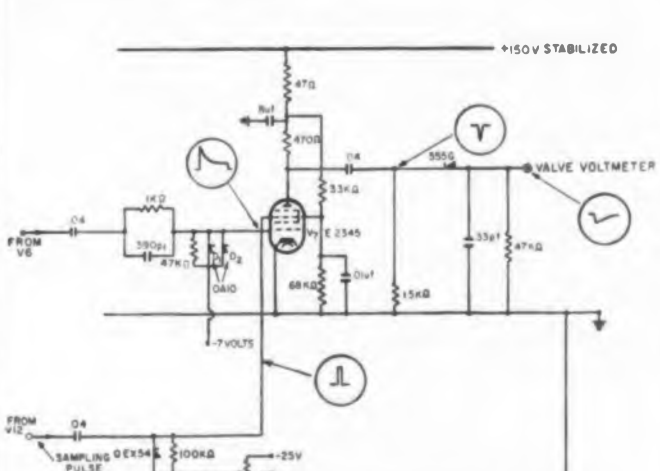


Fig. 3. Gating stage circuit diagram.

values of forward current and reverse voltage used, but also on the value of load resistance R_L, Fig. 1. The value of the latter will normally be chosen according to the particular circuit conditions of interest. It is important to note that the clamp diodes D_2, Fig. 1, are chosen to have very little hole storage; they should attain a reverse resistance value which is high compared with the load in a time not greater than 50 mμsec. They should therefore be preferably fast point-contact diodes; in practice Type GEX39 was used.

Another clamp diode D_3 is used in order to minimize variations in forward voltage drop when different types of diodes are being tested.

The stages V_5 and V_6 following the test diode form a wideband amplifier which has a bandwidth to the 3-db point of 20 mc. Its overall gain need not be very high; in practice it was made 10 db.

To avoid unwanted dc shifts occurring with different recovery curves, the amplifier is ac coupled throughout and uses an efficient dc restoring circuit at the grid of the gate V_7. This is shown in detail in Fig. 3. The negative potential to which the clamping diodes D_1 and D_2, Fig. 3, are returned is sufficient to give essentially linear amplification by the preceding stage, and avoids break-through of the peak of the recovery waveform into the output measuring circuit. If diodes having relatively long hole storage times are to be tested, the action of the dc restoring circuit can be made relatively independent of the recovery waveform by increasing the period of the test square wave, e.g. to 10 μsec.

The output circuit is arranged to give a value voltmeter reading which is proportional to the amplitude of the output pulse appearing at the anode of V_7. The negative bias applied to the sampling grid of V_7 can be adjusted by means of potentiometer VR_1 so as to eliminate the effect of any residual breakthrough via the anode to grid capacity of valve V_7.

Practical Results

The equipment described has been successfully used for measuring the reverse switching characteristics of a number of different types of semiconductor diode, e.g. germanium point contact and germanium gold-bonded diodes, also germanium and silicon junction types. The upper resolution limit of the equipment corresponds to a reverse resistance of about 200 kilohms. It has also been possible by means of this equipment to select diodes to provide a given level of adjacent channel cross-talk in time division multiplex pulse systems of the type previously described.

Abstracted from British Communications and Electronics, *Vol. 6, No. 11, November 1959, The Measurement of Semiconductor Diode Switching Characteristics by J. N. Barry and S. F. Fisher.*

REPORT BRIEFS

Wide-Range Multiple-Pulse Amplifier

A new negative-pulse amplifier circuit capable of amplifying multiple-pulse code groups and suitable for use in crystal video receiver design is presented together with the results of an experimental study of the performance obtained in both single-stage and multiple-stage versions. Measurements on a four-stage amplifier employing two 12AT7 and two 5814 dual triodes revealed the following capabilities: (a) 90-db voltage amplification of negative one-microsecond pulses without amplifier instability or appreciable pulse distortion, (b) multiple-negative-pulse-group amplification without appreciable recovery problems regardless of pulse separation in time, and (c) a usable dynamic range of 70 db or greater as a negative-pulse amplifier. When used in conjunction with a conventional S-band crystal video detector, a usable dynamic range of 40 db or greater was achieved with automatic limiting of all signals greater than —37 dbm, pulse reproduction and sensitivity depending mainly on characteristics of the crystal detector used. *A Wide-Range Multiple-Pulse Amplifier, R. E. Koncen, Naval Research Laboratory, Washington, D. C., June 29, 1959, 25 pp, Microfilm $2.70, Photocopy $4.80. Order PB 138044 from Library of Congress, Washington 25, D. C.*

High-Loss Ferromagnetic Materials

Prototype models of air-cooled dummy loads utilizing high-loss ferromagnetic materials as the dissipative element have been produced for several radar bands. It is characteristic of these thin ferromagnetic dissipative elements that their efficiency as dummy load material is almost constant as the frequency of operation is decreased. Copper fins 2 in. high and 1/32 in. thick were silver-soldered 3/4 in. apart on a 40-in. section of L-band rectangular waveguide. Thin layers of ferrite powder in silicone resin were properly applied to the inside walls to make a load capable of dissipating 10 kw of average power. The total weight of the load was 63 lb. Lithium ferrite was used to make a dissipative element for constructing an X-band dummy load capable of operating at temperatures well above those presently allowed. Thin strips of high-loss ferromagnetic material were placed on the narrow walls of X-band waveguide in order to make a variable attenuator with low insertion loss. *Waveguide Dummy Loads And Attenuators Utilizing High-Loss Ferromagnetic Materials, W. H. Emerson, R. W. Wright and others, Naval Research Laboratory, Washington, D. C., June 18, 1959, 27 pp., $0.75. Order PB 151637 from OTS.*

RF Energy In Millimeter Wavelength Range

The results of a survey of the literature on millimeter wavelength devices is presented. The high frequency limit for most conventional sources is in the range from 3 mm to 1 mm. Harmonic generators of several types are discussed. A detailed analysis of a velocity variation harmonic generator is followed by a preliminary analysis of frequency multipliers based on field emission and on the failure of Ohm's law in semiconductors. The feasibility of obtaining sub-millimeter waves from the radiation of electrons in a high magnetic field is also investigated. *Research On Physical Limitations On Production And Use Of RF Energy In Millimeter Wavelength Range, M. O. Thurston and W. H. Cornetet, Jr., Ohio State University Research Foundation, Columbus, July 1958, 61 pp, Microfilm $3.90, Photocopy $10.80. Order PB 139464 from Library of Congress, Washington 25, D. C.*

Power Distributed Amplifier

This report presents the results of an investigation into means of increasing the frequency capabilities of power distributed amplifiers. The design, physical construction, and electrical characteristics of a 6-tube 4X150A distributed amplifier and a 6-tube 4X250B distributed amplifier are described. These amplifiers demonstrate experimentally the validity of the theory of distributed amplifiers using dummy constant-k line sections between tubes. The amplifiers have upper cutoff frequencies in the neighborhood of 450 mc and useful output power capabilities. The output power capability is, however, a function of the duty cycle at which the amplifier is operated. *The Design and Measured Characteristics of 450 Mc Power Distributed Amplifier, D. Hamburg, Michigan University, Ann Arbor, Michigan, July, 1957, 31 pp., Microfilm $3.00, Photocopy $6.30. Order PB 139442 frfom Library of Congress, Washington 25, D. C.*

Silicone Insulated Cables

Representative specimens of electric cables utilizing silicone compounds as primary insulation were subjected to laboratory conditions simulating a fairly severe shipboard fire and subsequent extinction with salt water fog. A majority of the specimens sustained their rated operating voltage throughout the period of exposure to fire and subsequent salt water fog. *Effect of Combined Fire and Water On Silicone Insulated Cables, A. M. Deleeuw, Material Laboratory, New York Naval Shipyard, Brooklyn, New York, Feb. 20, 1959, 9 pp., $0.50. Order PB 151751 from OTS, Washington 25, D. C.*

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REPORT BRIEFS

Trough Waveguide Antennas

Line source radiators of the leaky wave type may be constructed readily with trough waveguide, which consists of a rectangular trough containing a symmetrically located center fin. Two types of such radiators are investigated: a continuously asymmetrical form suitable for near end-fire radiation, and a periodically asymmetrical design permitting radiation through broadside. The propagation characteristics of the leaky wave on the continuously asymmetrical structure are determined theoretically by means of a transverse resonance procedure, and comparison is made with measured values. The influence of finite center fin thickness is also accounted for. Designs and radiation patterns are presented for a typical antenna of each type. *Asymmetrical Trough Waveguide Antennas, W. Rotman and A. A. Oliner, Microwave Research Institute, Polytechnic Institute of Brooklyn, N. Y., June 18, 1958, 39 pp., Microfilm $3.00, Photocopy $6.30. Order PB 137483 from Library of Congress, Washington 25, D. C.*

Portable Frequency Standard

This report covers the development of a portable frequency standard utilizing a change-of-state oven for temperature control of a 5-mc quartz crystal. The crystal oscillator, buffer, and output stages are transistorized and powered by self-contained mercury batteries. Everything but the power source for the change-of-state oven heater is contained in a module with nominal dimensions of 3-1/2 in. x 4-1/2 in. x 6 in. and a total volume of 94-1/2 cu in. *Development of a Transistorized Portable Frequency Standard, R. L. Craiglow and J. P. Frederichs, Collins Radio Co., Cedar Rapids, Iowa, July 9, 1956-Nov. 1, 1957, 59 pp, Microfilm $3.60, Photocopy $9.30. Order PB 142632 from Library of Congress, Washington 25, D.C.*

Microwave Switch

The objectives of the project were to investigate techniques for the development, design and fabrication of a high power magnetic-field controlled gas discharge microwave switch for operation at S-band and to deliver three laboratory model switches and one electromagnet and power supply for switching control. *High Power Microwave Switch, S. J. Tetenbaum, Microwave Physics Lab, Sylvania Electric Products, Inc., Mountain View, Calif., Feb. 9, 1959, 14 pp, Microfilm $2.40, Photocopy $3.30. Order PB 142762 from Library of Congress, Washington 25, D.C.*

Electric Circuits and Synchros

Certain definitions, properties, and theorems regarding matrices and determinants are presented here as a necessary preliminary to the formulation of electric circuit and synchro performance equations in matrix notation. In general, properties and theorems are presented without proofs. Attempts have been made to illustrate various points through simple examples so that the reader can gain some familiarity with the notation and the mechanics of matrix operations as a convenient tool. Those interested in pursuing further study of the formal theory of matrices can find many good references on the subject, some of which are listed in the bibliography. *Matrices and Linear Transformations with Applications to the Analysis of Electric Circuits and Synchros, James B. Ward, Naval Avionics Facility, Indianapolis, Ind., June 15, 1957, 101 pp, Microfilm $5.70, Photocopy $16.80. Order PB 142495 from Library of Congress, Washington 25, D.C.*

Switching Transistors

Germanium pnp power transistors of 0.5 C/watt thermal resistance, H_{fe} current gain of 20 minimum at collector currents of 25 amp with saturation resistance of 20 milliohms maximum, rise, fall, and storage times of 15, 7, and 15, respectively, have been constructed. *Research and Development of Germanium pnp Junction Switching Transistors, Paul L. Meretsky, Clevite Transistor Products, Waltham, Mass., Dec. 9, 1958, 24 pp, Microfilm $3.60, Photocopy $4.80. Order PB 142760 from Library of Congress, Washington 25, D.C.*

Microwave Electronics

Noise measurements are described on a backward-wave amplifier with movable gun-circuit spacing in order to study the space-charge waves in their coupling to the backward-wave circuit. Theory of the effect of a virtual cathode is discussed. Design and construction of a diode for measuring noise effects in the gun region are also described. A solid-state maser using adiabatic fast passage in irradiated magnesium oxide is described. Theories of the effect of radiation damping on the adiabatic fast passage are given. Studies on the entrance conditions into a periodic focusing system for electron beams are described, and a unified point of view toward all focusing systems is also presented. *Basic Research in Microwave Electronics, J. R. Singer, C. Susskind and others, Electronics Research Lab, University of California, Berkeley, Calif., Oct. 1, 1957-Sept. 30, 1958, 30 pp, Microfilm $2.70, Photocopy $4.80. Order PB 142564 from Library of Congress, Washington 25, D.C.*

LETTERS

Uniterm Improved? Pro and Con

Dear Sir:

I read Mr. Meisters account of his modification of the Uniterm system, ELECTRONIC DESIGN, August 5, 1959, p56. The conventional Uniterm method has a certain amount of ambiguity to it (i.e., if indexing a transistor power supply, one would also draw cards to indicate the existence of power transistors). The system proposed in the article seems to have even more ambiguity however.

The author did not explain how one prevents the card used in the example from dropping out for any two or three word combination of the following eight words: TIME, CARBON, MOTOR, SILVER, DELAY, BIPOLAR, SPRING, RELAY. (A ninth word was missing from the card.)

The author says "The only limitation to the proposed plan . . . is the number of uniterms . . . " The fact that the Uniterm method has no limitation on the number of terms, or categories, is the feature that sets it apart from conventional filing systems.

The proposed system, with its built-in limitation might function more effectively if, instead of uniterms being used, the author chose to make his categories more specific. In this way he might avoid the necessity of providing such a large number of index points per card.

We have found that for general mechanical or electronic (not both in the same system) engineering files about 1000 uniterms are needed to index about that many engineering reports. As is characteristic of the system, the number of uniterms does not decrease nor increase as rapidly as the number of items indexed.

A good review of currently available methods is given by Casey, et al., in their PUNCHED CARDS published by Reinhold in 1958.

H. Bruce McFarlane, Engineer
University of California
Electronics Engineering Dept.
Livermore, Calif.

Dear Sir:

In the August 5th issue, Mr. Jack B. Meister discussed the use of edge-notched cards for implementing the Uniterm file system. For the most part, the article is entertaining and useful. The last part, "Coding Increases Capacity," is solely entertaining.

Mr. Meister may have put into practice the simple system he describes in the early parts of the article. He obviously has not attempted to implement the ideas suggested in the last part. In his example, in addition to extracting all cards keyed for "Time Delay Relay," he also will extract cards keyed for "Silver Spring Motor," "Bipolar Motor," and the rest of the possible combinations of descriptive terms that would cause the same notches to be cut.

In any event, the procedure of taking three passes, that is described in the last two paragraphs results in the same effect as doing the whole job in one combined pass.

Except for this minor extension of his article beyond the rim of his knowledge, Mr. Meister has described a very useful application of edge-notched cards.

M. L. Aitel, Engineer
RCA Missile and Surface Radar Div.
Building 108-129
Moorestown, N.J.

Dear Sir:

Mr. Aitel is quite right; a single pass is the equivalent of the multiple passes described in the last paragraph of my article. As he points out if there were an article entitled "Silver Spring Motor" it would also be selected. "Bipolar Motor" would not since this card would not be punched in the "list two" hole and the rod inserted through this hole would block it.

I do believe that in calling for the title of a particular article, in which the uniterms are related in a very special way, that the situation would often be encountered where the random grouping of words in the other lists would correspond to an article in the file. I have not had enough experience with the coded system to know what percentage of the time this would occur. The fact that one pass is sufficient to extract the desired cards, in my opinion, enhances the value of coding.

With respect to the limitation of the number of uniterms, the system was intended to catalog items in a particular field of interest and I readily admit that there are occasions where it may not be usable in its present form.

Jack B. Meister
Artisan Electronics Corp.
Director of Research
Morristown, N.J.

YOUR CAREER

NEWS AND NOTES

Memo to supervisors of creative groups:

Try this test to see if you measure up to what your staff would like a boss to be. You come close to "ideal," according to a survey by Deutsch & Shea, Inc., technical manpower consultants, if you:

- Are yourself creative, free of conformity and able to stir others to think.
- Have insight into the creative process, can recognize blocks and talk them over with the staff.
- Have high technical competence that commands the respect of specialists in the field.
- Bolster self-confidence by fostering a positive atmosphere.
- Are big enough to respect the ideas of others.
- Criticize in a way that does not tear down the ego of staff members.
- Care for your group's needs by doing the administrative work, getting materials and facilities and protecting the men from time-consuming "fire-fighting."
- Are the group's spokesman before management.
- Give credit fairly.
- Can assign responsibility skillfully without antagonizing the staff.
- Control "lightly."

Details of the survey, including other problems in creativity, are published in "Company Climate and Creativity" (Industrial Relations News, New York City, $10).

What do companies look for in a prospective engineer? Clues to this are offered in a booklet distributed to engineering school graduates by CGS Labs, Inc., 391 Ludlow St., Stamford, Conn. Here are some questions that CGS is interested in:

- How will you get along with other workers in the company?
- Do you possess scientific or intellectual curiosity?
- Are you inventive? (Some persons are expert at recognizing problems but do not have outstanding ability to solve them. Others may have a poor sense of recognition but be highly adept at solutions. Both may be needed in a company.)
- Are you scrupulously honest in your replies at the interview? (Or do you try to "snow" the interviewer to detract from your lack of knowledge.)
- What would you like to be doing a few years from now?
- What do you expect to get from your job?
- Why do you want the job?
- What do you think the company's goal is in business? (Profits.)
- Are you primarily interested in the professional aspects of the job?
- Do you desire primarily to advance professionally?

"The common denominator in all of these questions," CGS says, "is money, but it is surprising how often a college student is reticent to use the word 'money' in any of his answers. In the world of industry there is no stigma attached to the goal of making money.

"Business exists to make money. Business makes money because it has employes who want to make money. Therefore if an interviewer asks you why you want a job, the honest answer, 'To get money,' will be well received."

A brilliant technician named Bob
Loved transistors like all of the mob.
He built one so small
It was not there at all
And nothing was left but a knob.

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ELECTRONIC DESIGN's Reader Service Department will act as your private secretary and type neat, duplicate copies of your standardized resume and send them to all companies you may select . . . *the same day the resume is received.* (ELECTRONIC DESIGN will detach the circle number portion of the form so that no company will know how many numbers you circled.)

The standardized resume will permit personnel managers to inspect your qualifications rapidly. If they are interested, they will get in touch with you directly. In the past much time has been lost through personnel-manager requests for resumes from applicants who proved ineligible.

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925	926	927	928	929	930	931	932	933	934	935	936	937	938	939	940	941	942	943	944	945	946	947	948	949

CAREER NEWS

Last June an electronic finance executive, writing in a magazine, wondered out loud, "What If Peace Breaks Out?" and was promptly branded a "cold war inspirer" by Pravda, official organ of the Soviet Union. Not one to take inspired criticism too seriously, the official who kicked up the fuss, Casper M. Bower, now advocates that electronic companies add a military economist to their managerial staffs to interpret trends in defense spending.

Mr. Bower, vice president of finance for Sealectro Corp., manufacturers of electronic components, sees Government defense spending becoming a possible "sensitive economic barometer, its rise and fall influencing the purchasing moods of the public and businessmen alike."

The size of such expenditures, he argues, will influence industrial stock prices.

And whether or not an East-West Summit Meeting is held, he continues, "the amount of annual defense appropriations will continue to be a political football—kicked by the lobbies for or against expanding defense needs."

"The public," he says, "and many company managements will be hard-pressed to assess the validity of the conflicting issues in the face of bombast from protagonists on either end and the appeals from neutrals in the middle."

Which leads Mr. Bower to conclude that electronic concerns—"particularly those feeding almost completely from the trough of defense money"—would be well-advised to hire a military economist.

The military function of the economist, he says, would be to sift fact from fiction "in the muddy stream of domestic and foreign propaganda calculated to influence the nation's program for national and international security."

As an illustration, Mr. Bower cites the visit last summer of Nikita Kruschev to this country and President Eisenhower's planned visit in return to the Soviet. One electronic trade paper has interpreted the visits as not likely to have any effect on American industry. But a financial publication has predicted they will help curb defense outlays. The military economist would be expected to steer his company safely through the conflicting views.

Another important function of the economist, Mr. Bower says, would be to guard the concern against "electronic euphoria."

"This way of economic life," he notes, "seemingly has enveloped many unseasoned electronic company managements who are inclined to believe that defense funds are a one-way street going upwards only."

Mr. Bower presented his views in detail to the National Electronics Conference in Chicago.

• • •

Unlike baseball, the U.S. Chamber of Commerce doesn't approve of "bonus babies" when it comes to hiring rookie engineers. In a new leaflet, "The Principles and Practices of College Recruiting," it advises employers not to offer special gifts to students to induce them to take jobs.

Rather, the chamber suggests, interviews with prospective graduates should not depart from "commonly accepted practices."

College placement officers are advised in the leaflet to counsel students in job selection but not to influence them unduly. And students are told that they, too, have obligations.

"It is in the best interests of students, colleges and employers alike that the selection of careers be made in an objective atmosphere with complete understanding of all facts," the leaflet says.

Among suggestions are these:

"When a student is invited to visit an employer's premises at the employer's expense, he should include on his expense report only those costs which pertain to the trip. If he visits several employers on the same trip, costs should be prorated among them."

"Employers should not raise [salary] offers already made, except when such action can be clearly justified as sound industrial relations practices: such as, when an increase in hiring rate is required on an over-all basis to reflect salary adjustments in the employing organization."

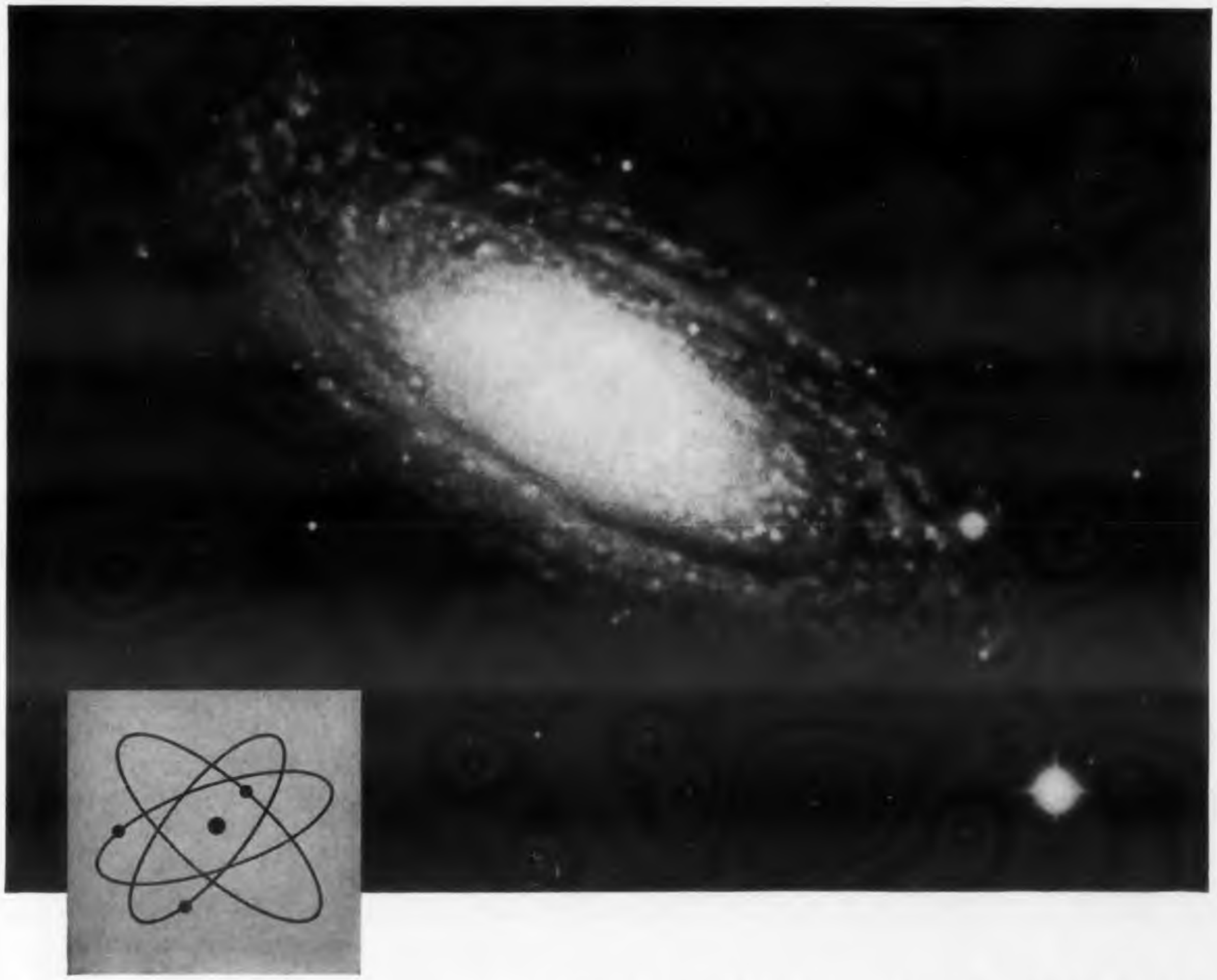
A shortage of top science graduates will continue with the class of 1960, the chamber predicts along with a boom in business.

The leaflet on recruiting, published jointly with College Placement Council, Inc., of Bethlehem, Pa., is being sent to 1500 college placement officers and 3000 industrial and Government executives.

ENGINEER–IMPROVEMENT COURSES AND SEMINARS

Managing Engineering Services Workshop Seminar, IEI, January 25-27, New York

This seminar will be of interest to engineers who are dependent upon service functions for the successful execution of their assigned tasks. It will also be of interest to those who are responsible for the supervision of engineering services themselves. Beyond these two groups the seminar will be of value to those who are interested in studying ways in which the effectiveness of engineering services can be utilized within the organization to increase the output from the engineering organization. Subjects to be covered will include basic concept of an engineering service, scope of responsibility, organizing the service function, staffing the service functions, establishment of working relationships with departments served and evaluating performance. For additional information on this seminar and the following four write



to: Industrial Education Institute, 25 Huntington Ave., Boston 16, Mass.

IEI Workshop Seminar in Creating-Evaluating Research Projects, Jan. 27-29, New York

This seminar will be of interest to research directors, executives directly associated with research projects and supervisory personnel responsible for projects in the research laboratory. The fundamentals of creating a well-thought out research project will be considered. Emphasis will be on initiation of projects; the research department and its capacity; adjusting work loads to capacity; types of controls, including selections based on both project characteristics and nature of goals; evaluating performance and use of data as a basis for future program planning.

Managing Applied Research Workshop Seminar, IEI, Jan. 27-29, New York

As used in this seminar, applied research covers activities on which top management has definite market ideas that it wishes to fulfill as soon as possible. The seminar is designed for top research personnel. Discussion will center on alternative ways of carrying out applied research through organization, personnel, coordination and communication. Subjects will include basic function of applied research, personnel, organization project selection and evaluation, utilization of outside facilities and program control and budgeting.

IEI Workshop Seminar in Managing Product Development Department, Jan. 25-27, New York

Management people who are responsible for product planning will be interested in this seminar. Discussion will cover the product development department, including its function and relationship to the rest of the organization. Other topics will include organization staffing and physical facilities for the department; factors requiring management; new product ideas—sources evaluations and determination of the required action; human relations problems and evaluation of performance.

IEI Workshop Seminar In Creativity In Research, January 25-27

The objective of this three-day seminar, to be held in New York, will be to analyze the creative faculty and discuss how it may be nurtured. This is a subject of importance to those charged with responsibility for research and development activity. Participants will discuss the research process, definition of creativity—characteristics of highly creative scientists, selecting creative scientists (key areas), roles of the research scientist, research

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scientist, research leadership and its attitudes (key area with regard to motivation), rewards, values placed on "thinking" vs. "doing" and other environmental factors.

UCLA Engineering and Management Course, January 25-February 4

A course for the professional development of managers and engineers will be held at the University of California, Los Angeles. The 10-day program will offer a choice of 22 subjects to fit the needs of both executives of large industries or of middle-level personnel from small companies. Emphasis will be on the principles and techniques which form a systematic approach to management, and on the quantitative methods which supply the facts for such an approach. Information on registration and living accommodations may be obtained from Reno R. Cole, College of Engineering, University of California, Los Angeles 24, Calif.

Telecommunication Technology Study, New York

The Communication Division of the New York section of AIEE is offering a fall, winter and spring study-group course in Telecommunication Technology. The fall session has terminated, however, the winter session on transmission techniques starts Jan. 12 and meets weekly through Feb. 23. All meetings run from 7 to 9 P.M. and are held at the Western Union Building Auditorium, 160 Broadway, New York, N.Y.

Study Group on Patents, AIEE, New York

This study group of six lectures will provide a comprehensive treatment of patents by recognized experts in the field. It will begin with an explanation of what constitutes invention, various kinds of patents, a history of the development of patent law and philosophy, and current revisions of the American patent system.

It will discuss record keeping, drafting claims, preparing the application and when one should consult an attorney. You will learn what information is available from the Patent Office, how a search is conducted and how the application is prosecuted in the Patent Office. Pointers will be given on how to read and understand claims, a discussion of patent uses, infringements, strength of a patent illustrated by famous litigation, marketing a patent, licenses and confidential disclosures.

Finally, since most engineers are employed by companies, typical company policies relating to patents, assignments, shop rights and rewards to inventors will be discussed.

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25; February 8, 15 and 29. All meetings run from 7 to 9 P.M. and are held at the Western Union Building Auditorium, 160 Broadway, New York, N.Y.

PAPER DEADLINES

January 15: Deadline for 100 word abstracts in triplicate and 500 word summaries in triplicate for the 1960 IRE Professional Group On Microwave Theory And Techniques to be held May 9-11 at the Hotel del Coronado in Coronado, Calif. Papers to be presented should deal with microwave components, systems and physics. Send all material to: Dr. David B. Medved, Chairman, Technical Program Committee, 1960 PGMTT Symposium, Convair, A Div. of General Dynamics Corp., Mail Zone 6-172, P. O. Box 1950, San Diego, Calif.

February 1: Deadline for 3 copies of a 250-word unclassified abstract for the 4th National Convention on Military Electronics (MIL-E-CON) to be held June 27-29 at the Sheraton-Park Hotel, Washington, D. C. Suggested topics include, but are not limited to the following: current problems of space technology, space electronics, ranging and tracking, electronic propulsion, data handling systems, guidance and control, inertial systems, reconnaissance systems, communication systems and operation analysis. Send abstracts to: Dr. Craig M. Crenshaw, Department of Army, Office of the Chief Signal Officer, R&D Div., SIGRD-2, Washington 25, D. C.

March 1: Deadline for rough draft manuscripts for the **Joint Automatic Control Conference,** scheduled for **September 7-9** in Boston, Mass. Papers may be on any significant aspect of automatic control. Possible topics might include: sampled data, theoretical aspects of computer control, operating results in computer control, nonlinear control, adaptive control, statistical control, cybernetics, super-slow control systems components, actuators, criteria objectives for control, maintenance in complex systems, component dynamics and techniques for testing dynamic system. Final copy deadline is May 1. Papers may be submitted to: *Harvey A. Miller, JACC Program Committee-IRE, Taylor Instrument Cos., 95 Ames St., Rochester 1, N.Y.*

A call for technical papers for the **1960 West Coast Audio Engineering Society Convention** scheduled for **March 8-11** at the Alexandria Hotel, Los Angeles, Calif., has been issued. Authors are urged to send titles and 25-50 word abstracts immediately to *Walter T. Selsted, Ampex Corp., 934 Charter St., Redwood City, Calif.*

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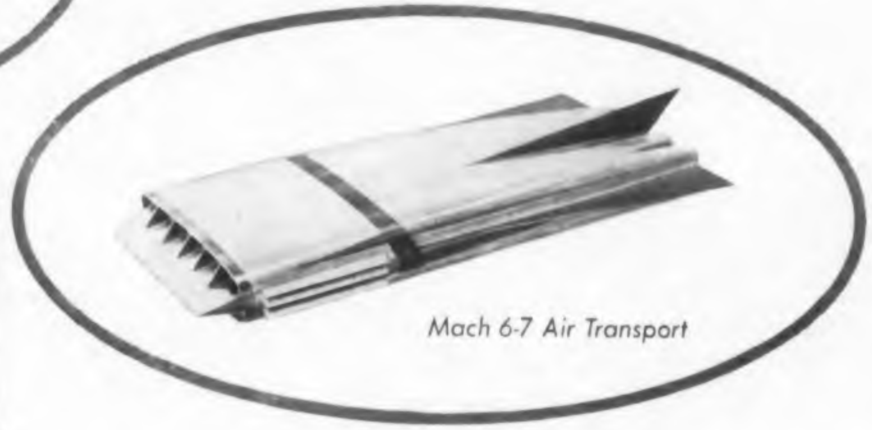

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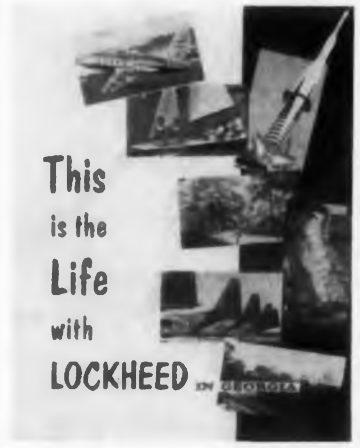

With words and pictures in the brochure "This Is the Life with Lockheed," the applicant is taken on a brief tour of Lockheed in Georgia. At present the Georgia Division is engaged in aircraft and nuclear research, development and manufacturing, work in missile support and special products fields, and designing of reactors for process heat and other peaceful uses.

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