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HIGHLIGHTS OF ISSUE

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DESIGN

BEHIND THE NEWS

AM Stereo Broadcasting Techniques Vie for Attention

At the last count, fifteen different methods have been designed and developed for broadcasting stereo programs. Techniques range from multiplex FM systems to separate-sideband AM to combinations of FM-AM.

In the past month alone, four systems (two-described below) have been demonstrated to members of the industry. Are the demonstrations and press notices aimed at pointing to latest advancements in the state of the art? Or are the manufacturers revealing slightly-modified techniques in their desire to join the stereo-publicity bandwagon? Engineers and bystanders in attendance are tending to sense a message to the effect—"To prove that we are not napping, here is our method of stereo broadcasting."

NSRC Formed

To evaluate and study the rising number of stereo broadcasting schemes, Electronic Industries Association (EIA) has recently formed the National Stereophonic Radio Committee (NSRC). Six panels have been set up to investigate the following points prior to submission of proposals to the FCC:

- System specifications—consider and investigate system proposals and set up initial transmission specifications.
- Interconnecting facilities—recommend characteristics for lines, networks, studio links, and related facilities between program origination and transmitter sites.
- Broadcast transmitters—study feasibility of proposed transmission methods and means of adopting proposals to existing equipment.
- Broadcast receivers—carefully check compatibility (how will existing monophonic receiver sound when tuned to stereo program), reverse compatibility (how will stereo receiver sound when tuned to monophonic signal), and stereo performance.
- Field testing—examination of coverage, interference, channel utilization, and other field problems.
- Subjective aspect—provide scientific information on subjective aspects of stereo reproduction to the other panels.

Primary aims of the various schemes include low-cost equipment investment for the listener as well as the broadcaster, entertaining listening for the stereo and monophonic consumer with a minimum of compromise, and compatibility with existing F. C. C. standards for AM broadcasting.

Two methods, recently demonstrated to industry representatives, offer fine examples of the trend towards simplification and economy although approached from different viewpoints.

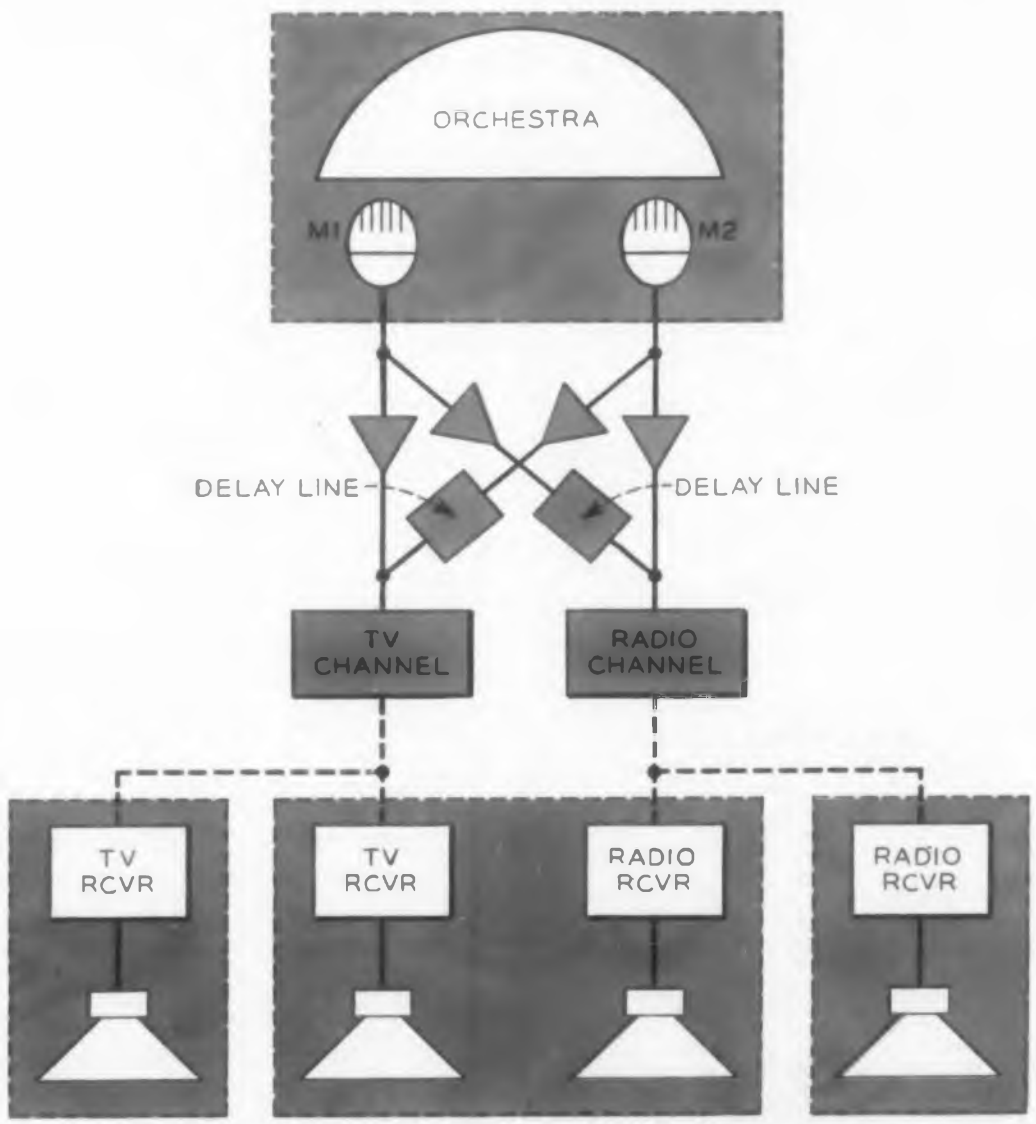


Fig. 1. Cross-connected delay lines between two stereo channels, A.T.T. system.

A.T.T. System

Stereo broadcasting techniques, when striving for utmost stereo effect, generally make use of two widely-spaced microphone pickups. While the stereo listener can then derive full depth and realism, the single channel listener hears the output of only one of the pickups and thus effec-

BEHIND THE NEWS

tively misses a portion of the program material. To preserve satisfactory reception for the single channel listener, the broadcaster would have to dilute the stereo effect.

Through the use of a new "compatibility" circuit, developed by F. K. Becker of Bell Telephone Laboratories, the single channel problem can be eliminated without affecting the stereo listener. The circuit depends for success on a psychoacoustic phenomenon known as the "Precedence Effect", discovered in 1933. This effect operates in such a manner that when a single sound is reproduced through two separate loudspeakers, but is delayed several milliseconds in one, the listener will "hear" the sound as if it came only from the speaker from which he heard it first. He will judge the second loudspeaker to be silent.

In the new development, the circuits between the microphone pickups and their corresponding radio or TV transmitters are cross connected through two delay lines, each with its own buffer amplifier see Fig. 1. Because of these cross connections, music or voice signals from the left microphone are transmitted directly to the left loudspeaker in the listener's home, while the same signal is slightly delayed before reaching the speaker to his right. The stereo listener will hear the sound as if it came only from the left loudspeaker because of the Precedence Effect.

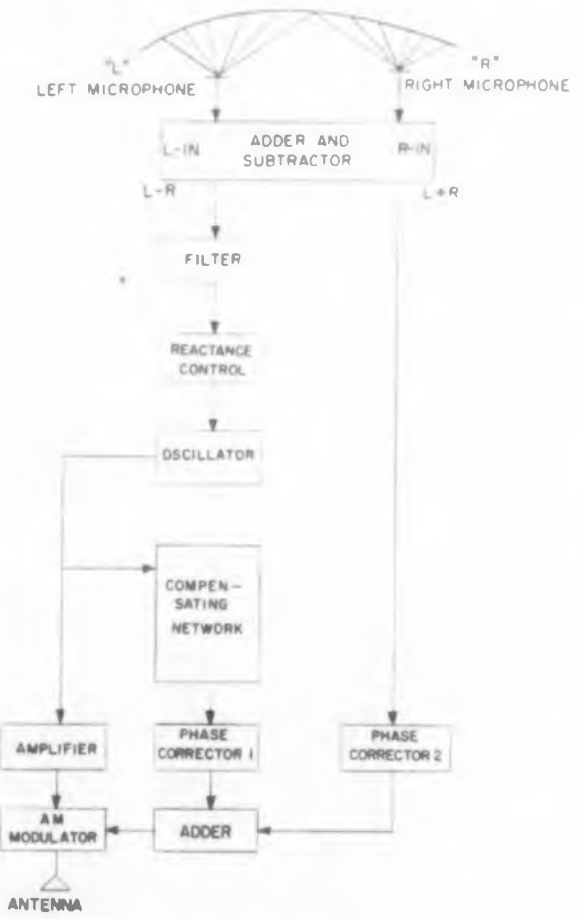


Fig. 2. Block diagram of Westinghouse AM compatible stereophonic transmitter.

Conversely, the sound from the right microphone goes direct to the right speaker, but is delayed before reaching the left speaker, and is therefore unheard. Thus, the brain of the stereo listener localizes the sound he hears as coming direct from each of his two speakers, and full stereophonic effect is maintained.

However, monophonic reception is completely compatible, since a listener to each single channel hears the total sound from both microphones in a balanced reproduction. The slight delay built in apparently does not affect his reception at all, according to subjective tests performed at Bell Laboratories.

This development should make it possible for many more broadcasters to offer double-channel stereo programming without diluting the stereo effect or penalizing the single channel listener, who will make up the majority of their audience.

Westinghouse Technique

Westinghouse's approach to simple, economical stereo broadcasting involves simultaneous amplitude and frequency modulation of the carrier. It is interesting to note that the initial patent for the present scheme was filed in 1925 by Dr. Frank Conrad, former research director of Westinghouse.

The amplitude modulation is predominately proportional to the algebraic sum of the two stereophonic signals (L-left microphone + R-right microphone) but includes a smaller signal that is a function of the stereophonic difference signal (L—R). This function to be developed by a compensating system.

The frequency modulation consists of components of the stereophonic difference signals between 300 and 3000 cycles per second. The filter cut-off rate is 6 decibels per octave; the maximum deviation is 3 kilocycles.

In the transmitter block diagram the compensation network, shown in Fig. 2, operates to modify the AM modulation as a function of the stereophonic signal. As a result, the envelope of the signal leaving the transmitter is precorrected so that a standard AM radio will receive and reproduce monophonic sound substantially independent of the stereophonic difference signals.

Basically, the monophonic listener would tune exactly on station and receive the sum of both (L + R) microphone signals. For stereophonic reception, two inexpensive AM radios would be used; one would be tuned to a frequency about two kc above the carrier with the other set about two kc below the carrier. A combination of amplitude modulation and slope-type frequency modulation would produce the separate left and right channel signals. Tuning of the receivers, it is claimed, would not require exact settings—rather broad tuning would still reproduce stereo effects.

BEHIND THE NEWS

Russian Oil Lamp Powers Radio

Tens of thousands of low-power thermionic generators are being put into service in the U.S.S.R., according to latest reports. The Russians have encouraged the development in their efforts to provide radio reception at low cost for their "educational" broadcasting programs.

Principally intended for use in rural areas devoid of electricity, the power generator (originally described—ED, May, 1956) makes use of the heat generated by a light-supplying oil-lamp. Enough energy is developed, from otherwise wasted calories, to operate a five or six tube radio receiver, according to Dr. A. V. J. Martin of the Carnegie Institute of Technology.

Construction

The usual glass chimney of the oil lamp is replaced by an aluminum tube carrying internal partitions so as to absorb a maximum of calories, see Figs. 1 and 2. Around this tube

Fig. 1. Thermoelectric generator installed on a lamp, with the connecting plug to a radio receiver.

Fig. 2. Method of assembling the lamp and the generator.

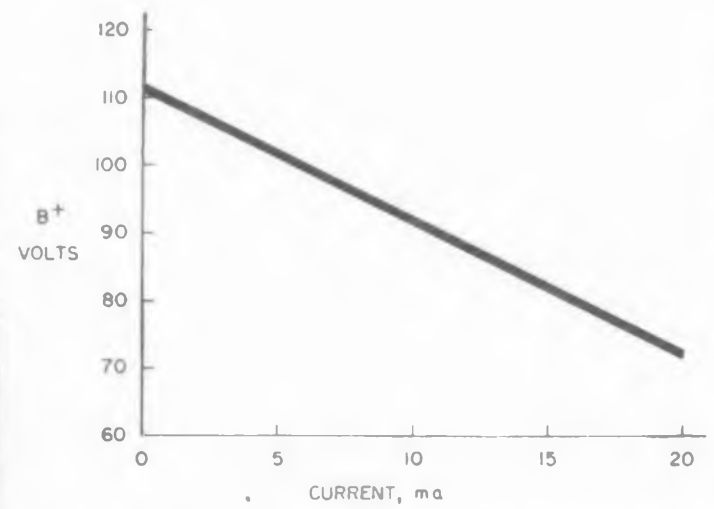


Fig. 3. Output voltage as a function of current drain.

Fig. 4. Generator can be taken apart for field maintenance or repair even by unskilled manpower.

are placed 14 thermocouple blocks, one of their faces being in intimate contact with the aluminum and hence at high temperature. The opposite face carries a U-shaped aluminum cooling plate. Each of its two fins measure approximately 100 x 75 mm, that is 4 x 3 inches. The total cooling area per block is then about 150 square centimeters.

The temperature difference between the two opposite faces of the thermocouple block is of the order of 233 C, providing the electrical power. The inner face of the blocks is at 295 C, and the outer face is at 62 C for normal room temperature. Of the 14 blocks, 1 is eventually used for bias, 3 for heaters voltage, and the remaining 10 for B+.

The heater supply voltage blocks measure 94 x 25 x 7 mm, and each contains 18 elements. Each element has a cross section of 7 x 5 mm. There are in all 54 elements, providing a current of 0.4 ampere under 1.4 volt. At no-load, the voltage goes up to 2.45 volts, so that if the required heater current is lower than 0.4 ampere, provision must be made for some limiting device, two selenium cells being commonly used.

The high-voltage blocks measure 94 x 25 x 11 mm. Each contains six vertical rows of 45 elements. The 10 blocks in series then represent 2700 thermocouples, and provide a no-load voltage of 111.5 volta. When loaded, voltage goes down as shown (Fig. 3).

The bias block measures 94 x 25 x 11 mm and contains 4 rows of 45 elements. If no bias is necessary, this block is connected in series with the 10 high voltage blocks.

Thermocouple Composition

The thermocouples used have a positive element made of an alloy of zinc and antimony with a small proportion of lead. The negative element is either constantan or maganine, tinned for the ease of assembly. The unit has no moving part, is not subjected to wear, and is exceptionally rugged and trouble-free, with an unlimited useful life, see Fig. 4. It uses only common metals readily available in USSR.

CIRCLE 7 ON READER-SERVICE CARD ➤

BEHIND THE NEWS

Sitting Pretty in $7,000 Electronic Super-Bed

The latest furniture invention, a £2,500 ($7,000) electronic bed, made its bow at London's Furniture Exhibition. A push of a button from either side of this twin super-bed will accomplish electronic wonders. It will open and shut the bedroom window curtains; control the room lights; switch the TV set at the end of the bed on and off; control the mattress heating units; adjust either mattress to any position; and connect the occupants by intercommunication system with the other room or the outside telephone.

According to its manufacturers, Slumberland Ltd. (Redfern Rd., Tyseley, Birmingham 2, England), the bed has been created . . . to herald the emancipation of the bedroom and a new era in relaxed living."

Additional items incorporated are—tape recorder for dictation or music, electric razor, built-in radios, and automatic tea (or coffee) maker.

Did someone ask if it will sell? It was purchased by a Frenchman on the first day of the exhibition.

Compact Geiger Counter Tubes

Thousands of average-size hospitals, industrial and medical laboratories can undertake research with radioactive tracers using reduced amounts of radioactive materials due to the development of two new Geiger tubes. A system, using two new Amperex tubes, weighs only 400 pounds as compared to 4,000 pounds for a conventional unit; only two tubes are needed whereas a conventional system may require as many as thirty. The Amperex type 18515 Geiger tube (bottom) is the beta radiation detector tube and fits into the cup-shaped anode of the Amperex type 18517 (top) cosmic-ray guard tube.

20,000,000th Tube

RCA's 20 millionth black and white television picture tube came off the assembly line Feb. 6 at the company's plant in Marion, Ind. D. Y. Smith (left) Vice President and General Manager, RCA Electron Tube Division, and L. Gillon, Plant Manager at Marion, examine the milestone tube.

High Altitude Simulated in Plastic Balloon

High-altitude antenna studies are being made at Boeing Aircraft Co., Seattle, Wash. in this 4-foot-diameter plastic globe. The air-evacuation system can simulate altitudes up to 300,000 feet.

The amount of energy which can be radiated from an antenna is limited by corona discharge. When too much power is fed into an antenna, the insulating properties of the air break down and part of the energy is dissipated as heat and light around the antenna. As the air pressure is lowered, its insulating properties decrease—an important consideration in antenna design and development.

Note the antenna inside the globe and the corona discharge occurring in the thin air.

BEHIND THE NEWS

Mountain to Mole Hill

The four-foot stack of papers at right represents th manufacturing data that was needed to bring t Navy's Aero 13 fire control system, for all weath interceptors, from blueprints to actual production Westinghouse Electric Corporation's Air Arm Divisi However, after completion of a unique program t drastically cut paperwork, save time and reduce cos the same work could be completed today with just th information being held here by R. J. Rattell, assista manager of manufacturing for the division.

Radioisotope Thermionic Converter

Electricity was directly produced from a radio isotope using a thermionic converter unde gamma radiation conditions in an experimen conducted at the General Electric Atomic Powe Equipment (APED).

This announcement follows closely the dis closure by the Atomic Energy Commission of th development of a small atomic generator whic uses polonium as its radioisotope and therm electric energy conversion device.

General Electric engineers said that, like th thermoelectric device, their thermionic converte demonstration was designed primarily for spac vehicle auxiliary electric power application Results indicate that the system has the potenti to produce an extremely high ratio of power t weight.

A power pack generating more than 100 wat of electricity, and lasting more than a year, coul weigh less than 25 pounds.

The General Electric device operated at tem

peratures up to 1700 degrees fahrenheit on the hot side" and 800 degrees F on the "cool side."

Gold, used as the radioactive material, consisted of a small strip about one-sixteenth of an inch thick, four inches wide and six inches long. Gold was selected as the radioisotope because it permitted an accelerated feasibility test under gamma radiation atmosphere.

The thermionic converter, employs two small discs about the size of half dollars to "boil" electrons off a hot metal surface to produce an electric current. It has no moving parts and operates in a manner similar to the vacuum tube.

Anti-Collision Alert for Autos

Efforts to reduce the growing number of auto accidents on turnpikes, super-highways, and expressways will be implemented by radar warning devices in cars of the future. Drivers will be warned when approaching another car too rapidly or when an obstruction or stalled vehicle lies ahead.

Developed by the Delco Radio Division of General Motors, the device consists of two 10 in aluminum reflectors mounted behind nose cones four feet apart on the front of the car. A transmitter and receiver are concealed in the front fenders of the car.

Microwave power, at 16.14 kmc, is generated by a reflex klystron and piped through waveguides to one reflector; it is then beamed out ahead of the car. Reflected signals are collected by the other reflector and piped through waveguides to a crystal diode for comparison of outgoing and incoming signals. Doppler frequency shift depends on the relative motion and spacing between the device and an object ahead. The difference is detected and amplified to a level sufficient to actuate a speaker or light-flashing device.

The equipment is sensitive to objects up to 1,000 feet ahead of the car and the intensity of warning increases with increasing rate of approach. It is presently being tested on the Cadillac Cyclone, GM's latest advanced design experimental car.

Note nose cones which house part of the experimental proximity warning device.

BEHIND THE NEWS

Radar for Jet Airliners

A self-contained long-range navigation device for jet and turbo-prop airliners, providing for the first time a navigation system that operates anywhere in the world and requires no ground facilities, has been successfully flight-tested.

The new device, developed by the Radio Division of Bendix Aviation Corp. is a light weight, compact system based on the Doppler radar principle that has been used successfully on military planes. The system provides the airliner pilot with a direct reading of his true ground speed (as contrasted with air speed), drift angle, actual course over the ground and distance-to-go to his destination.

By directing four beams of radar energy toward the earth from an airplane and measuring the Doppler effect in each beam, it is possible to solve several complex equations with an electronic computer to determine exactly how fast an airplane is moving, both horizontally and vertically.

Global Weather Probe

New details of a global undertaking to unlock secrets of weather were revealed by Bendix Aviation Corporation.

The project, to be carried out for the U. S. Air Force, will test the latest inventions in scientific sensing with electronic equipment mounted in a Boeing 707 pure jet transport plane. Weather data from the ground up to 150,000 feet will be continuously collected, analyzed and transmitted to the ground.

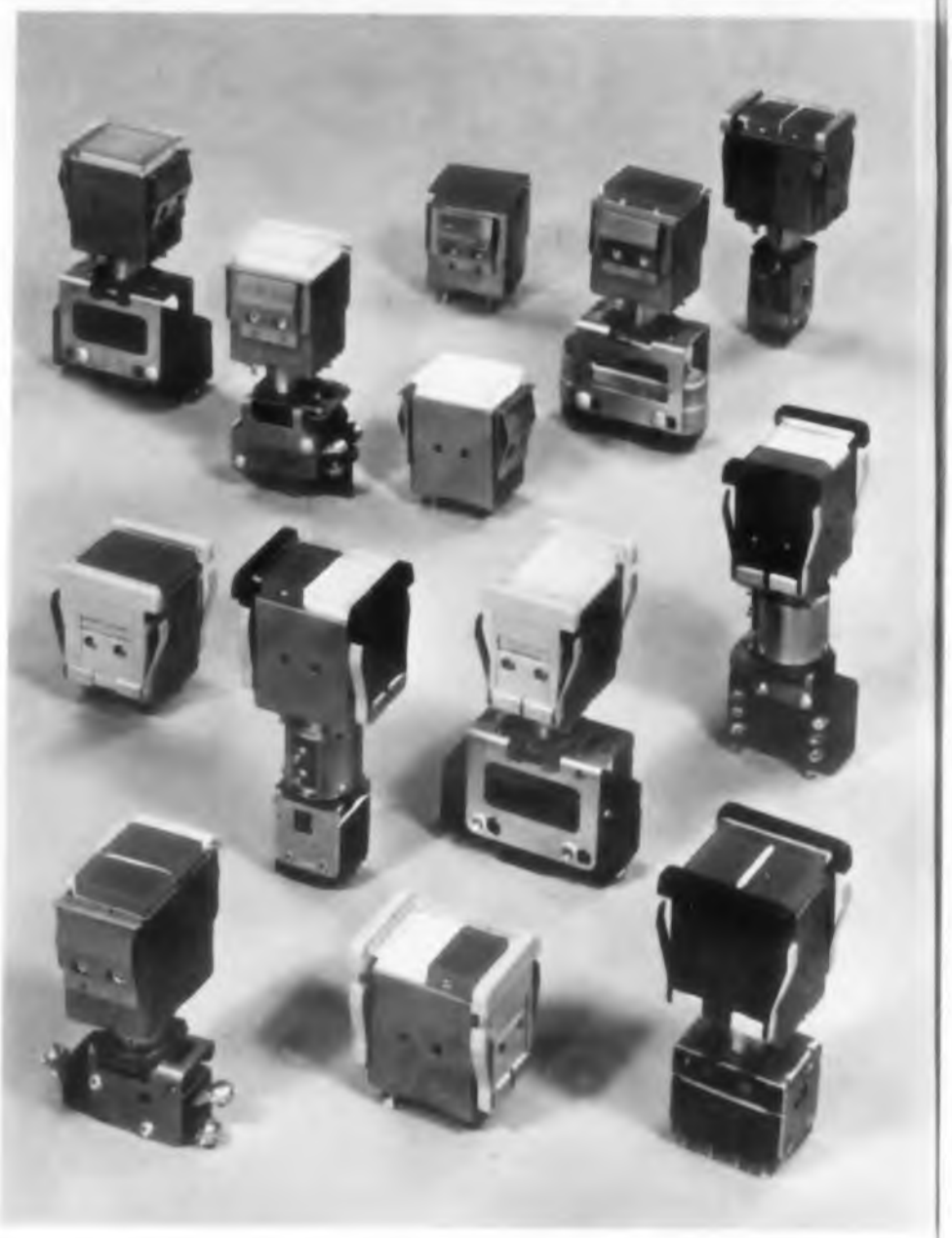
The cabin of the 707 test plane is to be a flying laboratory. In their atmospheric search around the world, the observers of the Air Weather Service of the U.S. Air Force will maintain a flight plan of up to 55,000 feet. They will probe the weather below the plane with parachuted "dropsondes," and the weather above with rockets to carry an instrument package to the upper atmosphere.

These expendable instruments

MICRO SWITCH Precision Switches

All new Series 2 lighted display and pushbutton switch devices offer new modular versatility in pushbutton switching

Yes, you can have the panel arrangement you want (preceding page) *and* the switch unit the application requires. At right you see a few of the hundreds of available combinations of Series 2 switch units and operator-indicator units. To attach an operator-indicator unit with a switch unit, just snap them together. All such combinations are available with or without magnetic d-c holding coil. Switch units are offered with switches from eight different MICRO SWITCH series of basic switches—"TB", "SM", "HS", Type "A", "MT", "DT", Type "Z", and "V3". Included are switches for low-energy circuits, switches for handling d-c loads of up to 10 amperes, 125 volts, and for direct control of a-c motors of up to two horsepower . . . alternate-action units, momentary-contact units, and units for control of multiple circuits.



Display screen, in four colors and white. Also available split lengthwise or across.

Operator-indicator unit, barrier type. Unit shown has long (side) barriers. Also available are short (end) barriers, and flange-type units without barriers.

Color filters in red, yellow, green, or blue fit over lamps, permit projected-color lighting.

Indicator unit, long flange type. Short flange and barrier types are also available.

Two, three, or four lamps can be used in operator-indicator or indicator units.

"SM" switch unit—one of many Series 2 switch units—snaps onto base of operator-indicator unit.

New Catalog 67 describes Series 2 devices in detail. Split pages aid selection of components. Contains detailed switch unit data and helpful ordering and color selection information. Sent free on request.

MICRO SWITCH . . . FREEPORT, ILL.
A division of Honeywell
In Canada: Honeywell Controls Limited, Toronto 17, Ontario

Honeywell
MICRO SWITCH PRECISION SWITCHES

will be ejected from the rear of the aircraft and will radio their data back to it for recording, computing and transmittal back to ground stations. The rockets will rise nearly ten miles before starting their parachute descent with their instrument package.

Two kinds of radar will be used for measuring cloud formations and storms. A "C" band will permit detection of storms as distant as 150 miles and allow 15 to 20 minutes observation of them. A "K" band with dual antennas will measure the bases and tops of cloud layers with precision from the ground to 100,000 feet.

All data, both raw and processed, will be permanently recorded on magnetic tape. It will then be fed into a general purpose digital computer of extreme flexibility for correction, computation, and correlation as required.

Automation for Small-Lot Manufacturers

A versatile, automatic-tool-changing, tape-controlled combination machine that makes automation economically feasible for small-lot manufacturers has been developed by Kearney & Trecker Corp. with General Electric Co. supplying the electronic program controls.

The new combination machine, called the KTNC Milwaukee-Matic, performs milling, drilling, reaming, tapping, and boring operations to bridge the gap between job shop mechanization and automation. By reducing setup time, production time, labor costs, and inventory, the machine can pay for itself in one to three years for any manufacturer producing goods in small or medium lots.

As many as 31 different tools can be loaded into the machine simultaneously—30 in a specially designed revolving storage drum and one in the spindle. There are 31 different combinations of 31 tools, ranging in size up to 2-5/8 inches in diameter, that can be utilized by the machine, making a total of 961 tools.

CIRCLE 13 ON READER-SERVICE CARD ➤

◄ CIRCLE 296 ON READER-SERVICE CARD

BEHIND THE NEWS

Combustion Checker

Knock, pre-ignition, rumble, and thud—odd sounding names for abnormal combustion processes that occur deep inside modern high compression engines—are ferreted out by this precision electronic equipment developed by duPont Company scientists and installed recently in the company's Petroleum Laboratory. The unique instrument permits instantaneous detection and recording of combustion phenomena simply by replacing the conventional spark plugs in the engine with special instrument plugs equipped with built-in, pressure-sensitive, piezo-electric crystals. The crystals transmit electronic signals which the instrument translates into accurate data on engine performance.

Thermoelectrically Cooled Diode Breaks All Barriers

Anybody can get excited about a small diode that can switch 54 amperes. With an average forward conduction of 17 amperes from —55 C to +385 C (without derating), this diode may well revolutionize the industry—especially with its 0.002 μsec recovery time.

Clinging to his production secrets, the manufacturer, Rare Avis Co. (Dept EEG), of 39-21 222 St., Bayside, N.Y., refuses to divulge the nature of the junction materials in the diode. He refuses, also, to disclose how the rapid switching is accomplished.

He does explain how the diode achieves its remarkable temperature range. Thermoelectric cooling is employed to remove heat from the main diode junction. Part of the diode's forward current is forced through an auxiliary thermoelectric junction. As the current rises, so does the rate of thermoelectric cooling.

At temperatures up to about 175 C, no external heat sink is required, but beyond this level, an auxiliary heat sink will help prolong diode life.

After a prolonged discussion with editors of ELECTRONIC DESIGN, the manufacturer agreed to make more information available on next April 1st.

High-Speed French Computer

A top French industrialist declared recently that France is in the midst of an electronics revolution which has immeasurably strengthened the scientific and technical structure of Western Europe. Mr. Georges Vieillard, founder and general manager of the Campagnie des Machines Bull, Paris, largest producer of electronic computing equipment in Europe, said that "this revolution has helped France expand its plant and equipment at the highest rate on the continent."

The company's Gamma 60 computer, expected to be in production within a year, is understood to be the first data processing machine in the world which can handle several independent problems at the same time.

It can read 300 punched cards a minute, print 120-character lines at 300 per minute. Printing speed can be increased by using more than one printing unit. The Gamma 60 comprises ten types of units: arithmetic, logic, comparer, translator, printer, card reader, paper tape, magnetic tape, magnetic drum, and card punch.

Time Reversal Studies

Engineers at Case Institute of Technology are attempting to turn back split seconds of time in order to improve long distance communication techniques. Their experiments depend on reversing the order of a series of signals sent over wires to improve the fidelity of transmission.

A contract in the amount of $29,600 for a year study of "Time Reversal Techniques" has been awarded to Dr. Harry M. Mergler by the Rome Air Development Center. Under his direction, the scientists will attempt to implement the theory that signals transmitted over long distances, if reversed in direction of flow at the midpoint of the distance from transmitter to receiver, will retain their fidelity over the entire route of transmission.

CIRCLE 15 ON READER-SERVICE CARD ➤

WASHINGTON REPORT

Ephraim Kahn

NASA's Policies

Engineering ingenuity will be a major by-product of U. S. efforts to explore space. As things stand, it is not likely that a large "space industry" will grow up in the near future. But the skills of electronic design engineers and technicians will be drawn upon heavily.

As progress is made, costs of the payloads—the instrument packages—carried by space-probing vehicles may become as large or even larger than the basic vehicle costs, according to space experts. The technical qualities of these far-ranging measuring and reporting devices, mostly electronic, will be "extremely advanced"—but production is "more likely in the dozens than in the hundreds."

Though costs of space exploration pale when compared with the billions spent through the Department of Defense, they are far from picayune in terms of individual company activity. In the current fiscal year, National Aeronautics and Space Administration is committing $220 million for procurement. It already knows where the "great bulk" of this is going, and has let contracts for more than half. In the coming fiscal year, it hopes to get another $333 million from Congress for new procurement—and the legislators may vote more.

Fund Allocation

Tentative allocation of fiscal 1960 funds indicates: 50 percent, procurement of instruments, vehicles, and scientific investigations of space; 20 percent, space propulsion technology; 20 percent, development of technology for manned space flight; 6 percent, specific investigations of satellite applications in the fields of communications and meterology; and 4 percent, contracts for tracking and data acquisition and advanced space technology.

This subdivision of funds reveals that the electronics industry's share is small. How much of the 50 per cent is pure electronics is hard to determine. One of NASA's future space explorers, Vega—a combination of Atlas, Vanguard and 6000 lb final thrust—is expected to cost $10 million; half of the dollars will go for electronics.

An additional supplemental $48 million for 1959 is expected to come through. Of this $12 million will be spent on tracking; $3.4 million for minitrack stations, $3.35 million for basic precision radar, $5.25 million for precision radar and other tracking means.

Patent ownership for inventions made under contracts with the National Aeronautics and Space Administration is slowly becoming clearer. Though the law allows NASA to take title to such patents, the agency realizes that industry would be under a heavy burden if the fruits of its efforts were invariably grabbed automatically by the government. This, in turn, would place NASA in a bad light. Many companies, hoping to achieve scientific breakthrough—or seeing them in the offing—might elect to avoid working under NASA contracts. They could decide to pay for exploratory research themselves or seek contracts with other agencies that have more liberal patent rules.

NASA Plans "Reasonable Interpretation"

To avoid finding itself in an "unworkable situation," NASA is planning a "reasonable interpretation" of the law. Thus, the mere purchase of a standard component with NASA funds will not involve any question of the possible loss or patent rights. On the other hand, much creative engineering, scientific, and technical work will be covered by the agency's sweeping powers to take title to patents. Even here, however, NASA will not exercise its authority to the fullest extent. As things stand, it is planned to have some, but not necessarily all, contractors make complete and prompt technical reports when an invention, discovery, improvement, or innovation is made. Most likely to be subject to this requirement are firms working under contracts with NASA (or financed by NASA) which contemplate that the contractor will work in accordance with the agency's specifications or special requirements.

Property rights in patents are to be decided on an individual basis. When a contractor files required information concerning new data, the agency will decide whether to exercise its legal right to take title. Officials say that NASA "will make every effort to administer its legal requirement concerning patents fairly and objectively with due consideration to the interests of both government and private industry."

Criteria For Granting Waivers

Some of the rules that will be discussed at a Waiver Regulations Meeting May 18 include these prima facie cases for waiver:

- invention conceived prior to contract.
- invention has only incidental utility to NASA and has promise of commercial utility.
- contractor has spent considerably more of his own funds on the work than did NASA.

EDITORIAL

Dishonest Bidding Must Go

Many engineers know that the only way to get a cost plus fixed fee (CPFF) contract from the government is to underbid. This is because it is usually the lowest reasonable bid that gets the contract. You bid low knowing that later you will ask for the additional funds to meet your costs.

It is therefore calculated dishonesty that pays off. Such dishonesty is so prevalent that it is unfortunately becoming recognized as normal procedure.

You know you can get money if needed and so does your competition. You also know that if you bid too low, your bid can be tossed out as irresponsible. You therefore bid to outguess your competition knowing that if you come in with a "just-lower" price and have a justifiable technical approach, you get the job. What you finally are paid for this job may be far higher than the honest bids that were refused.

The government knows this practice is going on and decries it but so far they have been unable to curb it.

Elimination of CPFF contracts in favor of fixed price contracts is often recommended by contracting officers and Congressmen but engineers know that such contracts do not offer the flexibility so often needed. The answer would seem to be to award a CPFF contract more on the basis of technical soundness and less on price.

One solution is to put a weighting on all the various points that are supposedly considered before a contract is awarded. With every factor, including price, worth only a few points, the more honest, straightforward and clear the proposal, the better are its chances of being accepted.

Admittedly it is no simple task to come up with a point system for evaluating a bid. But here engineers and only engineers can point the way. Who else can judge?

It may be that we need a panel of several technical judges to determine who is the winner of this best technical proposal contest. With rules for playing the game allowing, say only 25% of the total points to be influenced by price, such things as technical considerations and past performance of the contractor will assume their necessary importance.

Everyone will gain by an improvement in CPFF negotiations. Let's encourage our managements to press for a solution that would meet the approval of an engineer.

James G. Kippton

Circuit failures result from either catastrophic failure of components, or from components changing their values. By realistically analyzing value changes during the design of a circuit you . . .

Improve Circuit Reliability

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Fig. 1. Resistance distribution.

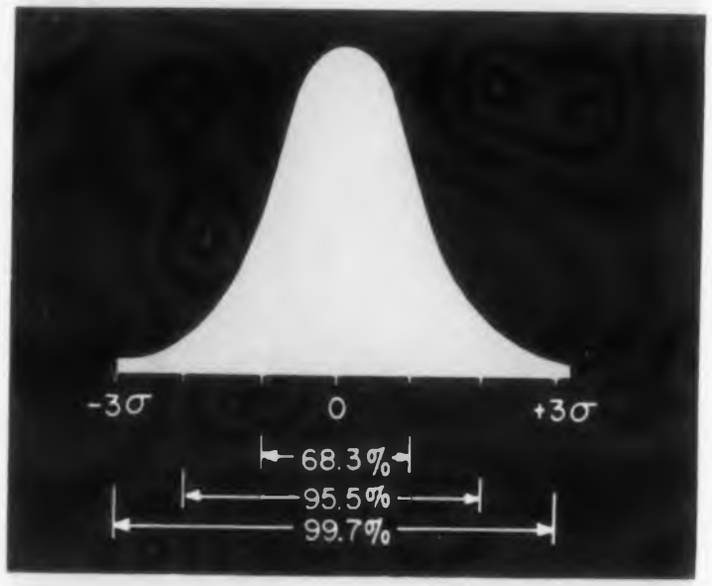

Fig. 2. Normal distribution.

CHANCES are very remote that all component parts in a circuit will simultaneously exist at their maximum tolerance. This point forms the basis for a scientific rather than artistic approach to handling component value variations in circuit design. The approach involves using some simple statistical techniques.

Overall variations in component part values under operating conditions are caused by factors such as environment and aging. Changes will result from unidirectional tolerances (coefficients) and from plus-or-minus tolerances (distributions).

Component Part Value Distribution

A manufacturing process typically produces component parts whose values are distributed. Most of the components will have values near some nominal value. And a few will have large deviations from the nominal value. Suppose that measurements were made of a large quantity of resistors of the same nominal value and ±10 per cent tolerance. Plotting vertically the number of resistors in each 1 per cent interval of resistance will usually result in a configuration shown in Fig. 1. It is called a frequency distribution or histogram. As the number of resistors measured increases and the resistance interval is narrowed, the envelope of the histogram will form a normal or Gaussian distribution curve as shown in Fig. 2. This curve is symmetrical about the average and asymptotic at the base.

Total area under the curve represents all the

Table 1. Variations to be expected in Resistors and Capacitors

	Resistors			Capacitors	
	Deposited Carbon	Composition (1 megohm or less)	Precision Wirewound	Paper	Glass
Typical manufacturing tolerance	±1%	±5%	±0.25%	±5%	±5%
Change at +125°C	−3.5%	+11%	+0.25%	+5%	+1.3%
Change at +85°C	−2.1%	±4%	+0.15%	+3%	+0.8%
Change at −54°C	+2.8%	+12%	−0.20%	−6%	−1.0%
Aging change	−0.4% ±1%	−5% ±2%	±0.20%	±2%	±1%
Change with heavy loading (near max rating)	−1.8%	+7%	+0.1%	—	—
Change due to voltage coefficient (100 v dc applied)	—	−1.5%	—	—	—
Soldering change	—	−2%	—	—	—
Change with high frequency operation	—	−5%	—	—	—

*Composition resistors may suffer a +10% additional change if exposed to 95% relative humidity, 55°C, for 100 hours.

resistors. Sigma (σ), the standard deviation, is the measure of variation of the distribution. The area bounded by ± 1 sigma covers 68.3 per cent of the total area. That is, 68.3 per cent of the resistors are included by ± 1 sigma. Ninety-five and one-half per cent of the resistors are included by ± 2 sigma. And 99.7 per cent are included by ± 3 sigma. Manufacturing tolerance will usually correspond to ± 3 sigma, or greater, depending upon the degree of production control.

Variations in Component Values

An estimate of resistance and capacitance value changes that may be expected of some most common component parts are presented in Table 1. Typical manufacturing tolerances have been listed to permit calculation of examples. Other values of manufacturing tolerances will be applicable when different from these shown. The reference value is that given by the manufacturer. The variations tabulated are not applicable to all component part manufacturers.

Effects of a given situation are combined by adding the portion of each appropriate change which has a single sign, and by combining each portion which has a $\pm$ sign according to the square root of the sum of the squares. This method of handling component part value variations will be used in all examples given here.

Resistors. As an example, consider a precision wirewound resistor that has a varying and occasionally heavy load, and must work at any temperature between -54 and $+125$ C. The drop in value will include:

Manufacturing tolerance		$\pm 0.25\%$
Temperature effect (-54 C)	-0.20%	
Aging effect		$\pm 0.20\%$
Loading effect (lightly loaded)	—	—
Total drop	-0.20%	$\pm 0.32\%$

Further, the rise in value will include:

Manufacturing tolerance		$\pm$ .25%
Temperature effect	$+0.25\%$	
Aging effect		$\pm 0.20\%$
Loading effect (fixed heavily loaded)	$+0.10\%$	
Total rise	$+0.35\%$	$\pm 0.32\%$

The extreme values encountered will be -0.52 per cent and $+0.67$ per cent. For any component part, if the manufacturing tolerance is adjusted out or compensated, it can be omitted from the combined tolerance.

Tubes. An estimate of changes in vacuum tube parameters is given in Table 2. It is assumed that environmental high temperatures will be compensated by operating the tubes at no more than and preferably less than 70 per cent of

normal rated plate dissipation. It is also assumed that the tubes are used near their design center values. This data is pertinent to tubes procured to the MIL-E-1 specifications. If the manufacturing tolerance is adjusted out, it can be omitted from the combined tolerance.

Suppose you want to know the lowest and highest values of plate current to be expected when the manufacturing tolerance will not be compensated and the filament voltage may vary ±10 per cent. The drop in plate current will be:

Manufacturing tolerance	−15%	±20%
Filament voltage effect	− 5%	± 3%
Aging effect	−10%	± 5%
Random change		+10%
Total drop	−30%	±23%

Plate current rise will be:

Manufacturing tolerance	+15%	±20%
Filament voltage effect	+ 5%	± 3%
Aging effect (new tube)	—	—
Random change		±10%
Total rise	+20%	±23%

As indicated, sizeable variations in tube performance may be expected and should be anticipated early in circuit design.

Circuit Design

Circuits must be designed to properly perform when the coefficient effects combine to produce the greatest deviation in the component part's nominal value. The discussion and examples below show several of the common types of tolerance calculations needed for electronic circuit design.

Most circuits can be represented by an analytical expression that relates the performance variable to the various component part values. The performance variable and the component part values in this type of analytical expression are continuous variables. When the component part values have a normal frequency distribution and are randomly combined in production to form circuits, the performance variable will also have a normal frequency distribution. Applying statistical methods for tolerances to the analytical expression will yield a realistic tolerance for the performance variable that will be obtained in production and usage.

The assumptions are that the component part values are normally distributed, that the component part tolerances are not large relative to the component part's nominal value, and that the component part values are not dependent or interacting.

Sum (or Difference) Tolerance. Tolerances of sums can be combined directly if the tolerances contain the same number of sigmas. If t denotes tolerances containing the same number of sigmas, then:

$$(t_s)^2 = (t_{x_1})^2 + (t_{x_2})^2 + \ldots (t_{x_n})^2 \qquad (1)$$

When items are combined in series, the familiar expression "square root of the sum of the squares" refers to actual values of the distribution and not the percentages of the nominal value.

Tolerances of differences or combinations of sums and differences are similarly combined.

Consider resistors combined in series as in Fig. 3. The resistor values have normal distributions, and the tolerances are the limits of the 3 sigma distribution.

The nominal resistance sum is:

$$R_t = R_1 + R_2 \qquad (2)$$
$$= 150 \text{ K} + 100 \text{ K} = 250 \text{ K}$$

and the distribution of the sum is:

$$(t_{R_t})^2 = (t_{R_1})^2 + (t_{R_2})^2 \qquad (3)$$
$$= 1500^2 + 1000^2$$
$$t_{R_t} = 1800 \text{ ohms}$$

The nominal value and 3 sigma distribution limits of the sum are 250 K ±1.8 K or ±0.72 per cent. This example illustrates that when items having a normal distribution are combined in series, the resultant sum distribution will exhibit a tolerance advantage. Resistors with a ±1 per cent tolerance combined in the example with a ±0.72 tolerance.

Product (or Quotient) Tolerance. Tolerances of products can be combined directly if the tolerances contain the same number of sigmas and are expressed as percentages. The basic equation for products is:

$$(T_p)^2 = (T_{x_1})^2 + (T_{x_2})^2 + \ldots (T_{x_n})^2 \qquad (4)$$

For products the familiar expression "square root of the sum of the squares" refers to the tolerances expressed as percentages and should not be confused with the case of sums in which

Table 2. Variations to be Expected in Tubes

	Transconductance		Plate Current		Amplification Factor	
	Low	High	Low	High	Low	High
Manufacturing Tolerance	−10% ±10%	+10% ±10%	−15% ±20%	+15% ±20%	−8% ±7%	+8% ±7%
10% Decrease in Filament Voltage	−5% ±3%	—	−5% ±3%	—	Negligible	
10% Increase in Filament Voltage	—	+5% ±3%	—	+5% ±3%	Negligible	
Aging change	−6% ±5%	—	−10% ±5%	—	—	+2% ±3%
Random change when First Energizing	±10%	±10%	±10%	±10%	Negligible	

Table 3. Expected Changes for Realistic Example

	Resistor, Composition		Tube, Transconductance Change	
	Low	High	Low	High
Manufacturing tolerance	±5%	±5%	−10% ±10%	+10% ±10%
Change at +85°C	±4%	—	—	—
Change at −54°C	—	+12%	—	—
Aging change	−5% ±2%	—	−6% ±5%	—
Change with heavy loading	+7%*	+7%*	—	—
Soldering change	−2%*	−2%*	—	—
High frequency change	−5%*	−5%*	—	—
Filament voltage change	—	—	−5% ±3%	+5% ±3%
Random change when first energized	—	—	±10%	±10%
Totals	−5% ±6.7%	+12% ±5%	−21% ±15%	+15% ±15%

*A fixed change that will affect both the low and high conditions.

ıe tolerances are the actual values. Tolerances f quotients or combinations of products and uotients are similarly combined.

The tolerance of the output of an idealized ransformer is used as an example of this technique. Values and tolerances are as shown in ig. 4; the tolerances are the 3 sigma normal istribution limits.

The nominal output voltage is:

$$E_o = N\,E_i \qquad (5)$$

$$= 4 \times 110 = 440 \text{ v}$$

nd the distribution of the output voltage is:

$$(T_{E_o})^2 = (T_N)^2 + (T_{E_i})^2 \qquad (6)$$

$$= 5^2 + 15^2$$

$$(T_{E_o}) = 15.8\%$$

he nominal value and 3 sigma distribution imits of the output voltage are 440 ±69.5 v or 40 ±15.8 per cent.

Tolerances of Other Expressions. When the nalytical expression relating the performance ariable to the various component part values s of a different form from the situations just iscussed, the general expression:

$$(\sigma_y)^2 = \left(\frac{\partial y}{\partial x_1}\right)^2 (\sigma_{x_1})^2 + \left(\frac{\partial y}{\partial x_2}\right)^2 (\sigma_{x_2})^2$$

$$+ \cdots \left(\frac{\partial y}{\partial x_n}\right) (\sigma_{x_n})^2 \qquad (7)$$

must be used to obtain the distribution limits of the performance variable.

For example, consider the tuned resonant circuit shown in Fig. 5. The resonant frequency is:

$$f = 1/2\pi \sqrt{LC} \qquad (8)$$

he tolerances are the 3 sigma normal distribution limits.

he nominal resonant frequency is:

$$f = 1/6.28 \sqrt{50 \times 10^{-6} \times 30 \times 10^{-12}}$$

$$= 4.12 \times 10^6 \text{ cps}$$

o determine the tolerance of the frequencies he general expression is used:

$$(\sigma_f)^2 = \left(\frac{\partial f}{\partial C}\right)^2 (\sigma_C)^2 + \left(\frac{\partial f}{\partial L}\right)^2 (\sigma_L)^2$$

$$(3\sigma_f)^2 = \left(\frac{-1}{4\pi \sqrt{LC}\,L}\right)^2 (3\sigma_C)^2 +$$

$$\left(\frac{-1}{4\pi \sqrt{LC}\,L}\right)^2 (3\sigma_L)^2$$

$$3\sigma_f = 23 \times 10^4$$

he nominal value and 3 sigma limits of the onant frequency are $4.12 \times 10^6 \pm 0.23 \times 10^6$ s or 4.12×10^6 cps ± 5.6%

Tolerance of Realistic Situations. Examples illustrated thus far consider only initial variations due to tolerance distributions. Under realistic operating conditions component part value variations will result from both negative and positive coefficient effects, in addition to distribution variations. In these situations the low and high conditions resulting from coefficient effects in the range of operation conditions are separately treated. And distributions are computed around each condition.

For example, take a high frequency amplifier with a large output signal range for gain limits under conditions encountered in military applications. Changes to be expected in the tube and resistor in operating conditions are shown in

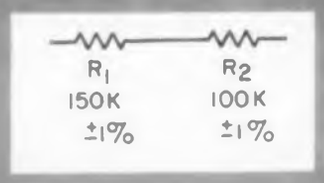

Fig. 3. Series resistance.

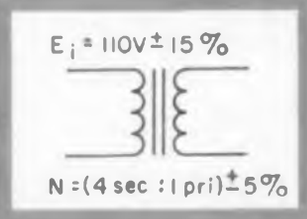

Fig. 4. Transformer.

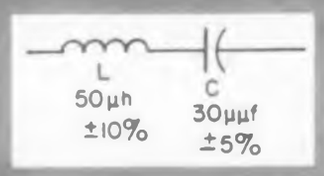

Fig. 5. Tuned resonant circuit.

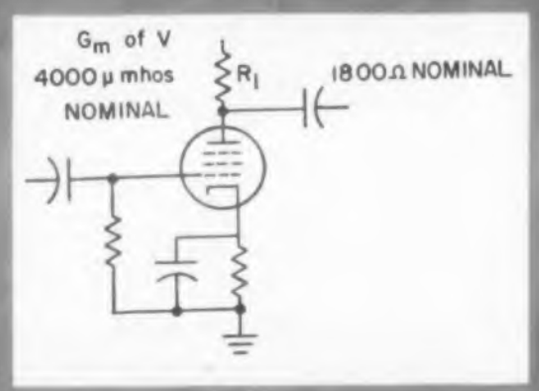

Fig. 6. High frequency amplifier.

$$= \sqrt{\left(\frac{600}{3160} \times 100\right)^2 + \left(\frac{121}{1710} \times 100\right)^2}$$

$$= \sqrt{19^2 + 7.08^2} = 20.2\%$$

For high conditions:

Tube contribution:

G_m high by 15% ±15%, G_m = 4000 (1.15 ±0.15) = 4600 ±600 micromhos

R_1 high by 12% ±5%, R_1 = 1800 (1.12 ±0.05) = 2020 ±90 ohms

Nominal gain is:

$$A = (4600 \times 10^{-6})\ 2020 = 9.29$$

Table 3. All tolerances cited are in the 3 sigma normal distribution limits.

For low conditions:

Tube contribution:

G_m low by 21% ±15%, G_m = 4000 (0.79 ±0.15) = 3160 ±600 micromhos

R_1 low by 5% ±6.7%, R_1 = 1800 (0.95 ±0.067) = 1710 ±121 ohms

Nominal gain is:

$$A = G_m R_1$$

$$= (3160 \times 10^{-6})\ (1710) = 5.4$$

Gain distribution is:

$$T_A = \sqrt{(T_{G_m})^2 + (T_{R_1})^2}$$

Gain distribution is:

$$T_A = \sqrt{\left(\frac{600}{4600} \times 100\right)^2 + \left(\frac{900}{2020} \times 100\right)^2}$$

$$= \sqrt{13^2 + 4.5^2} = 13.8\%$$

The gain nominal values and 3 sigma distribution limits at the low conditions are 5.4 ± 1.09 and at the high conditions are 9.29 ± 1.28. Therefore, the gain of this amplifier under production and operating conditions will be between 4.31 and 10.57.

Non-Normal Distributions. Occasionally component part values are not normally distributed. This condition exists when component parts are selected to small tolerances from a manufacturing process that has large tolerances. If component part value distributions are very nonsymmetrical

they will result in performance value distributions that are non-normal. This is particularly true if the component part values are all distributed in the same lopsided manner. Such a condition exists when oversized values representing half or more of a normal distribution are screened out. The method of handling this type of component part value distribution will depend on the factors present in the particular situation.

When the component part value distributions are rectangular, or near rectangular, the standard deviation, sigma, of the part value to be used in the general expression for finding the standard deviation of the performance is computed from:

$$\sigma = B/\sqrt{3} \tag{12}$$

where B is as indicated in Fig. 7.

The rectangular distribution has statistical properties that are far from the normal distribution. Certain precautions must be taken to get reasonable results. As a general rule, if there are only 2 component parts represented in the analytical expression and either or both has a rectangular distribution, design for both component parts simultaneously at their tolerance limits and in such a direction as to produce the greatest deviation in the performance variable. If there are 3 or more component parts, and any of the parts have rectangular distributions, the general technique shown previously for obtaining the standard deviation of the performance variable can still be used.

The 3 sigma normal distribution limits obtained from application of the general technique will actually be close to the worst possible deviations when there are only in the order of 3 or 4 component parts and most of these have rectangular distribution. However, the fact that the performance variable will be nearly normally distributed should be reflected in subsequent calculations and advantageously used.

As an example, the scaling factors of the 2-tap voltage divider shown in Fig. 8 are obtained at the upper tap from:

$$S_2 = \frac{E_{o_2}}{E_i} = \frac{R_2 + R_3}{R_1 + R_2 + R_3} \tag{13}$$

and at the lower tap from:

$$S_1 = \frac{E_{o_1}}{E_i} = \frac{R_3}{R_1 + R_2 + R_3} \tag{14}$$

The tolerance limits shown in Fig. 8 are the absolute tolerances (beyond which no value shall exceed) of the rectangular distribution. Considering only the smaller scaling factor of the lower tap, the nominal scaling factor is:

$$S = \frac{22{,}000}{(56{,}000 + 27{,}000 + 22{,}000)}$$
$$S = 0.2095$$

Fig. 7. Rectangular distribution.

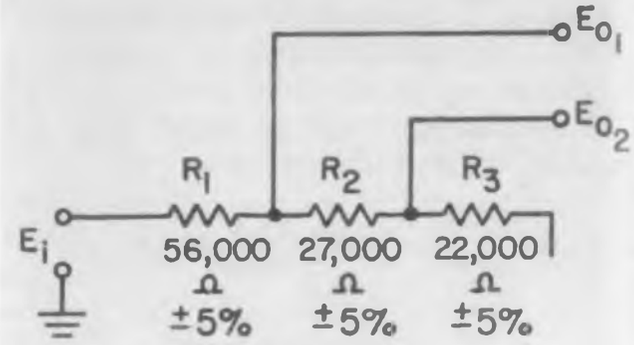

Fig. 8. Voltage divider circuit.

The standard deviation of the resistor's rectangular distributions are:

$$\sigma_{R_1} = \frac{B}{\sqrt{3}} = \frac{280}{\sqrt{3}} = 162 \text{ ohms},$$

$\sigma_{R_2} = 77.9$ ohms, and $R_3 = 63.5$ ohms.

To obtain the standard deviation of the scaling factor, which will be nearly normally distributed, the general technique is used:

$$(\sigma_s)^2 = \left(\frac{\partial S}{\partial R_1}\right)^2 (\sigma_{R_1})^2 + \left(\frac{\partial S}{\partial R_2}\right)^2 (\sigma_{R_2})^2 + \left(\frac{\partial S}{\partial R_3}\right)^2 (\sigma_{R_3})^2 \tag{15}$$

$$(3\sigma_s)^2 = \left(\frac{-R_3}{[R_1+R_2+R_3]^2}\right)^2 (3\sigma_{R_1})^2 + \left(\frac{-R_3}{[R_1+R_2+R_3]^2}\right)^2 (3\sigma_{R_2})^2 + \left(\frac{-R_1+R_2}{[R_1+R_2+R_3]^2}\right)^2 (3\sigma_{R_3})^2$$

$$= (3.96 \times 10^{-12})\ (23.6 \times 10^{3}) + (3.96 \times 10^{-12})\ (5.46 + 10^{3}) + (56.6 \times 10^{-12})\ (3.63 \times 10^{3})$$

$$3\sigma_4 = 17.9 \times 10^{-4}$$

The nominal value and 3 sigma limits of the smaller scaling factor are 0.2095 ± 0.00179 or 0.2095 ± 0.86%. Similar calculations on the larger scaling factor yield 0.4667 ± 0.57%.

Empirical Techniques

Electronic circuit or system design problems occasionally occur where the analytical expression or model is unknown. Situations also arise where the analytical expression used is a gross approximation and little reliance can be placed on it. Another similar situation occurs when an analytical expression is known but is complex, and obtaining the partial derivative of the performance variable with respect to the various part values by analytical techniques is difficult. One approach is the use of a simple technique that yields limited but useful results.

The technique is simply to vary a single component part's value over the range of typical variations and at various values of this component part to simultaneously measure the component part's value and the performance variable's value while holding all other component part values constant. An approximation of the partial derivative of the performance variable with respect to the component part that is being varied can be obtained in this manner. If all other component part values were at their nominal value and remained stable, an accurate estimate would be obtained. Therefore, the approximation error is determined by the deviation of the values of the remainder of the component part values, will yield an approximation of the performance variable's standard deviation. ■ ■

Acknowledgment

The author is indebted to other Motorola Reliability and Components Group staff members who assisted in collecting the component part variation information discussed in this paper.

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For Better Circuit Performance:

Degauss Pulse Transformers

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Although useful and necessary in many applications, residual magnetism is undesirable in pulse transformers. In this article, E. J. Watt provides some background on the polarization of pulse transformers and how to get rid of it. In a succeeding article the author explains how to measure pulse transformer parameters.

RESIDUAL magnetism in pulse transformers often results in poor circuit performances; degaussing the transformers will remedy this situation.

Residual magnetism can be of a plus or minus polarity. The polarity depends on the direction of current which previously passed through the transformer. This current also determines at what point on a magnetization curve the residual magnetism is located.

An ideal magnetization curve, or hysteresis loop, is shown in Fig. 1. The narrower the curve, the better the transformer. A more typical magnetization curve is shown in Fig. 2.

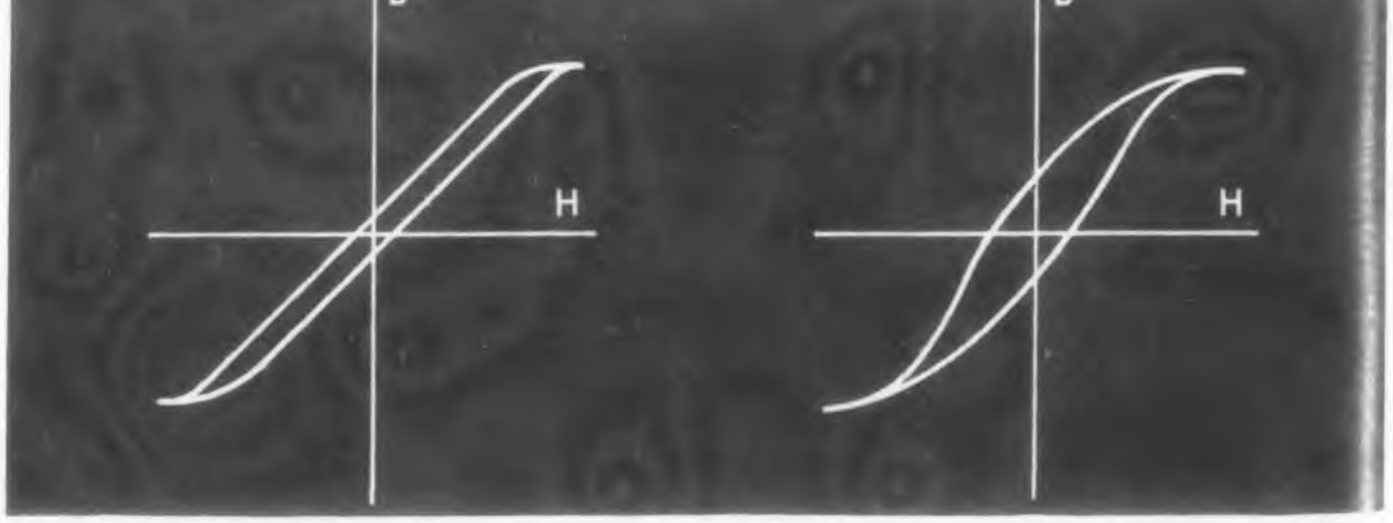

Fig. 1. An ideal magnetization curve.

Fig. 2. A typical magnetization curve.

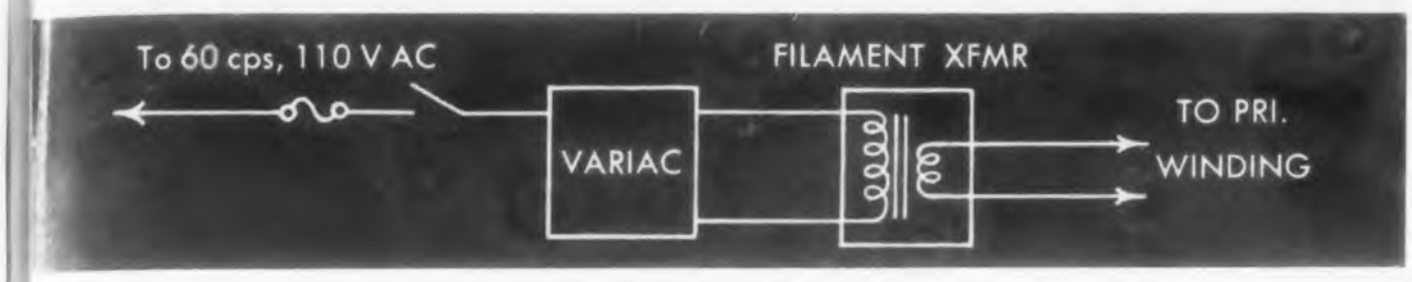

Fig. 3. A degaussing jig.

Causes of residual magnetism are many. Checking the continuity of a transformer with a meter will do it. Frequently, incoming inspection places the transformer into some sort of test fixture for an electrical test. High powered radar antennas in the immediate vicinity may sweep their beam across a transformer lying on a bench. Also, a transformer may be placed next to some cable through which a large amount of 60 cycle current is flowing.

The inductance of a transformer depends on the number coil turns and the amount of core. There is a limit to how much each can be varied. In certain applications, more core and less turns may be necessary for a given quantity of inductance. More core and less turns will (1) raise the saturation point, (2) decrease the core losses, (3) decrease interwinding capacitance, (4) increase intrawinding capacitance, (5) and increase the voltage breakdown between turns, as each turn will increase its potential gradient with respect to an adjacent turn. Somewhere optimum compromises are made.

Effects of Residual Magnetism

When a transformer is placed in a circuit and subjected to a current flow in a given direction, the core will maintain a certain amount of residual magnetism after the current source is removed. If this same current is reapplied, the transformer will continue to give repeatable performance.

If this same transformer should then be used in a different circuit, it will receive a new magnetic set. Returned to its original circuit, the performance of the transformer will not be the same as it first was.

In blocking oscillator applications slight magnetization of the transformer can cause 50 to 200 per cent variations in performance. When used as a coupling transformer, the difference in performance is not so noticeable.

The Solution

Frequently it may solve an engineer's blocking oscillator problem to polarize a transformer; positive if he wants to decrease output pulse width, and negative to increase pulse width. This is a short-cut solution, as little guarantee is had that the transformers assembled into a production item will be polarized in the proper direction and in the desired amount.

Using depolarized pulse transformers will provide consistent performance in every circuit. Depolarization will insure the transformer starting out from a neutral condition and establishing a residual magnetic set which it will maintain from the balance of its life.

Degaussing A Transformer

To depolarize, or degauss a transformer, the transformer is subjected to an alternating voltage of magnitude sufficient to saturate the core in each direction. The signal is gradually reduced to zero before the transformer is disconnected.

The basic magnetics formula is

$$E = 4.44\, fNBA\,(10)^{-8}$$

where E is volts maximum; f is applied frequency in cps; N is number of turns on winding being energized; B is saturation flux density (20,000 lines per cm^2 for grain oriented silicon steel); and A is the cross section area of core in cm^2.

Values of voltage E sufficient to saturate the various transformers at 60 cps (primary windings) are as follows:

1 mh	0.18 v
4	0.66
7	1.08
10	1.50
16	2.28
25	2.88

Values in between the above numbers can be extrapolated.

A simple degaussing jig is shown in Fig. 3. It is only necessary to have the Variac at zero volts when the primary winding is connected across the output of the filament transformer. The Variac is then turned by hand to near 100 v and back down to zero. This should be done in 1/2 to 2 seconds total time. ■ ■

Spring Spins Gyro

A SPIRAL "clock" spring spins the rotor of this roll reference gyro into action. Use of the spring as an energizing element reduces the weight of the gyro, which was designed for missiles and drones that must be maintained in operational readiness for long periods of time.

Advance energizing of the gyro is not necessary. Once wound and armed at the factory, the unit is capable of being stored in this condition for an indefinite time without loss of accuracy.

The frame-mounted spring brings the rotor to operational velocity in less than 10 msec after launching. Then the spring disengages and permits the gyro to function as an inertial reference. The units were developed by Telecomputing Corp., Whittaker Gyro Div., 16217 Lindbergh St., Van Nuys, Calif.

Weighing 3.5 lb, the gyro is hermetically sealed, but is available in a tape dust-seal for proving tests. Control period for the unit is 30 sec.

Flat Rotary Switch Saves Space

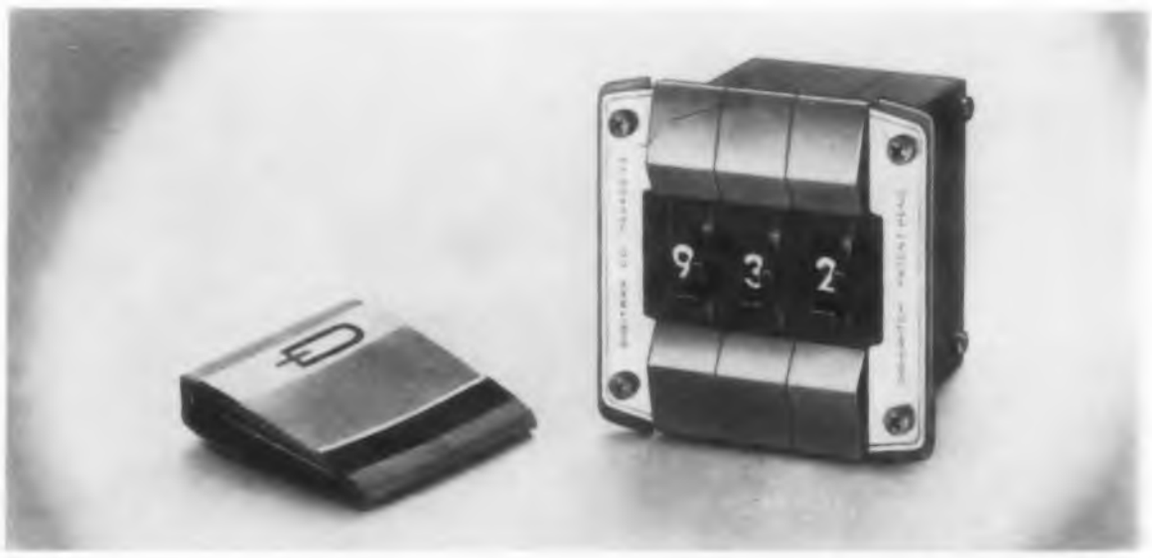

Fig. 1. Using a printed circuit element, this flat rotary switch converts visual decimal numbers to binary or octal codes.

Solenoid Triggers Gyro

A solenoid, when energized, triggers the gyro into operation. The solenoid releases a trip hammer that lifts the latch holding the main accelerating spring. Action of the trip hammer is strong enough to overcome any cold-flow welding between the latch and the restraining mechanism. A cold-flow weld may result from the tremendous force exerted by the spring on the latch over a long time.

The gyro is available in a cylindrical shape measuring 4 in. in diameter and 7.7 in. in length, and a rectangular shape measuring 3.5 x 4 x 5.5 in. And its operating temperature range is —65 or +160 F.

Drift rate of the gyro is within 0.625 deg per min, averaged over a 10 min period. It can withstand a shock of 10 g and has been able to take a vibration of 5 to 55 cps at 10 g during a sweep frequency of 1 min. Long storage periods have negligible effects on the power of the spring to perform as intended.

For more information on this spring-driven gyro turn to the Reader-Service card and circle **101**.

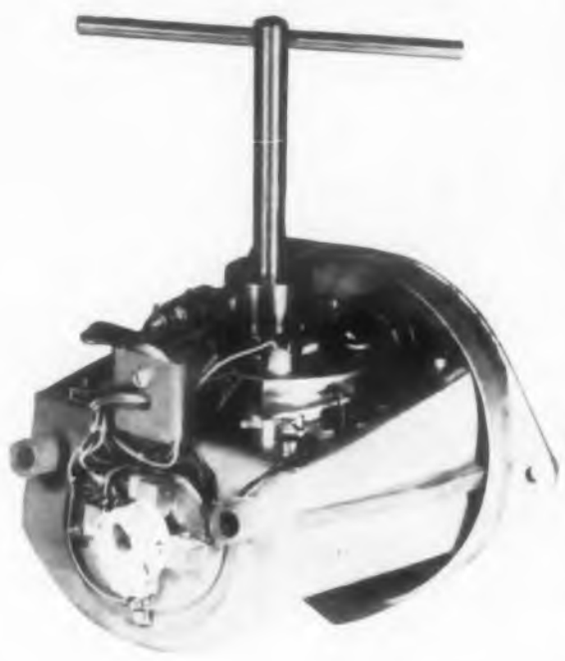

Fig. 1. Caging and winding of the gyro is done with a removable key at the factory. The unit is capable of being stored for an indefinite period in this condition.

FLAT AND small in construction, easy to set and read, simple conversion of visual decimal numbers into binary or octal code—all these properties characterize this rotary switch.

Called the Digiswitch, Series 7300, the unit was primarily designed for computer and control systems by the Digitran Co., 45 West Union St., Pasadena, Calif.

The switch can be used in place of a 10-position or octal switch unit of the conventional rotary construction. And, because a printed circuit board is used, the unit permits binary code (1, 2, 4, 8) or octal code (1, 2, 4, 7) to be set from a visual decimal number.

Attached to the rotating wheel of the switch is either one or four brushes, depending on whether the switch is designed for decimal, binary or octal operation. For decimal operation one brush is used, but there are four for binary or octal outputs.

The brushes rotate across a printed circuit board. On the rear of the board are plated-through holes to which wires are soldered for connection purposes. There are 11 connections for decimal operation, 5 for both binary and octal.

Ganging Possible

The switch is designed on a modular basis which permits ganging. Number of modules that can be ganged is limited only by panel space. Twenty switches can be mounted in the normal space required for five conventional rotary switch units.

Contacts on the switches are rated for 200 v at 1 amp. And contact resistance is 0.5 ohm. For decimal operation the 10 contact positions can be either single or double pole. The unit can operate in an ambient temperature of up to about 125 C.

Overall height of the switch is 2.32 in. as viewed from the panel side. Width per section is 1/2 in. Behind the panel the switch extends 1.61 in. and is 1.86 in. high. Overall extension in front of the panel is 0.2 in. Detents hold the switch securely in each position.

For more information of this switch, turn to the Reader-Service card and circle **102**.

Designing Zener Diode Voltage Regulators

R. G. McKenna

Texas Instruments Inc.
Dallas, Tex.

A few equations, a set of curves make the design of a zener diode voltage regulator easier. And too, they help predict the regulator's performance.

ZENER DIODES are well suited for shunt regulator applications. The power regulator diode provides a wider choice of voltages and larger current ranges than do gas-tube regulators. In addition to these advantages, it does not require a firing voltage higher than the regulating voltage, as does a gas-tube regulator.

A voltage regulator circuit employing a power regulator diode is shown in Fig. 1. The diode is connected across the load, R_L. This combination is fed from the unregulated supply voltage, V_i, through a series dropping resistor, R_S. The flat voltage characteristic of the diode holds the load voltage essentially constant as the load current or supply voltage changes. A change in load current results in a corresponding change in diode current. Therefore, the voltage drop across R_S remains unchanged with variations in load current. A change in input voltage, V_i, produces a corresponding change in diode current which causes the change in voltage drop across R_S necessary to cancel the change in input voltage, thus holding the load voltage constant.

Designing Zener Diode Regulators

For a specific regulator application, the load voltage and current requirements are known. The percentage variation in the unregulated supply voltage is estimated. The design of the regulator is accomplished by selecting the proper regulator diode and determining an input voltage and series resistance that will provide regulation over the required load current and input voltage changes without overloading the diode.

The diode voltage is determined by the load requirement. It must have a larger range between its maximum and minimum current limits than the expected range of load current variations. The maximum diode current is determined by the dissipation rating and is a function of case temperature. A curve of the maximum dissipation vs case temperature is obtainable from the diode data sheet. The maximum current may be expressed as:

$$I_{max} = \frac{P_{dmax}}{V_L} \qquad (1)$$

where

P_{dmax} = maximum dissipation rating of the diode.

V_L = load voltage

The minimum diode current, for regulator design, is the current at which avalanche breakdown occurs, and is also a function of temperature. A practical minimum for most applications is approximately 1 ma.

An equivalent circuit for the voltage regulator of Fig. 1 is shown in Fig. 2. The fundamental equations involved in the operation of the regulator are:

$$V_i = (R_S + r_d)I_d + R_S I_L + V_d \qquad (2)$$

$$V_L = r_d I_d + V_d \qquad (3)$$

$$P_d = V_d I_d \qquad (4)$$

$$P_L = V_L I_L \qquad (5)$$

where

V_i is the unregulated input voltage

R_S is the series resistance

r_d is the resistance in series with the fixed voltage, V_d, constituting the equivalent circuit of the diode

I_d is the diode current

I_L is the load current

V_L is the output, or load, voltage

P_L is the load power

To calculate the proper values for V_i and R_S, from these equations, refer to the operating region of the regulator shown in Fig. 3. It is assumed that the full current range of the diode will be utilized in providing regulation over the entire operating region, bounded by the maximum and minimum load currents and by the maximum and minimum input voltages. This region is contained between the load lines, representing the series resistance, R_S, drawn through the maximum allowable diode current and the minimum diode current required for regulation. The input voltage may be any value within the range of $V_{io} = \pm\Delta V_i$. If the ratio, $\Delta V_i/V_{io}$, is defined as k, permissible input voltages are

$$V_i = V_{io}[1 \pm k] \qquad (6)$$

It is clear from Fig. 3 that a compromise between load current variations and input voltage range must be made for a particular diode (i.e. a reduction in load current range, from that shown in Fig. 3, will provide a wider input voltage range or a reduction in input voltage range will provide a larger current range).

The important points in the operating region are the two corners through which the series resistance load line passes. The point representing the maximum input voltage and minimum load current determines the maximum diode current and the point representing the minimum input voltage and maximum load current determines the minimum diode current. An expression for

the ratio, k, in terms of the coordinates of these two points may be obtained from Eq (2) as follows:

$$2 V_{io} k = (R_S + r_d)(I_{dmax} - I_{dmin}) - R_S(I_{Lmax} - I_{Lmin}) \quad (7)$$

Since the nominal input voltage, V_{io}, is the average of the maximum and minimum input voltages, a second expression may be obtained from Eq (2), involving these quantities. It is:

$$2 V_{io} = (R_S + r_d)(I_{dmax} + I_{dmin}) + R_S(I_{Lmax} + I_{Lmin}) + 2 V_d \quad (8)$$

The values of input voltage, V_{io}, and series resistance, R_S, calculated from Eqs (7) and (8), are:

$$V_{io}[\alpha - k] = \beta \quad (9)$$

$$R_S = \frac{2 V_{io} - [r_d(I_{dmax} + I_{dmin}) + 2 V_d}{(I_{dmax} + I_{dmin}) + (I_{Lmax} + I_{Lmin})} \quad (10)$$

where

$$\alpha = \frac{(I_{dmax} - I_{dmin}) - (I_{Lmax} - I_{Lmin})}{(I_{dmax} + I_{dmin}) + (I_{Lmax} + I_{Lmin})}$$

$$\beta = 1/2 \left[\alpha \left[r_d(I_{dmax} + I_{dmin}) + 2 V_d\right] - r_d(I_{dmax} - I_{dmin})\right]$$

The maximum and minimum diode currents are determined by the design and rating of the diode. For fixed values of maximum and minimum load currents, the only variables in Eq (9) are V_{io} and k. This is the equation of a hyperbola, in standard form, with asymptotes of $V_{io} = 0$ and $k = +\alpha$. Since the load current excursions, I_{Lmax} and I_{Lmin}, and the percentage input voltage changes, $k \pm 100$, are known, the nominal input voltage, V_{io} is determined by Eq (9). Its value may therefore be directly calculated from known quantities. The series resistance may then be calculated from Eq (10).

It will be observed, from Fig. 3, that low values of series resistance and input voltage are desirable for large load current changes, provided there is no change in input voltage. However, in this case, no regulator is needed. On the other hand, large values of input voltage and series resistance are desirable for wide input voltage changes. The values of V_{io} and R_S, calculated from Eqs (9) and (10) are the lowest input voltage and series resistance that will provide regulation for simultaneous changes in load current and input voltage specified by I_{Lmax}, I_{Lmin}, and k. Therefore, these values represent the most efficient and economical diode regulator that can be designed to satisfy the load and input voltage requirements. It should be noted that R_S, calculated from Eq (10) includes the effective internal resistance of the input voltage source. The actual series resistance inserted in the circuit should be reduced in an amount equal to the internal resistance of the input voltage source.

Design Curves and Equations

If both sides of Eq (9) are divided by the load voltage, V_L, a dimensionless equation is obtained. Eq (10) may be reduced to a dimensionless form by following a similar procedure. The constants associated with these equations may be expressed in terms of voltage and power ratios, thus obtaining a set of generalized diode regulator equations that may be used for a wide range of zener diode voltages and power ratings. They are as follows:

$$\frac{V_{io}}{V_L}[\alpha - k] = \delta \quad (11)$$

$$\frac{R_S P_{dmax}}{V_L^2} = \frac{2\left[\frac{V_{io}}{V_L} - 1\right] + \frac{V_L}{V_L}}{1 + \frac{P_{Lmax} + P_{Lmin}}{P_{dmax}}} \quad (12)$$

where

$$\alpha = \frac{1 - \frac{P_{Lmax} - P_{Lmin}}{P_{dmax}}}{1 + \frac{P_{Lmax} + P_{Lmin}}{P_{dmax}}}$$

$$\delta = \left[\alpha - \frac{(1+\alpha)}{2}\frac{\Delta V_L}{V_L}\right]$$

These equations neglect the minimum diode current which is very small (1 ma or less). V_L is the voltage across the diode for maximum diode current and ΔV_L is the change in diode voltage for the full diode current swing, from I_{dmax} to I_{dmin}. While the ratio $\Delta V_L / V_L$ is not quite constant for all diodes, an error of only about 1 or 2 per cent is introduced by assuming an average value for this term.

Generalized design curves, for zener diode regulators, are shown in Figs. 4 and 5. The curves of Fig. 4 are obtained from Eq (11) and represent a minimum load power of zero. The input voltage regulation, k, is shown as a function of V_{io}/V_L for maximum load powers of 0.1 through 0.9 times rated diode power. Similar curves, obtained from Eq (12), representing $R_S P_{dmax}/V_L^2$ as a function of V_{io}/V_L are shown in Fig. 5.

Example

A regulated dc voltage of approximately 45 v and 35 ma peak current is required. The input voltage regulation, including ripple, is 20 per cent. It is desired to determine the nominal input voltage, V_{io}, and the series resistance, R_S. A zener diode, having a voltage of 46.85 v at $I_{dmax} = 110$ ma was selected for this application.

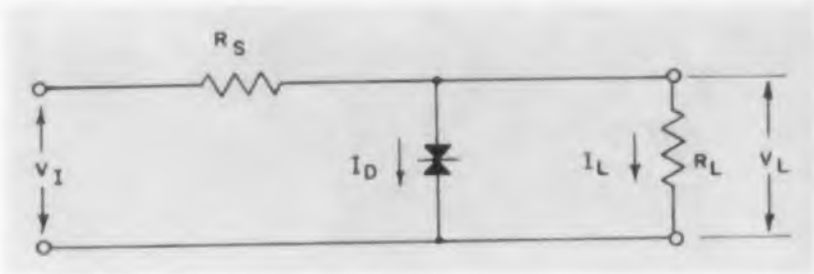

Fig. 1. Power zener diode voltage regulator.

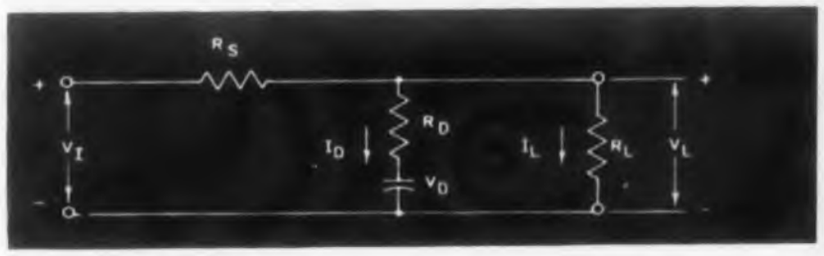

Fig. 2. Equivalent circuit for zener diode voltage regulator.

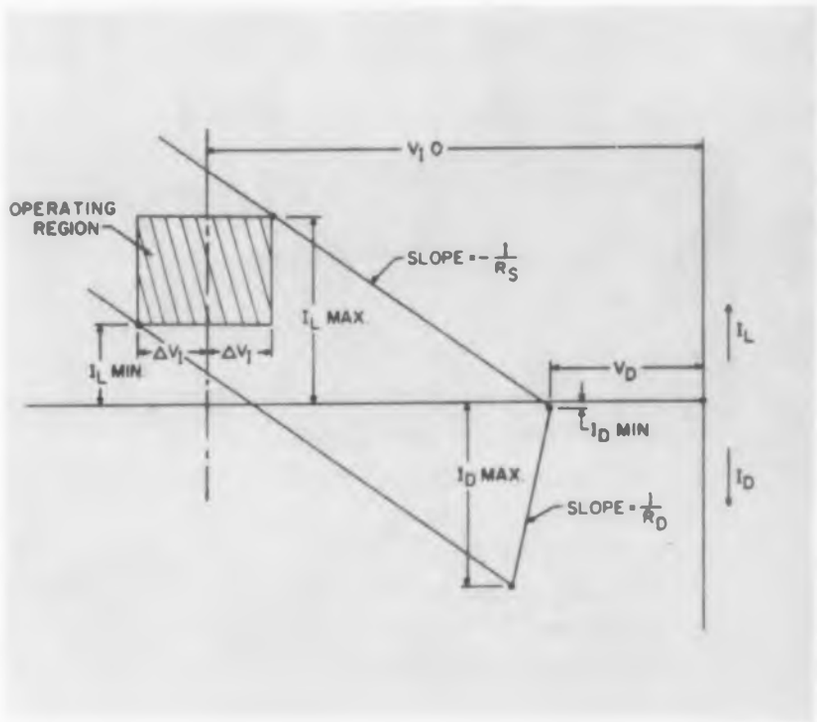

Fig. 3. Operating region of diode regulator.

The ratio of load to maximum diode power is:

$$\frac{P_L}{P_d} = \frac{V_L I_L}{V_L I_{dmax}} = \frac{46.85 \times 0.035}{46.85 \times 0.110}$$

$$\therefore \frac{P_L}{P_d} = 0.318$$

$V_{io}/V_L = 1.525$ is obtained from Fig. 4 and

$$V_{io} = 1.525 \times 46.85 = 71.4 \text{ v}$$

$R_S P_d / V_L^2 = 0.815$ is obtained from Fig. 5 and

$$R_S = \frac{0.815 \times (46.85)^2}{5.15} = 348 \text{ ohms}$$

The performance of the regulator was pretty much as predicted. For $V_i = 57.12$ v and $I_L = 35$ ma, the calculated and measured values of the diode current agreed, 0.1 ma. For $V_i = 85.68$ v and $I_L = 0$, the calculated diode current was 110 ma, while the measured diode current was 108.5 ma.

A small series resistance is indicated, from Fig. 6, for $V_{io}/V_L = 1$. This resistance is necessary to protect the diode when the maximum input voltage, $V_{io}(1 + k)$, is obtained with no

Fig. 4. (below) Generalized zener diode regulator curves. Voltage regulation, k, is a function of V_{io}/V_L for maximum load powers of 0.1 through 0.9 times rated diode power.

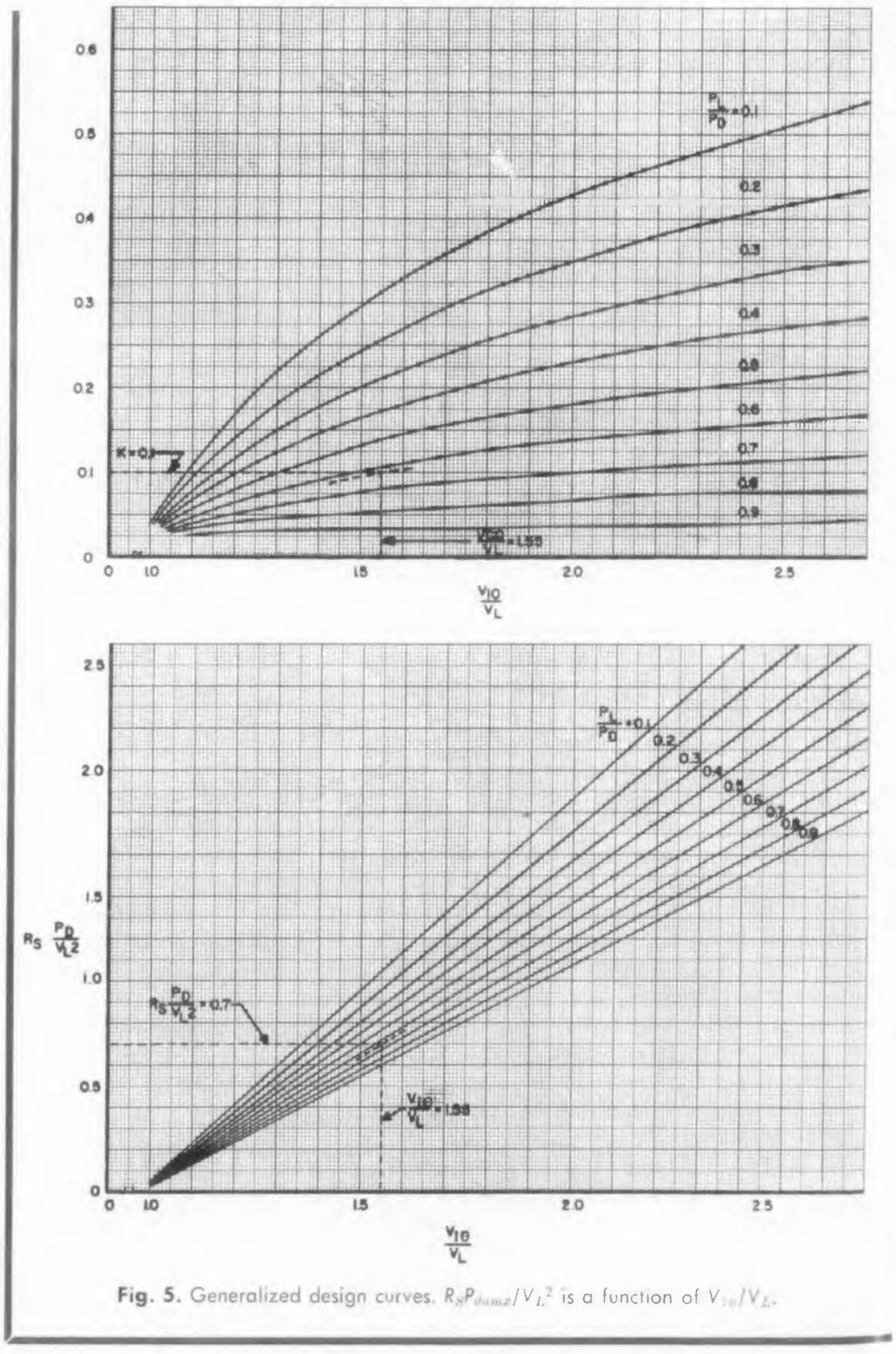

Fig. 5. Generalized design curves. $R_S P_{Dmax}/V_L^2$ is a function of V_{io}/V_L.

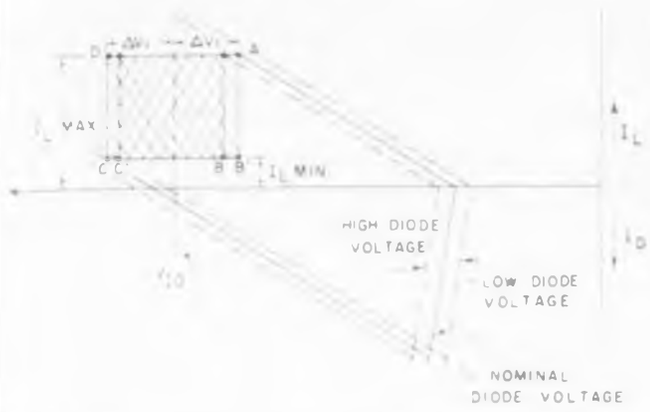

Fig. 6. Effect of low or high diode voltage on operating region.

current. The smallest value of k associated with these curves is about 0.025.

since the regulator components are selected to utilize the full operating range of the diode, it is desirable to evaluate the operation of a circuit designed for a nominal value. The effect on the regulator operating region of this condition is shown in Fig. 6.

For nominal diode voltage the operating region will cover the area *abcd*, in Fig. 6. This area is bounded by the maximum load current, $I_{L\,max}$, on the top, the minimum load current, $I_{L\,min}$, on the bottom, and the maximum and minimum input voltages, $V_{i_0} \pm V_i$, on the sides. If the diode voltage is too high, say by 10 per cent, the minimum input voltage that will provide regulation will be reduced from point "*b*" to point "*b'*". This point is reached when the diode current drops to the smallest value that will provide regulation. If the input voltage drops below the point "*b*", the circuit ceases to function as a regulator.

If the diode voltage is too low, the maximum input voltage, that produces maximum diode current, will be reduced from point "*c*" to point "*c'*". This condition may not be too serious, since the diode current rating is based on power dissipation. A low voltage diode can therefore tolerate a higher current than one of nominal voltage. The effect of high or low voltage diodes, representing the normal manufacturing spread, is to reduce the effective input voltage regulation from *b-c* to *b'-c'*. The estimated input voltage regulation should therefore be increased to allow for spread in diode voltages. The reduction in allowable input voltage change is exactly the deviation in diode voltage from its nominal value. Thus, the allowance in input voltage regulation for diode spread will depend upon the ratio of input voltage to diode voltage. For example, if $V_L = 2$, ± 5 per cent should be added to the estimated input voltage regulation to allow for a ± 10 per cent diode voltage spread. This allowance should be determined for each application and will always be less than the percentage diode spread. ■ ■

Improving the Emitter-Coupled Phase Splitter

An efficient phase-splitter using transistors can be designed with well stabilized operating points. The difficult problem of drift is solved by only a slight modification of the conventional phase-splitter circuit.

Maurice Price

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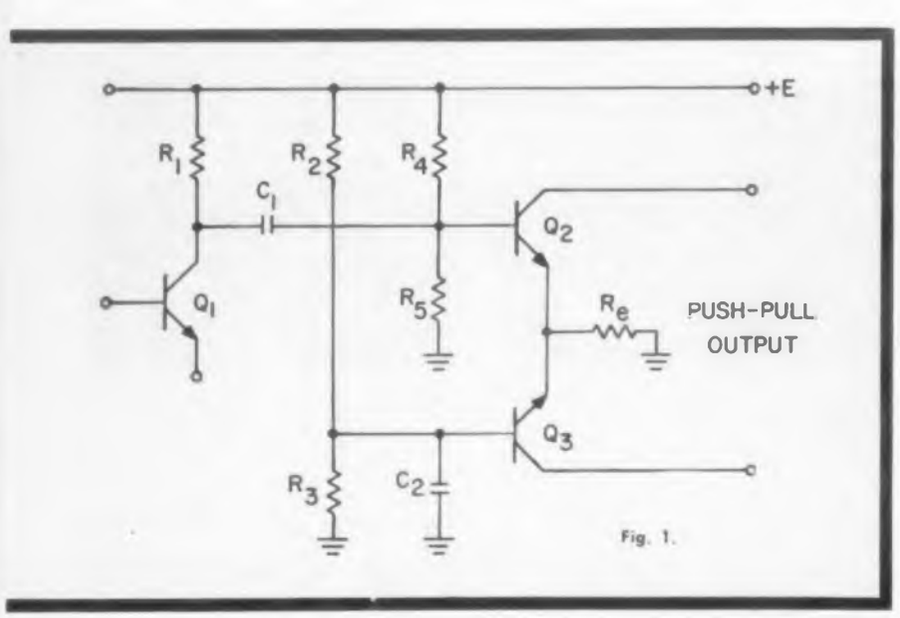


Fig. 1.

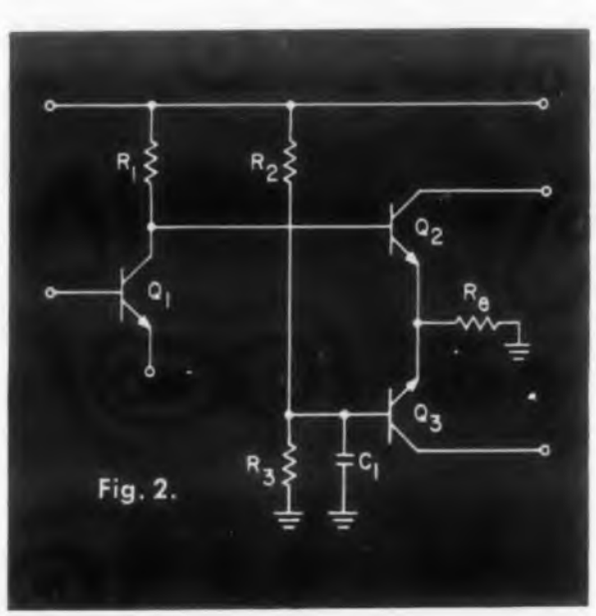


Fig. 2.

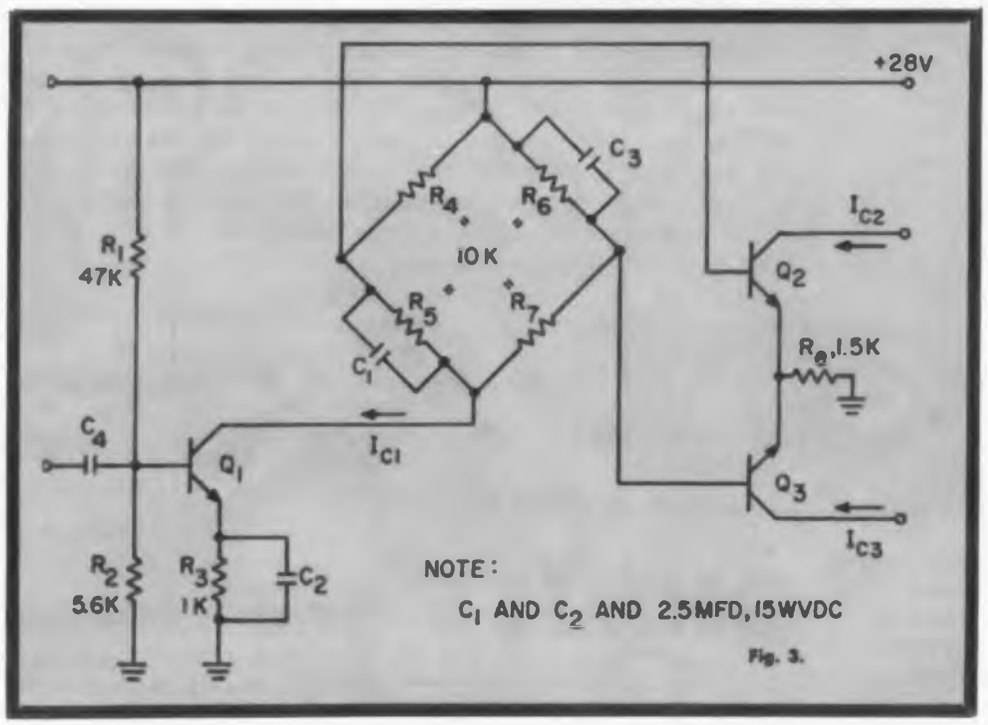


Fig. 3.

DESIGNING a phase-splitter with transistors, the engineer is faced with the problem of stabilizing the operating points. This is the source of most of the difficulty. In this article an efficient phase-splitter is described having a voltage gain of about 8000 and a power output of 10 mv. It can be designed with well stabilized operating points.

Conventional Phase-splitter Circuit

A convenient starting point for developing a well-stabilized circuit is the emitter-coupled pair shown in Fig. 1. Transistor Q_2 is driven from the single-ended first stage, while Q_3 is fed from the common emitter resistor R_e. The base of Q_3 is bypassed to ground by capacitor C_2 to achieve this feed. Both transistors Q_2 and Q_3 are shown with identical bias networks R_2, R_3 and R_4, R_5. The efficiency is adversely affected by the shunting effect of these networks on the signal and by the loss of dc power in them.

Fig. 1. An emitter-coupled phase splitter.

Fig. 2. Transistor Q_2 has been directly coupled to Q_1.

Fig. 3. Improved circuit has both Q_2 and Q_3 supplied with bias from the Q_1 collector circuit. The bypass capacitor C_1 may be omitted with an attendant loss of gain.

Improving Operating Point Stabilities

An improvement can be made by coupling Q_2 directly to the single-ended driver, as shown in Fig. 2. The disadvantage of this scheme is that Q_2 and Q_3 do not operate under identical conditions as far as the dc circuit is concerned. The operating point stabilities will be different and dc power is still wasted in the bias network R_2, R_3.

A further improvement is suggested in Fig. 3. The collector load of Q_1 has been split into a bridge arrangement of the four resistors R_4 through R_7. These four resistors may be made equal, although the only rigid requirement is that $R_4 = R_6$ and $R_5 = R_7$. The bases of Q_2 and Q_3 are then at the same dc potential as required for their biasing. Capacitor C_3 bypasses the base of Q_3 to the positive supply bus and thence to ground. For signal frequencies, resistor R_2 acts only as an undesired attenuator in series with the base of Q_2, and is therefore bypassed by capacitor C_1. If the loss of gain can be tolerated, C_1 may be omitted.

Note that the direct coupling of the two push-pull transistors to the first stage enables both their operating points to be equally stabilized. In this type of connection, the resistor values may be so chosen that the first stage compensates for the operating point drift of the second stage. There is no loss of signal through the shunting effect of the bias arrangements. The scheme of Fig. 3 will operate satisfactorily down to that frequency at which C_1 and C_3 fail to act as effective bypasses. The operating point stability factors are given by:

$$S_1 = \frac{\partial I_{c1}}{\partial I_{co}} = \frac{1 + \frac{R_2}{R_1} + \frac{R_3}{R_2}}{(1-\alpha) + \frac{R_2}{R_1} + \frac{R_3}{R_2}}$$

$$S_2 = \frac{\partial I_{c2}}{\partial I_{co}} = S_3 = \frac{\partial I_{c3}}{\partial I_{co}} = \frac{1 + \frac{2R_e}{R_4} - \frac{\alpha S_1}{2}}{(1-\alpha) + \frac{2R_e}{R_4}}$$

It has been assumed in these equations that all three transistors have identical I_{co} and α.

Sample Design

A sample circuit is shown in Fig. 3 using type 2N479 silicon transistors with an α of about 0.98. The output collectors are transformer coupled to a load measuring 7.2 K collector-to-collector. No attempt was made to maximize gain or power output. The stability factors are $S_1 = 5.4$ and $S_2 = S_3 = -4.3$. The two push-pull transistors have thus been slightly over-compensated. The voltage gain of the circuit measures about 8000, and some 10 mw of power output is available. ■ ■

William G. Royce has been with Kin Tel over nine years working principally in the design of low drift, precision dc amplifiers, both single-ended and differential, for data handling systems.

Differential amplifiers can . . .

Rescue Millivolts of Signal From Volts Of Noise

William G. Royce
Project Engineer
Kin Tel Division of Cohu Electronics
San Diego, Calif.

FLOATING differential dc amplifiers are better than single-ended amplifiers for rejecting noise in an instrumentation system. The differential amplifier can distinguish between millivolts of signal and volts of noise.

The disadvantage of the single-ended amplifier is that it needs a filter in its input to reject noise. The filter attenuates noise, but it also attenuates the signal.

In the system shown in Fig. 1, the signal output of the transducer might be 10 mv peak-to-peak. If the system is to have an overall resolution of 0.1 per cent, which is not unreasonable today, then the total allowable error can not exceed 10 μv peak-to-peak at the amplifier input. This error includes noise introduced into the system prior to the amplifier, amplifier performance, and other miscellaneous contributions.

If the amplifier is a good one, it will probably have an error equivalent to slightly less than 5 μv peak-to-peak input. This error within the amplifier is caused by drift, low frequency noise, and hum. The remaining contribution of approximately 5 μv peak-to-peak comes primarily from hum picked up in the wiring of the instrumentation circuit exterior to the amplifier.

To reject unwanted noise in such a system so that less than 5.6 μv peak-to-peak gets to the input terminals of the amplifier, the instrumentation wiring must be installed so that maximum ground loop impedance exists, with accompanying minimum ground loop current. Such precautions are mandatory; but even when grounding is properly taken care of, noise amplitudes of several volts often appear on the wires leading to an instrumentation dc amplifier. This noise is caused by ground loop current, which inevitably exists in the system. Sometimes the system lends itself to the inclusion of a series filter, but unfortunately, a noise filter always limits the band pass or frequency response of the circuit. Therefore, in many dynamic instrumentation installations a filter is not practical. In these cases the amplifier itself must be able to reject noise.

Ground Loops and Common Mode Voltage

The consideration of grounds involves comparing the relative merits of single-ended and differential amplifiers. A typical, conventional single-ended amplifier has one of its input terminals and one of its output terminals joined as a common ground connection. This ground terminal is usually connected to the amplifier frame. Such an arrangement results in a good amplifier, but often provides many headaches when either the transducer or the recorder, or both, must be tied to system ground. In a differential amplifier, the input and output terminals may be floating with respect to system ground, providing greater flexibility in wiring the instrumentation system.

One way to keep the noise low in the system shown in Fig. 1 is to keep the common mode voltage as low as possible. Common mode voltage is the difference in potential between widely separated ground points. Any grounding material connecting two points has some finite impedance —even so-called buss bars. Unfortunately, the use of heavy wire in the connecting cable does very little good. The reason for this is that the thermocouple resistance is relatively high.

The scheme shown in the illustration reduces noise considerably. The shield of the connecting cable is connected to ground at two points, providing a shunt circuit for the ground loop current I_1. The amplifier and the load are well isolated from ground. In addition, it is significant that the reference cold junction is in the line connected to the high side of the circuit; such placement is

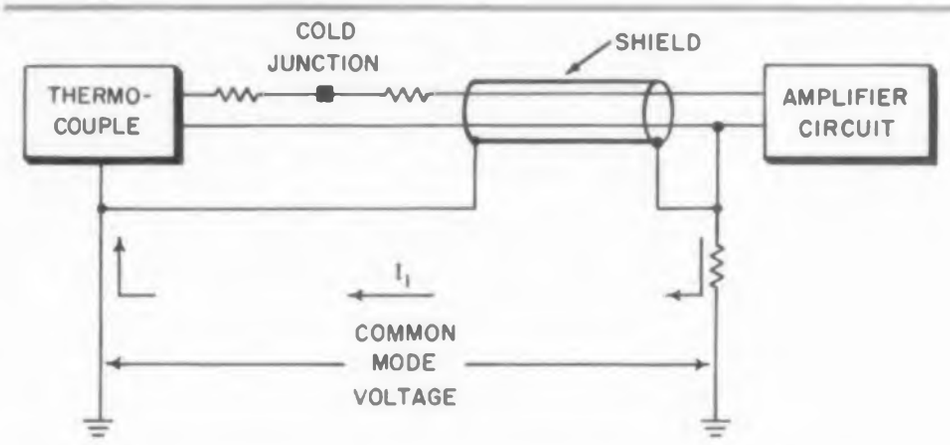


Fig. 1. Typical instrumentation system utilizing shielded cable "grounded" at both ends.

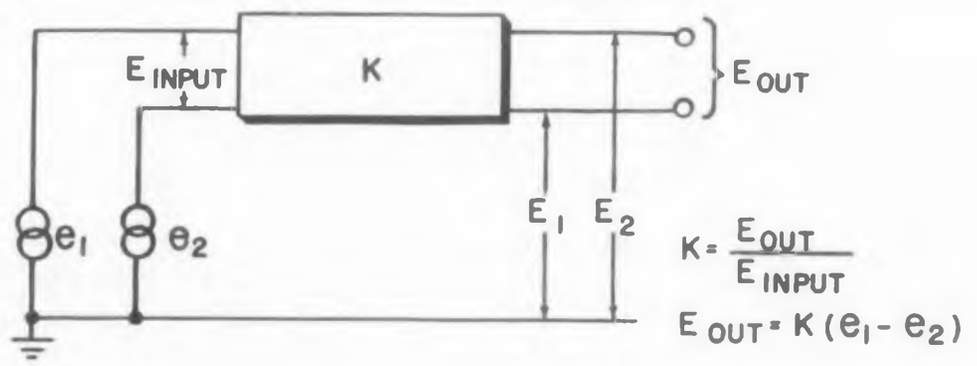


Fig. 2. Basic differential amplifier.

made because this line has more impedance than the other wire emanating from the thermocouple. The low-impedance line is chosen for the low or ground side.

With the circuit arrangement shown in Fig. 1, the ground loop current I_1 flows through the parallel paths of the cable shield and the low side of the thermocouple output wire. Since the shield has a much lower impedance than the instrument lead, most of the unwanted ground loop current flows through the shield. Such an arrangement will provide noise figures within the 5 μv peak-to-peak limitation mentioned above. The only rule of thumb broken by the circuit shown is that the shield is not unipotential; that is, the shield shown is grounded at both ends. This difficulty can be circumvented by using a double-shielded connector cable. The outer shield can be used for the ground connection, while the inner shield is connected at the amplifier end only.

Differential Amplifier Limitations

To make such a precision instrumentation system possible, a well-designed differential amplifier is highly desirable. A basic differential amplifier is shown in Fig. 2. In this theoretical circuit, the output voltage is proportional only to the difference between the two input voltages. These input voltages are referred to a common, invarying ground potential, which is entirely arbitrary.

However, such a theoretical circuit cannot be converted into actual hardware. A practical differential amplifier becomes the circuit shown in Fig. 3. Common mode voltage appears in this actual equipment, since there is a finite isolation impedance to ground inherent in any amplifier. In practice, though, this impedance can be made as high as 10^{15} ohms and 0.6 μμf.

The biggest advantage a differential amplifier possesses over a single-ended amplifier in many installations is its inherent ability to reject noise better than a single-ended amplifier. The principle of noise rejection is illustrated in Fig. 4. Assuming that two wires emanate from the transducer, and that both wires have identical impedance, the noise that is induced by electromagnetic pickup travels along both wires. This noise enters the amplifier via two terminals. The two terminals are connected so that the net difference in voltage between them is amplified. Since the noise voltage on each wire is the same, the net difference between the two is zero, and no noise passes through the amplifier.

Another way to look at what is happening is illustrated in Fig. 5. The currents i_1 and i_2 in Fig. 5 are noise currents. Each flows to ground through what amounts to a center-tapped transformer primary winding. The secondary of the

mythical transformer has no signal induced by the equal and opposite input noise currents. Meantime, a signal current flows through the entire primary winding of the mythical transformer, resulting in output signals.

High Noise Rejection

Because of the line unbalances and incomplete isolation from ground of the amplifier, the two circuits into a differential amplifier are not identical, and some noise always comes through. The measure of the ability of the amplifier to reject such noise or keep it to a minimum is termed the common mode rejection of the amplifier. Common mode rejection is the principal figure of merit of a differential amplifier. A very good dc differential amplifier will have a common mode rejection of 120 db for noise at a frequency of 60 cps. This means that the ratio of rejection is a million to one. The same amplifier can have a dc common mode rejection of 160 db. With such rejection figures, it is possible to rescue microvolts of signal from volts of noise. If, for example, a 5 v peak-to-peak noise signal is induced on the lines in Fig. 5, the output of the amplifier reproduces noise that looks like only 5 μv peak-to-peak of input added to the actual wanted information.

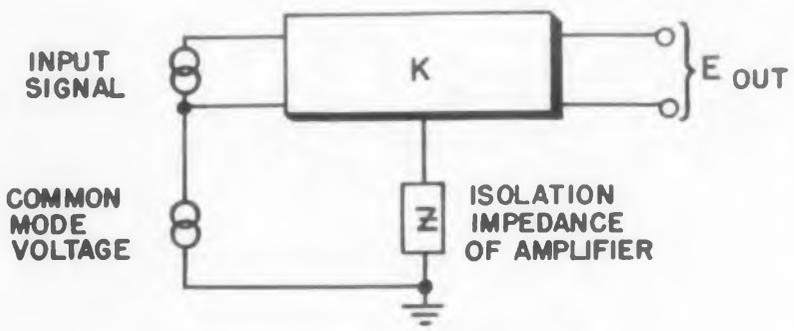


Fig. 3. Practical differential amplifier.

Suppose a 0.1 per cent accuracy system contains a transducer that provides a 10 mv peak-to-peak usable signal. The resolution required, then, is 10 μv peak-to-peak. Assume further that noise and drift generated within the amplifier account for half the system inaccuracy, or 5 μv peak-to-peak equivalent input signal. The noise induced on the line can be 5 v peak-to-peak in amplitude, and the amplifier will reject it satisfactorily if it has a common mode rejection of 120 db. If the amplifier used in the system has a common mode rejection of only 60 db (representing a thousand-to-one ratio), then a 5 mv peak-to-peak noise amplitude induced on the lines will not be seen in the 0.1 per cent system. However, it is quite difficult to extend long cables and have only 5 mv peak-to-peak of noise induced in the lines. In most practical installations, the induced hum is much higher. In these circuits, 60 db of common mode rejection would not be enough if 0.1 per cent accuracy is the overall target. Therefore, very high common mode rejection is essential in a dc instrumentation amplifier where high precision is a requirement.

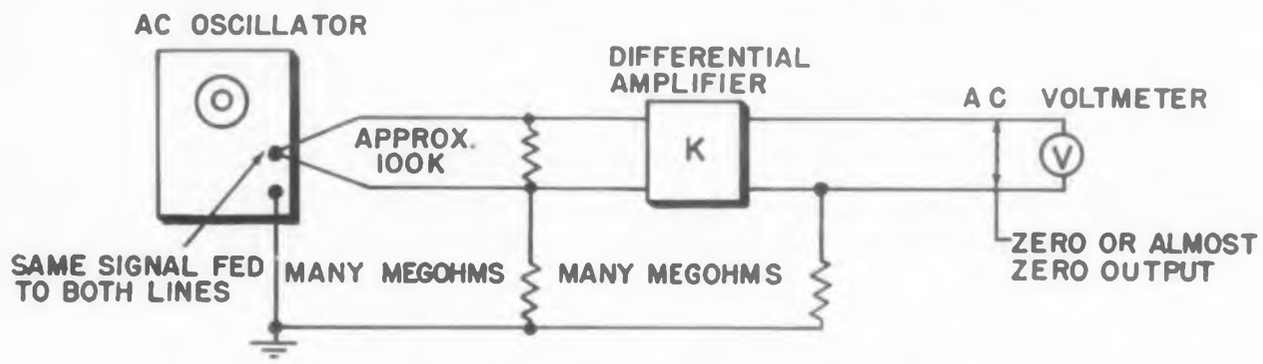


Fig. 4. How a differential amplifier rejects noise.

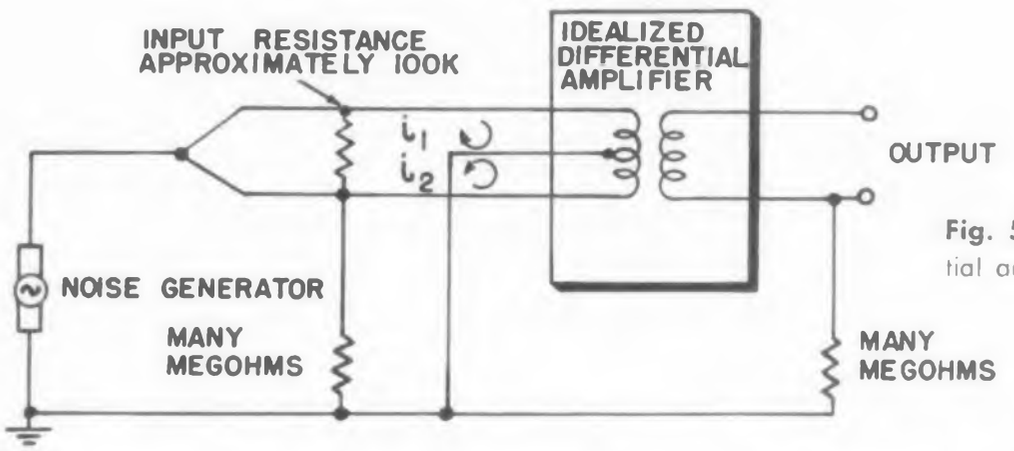


Fig. 5. Isolation action of differential amplifier.

Gain Stability Considerations

If gain settings in a dc instrumentation amplifier are to be significant, the source and line resistances must be considered in great detail. In the case of a typical chopper-stabilized dc amplifier with 100,000 ohms input impedance, if the gain settings must be stable to 0.1 per cent accuracy, then the combined source and line resistances must not vary more than 100 ohms. This requirement may not be too stringent under any given set of static ambient conditions; but when temperature and humidity changes are brought into the picture, the 100 ohm figure may become a severe handicap. For this reason, it is generally better to provide an amplifier with as high an input impedance as possible for any given circuit under consideration. The higher the input resistance of the amplifier, the higher can be the source and line resistances—and the changes in them—without affecting the gain of the amplifier too severely.

Of course, the gain of the amplifier itself is a

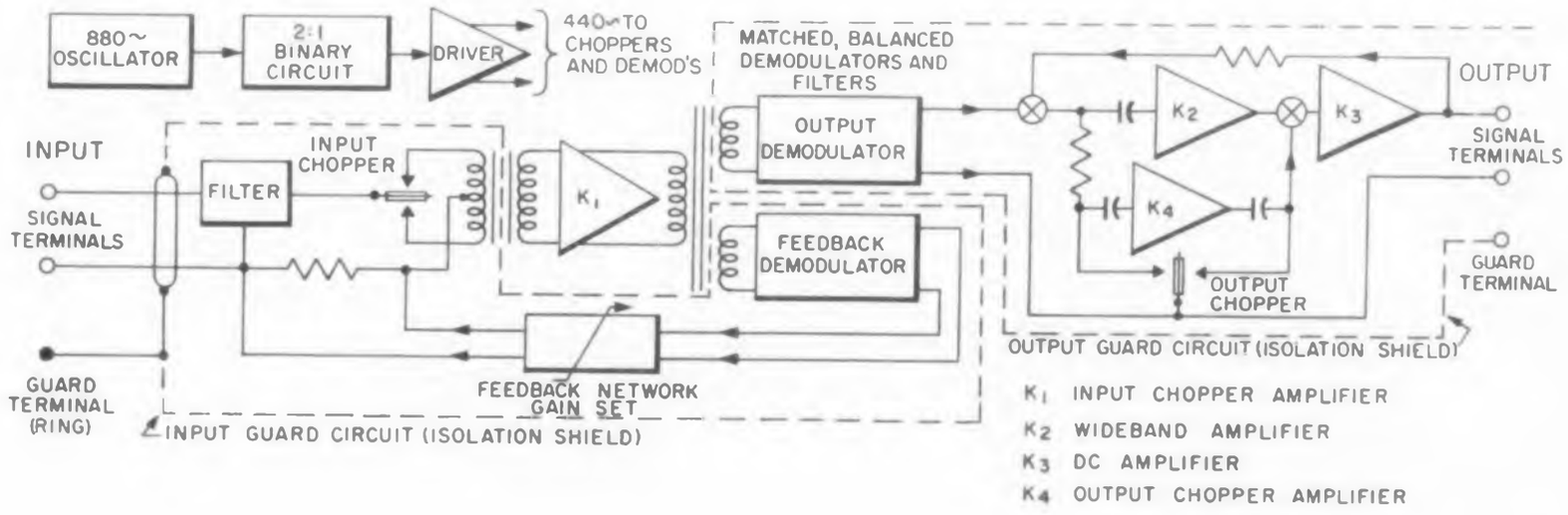


Fig. 6. Block diagram of a differential amplifier.

function of many components. The effect of gain changes during operation, however, can be considerably reduced by utilizing a large amount of negative feedback around the amplifier. If the gain of the basic amplifier is high, and a large amount of inverse feedback is used, then the gain of the combined amplifier plus feedback circuit is, of course, primarily dependent upon the values of the circuit components within the feedback circuit.

Precision components, carefully aged and matched with care during the construction of a differential amplifier, go a long way toward insuring gain stability of the amplifier under field operating conditions. In some cases, the feedback circuit is external and housed in a separate area under carefully controlled environmental conditions. Many commercially-available amplifiers have provisions for switching from internal feedback to external feedback circuits, for flexibility in various instrumentation situations. In any case it is the feedback circuit that must be controlled in order to maintain a true precision system.

DC Drift

Even when source impedance is kept as low as possible and amplifier input impedance is made extremely high, a margin of safety must be left in the design of an instrumentation system to allow for inevitable drift. This change in impedance values for practically all components within the system occurs, for the most part, because of changes in temperature. However, vibration and humidity can also seriously affect the many parameters in an instrumentation circuit. Add to these the possibility of unregulated power supply voltages, and the drift picture is complete.

If the transducers in a dc installation require isolation from the recording equipment, and especially if voltage gain is required, the dc differential amplifier becomes the logical item to perform the task.

Chopper-stabilized, as shown in Fig. 6, a dc amplifier is a dependable link in the instrumentation chain. Zero drift is minimized by the use of the chopper to electromechanically convert dc into ac. The ac signal is amplified with all the efficiency of an ac amplifier. Then the amplified signal is demodulated with carefully balanced semiconductor circuitry to provide an output dc signal proportional to the input dc signal, and completely isolated from it. This isolation is achieved by shielding the input circuits and separately shielding the output circuits. In this manner, stray voltage effects are reduced to a minimum, and ground current problems depend entirely upon the circuit configuration of the instrumentation system external to the amplifier. ■ ■

A "harness" is not necessarily a "cable." A cable must have uniform flexibility throughout its length. Flexibility is achieved by laying the conductors in a helical pattern around the cable core. If the conductors are not helical but are pulled straight through the jacket, the resulting assembly is stiff.

Cable design begins with the schematic of the basic circuit that requires cables of optimum configurations and materials for maximum reliability. It is important that system design, while still in the breadboard stage, consider the relationship between the cables and other components of the system. Frequently, through proper cable design, the number of subcomponents within the black boxes can be reduced. This results in increased reliability and lower cost. For example, high-impedance, low-loss shielded cable circuits may eliminate the need for an extra cathode follower or transformer. Similarly, rf, dc, and ac conductors can often be incorporated into the same cable. This can save both cable and connector costs, and at the same time improve reliability and performance.

Important parameters which must be considered in cable design include size and type of conductors, arrangement of conductors within the cable, filler material, tape, jacketing, connectors, sealing compound, flexibility and size of the cable assembly. Material choice is most important and depends to a great extent on the environment and application of the particular cable.

improving cable design

William J. Strauss
Pacific Automation Prod. Inc.
Glendale, Calif.

A handy nomograph and a handful of working equations make cable design easy.

KNOWLEDGE of cable characteristics like flexibility, tension loading and sheathing facilitates proper cable design. Knowing the "hows" and "whys," the engineer can then meet any rigid electrical, mechanical and environmental requirement.

Cable Flexibility

Unfortunately, there are no definite standards for flexibility or cables. Environmental and performance standards such as temperature, size, content, chemical resistance or current rating can be specified with precision. However, the terms "flexible" and "extra-flexible" are not precise and depend on their usage.

Nevertheless, flexibility can be engineered into a cable. The force required to bend a cable is lessened by winding individual conductors in a helical pattern along the length of the cable. The ratio of the length of one spiral turn to the diameter of the turn is defined as the lay ratio and is illustrated in Fig. 1. The lay ratio of cable generally ranges from 10 to 15. This results in an increase in wire length of from 2 to 5 per cent. The curve of Fig. 2 indicates the increase of wire length as the lay ratio decreases. In practically all cases, the increase in length, and consequently resistance, is either negligible or within the range of acceptable tolerance.

The outer lay of conductors in a multilayer cable will always have a left-hand lay, that is, the conductors spiral around the core in a left-hand direction. The next succeeding layer will have the opposite, or right-hand lay, with the third layer again reversing direction resulting in a left-hand lay. The actual lay ratio of each layer will depend on the number of conductors in each layer, but will, in general, remain constant from lay to lay within a cable.

Cable Tension Loading

Cable tension loads are limited by the allowable elongation of the individual conductors. For example, the permissible elongation of annealed copper conductors is 0.2 per cent. The maximum safe load in tension per conductor is equal to five times the wire weight per 1000 feet. For multiple conductor cables, the maximum allowable pulling force is given by the product of the number of conductors in the cable and the allowable force per conductor. In these calculations, the wire insulation has been excluded to provide a safety factor of approximately 15 per cent. The factor of wire weight has been reduced from 7.7 to 5.0 to provide an additional safety margin of 15 per cent for pulling loads only.

For vertically suspended loads on cables, the weight of wire insulation and jacketing must be added to the load weight of the wire. Insulation weight is approximately 20 per cent of the wire weight for conductors conforming to MIL-W-16878C, Type B, and MIL-W-5086A, Type I; 35 per cent of the wire weight for conductors conforming to MIL-W-16878C, Type C, and MIL-W-5086A, Type II; and 60 per cent of the

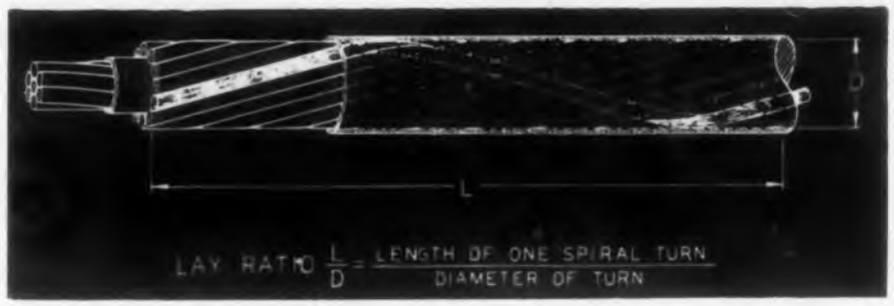


Fig. 1. Lay ratio defined and illustrated.

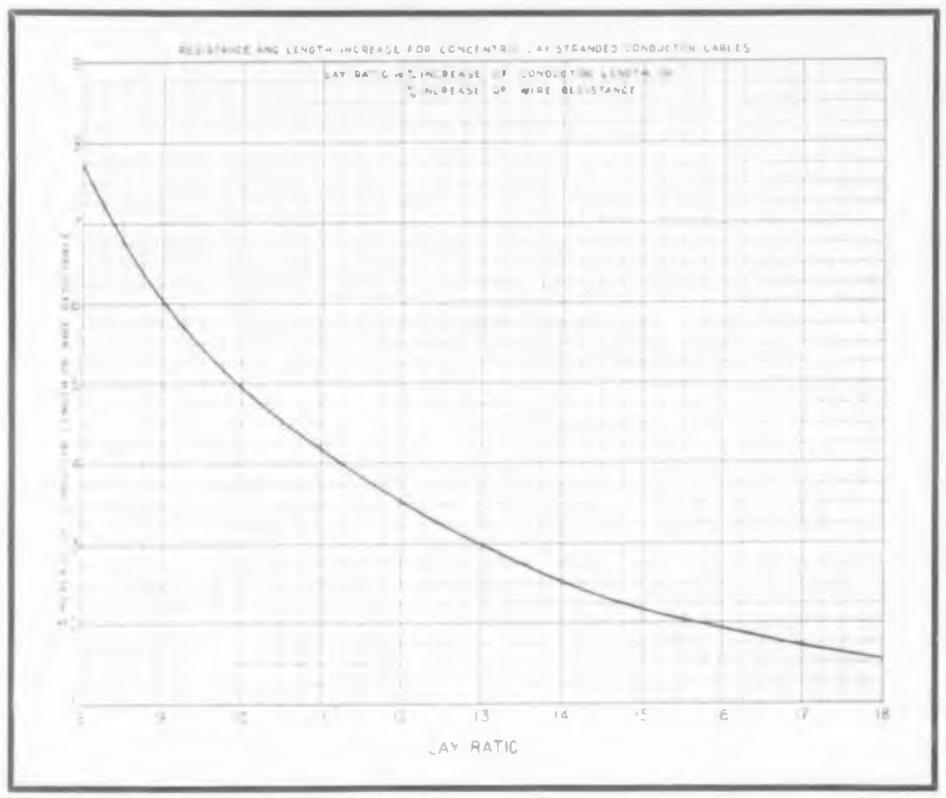


Fig. 2. Relationship between increase of wire and lay ratio.

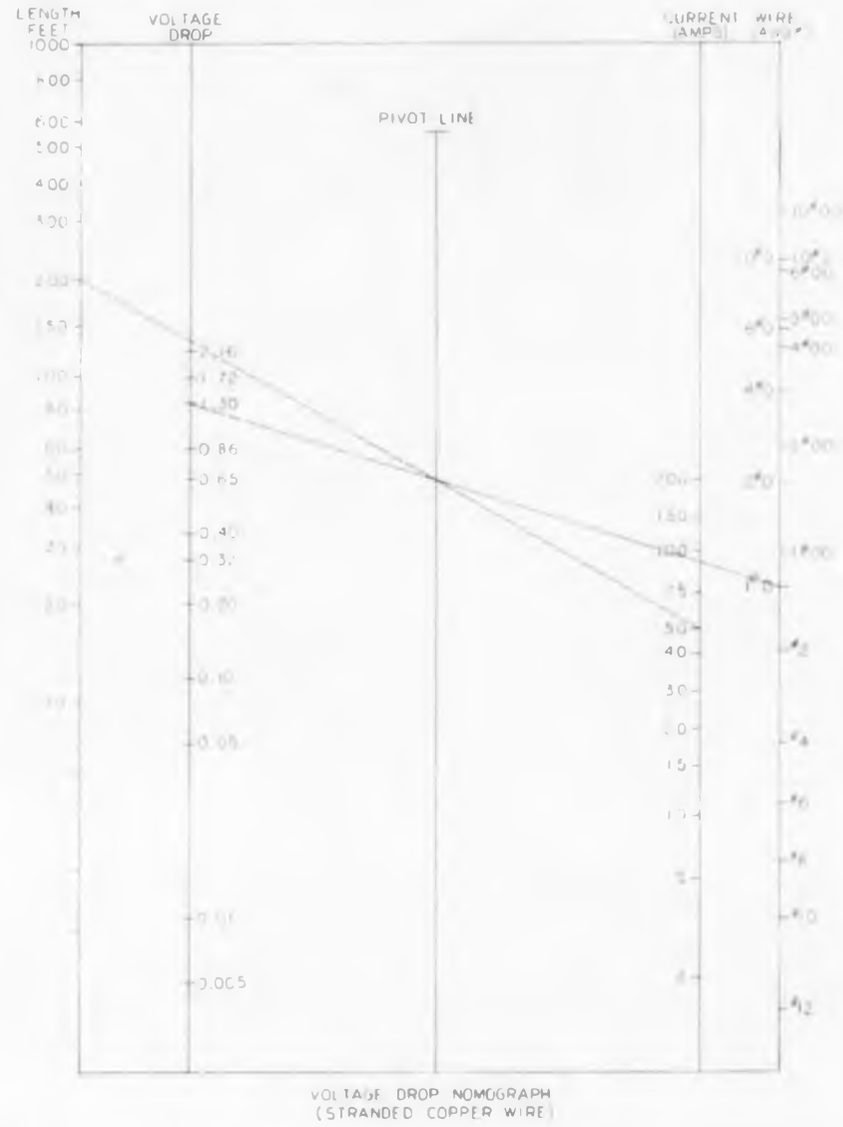


Fig. 3. Voltage drop nomograph for stranded copper conductors operating at 68 F.

wire weight for conductors conforming to MIL-W-16878C, Type D.

Neoprene jackets conforming to MIL-R-6855 will not significantly affect these figures since neoprene has a Young's modulus close to that of copper. Neoprene jackets for cables made in accordance with MIL-R-6855 have a density ratio to the amount of copper in the cable of approximately 75 per cent.

Resistance and Voltage Drop

Wire resistance varies with temperature and stranding as well as length. Table 1 lists the characteristics of number 10 AWG wire at 68 F.

These values are approximate because of the wide variation in data available from wire manufacturers, but they serve to illustrate that considerable difference does exist in the values for a given size wire.

Where cable operation takes place at other than standard temperature, correction must be made to compensate for the difference in resistance at the operating temperature. These factors can only be determined after analysis of a particular situation. But in general they become more critical as the current rating of the conductor is approached or the voltage drop becomes excessive because of long cable runs.

The nomograph of Fig. 3 has been prepared to assist the designer in voltage drop determinations and is based on stranded copper conductors operating at 68 F. For example, let us determine the voltage drop in a cable run of 200 ft carrying 50 amps in a 1/0 conductor. First place a straight edge along the line joining 200 ft on the left-hand scale and 50 amps on the second scale from the right. Then rotate the straight edge about the pivot line until it lies on the conductor size of 1/0 on the right-hand scale. The intersection of the straight edge and the voltage drop scale gives the result directly as 1.3 volts drop. This nomograph can be used to determine any of the four values when the other three are known or assumed.

Jacketing or Sheathing

Cable jacketing may be supplied in any material required to meet the environmental conditions of the system into which the cable is installed. However, certain neoprene compounds have been found to provide the best all-around resistance to the severe environmental conditions encountered in the field. They are better than either rubber compounds or other plastics. It is a matter of record that neoprene jacketed umbilical cables for missile launching, normally considered expendable items, have been successfully used for several firings.

Paprene, the proprietary neoprene compound used in combination with the unique technique of cable fabrication employed, results in a compact, flexible cable with properties that assure optimum performance and maximum reliability. Among the advantages of this combination is the ease with which "breakout" cables are fabricated. Breakout cable, illustrated in Fig. 4, provide systems engineers with greatest flexibility of design and maximum economy of hardware.

A further improvement in breakout cable design is provided by the "clamshell" joint shown in Fig. 5. This exclusive design produces a smaller, stronger, lighter joint than the former

method provided and affords greater flexibility in the area near the joint. The clamshell joint consists of two cast pieces of neoprene filled with a potting compound that has the same compositions as the cable jacket.

Of the many materials used as cable jacketing, each possesses certain physical and chemical properties for certain advantages in application. For example, some jacketing materials have excellent resistance to sunlight, while others are seriously deteriorated by sunlight's effects. Temperature, corrosion, contamination and radiation, as well as numerous other environmental factors affect each material differently. For this reason, consideration must be given to the actual environment to be encountered in service when specifications are being prepared, and to materials which will withstand these environmental conditions.

Table 1. 10 AWG Wire Characteristics

Stranding	Diameter	Circular Mil Area	Weight /M Ft.	Resistance /M Ft.
Solid	0.1019	10380	31.52	1.04
105 × 30	0.132	10553	32.99	1.10
65 × 28	0.119	10322	32.37	1.10
37 × 26	0.1113	9402	28.89	1.17

Shielded and Coaxial Cables

Shielded and coaxial conductors can be fabricated into special cables or used with other conductors in any combination. Although coaxial cables are less flexible than other cables, this is normally not a problem unless extreme flexibility is required.

Low capacitance signal leads are often used to advantage in long signal runs.To determine the capacitance between them conductor and

Fig. 4. Breakout cable.

Fig. 5. Clamshell joint.

...ld or ordinary shielded wire, to find out ...ther this wire can be used or special low ...pacitance wire is needed, the following for...mula can be applied:

$$\text{Capacitance}_{\text{(conductor to shield)}} = \frac{7.354 \times 10^{-4} K}{\text{Log}_{10} \frac{D}{d}} \ \mu\mu\text{fd/100 ft.}$$

where

D = ID of shield

d = OD of bare wire

K = Dielectric constant of insulation

To determine the capacitance between wires of two conductor shielded pairs, the following formula is used:

$$\text{Capacitance}_{\text{(wire to wire)}} = \frac{3.677 \times 10^{-4} K}{\text{Log}\left(\frac{2a}{d}\right)\left(\frac{D^2 - a^2}{D^2 + a^2}\right)} \ \mu\mu\text{fd/1000 ft.}$$

When shielded or coax wire is used, signal loss ...n be determined from the formula for attenuation:

$$\text{Attenuation} = \frac{4.6 f (d_1 + d_2)}{d_1 d_2 \ \text{Log}_{10} \frac{d_1}{d_2}} \times 10^{-6} \text{ db/ft.}$$

d_1 = ID of shield

d_2 = OD of shield

f = frequency (mc).

Cable Testing

...guarantee performance and reliability, ... should be subjected to a wide variety of ...al and mechanical tests, such as impact, ...ion, twist, bend, high and low temperature, ...static, as well as a number of other chemi... electrical testing procedures. ■ ■

NEW PRODUCTS

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

VIBRATION SYSTEM

Power generator of this vibration testing system is rated at 175,000 va output and the model A-182 shaker has a force output of 25,000 lb from 5 to 2000 cps. Model PP-175/240 amplifier is a 4-cubicle assembly that measures 18 ft in length and is 5 ft in depth while the shaker is almost 6 ft high. The system is completely self-contained and all control circuitry is included in the power generator cabinets. But all important controls and meters can be duplicated on a control console for remote control. The same basic power generator and control assembly can be applied to driving acoustic transducers.

Ling Electronics Inc., Dept. ED, 9937 W. Jefferson Blvd., Culver City, Calif.

CIRCLE 34 ON READER-SERVICE CARD

PRECISION FILM RESISTORS

These precision film resistors are epoxy coated and are applicable to transistorized circuitry. Model N65 is rated at 1/4 w and has resistance values from 10 to 500,000 ohms. Voltage rating is 300 v. The N70 is rated at 1 2 w and has resistance values from 10 ohms to 1 meg. Voltage rating is 350 v. The N style resistors will meet MIL-R-10509C, characteristic B. The coating will withstand chlorinated hydrocarbon solvents used in cleaning flux from printed circuit boards.

Corning Glass Works, Electronic Components Dept., Dept. ED, Bradford, Pa.

CIRCLE 35 ON READER-SERVICE CARD

SILICON ZENER DIODES

These silicon zener regulator diodes are available in four nominal basic power ratings: Series B,750 mw; Series T, 1 w; Series G, 3.5 w; and Series K, 10 w. The first two come in an axial pigtail top hat package and the higher power devices in 10-32 stud-mounted cases. Zener breakdown voltage ranges cover from 3.6 to 30 v in each power rating.

International Telephone and Telegraph Corp., ITT Components Div., Dept. ED, 100 Kingsland Road, Clifton, N. J.

CIRCLE 36 ON READER-SERVICE CARD

SUBMINIATURE TRANSFORMERS

The Weecoil H. F. line consists of a single tuned coil and an oscillator coil for transistorized printed circuit use in frequencies from 1 to above 10.7 mc. Overall height is 0.5 in. and base dimensions are 0.55 square. Both top and bottom tuning are possible. Normally-treated units stand 95% relative humidity at 120 F for 500 hr, and are suitable for use between —40 to 185 F. Fully encapsulated units are available for military applications. Q's of up to 100 are possible in shielded versions.

Wells Electronics Co., Dept. ED, 1701 South Main St., South Bend 23, Ind.

CIRCLE 37 ON READER-SERVICE CARD

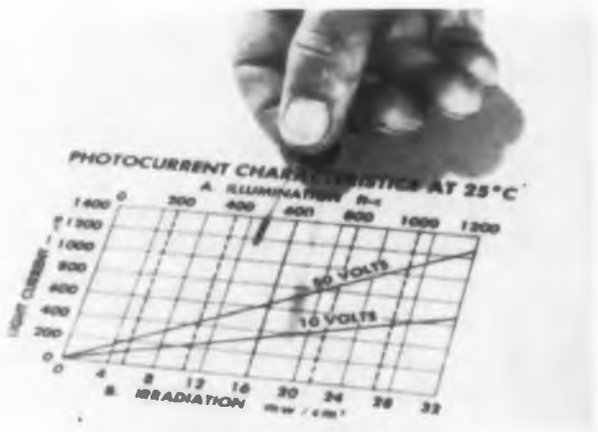


PHOTO-DUO-DIODE

Model 1N2175 photo-duo-diode passes up to 1200 μamp when exposed to 1200 ft-c. In darkness the unit passes less than 0.5 μamp. Dissipation is rated at 250 mw at 25 C, and any biasing voltage up to 50 v will operate the device. It will operate equally well on either ac or dc, and is rated to 125 C with a minimum operating temperature of —55 C. The single-ended glass case measures 0.5 in., and has a diameter of 0.085 in.

Texas Instruments Inc., Dept. ED, Post Office Box 312, Dallas, Tex.

CIRCLE 38 ON READER-SERVICE CARD

NEW PRODUCTS

High Fidelity Speakers

Use Ticonal steel magnets

Series T-7 twin-cone loudspeakers use Ticonal steel voice coil magnets and have a long air gap so that the coil is completely enclosed by a homogeneous magnetic field even at peak amplitudes. The Ticonal 7 magnet provides a high concentration of flux densities in the voice coil air gap and is about 30% more powerful than conventional magnets. Besides the cone for middle and low notes, the speakers are equipped with a high note cone which extends the frequency range to about 20 kc.

North American Philips Co., Inc., High Fidelity Products Div., Dept. ED, 230 Duffy Ave., Hicksville, N.Y.

CIRCLE 71 ON READER-SERVICE CARD

Silicon PNPN Controlled Switches

Replace thyratrons

Series 3A silicon pnpn controlled switches have electrical characteristics similar to those of thyratrons and provide high speed medium power switching in a wide variety of applications. They have three junctions and can replace magnetic amplifiers, thyratrons, tubes, semiconductor diodes, rectifiers, and transistors. Particularly suited to ac static switching and control circuits, they may also be used in magnetic core switching, logic circuitry, pulse generation and shaping, inverters, motor controls, power supplies, servo systems, and high level demodulators. The units have voltage ratings to 200 v, peak current ratings to 1 amp, and a typical turn-on time of 0.2 μsec. In the forward direction they will either conduct heavily or block depending on whether or not a gate current is applied. The reverse characteristic is similar to that of a conventional silicon diode.

Solid State Products, Inc., Dept. ED, 1 Pingree St., Salem, Mass.

CIRCLE 72 ON READER-SERVICE CARD

Transistorized Power Supply

0 to 1 amp range

Supplied with or without a meter, the LT 1095 transistorized power supply has a range of 0 to 1 amp and 0 to 32 v dc. Convection cooled, it has no moving parts or internal blowers.

Lambda Electronics Corp., Dept. ED, 11-11 131st St., College Point 56, N.Y.

CIRCLE 44 ON READER-SERVICE CARD

DC Insulation Testers

Portable

Series VON portable high voltage dc insulation test instruments and power supplies have ranges from 30 kv at 40 ma to 250 kv at 7 ma. All models are sectionalized to provide maximum portability and minimum weight, and supplemental stages may be added to the base power units to increase voltage ratings.

The Hewson Co., Inc., Dept. ED, 103 Broad St., Newark 2, N.J.

CIRCLE 45 ON READER-SERVICE CARD

Circuit Breaker

For 220 or 440 v ac systems

A thermal type, three phase circuit breaker, Klixon model D6760-5 operates on 220 or 440 v ac at 60 or 400 cps. With ratings of 5 to 60 amp, it will handle short circuits between 800 and 1000 amp at 440 v. Trip time is 2 to 6 msec on short circuit interruption.

Metals & Controls Corp., Spencer St., Dept. ED, Attleboro, Mass.

CIRCLE 46 ON READER-SERVICE CARD

CIRCLE 47 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Stabilized Amplifier

Provides outputs to ±100 v

Using no electrolytic capacitors or glow tubes, this modular stabilized amplifier provides an average open loop dc gain of over 50 million, with a minimum of 10 million. Long and short term drift is under 100 μv and output voltage is up to ±100 v. The unit requires a plus and minus 300 v dc supply and a 6.3 v ac filament source.

Applied Technology Corp., Dept. ED, 475 Fifth Ave., New York 17, N.Y.

CIRCLE 49 ON READER-SERVICE CARD

Shielded Trailers and Trucks

For on the spot interference testing

Completely self-contained, these shielded trucks and trailers are custom designed for radio interference testing. With one, two, or three shields, they provide over 100 db attenuation at all frequencies from 15 kc through 1000 mc. They will closely approximate 100 db at 10,000 mc, exceeding the attenuation requirements of MIL-E-4957A. Provisions can be made for mounting antennas, shock-mounting test equipment, and installing intercommunication systems and coaxial connector panels. The units can be equipped with a power control panel and a diesel driven generator with outputs up to 20 kw. External power connections can also be furnished. The trucks can be built with living quarters that have all the facilities necessary for the comfort of operating personnel, including heating and air conditioning. Engineered to provide high attenuation and efficient performance, the units are also designed to meet the legal specifications of all states.

Ace Engineering & Machine Co., Inc., Dept. ED, Tomlinson Rd., Huntington Valley, Pa.

CIRCLE 50 ON READER-SERVICE CARD

Power Supplies

0 to 60 v

Transistorized and short circuit proof, these power supplies can be used from less than 1 v up to 60 v without loss of regulation or stability. Three models are available with maximum ratings of 2.5, 5, and 7.5 amp. Regulation is 0.1 per cent or 0.01 v no load to full load with 105 to 125 v lines.

Electronic Measurements Company of Red Bank, Dept. ED, Eatontown, N.J.

CIRCLE 51 ON READER-SERVICE CARD

Miniature Chopper

Shock resistant

This miniature dpdt Syncroverter chopper affords good tracking and is resistant to shock and vibration. It has a contact rating from dry circuit to 100 v, and its phase angle is virtually unaffected by temperatures from —65 to +125 C.

The Bristol Co., Dept. ED, Waterbury 20, Conn.

CIRCLE 52 ON READER-SERVICE CARD

Twin-Triode Tube

Low-level

A nine-pin miniature twin-triode tube, type WL-7025 is designed for service as a low-level input voltage amplifier for tape recorders and audio preamplifiers. Interchangeable with tube types 12AX7, 12DF7, and ECC83, it can withstand high voltage surges.

Westinghouse Electric Corp., Electronic Tube Div., Dept. ED, Box 284, Elmira, N.Y.

CIRCLE 53 ON READER-SERVICE CARD

NEW PRODUCTS

Circuit Breaker

Protects fhp motors

Model MP-1600 circuit breaker is a remote mounted, manual reset unit designed to provide overload protection for fhp motors in ratings from 5 to 20 amp. It employs a snap action thermal element that trips and shuts off a motor when current exceeds a predetermined limit. Once the motor is shut off, it cannot resume operation until the breaker has been reset.

Mechanical Products, Inc., Dept. ED, Jackson, Mich.

CIRCLE 56 ON READER-SERVICE CARD

Beryllium Oxide Ceramic Insulator

For use to 4600 F

A high purity, high density beryllium oxide ceramic, Berlox is an electrical insulator with thermal conductivity equal to that of brass. It can be used at temperatures up to 4600 F. It also withstands corrosive media and has maximum thermal shock resistance. Fabricated, fired-to-shape, and extruded forms of this material can be used in nose cones, metal processing, waveguide windows, pyrometer sleeves, electron tube spacers and envelopes, heat exchangers, and reactor moderators. A variety of standard size Berlox crucibles and laboratory ware is also available.

National Beryllia Corp., Dept. ED, 4501 Hell Ave., North Bergen, N.J.

CIRCLE 57 ON READER-SERVICE CARD

Solid State Rheostats

Resistances to 500 meg

Designed for panel mounting, these static rheostats have no windings or sliding contacts. They are moisture proof. In a variety of sizes down to units that weigh 7 g, they have resistance values from a few ohms to 500 meg.

Clark Electronic Labs, Dept. ED, Box 55, Palm Springs, Calif.

CIRCLE 58 ON READER-SERVICE CARD

Strain Gages

For medical and other electronic use

Initially designed for viewing the waveform of arterial blood pressure during heart surgery, these strain gages have many other uses. They are made from polycrystalline palladium alloys and permit the reading of very small tension changes on simple instruments.

Clark Electronic Labs, Dept. ED, Box 185, Palm Springs, Calif.

CIRCLE 59 ON READER-SERVICE CARD

Epoxy Resins

Have high heat resistance

For casting, laminating, and adhesive uses, these liquid epoxy resin systems come in two formulations. Resin 617-A is aluminum-filled and 617-C is clear. Both have low viscosity, which can be maintained at room temperature for as long as 30 minutes after mixture with a hardener. They have a heat distortion point of 425 F and show heat resistance at operating temperatures up to 500 F. At higher temperatures they retain elasticity and have a maximum deformation of 0.01 in. per in., which is partially recoverable.

Marblette Corp., Dept. ED, 37-31 30th St., Long Island City 1, N.Y.

CIRCLE 60 ON READER-SERVICE CARD

Capacitor Clip

Vibration proof

For use with any capacitor that has a diam between 31/32 and 1-5/8 in., these clips provide vibration proof retention that cannot crush or damage the capacitor. Each clip can retain capacitors of varying size with no loss of holding power, and all mounting is quickly done from the top of the chassis without the aid of special tools. The clips can also be used for cable, tube, or harness retention.

Sherman Products, Inc., Dept. ED, P.O. Box 6688, Cleveland, Ohio.

CIRCLE 61 ON READER-SERVICE CARD

NEW PRODUCTS

Transistorized Tachometer

Measures speeds to 60,000 rpm

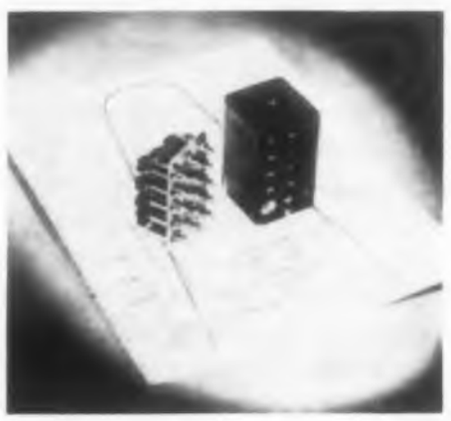
The Transi-Tach transistorized tachometer is available in a 19 in. rack panel version, a portable version, or a remote indicator version. All units are self-powered by a 9 v battery and can also be used with 115 v ac, 60 cps. Speeds up to 60,000 rpm can be accurately measured, and rpm is read directly on a large meter scale which can be calibrated in any speed range with up to 120 linear scale divisions. Essentially a frequency meter, the unit can be supplied for audio or ultrasonic frequency measurement and may also be adapted for use with any transducer which converts flows, pressures, or other physical forces into electrical signals of variable frequency. Accuracy is ±2% of full scale.

Kahn and Co., Inc., Dept. ED, 547 Windsor St., Hartford 1, Conn.

CIRCLE 64 ON READER-SERVICE CARD

I-F Filter

Highly selective



Weighing less than 12 oz, this highly selective i-f filter has a center frequency of 460 kc and surpasses MIL-T-27A vibrational, shock, and humidity specifications. Insertion loss is about 14 db. The filter permits a high degree of selectivity before appreciable signal amplification with resultant reduction in intermodulation effects. Changes in selectivity due to regeneration in the i-f amplifier or to Miller effect, are readily corrected by retuning. Temperature stability equals 0.1% or better. The unit provides 100 to 6 db bandwidth ratios of less than 2, depending on shape and impedance mismatch of from about 5 to 25% of center frequency. At 500 kc center frequency, there is less than 1 db per section insertion loss. Peak to valley ratio is less than 0.5 db, and the unit can be used above 50,000 ft.

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

CIRCLE 65 ON READER-SERVICE CARD

Altitude Simulation Chambers

Ranges to 100 miles

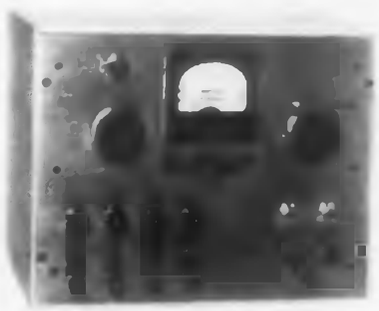
Available in sizes from small laboratory units to large walk-in chambers, series 900 high-altitude simulation chambers simulate altitudes up to 100 miles. They incorporate automatic systems for recording and controlling at constant altitude or programmed climb and descent; feed-throughs for power, instrumentation, gas and liquid sampling; locks for specimen introduction or removal; and high-capacity high-vacuum pumping systems.

General Vacuum Corp., Dept. ED, 400 Border St., East Boston 28, Mass.

CIRCLE 66 ON READER-SERVICE CARD

Relay Life Test Generator

Provides pulses to 4 amp peak



The model 25 relay tester operates relays and other magnetic actuators under life test. In operation, a cycling transistor switch is combined with a dc supply to generate pulses of up to 4 amp peak. Three square wave frequencies and one short duty pulse wave are available. The peak output voltage is adjustable from 6 to 35 v, and input is 115 v, 60 cps. The unit is housed in a hardwood case 11-1/2 x 9 x 9 in.

Crane Electronics Co., Dept. ED, 4345 Hollister Ave., Santa Barbara, Calif.

CIRCLE 67 ON READER-SERVICE CARD

Resistance Ratio Recorders

Operate with 1 to 10 K transducers

Using a ratio form of Wheatstone bridge circuit, the Speedomax Type H indicates and records measurements of pressure, flow, and other variables detected by three-terminal potentiometer type transducers. Designed to operate with 1 to 10 K transducers, it is supplied in round or strip chart models and can be equipped with any of the company's automatic control systems.

Leeds & Northrup Co., Dept. ED, 4939 Stenton Ave., Philadelphia 44, Pa.

CIRCLE 68 ON READER-SERVICE CARD

NEW PRODUCTS

Insulation Resistance Tester

Range of 0 to 10,000 meg for 6 voltages

Rectifier operated, this Megger insulation resistance tester has a single range of 0 to 10,000 meg for output voltages of 500, 750, 1000, 1500, 2000, and 2500 v.

James G. Biddle Co., Dept. ED, 1316 Arch St., Philadelphia 7, Pa.

CIRCLE 41 ON READER-SERVICE CARD

Resin Fluxes

For printed circuits

Finely demarcated for increased solderability and low corrosion potential. Lonco resin fluxes are designed for printed circuit production. They permit the soldering of badly oxidized surfaces and become active at heats ranging from below the melting point of solder to any higher temperature desired. Maintaining properly balanced-wetting for low temperature soldering, these fluxes permit filleting of the solder in and up the holes for reliable connections. They are available in five grades of solderability value, corrosion potential, and specific gravity.

London Chemical Co., Dept. ED, 1535 N. 31st Ave., Melrose Park, Ill.

CIRCLE 42 ON READER-SERVICE CARD

Transistorized Motor Operator

For control application

This transistorized motor operator is designed for damper and valve control in heating, ventilating, and air conditioning systems. It affords a choice of sensing elements, selection of compensated control, and wide adjustability of range and ratio settings.

Barber-Colman Co., Dept. ED, 1300 Rock St., Rockford, Ill.

CIRCLE 43 ON READER-SERVICE CARD

◀ CIRCLE 40 ON READER-SERVICE CARD

(below) One of the Santa Cruz test stands with dynamic thrust mount to simulate flight environment. Vibration oscillator functions during the static firings.

(above) Navy Polaris AX-1 flight test vehicle at beginning of launch. Lockheed's Polaris fleet ballistic missile is more than a year ahead of original schedule.

(right) Large centrifuge for environmental testing has unique shaker attachment to provide vibration simultaneously with high G-loadings.

TEST / Expanding the Frontiers of Space Technology

Testing is a vital part of every stage in the development of missile and space programs at Lockheed Missiles and Space Division.

The Division maintains one of the most completely equipped missile and space test laboratories in the world. Equipment includes: altitude, temperature and humidity chambers; shaker and vibration systems; G-accelerators; and apparatus capable of performing chemical, metallurgical, plastic, heat transfer, hydraulic, pneumatic, shock, acceleration, sinusoidal and random vibration, structural, electrical, and electronic tests. Static field testing; research and development testing on controls; testing in ordnance and hydraulics and high-pressure gas and propulsion systems are conducted at the 4,000 acre, company-owned test base in the Ben Lomond mountains near Santa Cruz, California.

As weapon systems manager for such major, long-term projects as the Navy Polaris FBM; Discoverer Satellite; Army Kingfisher; Air Force Q-5 and X-7; and other important research and development programs, Lockheed is engaged in expanding the frontiers of technology in all areas.

Flight testing is conducted at Cape Canaveral, Florida; Alamogordo, New Mexico; and Vandenberg AFB near Santa Maria, California; in a unique manner. All components and sub-systems of a new project are initially tested on known-performance, production missiles. Thus, when the final system is ready for first flight, its individual components already have flight-tested reliability. This new concept of flight testing is a major contribution and has enabled Lockheed to produce extremely complex missile systems in record time and at greatly reduced expense.

Underwater launch tests—including studies of cavitation, wave simulation and skip motion—are carried on at the Sunnyvale facility and at the Navy test base on San Clemente Island. Structural and other tests are performed at Hunter's Point Naval Shipyard, California.

If you are experienced in any of the various phases of testing, we invite your inquiry. Positions also are available in physics, mathematics, chemistry, or one of the engineering sciences. Write: Research and Development Staff, Dept. D-21, 962 W. El Camino Real, Sunnyvale, California.

"The organization that contributed most in the past year to the advancement of the art of missiles and astronautics." NATIONAL MISSILE INDUSTRY CONFERENCE AWARD

Lockheed / **MISSILES AND SPACE DIVISION** / SUNNYVALE, PALO ALTO, VAN NUYS, SANTA CRUZ, SANTA MARIA, CALIFORNIA
CAPE CANAVERAL, FLORIDA
ALAMOGORDO, NEW MEXICO

NEW PRODUCTS

Modular A/D Converter

Weighs seven pounds

Designed mainly for airborne use, the model CG 591 analog to digital converter can scan 12 input channels at a 120 cps rate, or as many as 50 channels at a slower rate. This completely solid state system uses PCM to provide accuracies of 0.2 per cent. Output, from a three digit, decimal coded binary register, can drive Nixie readout tubes, punched tape or cards, or can be used for telemetry transmission. The miniaturized system is completely modular, using 2 in. by 3 in. plug-in etched circuit cards.

C. G. Electronics Corp., Subsidiary of Gulton Industries, Inc., Dept. ED, Albuquerque, N. Mex.

CIRCLE 74 ON READER-SERVICE CARD

50 Ohm Coaxial Terminations

Have type TNC connectors

Model 535 50-ohm coaxial terminations are available with type TNC male or female connectors. They can also be supplied with types N, C, SC, and BNC connectors. The units have a dc to 10 kmc frequency range; 1 w average and 1 kw peak power handling capacity; and individual vswr calibrations of dc, 400, 1000, 2000, 4000, 7500, and 10,000 mc. The film resistors used are artificially aged for maximum stability.

Weinschel Engineering, Dept. ED, 10503 Metropolitan Ave., Kensington, Md.

CIRCLE 75 ON READER-SERVICE CARD

NEW PRODUCTS

Automatic Spectrometer

Scans between any two levels from 0 to 85 v

The model 50-1 automatic spectrometer consists of the company's model 33-1 single channel pulse height analyzer; its model 39-2 electronic sweep-count rate meter; a high voltage supply; and a Brown ElecktroniK recorder. An electronic sweep circuit automatically scans the spectrum between any two predetermined levels from 0 to 85 v and then resets and repeats the cycle. The data is automatically plotted on the recorder. An automatic sample changer, the model 48-1, can be used to change the sample when the sweep circuit resets. The system may also be operated as a manual spectrometer.

Radiation Instrument Development Lab, Inc., Dept. ED, 5737 S. Halsted St., Chicago 21, Ill.

CIRCLE 78 ON READER-SERVICE CARD

Analog Computer Kit

For educational and industrial use

This kit contains parts for the model EC-1, an analog computer designed for educational and industrial laboratory use. The computer is completely self-contained with nine dc operational amplifiers, three initial condition power supplies, five coefficient potentiometers, four sets of relay contacts, an electronically regulated power supply, and a repetitive oscillator for automatic operation. Included with the kit are assorted precision resistors, Mylar capacitors, special silicon diodes, and patch cords for setting up complex problems. Problem results are read directly from the meter supplied or with an external readout device.

Heath Co., Dept. ED, 305 Territorial Rd., Benton Harbor, Mich.

CIRCLE 79 ON READER-SERVICE CARD

256-Channel Analyzer

Has interchangeable logic units

Completely transistorized, the model CN-110 256-channel analyzer has interchangeable plug-in logic units for pulse height analysis, neutron time of flight studies, and counting as a function of time. It has a complete magnetic core data storage system, a 3 in. crt display, analog address and arithmetic readout, and preset count. Average dead time with the pulse height analyzer unit is 42 μsec. The unit is 19 x 20 x 8-3/4 in. and weighs 40 lb.

Technical Measurement Corp., Dept. ED, 441 Washington Ave., North Haven, Conn.

CIRCLE 80 ON READER-SERVICE CARD

Crossbar Scanner

Self-stepping

The model SC-4 self-stepping crossbar scanner sequentially connects a six-wire circuit with each of 100 sets of six-wire terminals at speeds of up to 50 sets per sec. It also has a facility for random access. It has a life of 20 million operations per crosspoint without adjustment and offers low crosstalk between adjacent circuits at frequencies up to 10 mc. Insulation resistance is 10,000 meg; conductor resistance is 0.3 ohm through the longest path; and current carrying capacity is 100 ma noninductive at 50 v dc. Contact bounce is less than 200 μsec on make, none on break. For scanning, the SC-4 needs two mercury-wetted contact relays besides the crossbar switch. One drives the select magnet chain, the other the hold magnet chain. Self-stepping of these chains is effected by a set of control contacts on each magnet.

James Cunningham, Son & Co., Inc., Dept. ED, P.O. Box 516, Rochester 2, N.Y.

CIRCLE 81 ON READER-SERVICE CARD

NEW PRODUCTS

Elapsed Time Indicator

Measures missile component reliability

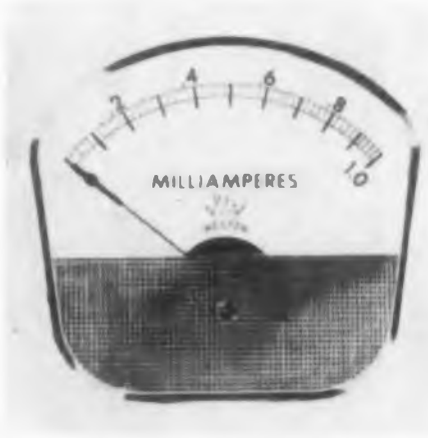
This elapsed time indicator is designed to measure equipment reliability. It is 0.665 in. in diameter and 1.415 in. long, weighs 1.2 oz, and draws 0.018 amp at less than 1 w. The unit contains an electric motor that operates from 115 v, 400 cps, single phase and a jeweled gear train with a 180 million to one ratio. It records up to 1000 hr. Suited for inclusion in the black boxes of missile and aircraft components, it stands vibration up to 10 g to 500 cps, shock up to 15 g, and temperatures from —40 to +165 F. It contains an internal reset and is enclosed in a hermetically sealed case with solder pin terminals.

Elgin National Watch Co., Elgin-Micronics Div., Dept. ED, 366 Bluff City Blvd., Elgin, Ill.

CIRCLE 84 ON READER-SERVICE CARD

Panel Instruments

For ac and dc use



These panel instruments feature the Cormag mechanism for positive shielding from external magnetic fields. Model 1741 is a 4.5 in. dc unit and model 1724 is a 2.5 in. ac unit. Also available are three ac moving iron type instruments capable of obtaining controlled ballistics characteristics.

Weston Instruments, Div. of Daystrom, Inc., Dept. ED, 614 Frelinghuysen Ave., Newark 12, N.J.

CIRCLE 85 ON READER-SERVICE CARD

Tachometers and Frequency Counters

Accuracy of ±1 count

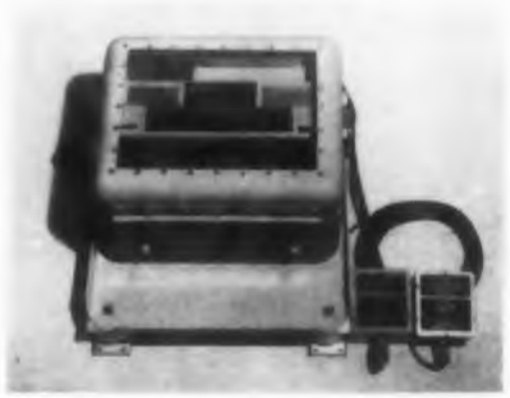
The 1300 series of electronic tachometers and frequency counters includes types for remote indication, for explosion-proof installation, and for dual readout requirements. Time bases available have fixed selectable times of 0.1, 0.5, and 1 sec. The units have an accuracy of ±1 count, a display time that is adjustable from 0.1 to 10 sec, and a sensitivity of 50 mv rms. They have an input impedance of 1 meg and automatic or manual reset.

I-L-S Instrument Corp., Div. of The Meriam Instrument Co., Dept. ED, 4527 W. 160th St., Cleveland 35, Ohio.

CIRCLE 88 ON READER-SERVICE CARD

Impact Recorder

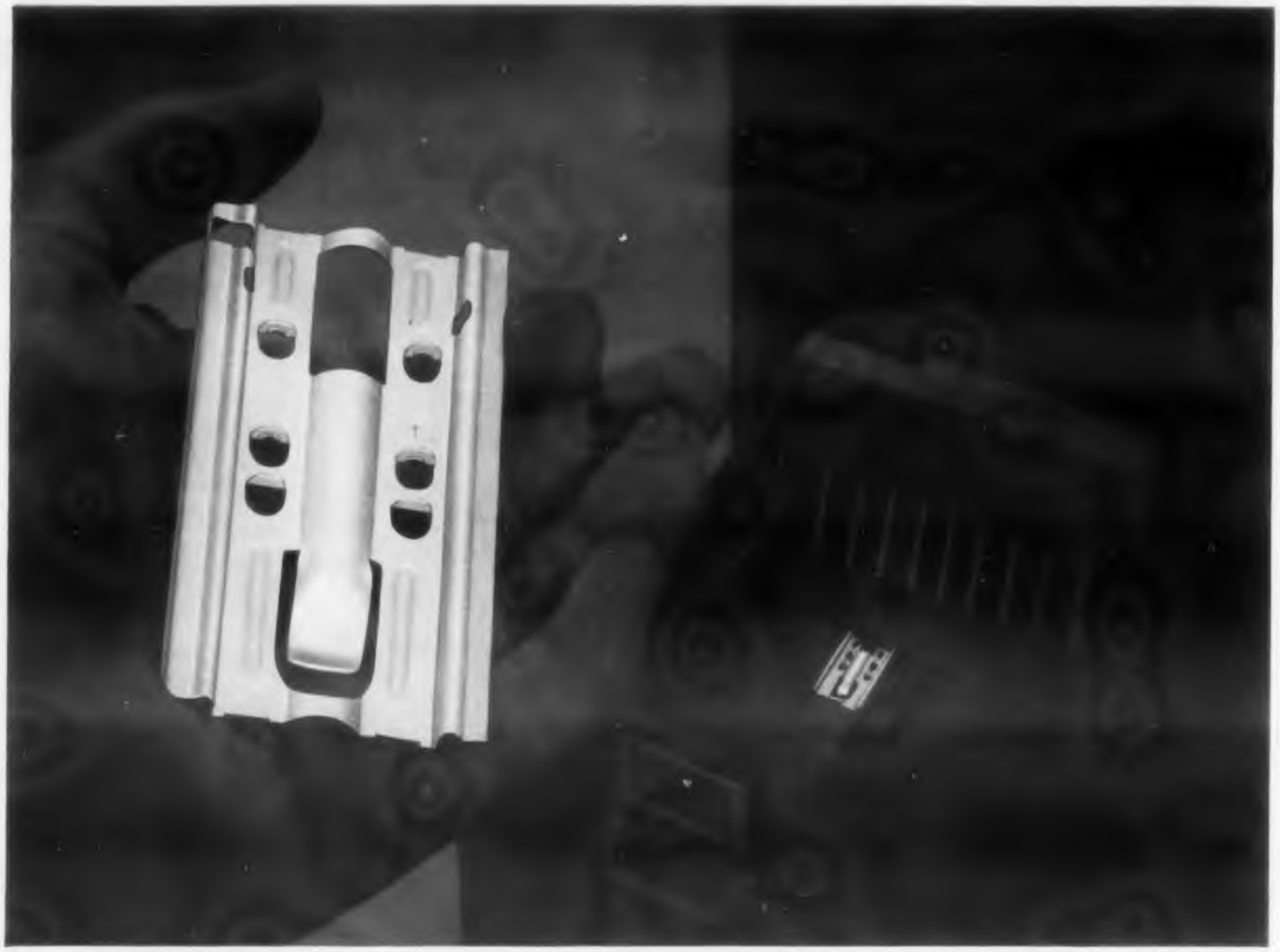
Measures up to 7 g



Designed for use in the carrying cases of various missiles, this impact recorder is adaptable for all types of ground and air transportation. It measures and records on-off digitized acceleration data from impacts, shocks, or gravity loads up to 7 g in temperature ranges from 0 to 160 F and at altitudes to 20,000 ft. The unit can operate for 30 days or for 36,000 impacts on its integral rechargeable battery and can respond to 30 discreet shocks or impacts per sec. It is housed in a portable aluminum case 14-1/2 x 11-3/4 x 8-3/4 in.

Lockheed Aircraft Service, Inc., Special Devices Div., Dept. ED, Ontario, Calif.

CIRCLE 89 ON READER-SERVICE CARD



NEW PRODUCTS

Signal Source

Provides remote tuning

A remotely tuned signal source, the model 301 is especially suited for antenna test applications. It consists of the company's model 301 carcinotron power supply; a series C rf head; and a model 301R remote tuning panel. The power supply is designed for cw operation and the carcinotron backward-wave oscillator is voltage tunable over its full frequency range. The weatherproof rf heads are available for the 100 to 16,000 mc range, and power output varies from 500 to 5 mw.

Scientific-Atlanta, Inc., Dept. ED, 2162 Piedmont Rd., N.E., Atlanta 9, Ga.

CIRCLE 92 ON READER-SERVICE CARD

Magnetometer

Portable

Model M-6 magnetometer measures strength, direction, and polarity of weak magnetic fields. The portable unit is ruggedly built for field use, with the magnetometer element hermetically sealed in plastic. It can be used for magnetization of steel studies, measurements of magnetic pole strengths, determinations of current flow through conductors, and factory inspection of aircraft parts for residual magnetism. The 8 lb unit is calibrated on the strength of the earth's magnetic field. Its power requirements are 40 w, 115 v, 60 cps.

Irwin Labs, Inc., Dept. ED, 1238 S. Gerhart Ave., Los Angeles 22, Calif.

CIRCLE 93 ON READER-SERVICE CARD

AC and DC Voltmeters

Expanded scale

These expanded scale ac and dc voltmeters linearly expand a selected, narrow voltage range with ±0.3% accuracy. They are available with up to three separate ranges in one meter. The ac meters read true rms regardless of input waveform and may have any center scale value between 5 and 230 v. The voltage range that can be expanded across the full meter scale is 5 to 17% to each side. The dc multirange models are completely self-contained and may have any center scale value between 5 and 300 v. Voltage range is 5 to 20% of center scale value to each side. The units are available in 2.5, 3.5, and 4.5 in. diameter round models; in 2.5 and 3.5 in. square models; and in 4 x 6 in. rectangular models.

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

CIRCLE 94 ON READER-SERVICE CARD

10,000 Watt Ceramic Tetrode

Water cooled

The model 4CW10,000A 10,000 w ceramic and metal tetrode is a water cooled version of the company's model 4CX50000A. Maximum plate ratings of 7500 v and 3 amp apply to 30 mc. From 30 to 110 mc, 5500 v and 2 amp may be used. The unit is 11.4 in. long and 4.7 in. in diameter.

Eitel-McCullough, Inc., Dept. ED, San Carlos, Calif.

CIRCLE 95 ON READER-SERVICE CARD

NEW PRODUCTS

Vibration Indicator

Hand instrument

The Vibrometer is a light hand-held instrument which can be used to measure vibration frequency and amplitude; to determine the direction of maximum transmitted disturbances; to locate the cause of unwanted noise due to resonant vibration; and to measure the speeds of rotating equipment where shafts or rotors are not readily accessible by placing the probe against the machine housing. The unit can also be used to analyze component frequencies of complex vibrations. The output of the built-in pick-up can be attached to an oscilloscope or oscillograph. The Vibrometer achieves a full range from 120 to 15,000 cpm by using a weighted reed up to 600 cpm and a free reed above. Accuracy is within 10% with a weighted reed and within 3% with a free reed.

The Korfund Co., Inc., Dept. ED, 48-22H 32nd Place, Long Island City 1, N.Y.

CIRCLE 98 ON READER-SERVICE CARD

Transistor Tester

In-circuit

The model 219 A transistor tester permits the measurement of transistor beta parameters with transistors in the circuit. Beta and collector leakage current parameters may be measured with the transistors removed from the circuit. The unit is packaged in a compact carrying case and operates from either a self-contained battery supply or 110 v, 50 to 60 cps.

Sierra Electronic Corp., Dept. ED, 3885 Bohannon Dr., Menlo Park, Calif.

CIRCLE 99 ON READER-SERVICE CARD

Frequency Sensor

Operates on go, no-go principle

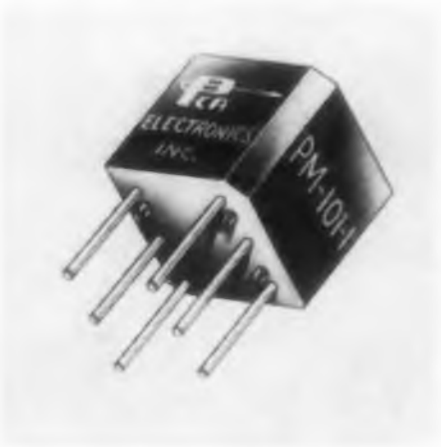
The C-400FSI go, no-go frequency sensor provides automatic instrumentation of frequency for aircraft, missiles, ground control installations, telemetering equipment, and industrial control equipment. The unit is accurate to 0.25% and has a red and green light readout. Several sensors may be connected to a logic circuit so that one readout will indicate the no-go condition if any one of the readings is out of tolerance. The unit operates at 115 v and has nominal frequency and tolerance limits made to customer specifications. The 2 w output drives 24 v lamps or relay drives and will also work with an annunciator system.

Magnetic Circuit Elements, Inc., Dept. ED, 3722 Park Place, Montrose, Calif.

CIRCLE 111 ON READER-SERVICE CARD

Pulse Transformers

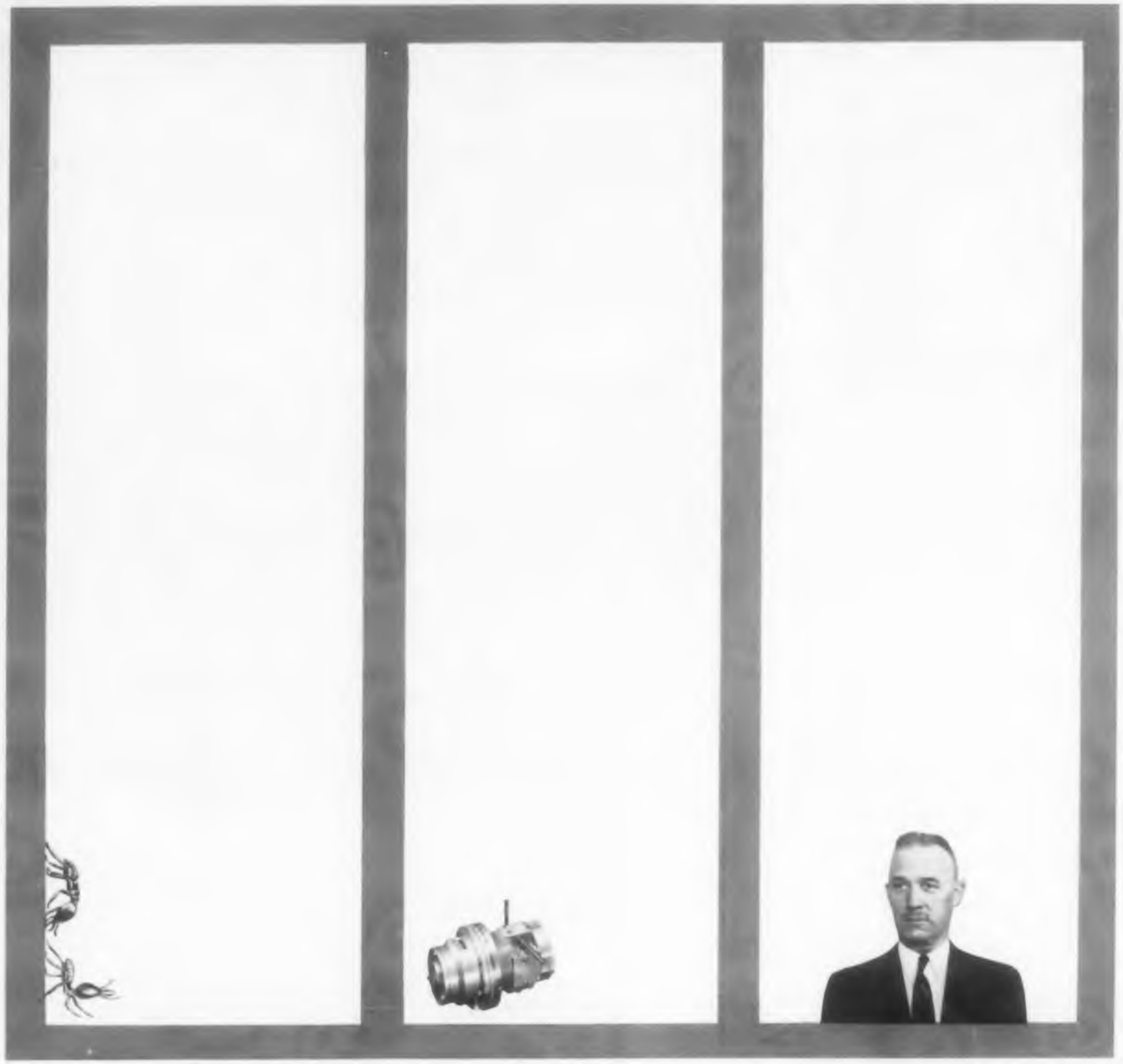
For varied applications



These permanent magnet pulse transformers are applicable in blocking oscillators; in triggering, low voltage, and counting circuits; for dc isolation; for pulse shaping; and for use as wideband input and output transformers. The units have a core of grain oriented silicon steel and a chamfered band 0.062 in. wide which keys it for automatic mounting by soldering into etched circuit boards. They are available in three sizes: 0.4 x 0.4 x 0.4; 0.562 x 0.562 x 0.5; and 0.7 x 0.7 x 0.65 in.

PCA Electronics, Inc., Dept. ED, 16799 Schoenborn St., Sepulveda, Calif.

CIRCLE 112 ON READER-SERVICE CARD



Miniature Soldiers. Army ants carry out intricate maneuvers of wheeling, flanking, and envelopment with faultless precision. Their columns are led by "majors", preceded by "scouts". Raids are conducted by "skirmishers". Between campaigns, they form "bivouacs". Army ants are nature's tiny troopers.

Miniature Ball Resolver, approximately 3⅜" x 2½" O.D. continuously calculates position of aircraft and missiles traveling at supersonic speeds. MPB bearings at critical points keep torque low, and help make possible an accuracy of 0.33 of 1%. This is another man-made miracle in miniaturization.

Man with Miracles. This is Jim Mitchell, one of MPB's technical representatives, whose close liaison with the manufacturer of the ball resolver facilitated its design and development. MPB's technical staff, most experienced in its field, can assist you with your own miniaturized miracles.

New Worlds for ○ Miracles in Miniaturization

ACTUAL SIZE OF THE MPB BEARINGS IN BALL RESOLVER SHOWN ABOVE

Every day man's advances, both on this planet and beyond, are opening new and challenging areas of application for miniature components and mechanisms. And at each step forward, MPB is ready to help with research, engineering and manufacturing facilities unsurpassed in the miniature bearing industry. MPB makes more than 500 types and sizes of bearings ranging from ⅜" O.D. down . . . designed to meet requirements of the most exacting nature. Specials are developed on request. For a confab on design problems or our latest catalog **write Miniature Precision Bearings, Inc.,** 904 Precision Park, Keene, N. H.

MINIATURE PRECISION
MPB
BEARINGS INC
Helps you perform miracles in miniaturization

CIRCLE 114 ON READER-SERVICE CARD

NEW PRODUCTS

Scaler-Analyzer

Has 128 channels

A completely integrated system, the RCLiac-128 is a 128 channel scaler-analyzer that performs nuclear data processing operations from gross counting through scintillation spectroscopy. It is of plug-in modular construction and has a magnetic core memory capacity of 1 million counts per channel; an instant number or curve crt display; preset time from 0.19 sec to 28 hr; and preset count from 2^1 to 2^{24}. Negative high voltage is 600 to 1500 v, stable to 50 ppm; overall amplifier gain is 1000; and integral linearity is ±1% for channels 5 through 128.

Radiation Counter Labs, Inc., Dept. ED, 5121 W. Grove, Skokie, Ill.

CIRCLE 115 ON READER-SERVICE CARD

Heat Sinks

For JETEC 30 transistors

The 1101-A is an insulated stud mounted heat sink for medium power transistors in JETEC 30 round welded packages. It is easily attached to the transistor, converting it to a double ended package, and heat dissipated in the transistor is conducted to the chassis through the 10-32 stud. Electrical insulation is provided by the addition of a hard coat anodize finish which furnishes over 400 v breakdown and eliminates the electrical problems in heat sinking transistors which have the collector common to the case.

Jadaro Machine Products, Dept. ED, P.O. Box 155, Garland, Tex.

CIRCLE 116 ON READER-SERVICE CARD

Vacuum Transfer Relay

For high voltage applications

The model RB4 transfer relay is designed for high voltage applications involving antenna switching, pulse forming networks, and similar rf and dc circuits. The 4pdt unit has a vacuum dielectric, sapphire actuating rods, and removable actuating coils for 26.5 or 115 v dc operation. Peak test voltage is 25 kv dc or rf and rated operating voltage is 20 kv at 2.5 mc and 10 kv at 16 mc. Contact resistance is under 0.01 ohm and current rating is 13 amp rms at 60 cps and 8 amp at 16 mc.

Jennings Radio Mfg. Corp., Dept. ED, P.O. Box 1278, San Jose, Calif.

CIRCLE 117 ON READER-SERVICE CARD

Indicator Lights

Incorporate transistorized driver circuits

These indicators have built-in transistorized driver circuits that operate directly from low level signals. Filament type R-441 is a high gain unit using a low voltage, plug-in incandescent lamp that lights when the input level is 11 v. High temperature types R-561 and R-661 have silicon transistor circuits for −55 to +100 C operation. Also available are model R-901, a memory light; model R-1004, which has an encapsulated plug-in insert; and miniature models R-121 and R-221, which mount in a 3/8 in. hole.

Engineered Electronics Co., Dept. ED, 506 E. First St., Santa Ana, Calif.

CIRCLE 118 ON READER-SERVICE CARD

NEW PRODUCTS

Contact Inserts

Push-in type

With Mod. 2 inserts, contacts are crimped automatically or semiautomatically to wires outside of the connector. A cross-hole in each contact permits ready inspection of the termination joint to determine the depth of the wire engagement. A special hand tool is available for inserting the contacts into the premounted resilient insulation within the connector barrel shell. Retention of the insulation exceeds the requirements of MIL-C-5015 D after many reassemblies. The units can be furnished with up to 100 poles for wire sizes 16, 12, or 10.

The Pyle-National Co., Dept. ED, 1334 N. Kostner Ave., Chicago 51, Ill.

CIRCLE 121 ON READER-SERVICE CARD

Microwave Power Meter

Has 0.001 to 10 mw range

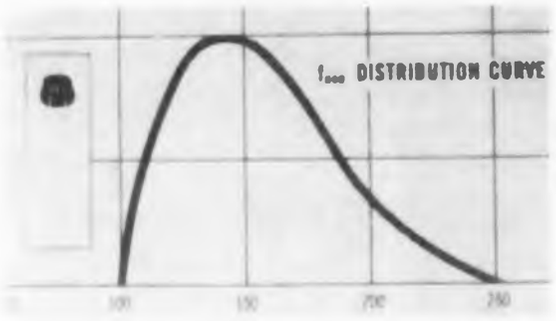
Self-balancing and transistorized, the model 440 microwave power meter provides automatic direct-reading measurements of cw or pulsed power. It may be used with all 100 or 200 ohm bolometers or thermistors, of positive or negative temperature coefficient, requiring any bias current up to 18 ma in any frequency range for which there are bolometer or thermistor mounts. It has 0.001 to 0.01 mw and 0.003 to 0.03 mw scales in addition to the five standard scales up to 10 mw.

Narda Microwave Corp., Dept. ED, 118-160 Herricks Rd., Mineola, N.Y.

CIRCLE 122 ON READER-SERVICE CARD

Silicon Logic Transistor

High speed



Typical total switching time of the 2N1139 silicon logic transistor is under 30 μsec. Minimum alpha cutoff is 100 mc.

Transitron Electronic Corp., Dept. ED, 168 Albion St., Wakefield, Mass.

CIRCLE 123 ON READER-SERVICE CARD

Ribbon Cable

Color coded

These color coded, multiconductor ribbon cables are available in single conductors, twisted pairs, and coaxial cables. A variety of widths and designs can be furnished.

Plastoid Corp., Dept. ED, 42-61 24th St., Long Island City, N.Y.

CIRCLE 124 ON READER-SERVICE CARD

Digital Voltmeter

Covers 0 to 1 kv dc

General purpose digital voltmeter model 410 covers a range of 0 to 1 kv dc. It has 0.5% full scale accuracy and a three column vertical readout.

Franklin Electronics Inc., Dept. ED, Bridgeport, Pa.

CIRCLE 125 ON READER-SERVICE CARD

NEW PRODUCTS

CARRIAGE, MACHINE BOLTS.—Complete selection of hex head machine and carriage bolts in a range of 500 sizes. Machine bolts are supplied with or without finished hexagon nuts and have a minimum tensile strength of 55,000 psi. Stock sizes include diameters from 1/4 to 1-1/4 in.; lengths from 1-1/2 to 24 in. Carriage bolts have no. 10 to 3/4 in. diameters; 1/2 to 18 in. lengths.

Standard Screw Co., Stanscrew Fasteners, Dept. ED, 2701 Washington Blvd., Bellwood, Ill.

CIRCLE 128 ON READER-SERVICE CARD

PELLET TEMPERATURE INDICATORS.—These pellets melt at 525 and 650 F, filling the gap in a series covering 100 to 2700 F in 90 spaced intervals.

Tempil Corp., Dept. ED, 132 W. 22nd St., New York 11, N.Y.

CIRCLE 129 ON READER-SERVICE CARD

THIN SLIDES.—Designed to carry a 50 lb maximum load, these lightweight slides are 1.687 in. high. They are available in the nontilt model 300-S or the basic model 300-B.

Chassis-Trak, Inc., Dept. ED, 525 S. Webster St., Indianapolis, Ind.

CIRCLE 130 ON READER-SERVICE CARD

PULSE, SWEEP, AND TIME DELAY GENERATOR.—Type 1391-B generates pulses, time delays, and linear sweep voltages with wide ranges of operation. Pulse rise time is 15 μsec.

General Radio Co., Dept. ED, 275 Massachusetts Ave., Cambridge 39, Mass.

CIRCLE 131 ON READER-SERVICE CARD

SOLDERING IRON TIPS.—These low cost tips are plated with a Tifeni alloy. They feature long life and high heat and come in all standard shapes and sizes.

Altimag Inc., Dept. ED, P.O. Box 20148, Indianapolis 20, Ind.

CIRCLE 132 ON READER-SERVICE CARD

MAGNESIUM OXIDE REAGENT.—Electronic grade M-300 features high purity, small particle size, and low reactivity. It can be used to coat tapes for winding magnetic amplifier cores, and also to prevent surface currents on mica punchings used to mount vacuum tube filaments.

Fisher Scientific Co., Dept. ED, 717 Forbes St., Pittsburgh 19, Pa.

CIRCLE 133 ON READER-SERVICE CARD

DOUBLE TRIODE.—Dissimilar-section type 7247 combines in a single envelope the first two stages of preamplification for high fidelity disc or tape equipment.

CBS-Hytron, Dept. ED, Danvers, Mass.

CIRCLE 134 ON READER-SERVICE CARD

LANAR TRIODE.—Developed for use in telephone relay stations, type 6280 can be used in all types of microwave communications equipment. It operates in the 4 to 5 kmc range and is a direct replacement for type 416B. Acorn sized, it has a gain of 9 db at 50 mw output and a transconductance rating of 50,000 μmho.

Allen B. Du Mont Labs, Inc., Dept. ED, 750 Bloomfield Ave., Clifton, N.J.

CIRCLE 135 ON READER-SERVICE CARD

PRECISION RC OSCILLATOR.—Model G.432 supplies sine and square wave output, balanced or unbalanced, plus a subsidiary control providing a small incremental frequency variation independent of the main dial. The main dial covers 25 cps to 250 kc in four decades and is calibrated to 1%.

Furzehill Labs Ltd., Dept. ED, 550 Fifth Ave., New York 36, N.Y.

CIRCLE 136 ON READER-SERVICE CARD

CASTING RESIN ABSORBER.—For molding waveguide terminations, attenuators, and loads, Eccosorb CR has, when cured, a high attenuation over the full microwave frequency range. Temperature range is −70 to +350 F.

Emerson & Cuming, Inc., Dept. ED, 869 Washington St., Canton, Mass.

CIRCLE 137 ON READER-SERVICE CARD

UHF INSULATING MATERIAL.—An irradiated polyolefin, Enrad II has a dielectric strength of 1000 and a dissipation factor of 0.0005. It has good form stability to 300 C and can be used as a microwave strip line material and in electrical insulators, tube sockets, connectors, and wire insulation. It is available as a powder or as bars, rods, and sheets for ready machining.

Enflo Corp., Dept. ED, Fellowship Rd. and Rt. 73, Maple Shade, N.J.

CIRCLE 138 ON READER-SERVICE CARD

VANEAXIAL FAN.—This motor driven unit has an impeller less than 2 in. in diameter and provides a flow of 46 cfm under 2-1/2 in. water pressure and 37 w input. A 400 cps three phase version delivers 75 cfm. The unit may be used as a direct cooling device or with a heat exchanger.

The Garrett Corp., Dept. ED, 9851 Sepulveda Blvd., Los Angeles 45, Calif.

CIRCLE 139 ON READER-SERVICE CARD

CONTACT CLEANING SPATULAS.—Covered with an abrasive surface of diamond particles, Diacron spatulas are designed specifically for cleaning relays and contacts. They do not become clogged or affect the normal gap between contact points.

Leonard International Corp., Technical Tools Div., Dept. ED, 624 Madison Ave., New York, N.Y.

CIRCLE 140 ON READER-SERVICE CARD

NEW PRODUCTS

GUSSET MOUNTING ASSEMBLIES.—For front reel rack and cabinet mounting, these gussets are designed to fit all four of the company's standard slides. They are furnished preassembled and can be quickly installed.

Chassis-Trak, Inc., Dept. ED, 525 S. Webster St., Indianapolis, Ind.

CIRCLE 332 ON READER-SERVICE CARD

VHF FREQUENCY METER.—Model LA-70 is available in a redesgned version. The unit has a 10 kc to 3 kmc range and is accurate to 1 pm from 20 mc to 3 kmc.

Lavoie Labs, Inc., Dept. ED, Mattawan-Freehold Rd., Morganville, N.J.

CIRCLE 333 ON READER-SERVICE CARD

LOW PASS FILTER.—The Microid type TCLJ starts at 400 cps and measures 11/16 x 1-11/16 x 1/2 in. For frequencies from 7.5 to 100 kc, size is 3/4 x 1 x 1/2 in. The unit is fully encapsulated.

Burnell & Co., Inc., Dept. ED, 10 Pelham Pkwy., Pelham Manor, N.Y.

CIRCLE 334 ON READER-SERVICE CARD

LAMPHOLDERS.—In molded Bakelite housings with built-in wire leads, models 14-71 and 14-72 are designed for intermediate screw base lamps. They are UL and CSA approved for 75 w, 250 v and utilize a square shoulder as a permanent locking device. Other mountings are available, and wire leads can be supplied in any length with a variety of insulations.

Leecraft Mfg. Co., Inc., Dept. ED, 60 Greene St., New York 12, N.Y.

CIRCLE 335 ON READER-SERVICE CARD

OSCILLOSCOPE RECORDING CAMERA.—This has a 75 mm, F/1.9 lens and reduces linear distortion to less than 0.5%.

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

CIRCLE 336 ON READER-SERVICE CARD

FIXED COMPOSITION RESISTORS.—Model GBT-1/2 and GBT-1 are designed for trouble-free use in standard automation insertion equipment.

International Resistance Co., Dept. ED, 401 N. Broad St., Philadelphia 8, Pa.

CIRCLE 337 ON READER-SERVICE CARD

PERMANENT MAGNET.—A highly oriented ceramic permanent magnet material, Indox VI is especially suited for traveling wave tubes. It has a coercive force of 2550 oersteds, a residual reduction of 3200 gauss, and a peak energy product of 2.4 x 10^6.

The Indiana Steel Products Co., Dept. ED, Valparaiso, Ind.

CIRCLE 338 ON READER-SERVICE CARD

VACUUM TUBE BRIDGE.—For precision measurement of vacuum tube and transistor parameters, the type 1661-A can be used to measure twin triodes and pentodes without change in external connections.

General Radio Co., Dept. ED, 275 Massachusetts Ave., Cambridge 39, Mass.

CIRCLE 340 ON READER-SERVICE CARD

EPOXY RESIN SYSTEM.—A flexible system with a wide range of possible cures, Hysol 6621 can be used for potting transistorized circuits and transformers with strain sensitive cores. It is also adapted to the casting of large masses.

Houghton Labs, Inc., Dept. ED, Houghton Ave., Olean, N.Y.

CIRCLE 341 ON READER-SERVICE CARD

SCANNER AND PLOTTER.—Model 115 converts the uncorrelated information collected on IBM punched cards into visual plotted form. It can be used for structural test work where strain gage data can be plotted as strain vs load; for wind tunnel data such as temperature vs time; and for proper evaluation of data against design specifications and limits.

Gilmore Industries, Inc., Dept. ED, 13015 Woodland Ave., Cleveland 20, Ohio.

CIRCLE 342 ON READER-SERVICE CARD

MOBILE POWER SUPPLY KIT.—Model MP-1 contains everything required for complete installation of a heavy duty transistorized dc supply that delivers 120 w. The unit furnishes all power required to operate the company's MT-1 transmitter and MR-1 receiver. Chassis size is 9-1/16 x 4-3/4 x 2 in.

Heath Co., Dept. ED, 305 Territorial Rd., Benton Harbor, Mich.

CIRCLE 343 ON READER-SERVICE CARD

DIRECT-READING COUNTER.—Designed for continuous operation at 6000 rpm, this unit is resistant to corrosion, humidity and vibration. Case size is 2-3/4 x 2 x 1-1/2 in.; figures are 0.25 in. high.

Veeder-Root Inc., Dept. ED, 70 Sargeant St., Hartford 2, Conn.

CIRCLE 344 ON READER-SERVICE CARD

FOOT SWITCH.—Cast iron model VH is available with a guard and comes in ratings from 15 to 40 amp.

Vemaline Products Co., Dept. ED, Hawthorne, N.J.

CIRCLE 345 ON READER-SERVICE CARD

SIGNAL GENERATORS.—These units feature direct digital readout of frequency, accuracy to ±1%, and a wide range of modulation capabilities, both am and fm.

Polarad Electronics Corp., Dept. ED, 43-20 34th St., Long Island City 1, N.Y.

CIRCLE 346 ON READER-SERVICE CARD

NEW PRODUCTS

PRINTED CIRCUIT RESISTOR.—Type PC5 is a low operating temperature, 5 w unit for aircraft and missile applications. It has alloy coated leads secured to a resistance element uniformly wound on a glass fibre core and sealed in a rectangular ceramic case.

International Resistance Co., Dept. ED, 401 N. Broad St., Philadelphia 8, Pa.

CIRCLE 349 ON READER-SERVICE CARD

SELF-FASTENING DEVICE.—The Pushlock principle permits quick insertion and locking of a wide variety of plastic parts including standoff and feed through terminals, drawer glides, casters, bearings, cable support clamps, and tip jacks. Pushed through a punched or drilled hole, the parts lock into place by means of a series of molded flutes extending radially from a plastic stud.

Whitso, Inc., Dept. ED, 9330 Byron St., Schiller Park, Ill.

CIRCLE 350 ON READER-SERVICE CARD

HANDLES.—Die or sand cast of aluminum alloy, these handles have a chip resistant finish which passes a 1000 hr salt spray test and a 200 hr 100% humidity test.

Chassis-Trak, Inc., Dept. ED, 525 S. Webster St., Indianapolis, Ind.

CIRCLE 351 ON READER-SERVICE CARD

PLASTIC CONTROL KNOBS.—Made to conform with MS-91528 specifications, these knobs are available in round, pointer, and spinner types with or without skirts, and also with the dial skirted round. Each type comes in three shaft sizes and a variety of colors and finishes.

National Co., Inc., Dept. ED, 61 Sherman St., Malden 48, Mass.

CIRCLE 352 ON READER-SERVICE CARD

SERVO ACTUATOR.—Designed for use in hydraulic or pneumatic servo systems, the Roto-Drive provides direct rotary drive without the use of bell cranks or other mechanical linkages. In a range of sizes with power ratings from less than 1 w to 10 hp, the unit has a frequency response up to 100 cps and positioning accuracy within 1 min of arc.

Parameters, Inc., Dept. ED, 195 Herricks Rd., New Hyde Park, N.Y.

CIRCLE 353 ON READER-SERVICE CARD

PHASE SEQUENCE INDICATOR.—Panel mounted model VA7 provides a means of rapidly determining the order in which the voltage peaks occur in a three phase power source. Voltage and frequency ranges are 104 to 480 v and 30 to 1000 cps. The unit has two pilot lamps for both 1-2-3 and 3-2-1 sequence and will operate continuously at maximum rated voltage in −65 to +160 F temperatures.

Opad Electric Co., Dept. ED, 69 Murray St., New York 7, N.Y.

CIRCLE 354 ON READER-SERVICE CARD

TIME DELAY GENERATOR.—Type 1392-A produces an accurately known time delay continuously adjustable over a range from 0 to 1.1 sec with a frequency from 0 to over 300 kc. It can be used as a range calibrator for radar, sonar, and radio navigation systems.

General Radio Co. Dept. ED, 275 Massachusetts Ave., Cambridge 39, Mass.

CIRCLE 356 ON READER-SERVICE CARD

STANDARD RESISTORS.—For use with the company's Megatrometer, these units are available in values of 10, 100, 1000, and 10,000 meg. Each is certified to 0.2% and is supplied with a temperature curve. They are mounted in a Faraday box which plugs directly into the megatrometer.

Mid-Eastern Electronics, Inc., Dept. ED, 32 Commerce St., Springfield, N.J.

CIRCLE 357 ON READER-SERVICE CARD

PHONE AND PHONO PLUGS.—Designed for high fidelity, stereophonic, tape recorder, and audio use, this line includes the M-1054 straight phono plug; the M-1058 right angle phono plug; the M-1059 straight phone plug; and the M-1060 right angle phone plug.

Phalo Plastics Corp., Dept. ED, Shrewsbury, Mass.

CIRCLE 358 ON READER-SERVICE CARD

MULTIFREQUENCY OSCILLATOR.—This thermostable oscillator has up to six different switch selected frequencies in the 4 to 16 mc range. Warmup time is less than 2 min and thermal stability is 5 parts in 10^8 per deg C.

Marconi Instruments, Dept. ED, 111 Cedar Lane, Englewood, N.J.

CIRCLE 359 ON READER-SERVICE CARD

SPECTRUM ANALYZER.—Model SA-84W covers 10 to 40,880 mc in one self-contained unit and offers the choice of dispersion bandwidths for wide and narrow pulse analysis.

Polarad Electronics Corp., Dept. ED, 43-20 34th St., Long Island City 1, N.Y.

CIRCLE 360 ON READER-SERVICE CARD

TUNGSTEN WIRE FORMS.—These preformed shapes and coils include all types of heaters for cathode ray tubes and electron tubes and coils for vacuum metallizing.

Mansol Ceramics Co., Dept. ED, 104 Little St., Belleville, N.J.

CIRCLE 361 ON READER-SERVICE CARD

CHOPPER CONVERSION KIT.—For modernizing the company's old dc vacuum tube voltmeters, this kit contains a 60 cps untuned chopper with low contact noise characteristics and a 10,000 hr life expectancy.

Millivac Instruments, Div. of Cohu Electronics, Inc., Dept. ED, Box 997, Schenectady, N.Y.

CIRCLE 362 ON READER-SERVICE CARD

Quick-Opening Fasteners: Screw Type or 1/4 Turn?

Know the features of each before you specify.

M. R. TUOZZO

The selection of a quick-operating door fastener usually involves a choice between two basic designs; the quick-acting screw fastener and the 1/4 turn fastener. Both are relatively inexpensive. Each has advantages that make it the logical choice for certain applications.

THE SCREW FASTENER is a rugged, square threaded screw assembly engaging in a special heavy stamped nut. The nut is clipped, riveted, or welded to the door frame. A special washer behind the thread captivates the screw in an oversize hole in the door.

Because of its exceptional "float," it is installed without precision measurements and will always line up with ease. Where a variation in material thickness may occur or a gasket must be compressed, the screw fastener is preferred, since a single grip length can be used throughout. Under most conditions it will completely disengage in two to four turns. It offers excellent resistance to vibration and forms a solid joint with no "give."

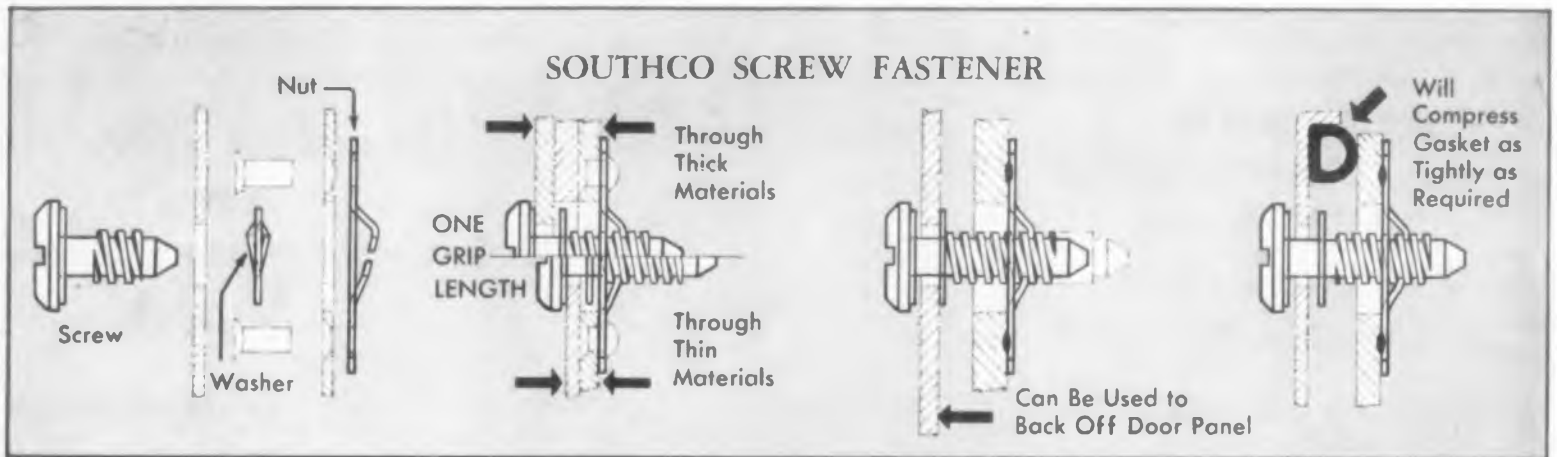
The screw fastener can be backed all the way out of the door frame without moving the door. If required, it can be installed so as to jack the door open as it is unscrewed.

THE QUARTER-TURN FASTENER is usually selected for application on aircraft (under Army-Navy-Air Force specification MIL-F-5591A) where instantaneous removal of fastened parts is required. As the name implies, it is quickly locked or unlocked by a fractional turn.

Its strength characteristics also are very high when the stud is formed from a single piece and no thin springs, wires, or cross pins exist in the assembly. The stud is retained in the door panel by a metal grommet, and engages in a full floating spring-loaded receptacle, riveted or welded to the door frame.

Where the thickness of door and frame are fairly constant through an entire production run, the quarter-turn fastener is a wise choice. Its design affords maximum speed in fastening, and excellent vibration resistance.

COMPARISON OF STANDARD QUICK-OPENING FASTENERS



SOUTHCO FASTENERS

LION

©1956

Southco Div., South Chester Corporation

235 Industrial Highway, Lester, Pa.

CIRCLE 144 ON READER-SERVICE CARD

PRODUCTION PRODUCTS

Bench Punch Press

Has 4 ton capacity

Model BM-4 is a bench type punch press with a capacity of 4 tons. Originally designed for automatic electrical terminal crimping, it can be used for any standard punch press operation such as shearing, blanking, forming, drawing, riveting, and cutting. Die space is 6-1/2 in. open height and 4 in. throat space. The opening in the bed is 2 x 2 in. and the opening between uprights is 4 x 3 in. The ram has adjustable, replaceable V-type gibs and easily adjusts for die settings. The punch chuck hole in the ram is 1 in. in diameter. Standard stroke is 1 in. The unit weighs 223 lb and measures 10-5/8 x 17-1/2 x 24-5/8 in.

Alva Allen Industries, Dept. ED, 1001-15 N. Third St., Clinton, Mo.

CIRCLE 145 ON READER-SERVICE CARD

Automatic Memory Core Handler

For testing 80 mil ferrite cores

Model 4012 core handler is designed for fully automatic or manual rate feeding of standard, 0.08 in. OD ferrite memory cores to a testing point. It has a maximum handling rate of 3600 cores per hr and provides for the separation of the tested cores in five different grades. The

grades, as well as the rate of handling, are selected by an operator or by a fully automatic core analysis equipment such as the company's REACT. For laboratory analysis of moderate quantities, provision is made for holding the core to the test contacts for an indefinite length of time to observe its voltage response. The core handler is 12 x 12 x 12 in. The control unit is 21 x 18 x 17 in. and operates from a 115 v, 50 to 60 cps line.

Rese Engineering, Inc., Dept. ED, 731 Arch St., Philadelphia 6, Pa.

CIRCLE 146 ON READER-SERVICE CARD

Toroidal Coil Winder

For miniature units

The model U-2 Toroyd is a bench machine designed to provide accurate windings on miniature coils. It handles 28 to 41 wire at shuttle speeds of 0 to 500 rpm. It is furnished with a 0.06 in. magazine and geared predetermining and magazine loading counters. A self-releasing shuttle locks the magazine to the shuttle gear for loading and automatically disengages when winding proceeds. The unit operates on 110 v ac, 60 cps.

Universal Mfg. Co., Inc., Dept. ED, 1168 Grove St., Irvington, N.J.

CIRCLE 147 ON READER-SERVICE CARD

Inductance Comparator

For toroidal coil winding

Designed as an attachment for the company's S-series winding machines, the 1C-601 inductance comparator provides a means of winding toroidal coils to preset inductances on permalloy powdered or ferrite cores. The unit eliminates core grading and inductance adjustments and permits accuracies up to 0.5%. It has built-in decade inductances which allow a setup range and provides continuous monitoring of the winding process.

Universal Mfg. Co., Inc., Dept. ED, 1168 Grove St., Irvington, N.J.

CIRCLE 148 ON READER-SERVICE CARD

PRODUCTION PRODUCTS

Surface Finish Tester

Semiautomatic

Model 100 Talysurf is a portable, semiautomatic instrument for production inspection and precision testing of surface finish. The assembly includes work table, pick-up, stylus, support, and motorized drive. It can carry small work in universal work-holding fixtures or be fitted with quick loading production tooling. The same unit, inverted, can be used to check large flat or cylindrical work.

Engis Equipment Co., Dept. ED, 431 S. Dearborn St., Chicago 5, Ill.

CIRCLE 366 ON READER-SERVICE CARD

Production Marker

Prints on variety of materials and shapes

The Anderpress is a high speed, foot operated production marker which prints on metal, plastic, wood, and other materials. It can mark parts of many shapes, including those with projections such as studs and brackets. The printing coverage area is 2.5 x 5.5 in.

Anderson-Stanley Stamp Co., Dept. ED, 4101 W. Grand Ave., Chicago 51, Ill.

CIRCLE 367 ON READER-SERVICE CARD

Shock Testing Equipment

Provides variety of pulses

Designed to comply with pulse defining specifications, Varipulse machines permit independent variation of the pulse with respect to its configuration, peak acceleration, and duration. Accurate, uniform half-sine waves, saw tooth pulses, and other tailored wave shapes can be produced and repeated. In specimen capacities of 100 and 400 lb, the machines can apply the essential shock testing requirements of specifications MIL-S-5272A and MIL-E-5400. They also meet the Ramo-Wooldridge GMRD-E-56-1 specification.

Barry Controls Inc., Dept. ED, 700 Pleasant St., Watertown, Mass.

CIRCLE 368 ON READER-SERVICE CARD

Diffusion Pumps

For low pressure use

Handling large gas loads at low pressures, ...se oil and mercury diffusion pumps can be ...d in particle accelerator work, environmental ...t chambers, and jet propulsion work. Maxi...m pumping capacity of the MCF oil pump is ...000 micron liters per sec at 4 x 10^{-4} mm Hg. ...r speed is about 45,000 liters per sec in the 10^{-5} ... 10^{-4} mm Hg pressure region with an ultimate ...ssure of 4 x 10^{-7} mm Hg. The MHG mercury ...mp has an air speed of 53,500 liters per sec at ... 10^{-4} mm Hg.

Consolidated Electrodynamics Corp., Roches... Div., Dept. ED, 1775 Mt. Read Blvd., Roches... 3, N.Y.

CIRCLE 153 ON READER-SERVICE CARD

Welding Probe

Designed for thermocouples

Model HP-3030 pressure-sensitive resistance welding probe is designed for welding thermocouples. A handpiece, it consists of a welding lead with a pressure-sensing mechanism and a separate ground lead. The probe fires at a preset pressure from 1 to 25 lb, producing a heavy current for millisecond durations of exact repeatability. The unit may be plugged into any of the company's power supplies or welders. It has a ...imum power capacity of 500 w-sec. Besides ...mocouples, it may be used to weld honeycomb sections and special electrical and elec... ...ic assemblies.

...nitek Corp., Weldmatic Div., Dept. ED, 380 N... falstead Ave., Pasadena, Calif.

CIRCLE 154 ON READER-SERVICE CARD

SERVICES FOR DESIGNERS

Coils Built to Your Specifications

The new fine wire plant of Deluxe Coils, Inc. will supply the miniature 48-56 gage wire coils you need for applications from hearing aids to missile systems. The coils will be built to your specifications for precision and accuracy. Newest facility of this company, spanning 15,000 sq. ft., is air and sound conditioned and completely equipped to produce all types of miniature fine wire coils, 40-47 gage, ultra fine wire coils, 48-56 gage, and components.

Information on the firm's fine wire production capabilities will be supplied by Deluxe Coils, Inc., P.O. Box 318, Wabash, Ind.

Reliability Laboratory

Forces as high as 500 g will be hurled against missile components and systems in a deliberate effort to destroy them in a new reliability center established in Los Angeles, Calif., by Leach Corporation. Goal of the laboratory is plus 99.9% performance under space operating conditions to meet the increasingly higher reliability demands of jet and rocket airplanes and missiles and space satellites. The destruction laboratory, now in the final stages of completion, will be made available to all manufacturers including component companies. Extremes of both heat and cold in environmental chambers, vibrational intensities of 70 g and shock up to 120 g are some of the other trials to which systems and components will be subjected.

Leach Corporation, Dept. ED, 18435 Susana Rd., Compton, Calif.

CIRCLE 159 ON READER-SERVICE CARD

Testing Facilities

The Electronics Laboratory of the United States Testing Company conducts tests and evaluations on electronic components, units, systems and products. Typical of these operations is the ASESA program where components are tested in strict comformance to MIL specifications. Automated facilities for reliability testing and failure analysis include a high-speed digital, self-balancing readout system which automatically measures and records resistance or voltage values, either ac or dc, to within 0.1 of 1% or better.

United States Testing Co., Inc., Dept. ED, 1415 Park Ave., Hoboken, N.J.

CIRCLE 160 ON READER-SERVICE CARD

Design and Development Facilities

A complete digital instrumentation engineering service for the electronic and missile industries is being offered by Franklin Electronics, Inc. Services include every phase of engineering from initial development to manufacturing. Individual digital instruments as well as complex systems can be handled. Main site of the engineering service is Van Nuys, Calif., and most manufacturing is done at Bridgeport, Pa.

Franklin Electronics Inc., Dept. ED, Communications and Control Div., Bridgeport, Pa.

CIRCLE 161 ON READER-SERVICE CARD

Precision Plating Techniques

New and improved techniques for precision plating of precious metals for the electronics and related industries have been developed by a new company in Waltham, Mass., Plating for Electronics, Inc. Services offered by this new firm include modern facilities using the latest plating equipment for precision plating to specifications of precious metals such as gold, silver, and rhodium anodizing; and precision plating of cadmium, nickel, and copper.

Plating for Electronics, Inc., Dept. ED, 249 Lexington Street, Waltham, Mass.

CIRCLE 162 ON READER-SERVICE CARD

Ultrasonic Machining

Special report on ultrasonic machining and machining service offered by Connecticut Instrument Corporation points out that hard and brittle materials such as glass, ceramics, crystals, tungsten, carbide and the like can be machined with precision and that any shaped hole or cavity can be produced. The service includes assistance in material selection and production design, as well as ultrasonic machining in both experimental and production quantities.

Connecticut Instrument Corporation, Dept. ED, Ultrasonics Div., Wilton, Conn.

CIRCLE 163 ON READER-SERVICE CARD

NEW LITERATURE

Computer Services 201

General Electric Co.'s Computer Dept. with headquarters in Phoenix, Ariz. and its specialized Computing Services Center, are described and illustrated in two attractively illustrated brochures. "Computing Services" is a 12-page brochure presenting the computing services offered to clients in business, military, or government, including: problem analysis, mathematical analysis, programming, coding, machine time, training, and full operation of customer's computer facility. Personnel, details of services and applications, and advantages of computing services are covered. "Military Competence," 14 pages and photographically illustrated, discusses plant facilities, personnel, manufacturing facilities, computing services center, and products of the Computer Department. Military projects undertaken by the Department are emphasized and products and services available from the Computer Department are briefly described. General Electric Co., Computer Dept., 1103 N. Central Ave., Phoenix, Ariz.

Precision Gears 202

This 100-page catalog on "Fine Pitch Precision Stock Gears" lists stainless steel and aluminum spur gears, 48 through 200 pitch with solid and clamp type hubs to A.G.M.A. precision class 2 and precision class 1 standards. Other types of gears are also included. U. S. Gear Corp., 81 Bay State Road, Wakefield, Mass.

Ultrasonic Delay Lines 203

Bulletin TD58, 35 pages, is a mimeographed manual entitled "Procedures For Testing Ultrasonic Delay Lines." It covers basic inspection, single terminal impedance measurements, overall insertion loss, bandwidth, ripples in the band pass, secondary signals, multiple travel signals, direct feed through, sum of secondaries, delay time, absorption in medium, temperature effects and other variables. Applications to high speed computers, radar MTI and integration kits, as well as timing devices are considered. *Arenberg Ultrasonic Laboratory, Inc., 94 Green St., Jamaica Plain 30, Mass. Cost is 25¢.*

Electronic Equipment 204

In 34 pages, and with pictures, this catalog provides the specifications and dimensions of such units as attenuators, potentiometers, matching networks, decade units, bridge units, switches and other miscellaneous equipment. Tech Laboratories, Inc., Bergen and Edsall Boulevards, Palisades Park, N. J.

Wire Cloth and Mesh 205

Fully illustrated, this booklet describes the many uses of nickel alloy wire cloth and mesh in 15 pages. It describes the physical advantages of wire cloth and indicates the range of weaves and sizes available for various purposes including microwave applications where it is used to minimize electrical harmonic interference. The International Nickel Co., Inc., 67 Wall St., New York 5, N. Y.

Semiconductor Catalog 206

Included in this semiconductor products catalog are a transistor chart, a transistor replacement chart, price lists, as well as data sheets on many germanium transistors and silicon rectifiers. Bendix Aviation Corp., Red Bank Div., 201 Westwood Ave., Long Branch, N. J.

Design Data 207

This 2-page data sheet, with graphs, provides practical data for the dimensional design of quarterwave coaxial (TEM) cavities. The data is simplified for rapid use and theoretical relationships have been altered to conform with observed results. Radar Design Corp., P. O. Box 38, Pickard Dr., Syracuse, N. Y.

Pushbutton Actuators 20

Data Sheet 155, with pictures, mounting information, and electrical specifications, describes the 12MA series of pushbutton actuators. Micro Switch, Division of Minneapolis-Honeywell Regulator Co., Freeport, Ill.

Motor Controls 209

Motor Controls Catalog No. 14, 80 pages, is illustrated with product pictures and contains wiring diagrams, dimensional drawings and prices. It gives complete size, weight and rating information on the manufacturer's complete line of motor controls and accessories. The catalog has an index which lists catalog numbers and type identifications about the equipment. One section lists and describes replacement parts available and another section contains heater tables and motor charts. Industrial Control Div., The Arrow-Hart & Hegeman Electric Co., 103 Hawthorn St., Hartford 6, Conn.

Equipment Data Sheets 210

Containing pictures, block diagrams, operating specifications and descriptive text, Bulletins 7004A, 7006A, 7003A, and 1500A cover the following, respectively: Model 15A ac Electronic Voltmeter, Model 21A Test Oscillator, Model 14A True root mean square Voltmeter, and Ceramicite, a high-temperature ceramic insulator. Consolidated Electrodynamics Corp., 300 North Sierra Madre Villa, Pasadena, Calif.

Silicone Rubber 211

Bulletin CDS 170 describes RTV (room temperature vulcanizing) silicone rubber, used in electrical potting and encapsulating. The material is also used for flexible mold-making and for high and low temperature sealing and caulking. Complete product and application data for three new RTV compounds is included in the bulletin. Silicone Products Dept., General Electric Co., Waterford, N. Y.

Potentiometers 212

This catalog covers single turn, wirewound precision potentiometers from 1/2 to 3 in. diameter. Complete specifications such as size and dimensions, mechanical requirement and electrical properties are given. These high reliability units are built to applicable requirements of Mil-R-[illegible]A, NAS 710, Mil-R-19518, Mil-E-[illegible]2A, Mil-R-12934B. Maurey Instrument Corp., 7924 S. Exchange Ave., Chicago 17, Ill.

Filled Teflon Bearings 213

Bulletin CP-558 covers the Chempro line of filled Teflon bearings. These filled materials have electrical and electronic applications, including molded and machined spacers, inserts, connectors and other parts for use in high voltage, high temperature and high frequency. Chemical & Power Products, Inc., 11 Broadway, New York 4, N. Y.

Antenna Coupler 214

In 14 pages, this illustrated booklet describes the operation of the CU-483 Antenna Coupler. The coupler is designed for the 2 to 32 mc range. The booklet contains pictures, schematic diagrams and a table of operating specifications. An analysis of the circuits is also given. CGS Laboratories, Inc., 391 Ludlow St., Stamford, Conn.

Logis Modules 215

Entiled "Simplified Design of Digital Logic Using Magnalog System," this 8-page brochure, in two colors, describes 12 typical applications for logic modules. Each application, with recommended power supply circuitry, is illustrated by a logic diagram, wiring diagram and waveshape photograph. Hoffman Electronics Corp., Semiconductor Div., Dept. K, 930 Pitner Ave., Evanston, Ill.

Strain Gages 216

A new catalog of SR-4 Strain Gages, Instruments and Accessories contains over 250 types. This latest catalog is a complete and authoritative listing of bonded filament resistance strain gages. Complete electrical and physical specifications of each gage type are included, together with prices and quantity discounts. A separate section provides data useful in the selection of gages for various applications. A wide variety of etched foil gages for high, intermediate and room temperature applications are listed, as well as all standard, semi-standard and special purposes SR-4 Wire Gages. In addition to strain gages, the new publication lists strain gage instruments and a variety of strain gage kits and accessories. Baldwin-Lima-Hamilton Corp., Electronics & Instrumentation Div., 42 Fourth Ave., Waltham, Mass.

NEW LITERATURE

Constant-Temperature 219

A new 60-page, fully illustrated, Constant-Temperature Catalog describes a complete line of baths, conditioned-air devices, and temperature-humidity cabinets. The new two-color catalog lists over 100 constant-temperature laboratory instruments applicable to every field of research, materials testing, quality control and production. Included in the new catalog are baths, ovens, sterilizers, incubators, environmental test equipment, steam-generating humidifiers, dry-ice cabinets and various types of thermometers, as well as many unique accessory items designed to provide utmost flexibility. A convenient temperature-conversion table (Centigrade to Fahrenheit) is incorporated. American Instrument Co., Inc., 8030 Georgia Ave., Silver Spring, Md.

Flexible Shafting 220

A new bulletin on their Circle Ess flexible shafting explains briefly the advantages and the simplicity of designing a flexible shaft into products having an application which requires control from remote places. Included within the pages of this bulletin are the latest specification charts on both remote control and power drive cables plus complete data charts of the Circle Ess casing materials. A brief explanation of the uses of adapters for flexible shafting and illustrations of a number of these adapters are also given. F. W. Stewart Corp., 4311-13 Ravenswood Ave., Chicago 13, Ill.

Button Cell Batteries 221

Publication of a brochure on the smallest, most complete line of button cell batteries, is announced by Gulton Industries, Inc. This four-page, colored and illustrated brochure on button cell batteries, highlights the features, design potentials and specifications of the VO-Series, nickel cadmium, button cell battery line which includes types from 100 MAH to 1750 MAH capacities in more than 50 distinct sizes and voltages. Specify request for bulletin No. VO-110, Sales Manager, Alkaline Battery Div., Gulton Ind., Inc., Metuchen, N.J.

Fan and Blower Catalog 223

The 1959 McLean catalog features packaged fans, blowers, and accessory equipment used in conjunction with the cooling of electronic or electrical apparatus. Many new and improved models, construction features and specifications are included in the new 36-page catalog. Shown are ready-to-use cabinet cooling units available in panel heights ranging from a space saving 1-3/4 in. up to 10-1/2 in. and with air deliveries ranging from 100 to 1200 cfm. Prices, quantity discounts and terms on all models are included as well as complete price information on accessories. McLean Engineering Laboratories, P.O. Box 228, Princeton, N.J.

Contact Switches 224

In this specification sheet are details of design, construction and operation of the 1901 Series 30 amp momentary contact switches. McGill Mfg. Co., Inc., Electrical Div., Valparaiso, Ind.

Potentiometer Definitions 225

In this illustrated, 6-page brochure are functional definitions as a guide to users of Clarostat products. Included in the brochure are diagrams and graphs to clarify concepts. Clarostat Mfg. Co., Inc., Dover, N. H.

Wires and Cables 226

A six-page folder on "Plasticote" wires and cables for military and commercial electronic service is a condensed catalog listing coaxial cables, military hook-up wire, multi-conductor cables, appliance wire, miniature and audio wires and cables, high voltage and frequency wires, antenna loop, rvc-300 apparatus and annunciator (bell) wire, also television transmission lines—primary and secondary lead-in cable, "parallead" and "parsac" lead-in wire and TV rotor cable. These cables are available in a variety of conducting, insulating, jacketing, shielding and armoring materials. Chester Cable Corp., 159 Oakland Ave., Chester, N.Y.

Welding Equipment 227

Bulletin 2-100 covers, in 16 pages, welding heads, controls and power supplies and welding accessories. Applications of this equipment includes use with vacuum tubes, relays, capacitors, meters, resistors, instruments, transistors, and electronic chassis. Raytheon Mfg. Co., 100 River St., Waltham 54, Mass.

Electronic Equipment 228

In condensed form, this catalog provides the essential operating characteristics, in 12 pages, of such units as pulse equipment, oscillators, signal generators, bridges, filters, meters, amplifiers, vhf, and measuring equipment, coaxial elements, frequency standards and RLC components. General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

Polyester Glass Laminates 229

Titled "Polyester Glass Dilecto and Celoron," this four-page, two-color bulletin completely describes the various grades and properties of CDF polyester glass Dilecto and suggests applications. The bulletin also describes custom molding available with CDF Celoron Polyester Glass, and presents in tabular form all physical, mechanical, and electrical properties of polyester glass Dilecto. Continental-Diamond Fibre Corp, Newark, Del.

Power Supplies 231

Information and specifications on the company's full line of transistor-regulated and tube regulated power supplies is contained in this 36-page catalog. In addition, the brochure explains the background of firm's exclusive five-year guarantee, gives detailed outline drawings of the equipment and pictures various company power supplies in use. The catalog is available from Lambda Electronics Corp., 11-11 131 St., College Point 56, N.Y.

Electronic Catalog 232

A new 1959 catalog of electronic parts and equipment contains 244 pages devoted to complete details on company's comprehensive selection of electronic parts and equipment for industrial replacement, high fidelity, audio, and ham applications. Herrlinger Distributing Co., 15th and Vine St., Cincinnati 10, Ohio.

NEW LITERATURE

Electronic Tubes 238

Specifications on the company's complete line of electronic tubes for industry and communications are given in a six page brochure. Illustrated in two colors, the brochure contains detailed applications and performance data covering power triodes, rectifier and clipper diodes, gas noise source tubes, TR tubes, pressurized waveguide windows and ionization gauge tubes. Data on the company's model 3050 vacuum gauge, designed to measure pressures of 1/1000 to 1/10,000,000 mm. of mercury, are also included. Central Electronic Manufacturers, Denville, N.J.

Keyer 239

Providing the essential electrical characteristics, this 2-page data sheet describes the F-1B Keyer. It is designed for use with one or two warning lights and when energized, a flashing signal is given. General Electronics Co., Inc., 4200 Mobile Road, Montgomery, Ala.

Automatic Testing 240

This delightful, illustrated booklet describes a new approach to the problem of checking complex electronic systems. An automatic electronic tester denotes by means of red and green lights whether the equipment is operating properly. The booklet includes a humorous presentation of equipment check-out problems and their solution. Brochure is called "Fourteen Men in a Box." Checkmate Automatic Test Equipment Co., Ridgefield, Conn.

Components Catalog 241

A new 24-page catalog, containing hundreds of products and components for use in electronics, science, engineering, also includes telephone, radio and inter-communication equipment for use in plants, warehouses and offices. Copies may be had by writing to the Industrial Products Div., Herbach & Rademan Inc., 1204 Arch St., Philadelphia 7, Pa.

Stroboscopes 243

Two-color data sheet describes a small-size, high-intensity stroboscopic lamp and power unit for visual and photographic strobe work. Unit is used for continuous slow-motion observation of vibrating or rotating specimens for precision measurement of rotary or oscillator speed, or as uniform, fast illumination in photographing high-speed objects. The unit can use a wide variety of triggering modes as input. The lamp produces 0-100 flashes per sec, and is visually effective even in a normally lighted room. Chadwick-Helmuth Co., 472 E. Duarte Road, Monrovia, Calif.

Saturable Reactors 244

Proportioning reactors, transductors, switching reactors and preamplifiers are described in this 4-page bulletin (C-15-S). Physical and electrical characteristics of the four product lines are covered. Also, complete dimensional outlines and tables are provided, in addition to instructions for ordering Control, Magnetics, Inc., Butler, Pa.

Electronic Chopper 245

Model 50 transistorized chopper is described in this 4-page data sheet. Topics covered include electrical operating characteristics, various applications and a general description. Block diagrams are provided. Solid State Electronics Co., 8158 Orion Ave., Van Nuys, Calif.

Cold Drawn Wires 246

A new booklet describing the properties and applications of a wide variety of cold drawn fine wires lists both the physical and chemical properties of the company's alloy, plated and clad wires. The booklet analyzes factors which determine the most economical and efficient wires for specific applications. In addition to cold drawn wire, the division manufactures formed metal parts, strip material for electronic tubes, radio tube and fluorescent lamp bases and sockets, plastic closures, tools, dies and many other electronic component parts. Copies of the brochure may be obtained from Sylvania Electric Products Inc., Warren, Pa.

NEW LITERATURE

Electronic Equipment 250

With pictures, prices and technical specifications, this bound catalog covers the principal products which Scientific-Atlanta offers as standard items. A number of products for industrial and military applications are also covered. Units include: antenna pattern recorders, recording consoles, plug-in balancing potentiometers, wide range receiving system and signal level monitor. Scientific-Atlanta, Inc., 2162 Piedmont Rd., N. E., Atlanta 9, Ga.

Lamps

A 24-page industry-wide booklet, provides listings of all available panel, flashlight, neon glow, automotive and multipurpose lamps. The new booklet is a composite listing, arranged numerically, of lamps manufactured by Chicago Miniature Lamp Works, General Electric, National Carbon (Eveready), Oxford Components (Hudson), Radio Corp. of America, Raytheon, Tung-Sol and Westinghouse. Simply by checking the lamp number the user can determine at a glance the respective manufacturers, bulb type, base, volts, amps and bead color. All bulb types are illustrated with physical dimensions. *Send 10¢ to cover the cost of handling to The Radio-Electronic Master, Dept. ED, 60 Madison Ave., Hempstead, L.I., N.Y.*

Plug/Harness Systems 251

These Plug/Harness Systems (special lengths of cable, custom-made for specific applications, terminating at each end with one or more electrical plugs) are used in missile circuitry and other applications where unusual ruggedness and reliability are required. Catalog HC-1, illustrated, describes the tangible and intangible factors that go into the system, such as plugs and conductors, soldering, cable lay, jacketing and junctions. Cannon Electric Co., P.O. Box 3765, Terminal Annex, Los Angeles 54, Calif.

RFI Data File 253

Data Sheets RF-1 through RF-7 cover such topics as: What is RFI; Standard RFI strips available with models and dimensions shown; Formed Gaskets; RFI Endogaskets and Duostrips. Technical Wire Products, Inc., 48 Brown Ave., Springfield, N.J.

Ceramic Magnets 254

This 4-page, two-color bulletin (#1-59) describes Barium Ferrite material F-300. Magnetic data, curves, design information are given. D. M. Steward Mfg. Co., Chattanooga, Tenn.

Footswitches 255

The 1959 Footswitch catalog shows a complete line of 40 footswitches from light application to heavy duty cast iron models. Ratings are from 7 amps to 40 amps. Over fifteen new models have been added and are shown for the first time in this new catalog. Price list included. Vemaline Products Co., P.O. Box 222, Hawthorne, N.J.

Selenium Rectifiers 256

This 10-page catalog describes selenium rectifiers designed for efficient, economical ac to dc rectification in the widest range of sizes in industry. The illustrated catalog presents complete descriptions, data and specifications for cell sizes in a range from one inch square to 12 x 16 in. and for stacks of practically any size. Also illustrates rectifier circuits and gives four pages of continuous dc current ratings for 26, 33, 36, 40, 45 and 52 v rms cells. Syntron Co., 1186 Lexington Ave., Homer City, Pa.

Differential Transformers 257

Literature on the applications of linear variable differential transformers include information on the use of LVDT's with universal analyzers, null balance systems, rectifier diodes, strain gage amplifiers, and in the measurement of very small displacements. The publications issued include application notes and bulletins summarizing standard LVDT's and rotary accelerator specifications. Schaevitz Engineering, Route 130 & Schaevitz Blvd., Pennsauken, N.J.

NEW LITERATURE

Laboratory Furnaces 261

A data sheet briefly describes various heating, treating, processing, production and laboratory furnaces and two series of forced convection ovens for laboratory and production use. This literature is a guide on the various types of heating equipment available for the modern processes. L & L Manufacturing Co., 202 8th Street, Upland 43, Delaware Co., Pa.

Resistors and Capacitors 262

Bulletin 162 describes three assortments of precision resistors and tantalum capacitors. One assortment consists of tantalum wire capacitors in a variety of case sizes, capacitance and voltage values. Another consists of power type, precision resistors and another of metal film precision resistors. Each assortment is offered in a handy 5-drawer, 40-compartment plastic case in values most commonly encountered in modern circuitry. Ohmite Mfg. Co., 3670 Howard St., Skokie, Ill.

Rectifier Catalog

This 16-page catalog gives ratings, electrical characteristics and descriptive data on 405 types of silicon and selenium rectifiers and diodes. Specifications cover more than 140 types of silicon rectifiers (including 63 zener diode types), 47 silicon cartridge rectifiers, and more than 130 selenium rectifier and contact protector types. *Write on letterhead for "Short Form Catalog," International Rectifier Corp., Dept. ED, El Segundo, Calif.*

Phenolic Products 263

Booklet CDC-358, 8-pages, describes a complete line of phenolic resins, varnishes and molding powders. The catalog includes product features, special properties, and detailed technical data on GE phenolic molding powders, phenolic laminating varnishes and phenolic foundry resins. General Electric Co., Chemical Materials Dept., One Plastics Ave., Pittsfield, Mass.

Extruded Teflon Tubing 265

Titled "Extruded TFE Teflon Tubing," this bulletin describes and illustrates the full line of CDF Teflon Tubing. Complete tables of sizes and tolerances are given. This 4-page, 2-color brochure also presents in tabular form complete lists of electrical and physical properties of the tubing. The test method is indicated for each property. Continental-Diamond Fibre Corp., Newark, Del.

Micro Volt-Ammeter 266

Keithley Engineering Notes, Vol. 7 No. 1, 4-pages, features the Model 150 Micro Volt-Ammeter for measuring voltages as low as 0.03 microvolt and currents down to two micromicroamperes. The bulletin gives a detailed description including circuit design considerations, schematic diagram and actual reproductions of stability performance tests. Also included are specifications, prices and ordering information. Copies are available upon request on your company letterhead from Keithley Instruments, Inc., 12415 Euclid Ave., Cleveland 6, Ohio.

Production Tools 267

This catalog fully describes and illustrates, in 12 pages, a complete line of solenoid-operated impact hammers, punches, stakers and Geneva Action indexing tables. Included is a section on custom engineering automatic production machinery. The tools are used in a multitude of operations including riveting, staking, crimping, swaging, punching and marking. Black and Webster, Inc., 445 Watertown St., Newton 58, Mass.

Test Instruments 268

Fully-illustrated Catalog 558 covers such precision laboratory test instruments as Low Frequency "Q" Indicators, Comparison Bridges, Incremental Inductance Bridges, Universal Bridges, Null Detector & Vacuum Tube Voltmeters, Harmonic Distortion Meters, Megohmmeters, Decade Inductors, and Decade Capacitors. The Catalog gives complete specifications for each test unit, plus a full description and suggested uses. Freed Transformer Co., Inc., 1727 Weirfield St., Brooklyn 27, N.Y.

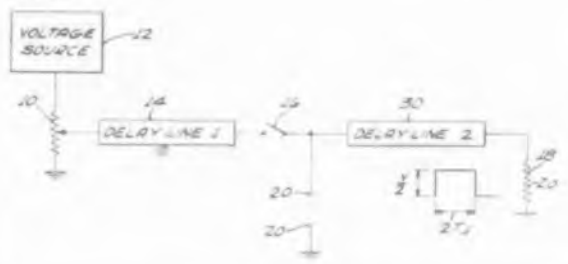
PATENTS

Pulse Generator

Patent No. 2,863,072. Mathew Arnold Alexander. (Assigned to Telemeter Magnetics Inc.)

By discharging a delay line into a matched line terminated by its characteristic impedance, a truly flat-top pulse is generated.

In the schematic shown, the two delay lines may comprise equal sections of a line having twice the desired delay time. Delay line *1* is charged by voltage source *12* and then microswitch *16* connects this line to delay line 2. An impulse travels back along line *1* and is reflected back to junctions *20* terminating the pulse. There is no reflected wave along delay line 2 since the line is matched by the load.



Stabilized Signal Translating Circuits

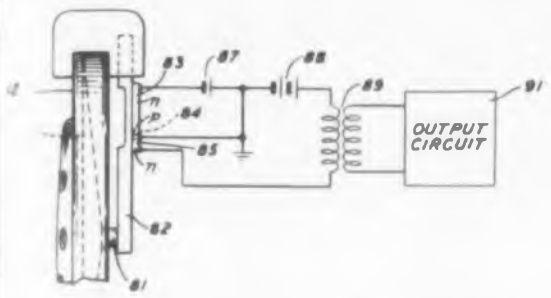
Patent No. 2,866,017. John Paul Jones, Jr. (Assigned to Navigation Computer Corp.)

Temperature stabilization in a common emitter circuit. The tap, located experimentally, depends upon the desired stability. In operation, as the temperature increases, a larger fraction of the input signal is diverted to ground to maintain the output current independent of temperature.

Piezoresistive Acoustic Transducer

Patent No. 2,866,014. Fred P. Burns. (Assigned to Bell Telephone Labs, Inc.)

Change of resistance in a semiconductor due to applied stress is used in a microphone to convert acoustical energy linearly to a change in electrical current. For N-type germanium, as an example, resistance increases with compression; P-type germanium shows the opposite effect. Hence, when complementary type



semiconductor elements are clamped in series to opposite sides of the vibratory member, a large change in resistance results.

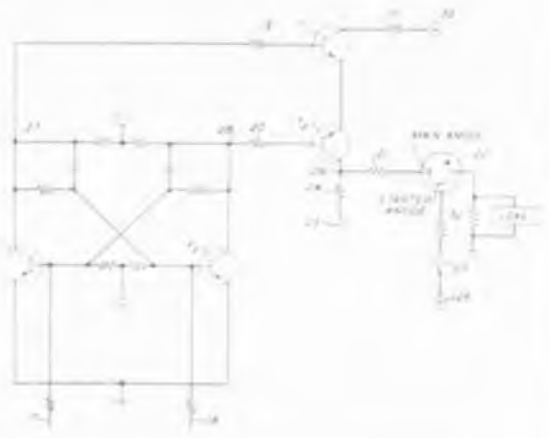
In a practical application, a transistor acts as the piezoresistive element and, in addition, produces amplification. As beam 82 bends, the current through the elongated emitter 83 varies substantially and the change in collector current flowing through the primary of transformer 88 is coupled to the output circuit.

Transistor Gating Circuit

Patent No. 2,848,653. Luther W. Hussey. (Assigned to Bell Telephone Laboratories, Inc.)

Complementary transistors, used as a switch and as current limiters, improve the characteristics of gas tube circuits and protect the tube against damage.

Npn transistor T_1 and pnp transistor T_2 are in series with the power supply applied to gas tube 22. Initially, the transistors are nonconducting and the gas tube is off. A negative pulse to terminal *17* causes transistors F_1 and F_2 to flip with transistor F_1 now conducting. The base of T_1 is now positive and the base of T_2 is negative such that the two transistors carry saturation current and the gas tube fires. To extinguish the gas tubes, a negative pulse applied to lead *18* reestablishes the original condition by shifting transistors T_1 and T_2 to cut off.



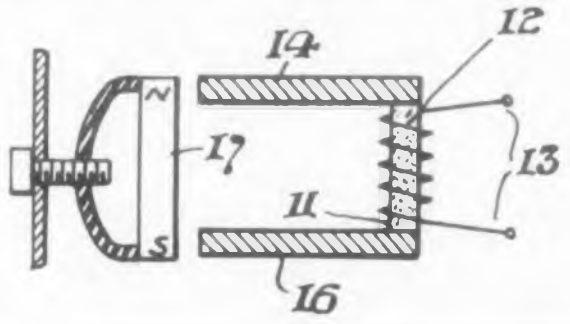
PATENTS

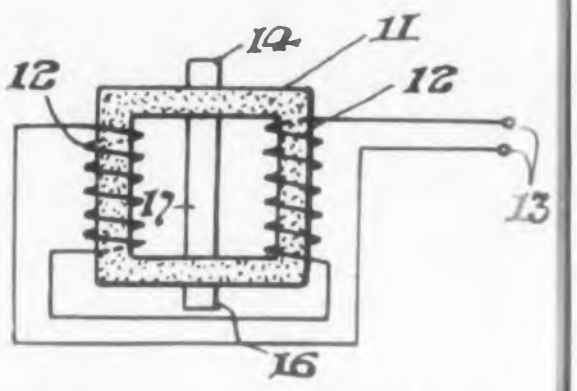
Inductive Tuning Device

Patent No. 2,860,313. Dorman D. Israel. (Assigned to Emerson Radio & Phonograph Corp.

Radio frequency coils are tuned by adjusting the reluctance of the cores on which the coils are wound. The variation in inductance may be 50 to 1, which is equivalent to a 7 to 1 change in frequency in the broadcast band. Various mechanical arrangements are suggested to make the tracking linear.

To tune a single coil *12*, mounted on core *11*, magnetic pole pieces are attached to the core and a bar magnet *17* is rotated in the vicinity of the pole pieces. With the maximum area of the





magnet opposite the ends of the pole pieces, a large magnetomotive force develops, producing a large steady flux through the core and minimum inductance results. Rotation increases the air gap, less flux passes through the core and the inductance increases.

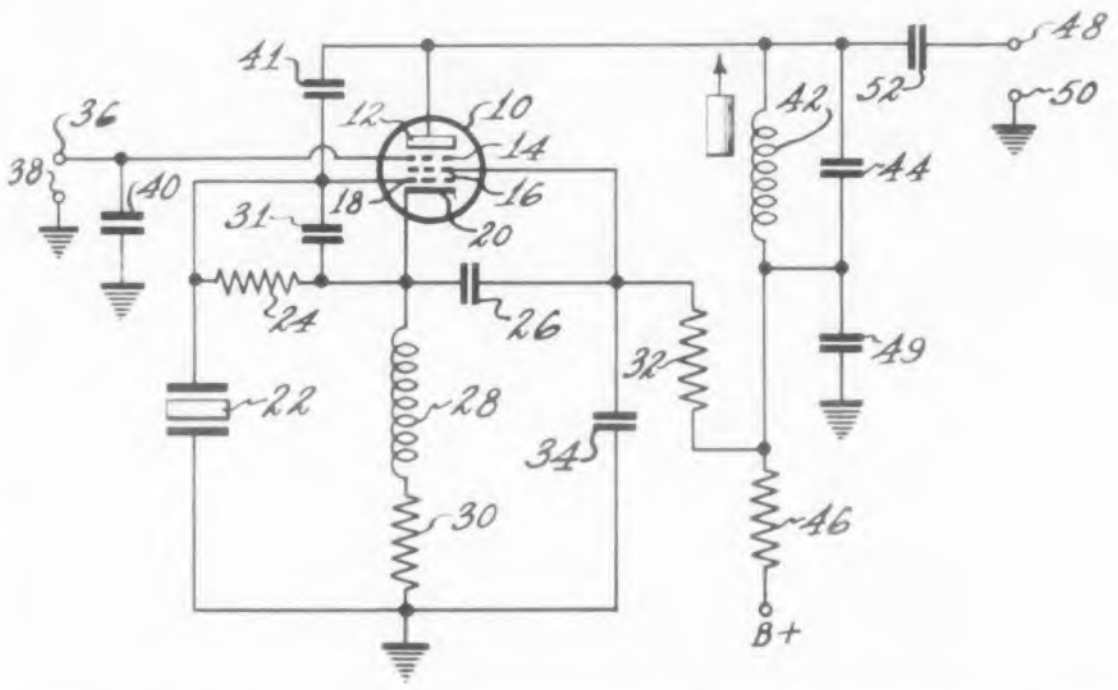
Oscillator-Modulator Circuit

Patent No. 2,866,162. Charles Rosen, Charles J. Weidknecht. (Assigned to Tele-Dynamics Inc.)

Phase modulation occurs in the inductive plate load of an oscillator-modulator pantode stage when constant-ampli-

ide crystal-controlled oscillations are ixed with amplitude-modulated oscil-tions at the same frequency.

Cathode *20*, grid *18* and screen *16* are e triode elements producing the con-ant-amplitude oscillations fixed by ystal *22* and inductance *28*. The elec-on stream to plate *12* is amplitude odulated by the signal applied to high transconductance suppressor *14*. Capacitor *41* couples the constant amplitude signal from grid *18* to plate *12*. Since the a-m signal lags the signal on the control grid *18* by substantially 90 deg. and the signal coupled by capacitor *41* leads by about 180 deg, the vector addition of these voltages is a signal phase modulated with the modulating voltage.



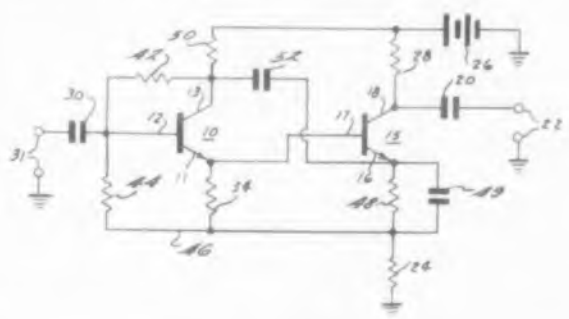
PATENTS

High Input Impedance Transistor Amplifier Circuits

Patent No, 2,858,379. Thomas O. Stanley. (Assigned to RCA)

A transistor amplifier, comprising a common collector stage in cascade with a common emitter stage, exhibits an input impedance of 500,000 ohms. The bias network and collector of the first transistor stage are driven essentially by the input voltage such that loading of the input circuit is reduced.

The bias network of resistors *42* and *44* in series, as well as collector *13*, are driven at signal frequency by emitter *15* by the voltage developed across resistor 24. As a result, the currents of collector



13 bias network are both kept small and the input current therefore consists only of the emitter-base current of transistor 10. An additional improvement is obtained by coupling to the output through collector 18.

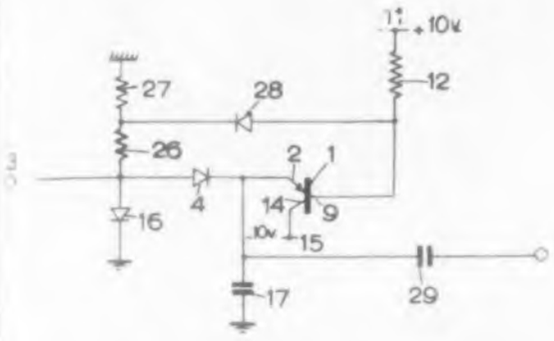
Note: An identical circuit using a 12AT7 tube gives an input impedance of 10 megohms (see *Patent 2,839,618* as reported in ELECTRONIC DESIGN, Oct. 29, 1958, page 86).

Transistor Bistable Circuit

Patent No. 2,850,646. William Ellis Ingham. (Assigned to Electric and Musical Industries, Ltd.)

Binary counters, comprising a single transistor, are triggered alternately from low conduction to high conduction by negative pulses.

If the transistor is in the low conduction state, the next input pulse through diode 28 drives the base below ground, while the emitter voltage is fixed by capacitor *17*; this causes the transistor to



conduct hard. Capacitor *17* now charges and diode *4* becomes conducting. The next pulse causes diode *4* to become a high impedance and the transistor sharply cuts off. The base returns to ground voltage, its initial state.

Diode Gate and Sampling Circuit

Patent No. 2,866,103. John T. Blake, Austin L. Ely. (Assigned to Bell Telephone Labs., Inc.)

In the logical And device, diodes in series-shunt configuration control passage of signal to the load. A floating inductance accelerates the switching action.

Initially, the gate is open since battery *20* sends current through diodes *15* and *12*, in series with inductance *16*, to set P_1 and P_2 voltages to cut off diodes *11* and *14*. However, a positive-going pulse from source *23* cuts off diodes *12* and *15* and the voltage across inductance *16* reverses to quickly bias diodes *11* and *14* to conduction. As long as the control pulses are present, a positive going voltage from generator *17* will pass to load *19* by the path including diodes *13* and *17* plus inductance *16*. A negative-going voltage will pass through inductance *16* by means of diodes *10* and *14* in series.

Get $10.00 plus a by-line for the time it takes you to jot down your clever design idea. Payment is made when the idea is accepted for publication.

Frequency Sensitivity without Reactors

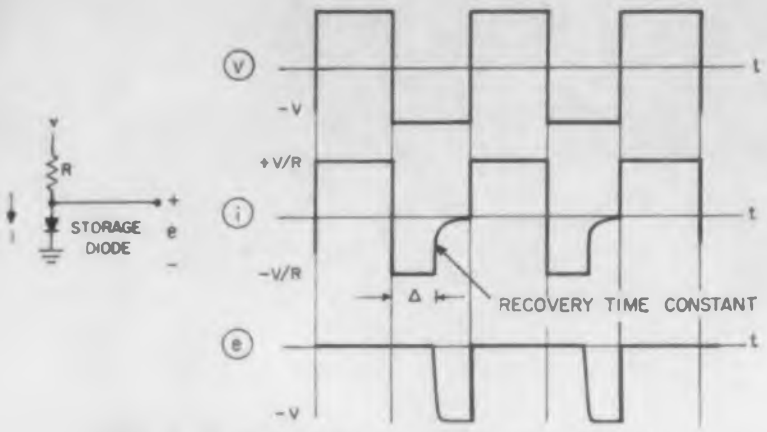


Fig. 1. Representative waveforms for a storage diode.

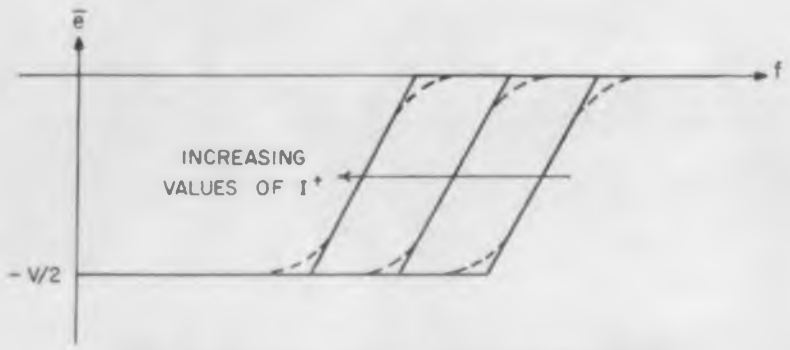


Fig. 2. Average voltage across storage diode as a function of frequency and forward current.

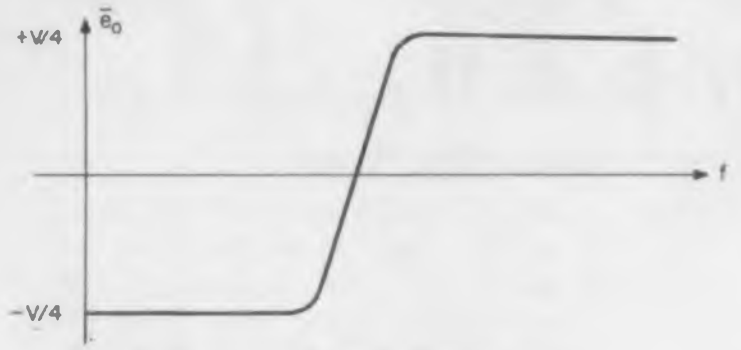


Fig. 3. Response of a null discriminator.

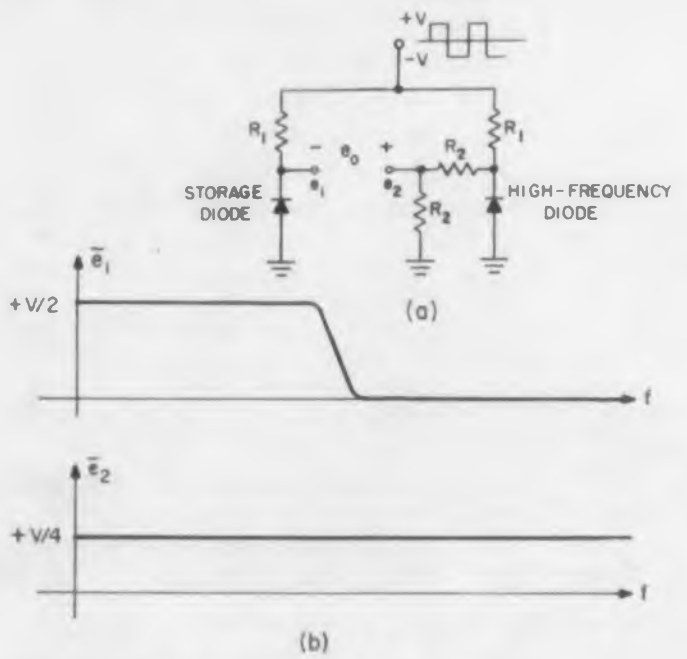


Fig. 4. Circuit and response of a null discriminator.

CIRCUITS which are frequency sensitive can be built without reactive elements by employing the phenomenon of minority carrier storage time that exists in semiconductor diodes and transistors. Storage time results from the fact that minority carriers injected during the forward conduction of a diode cannot be dispersed instantaneously when the junction is reverse biased.

If a "storage" diode is subjected to an alternating potential, current flows in the reverse direction until the net charge injected during forward conduction has been removed, at which time the diode assumes an open state. Somewhat idealized sketches of the current and voltage waveforms obtained with such a diode are shown in Fig. 1.

If the recovery time constant is negligible compared to the excitation period, then the storage time, Δ, is given by $\Delta = S\ I^+$, where I^+ is the magnitude of the forward conduction current, and S is a constant which is a function of diode properties and temperature.

For the circuit of Fig. 1, with fixed values of I^+, the average value of output voltage, e, varies with excitation frequency as shown in Fig. 2.

Ideally, the drop-off in average voltage should be a linearly decreasing function of excitation period and consequently an inverse function of frequency. In actual practice however, the curvature indicated by dotted lines is obtained because of device nonlinearities and non-zero recovery time.

This effect can be used in a number of circuit configurations to provide interesting and useful circuit responses. Some of these applications are described in the following paragraphs.

A Null Discriminator

This circuit uses a storage diode such as a 1N91

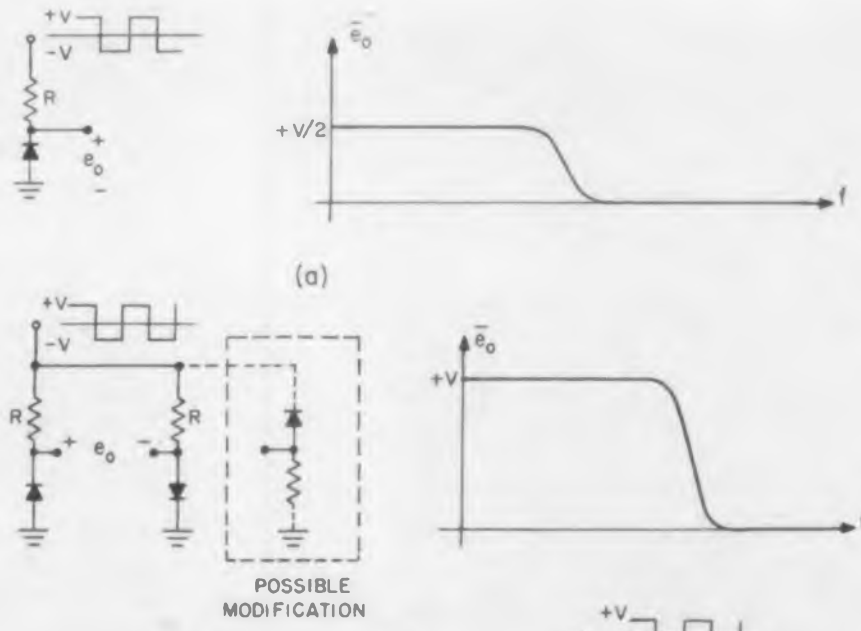


Fig. 5. Circuits and characteristics of low pass networks.

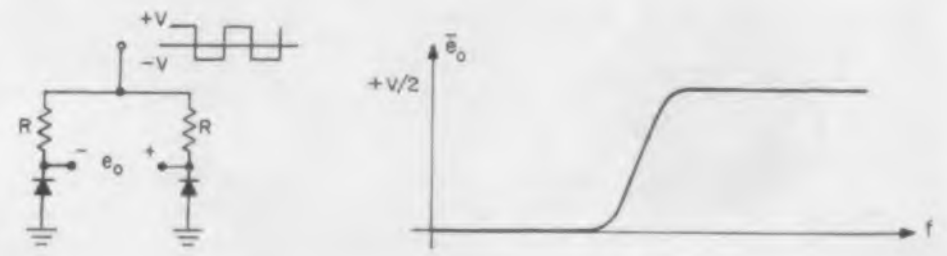


Fig. 6. Circuits and characteristics of high pass networks.

HOW HIGH RELIABILITY?

Unique Leach Production Reliability Center offers the ultimate in active component testing

The new $100,000 Leach Production Reliability Center – first in the relay industry – is designed as an integral part of the Leach assembly operation.

Its purpose: testing to customer requirements – up to a checkout of 100% of the total production run of components.

This laboratory checkout system was created to meet the ultimate in critical reliability requirements. Its facilities and equipment are available for testing to exacting customer specifications. Any customer may specify the types of testing and the sequence of testing procedures he requires within the tolerances and limits of the capability of the Leach equipment described and pictured here.

COLD TEST is conducted in a chamber where temperatures may be specified in a range of −100°C to +25°C.

VIBRATION TEST checks units from 5 cps to 3,500 cps up to 50 G's. This test normally is performed with direction of vibration applied through each of three mutually perpendicular axes.

ELECTRICAL TESTS fall into many categories. These are typical: measuring coil resistance, testing pickup and dropout current, checking dielectric characteristics, and testing millivolt drop across contacts.

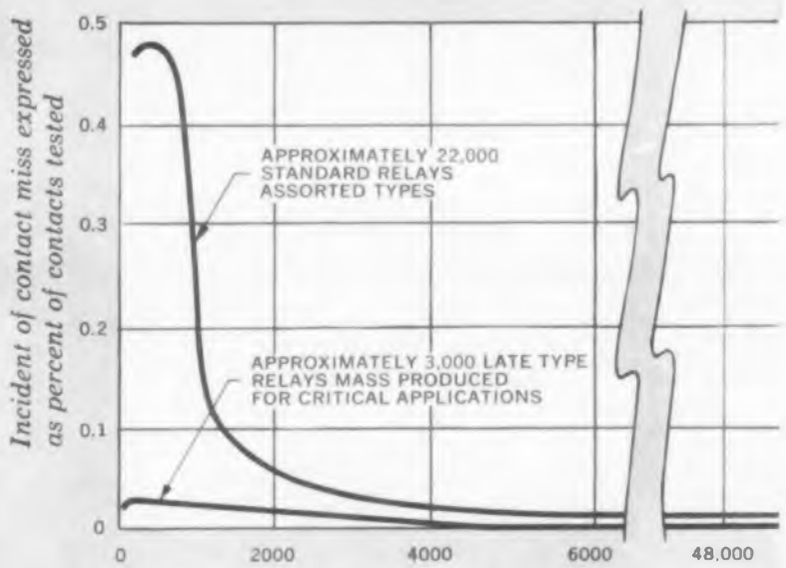
HEAT TEST subjects components to specified temperatures ranging from +25°C to +550°C in a heat chamber.

SHOCK TEST in each of three mutually perpendicular planes is available up to 150 G's – with concurrent electrical testing.

LEAK DETECTION TEST subjects components to minute inspection of hermetic sealing with a mass spectrometer type leak detector.

ACCELERATION TEST places components in a centrifuge for acceleration testing to 500 G's. While undergoing this test, units may be subjected to electrical testing as well.

RELIABILITY TEST



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CIRCLE 283 ON READER-SERVICE CARD

and a high frequency diode such as a 1N100 (one having break frequencies much greater than those in the desired operating range) to produce a dc output voltage which varies with frequency as shown in Fig. 3.

This characteristic is produced by the circuit of Fig. 4a by taking the difference of the two bridge arm outputs shown in Fig. 4b.

A limiter must precede the circuit to prevent breakpoint frequency shift. This is, of course, also necessary for a conventional discriminator, though for a different reason.

A Low Pass Network

As in the previous case, this network normally requires limiters. Two configurations have been developed, one a series circuit similar to Fig. 1, and the other a bridge. The circuits, together with their characteristics are shown in Figs. 5a and 5b. It is evident that the sensitivity of the latter circuit is twice that of the former, and that it can be modified as shown in dotted lines to give an identical response.

A High Pass Network

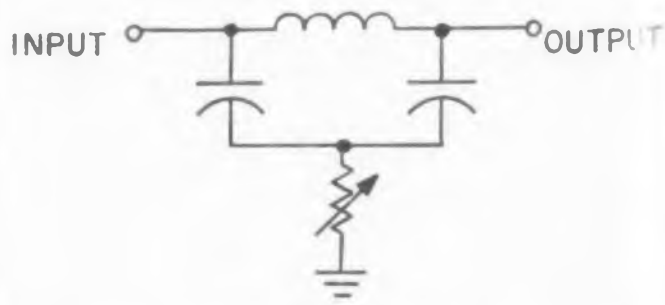
A simple modification of the network in Fig. 4b results in the circuit of Fig. 6 having the high pass characteristic shown. This circuit can also be modified for greater sensitivity.

Donald W. Boensel, Electronic Research Engineer, La Crescenta, Calif.

Network to Pass 30, Stop 60 Cps

Quite often a designer encounters a problem with a low frequency amplifier when he needs flat response to say 30 cps but must attenuate 60 cps because of hum pickup. The big problem is to design a circuit which will attenuate 60 cps but pass 30 cps without attenuation. It can't be done using conventional components because of the low Q of most components at that frequency.

The circuit shown really works. When R is adjusted for minimum output at 60 cps, it is difficult to measure the amount of 60 cycle voltage in



Resistor in center leg of T network allows relative flat low frequency response, yet attenuates 60 cps

scope. Voltage at 58 cycles is, however, up to 5 per cent of level at 30 cps.

Here is how it works. When changing a *pi* to a network the center leg of the *T* network comes out with a capacitor, an inductor and a negative resistor whose resistance is a function of the dc resistance of the choke. By placing a positive resistance in series with the center leg it becomes a series resonant circuit with an almost infinite *Q*. The product of *L* and *C* should be 24 for 60 cps and is inversely proportional to frequency.

John Massey, Reliability Eng., Barber-Colman Co. Rockford Ill.

Making a Log Scale On Linear Paper

Without a slide rule, one can easily construct a logarithmic scale from uniform squared graph paper.

The whole trick rests in the fact that the logarithm of 2 is pretty close to 0.3. If 10 equal spaces represent a factor of 10, then 3 spaces represent a factor of 2. This permits dividing the scale for points *1*, *2*, *4*, *5*, *8*, and *10* as in Fig. 1.

It remains to place *3*, *6*, *7*, and *9* on the scale. *9* can be placed midway between *8* and *10*, or at 9.5 spaces from *1*.

Since $3 \times 3 = 9$, *3* should occur midway between *1* and *9* on the scale, or at 4.75 spaces from *1*.

Number *7* is placed just slightly to the right of midway between *6* and *8*, as shown in Fig. 2.

This method may appear crude, but reference to a log table shows that the method is correct to better than one per cent. It is also easy to memorize.

Elliott Barr, Taylor Instrument Co., Rochester, N.Y.

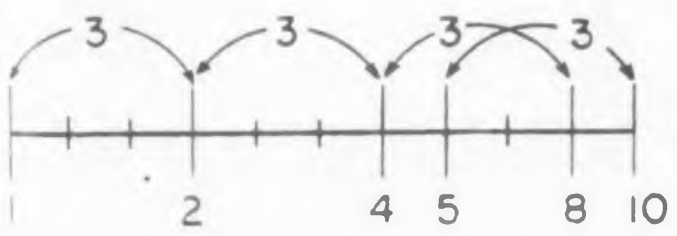


Fig. 1. Since the logarithm of 2 is 0.3, it is easy to divide linear paper into three-part divisions and insert *1, 2, 4, 5, 8,* and *10*.

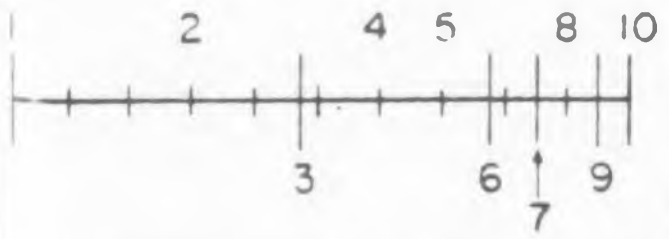


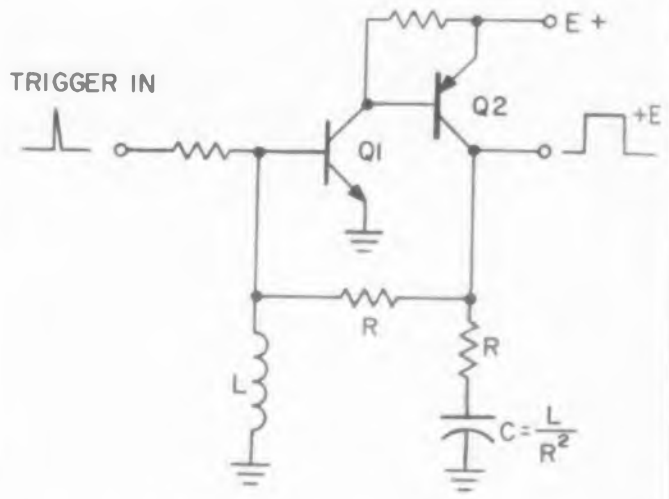
Fig. 2. Remaining numbers *3, 6, 7,* and *9* are easily inserted.

IDEAS FOR DESIGN

Near-Perfect Output From Fast, One-Shot Multi

RC timing is far more popular than *RL* timing. Yet, it's possible to get faster rise times if inductors are used instead of capacitors. In the circuit shown, the capacitor can be used to compensate for the load, and make the load look like an almost pure resistance.

McKenny W. Egerton, Jr., Hoover Electronics, Timonium, Md.



Using *RL* timing instead of *RC* allows the capacitor to be used to compensate for the load at the collector of Q2.

3-In-1 Meter. The French firm Le Boeuf hit upon a good idea when it decided to produce this triple dial meter.

It is more economical and a good deal less ungainly than three separate meters. Moreover, the close grouping of the dials gives, at a glance, a complete indication of the operation of an entire stage.

Of course, all combinations of units and ranges are available, a number having been standardized.

Dr. A. V. J. Martin, Carnegie Institute of Technology, Pittsburgh 13, Pa.

Wet Felt Sinks Heat

Everybody knows that when components are soldered into a circuit, heat is conducted along the soldered joint to the component. Heat-sensitive components, like transistors and diodes, can be ruined if precautions are not taken.

The latest suggestion for preventing such damage comes from a manufacturing research engineer at the Boeing Airplane Co. in Seattle, Wash. He uses a standard metal clamp (alligator clip) lined with felt (Fig. 1). He saturates it with water and attaches the clamp to the lead wire between the soldered joint and the component (Fig. 2).

Heat traveling along the lead wire is dissipated by evaporation of water from the felt, thus protecting the component.

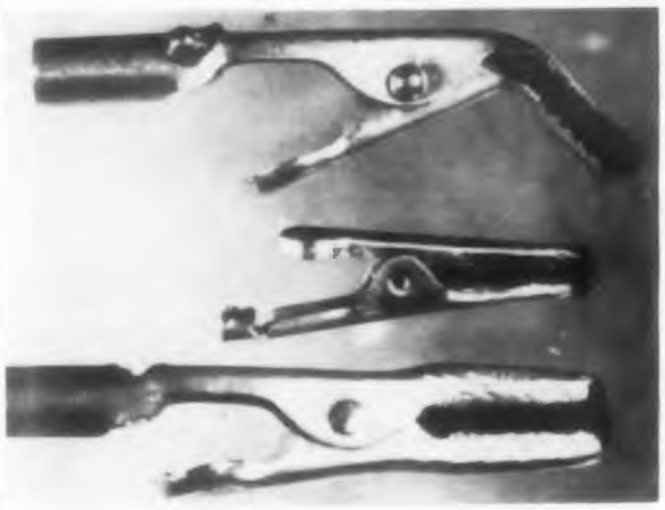


Fig. 1. Simple, effective, wet-felt heat sink.

Fig. 2. The wet-felt heat sinks, to the right of the soldering iron, protect the diode from thermal damage during soldering.

IDEAS FOR DESIGN

Sensitive, Stable Bridge with Reversible Polarity and Low Output Impedance

In regulating and servo systems it is necessary to have an error detector to compare the measured or detected signal with a reference source and provide an error signal proportional to the difference.

The internal resistance of the detector determines the power that will be available at the output terminals without distortion introducing nonlinearity in the output.

By inserting double-ended silicon voltage regulating diodes d in two legs of the bridge, two objectives are attained.

1. The diodes feature a low dynamic impedance (approximately two ohms), and provide the voltage reference.

2. By proper choice of diodes, the temperature drift of the bridge can be minimized.

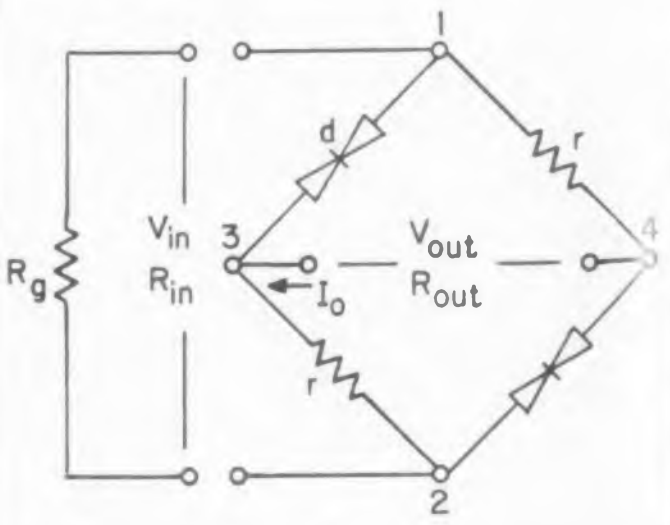
Efficiency, economics, power availability and specific system dynamics will determine the input impedance to the bridge R_{in}.

If the diodes d are operated at approximately 10 per cent of their rating, their self-heating will be low and so will the initial drift of the bridge output. The diodes, though, should be operated above their V-I knee. The bridge resistors r should be selected to limit diode current. As an example, a bridge for a 28 v dc line is computed here.

The source impedance R_g is small compared with r. The equivalent Thevenin resistance of the bridge R_o, with R_{in} about 56 ohm is

$$R_o = 2\,R_d = 4$$

For ±0.05 per cent regulation of the 28 v dc line, the error voltage available will be ±0.007 v dc = V_{out}.



Double-ended diodes in the legs of a bridge provide voltage regulation and low output impedance.

It can easily be seen from the figure that the polarity of V_{out} will depend on whether the input is above or below rated input. With the line being 28 v + 0.014 v, the voltage V_{out} is positive at point 3 and negative at 4; with 28v—0.014 v, V_{out} is positive at terminal 4.

To prevent loading of the bridge circuit the error current I_o, required to swing the load from minimum to maximum, should be made low. The input impedance to the load should be high.

$$dV_o = dI_o R_o$$

$$\frac{dV_o}{dI_o} = R_o$$

Baruch Berman, Group Engineer, Action, Div. ACF, Paramus, N.J.

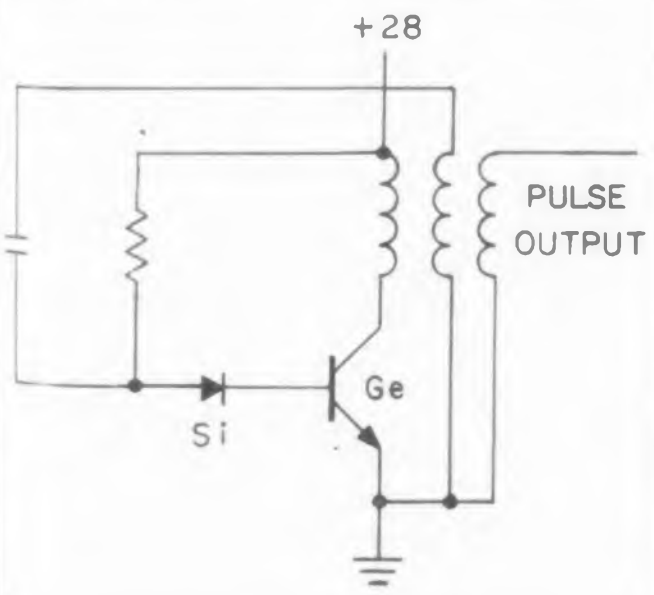
Stable Pulse Generators

It's easy to build a pulse generator whose output frequency is constant within one per cent with power supply variations of 50 per cent and with operation at temperatures up to 70 C.

Any transistorized relaxation oscillator, blocking oscillator or multivibrator is good for a frequency stability of two to three per cent, but if special care is taken, one per cent is a practical limit—even with 50 per cent power supply fluctuations.

In the blocking oscillator shown in the figure, a single power supply is used. The negative swing of the base varies with *B plus* changes. The silicon diode raises the back resistance of the base junction. Since the period of oscillation is a function of the *RC* time constant, it is not affected by *B plus*.

David H. Bryan, Project Engineer, Fenske, Fedrick and Miller, Inc., Los Angeles, Calif.



Transistorized blocking oscillator with frequency stability to one per cent.

REPORT BRIEFS

Solid Electrolyte Battery Systems

This report describes the work leading to the development of the Ag/AgCl/KICl$_4$ cell system and the cup-shaped cell configuration. This combination results in a cell of outstanding properties which appears to be capable of meeting the original goals of the contract. The various cell systems studied and the important features of each of these reported in detail in the main text. Supplementary material is discussed in the various Appendices: (a) Detailed discussion of current-voltage relations in mixed conductors. (b) Discussion of the silver-iodine tarnishing experiments. (c) Reaction with iodine and chlorine of silver containing cadmium. (d) Effect of ultraviolet radiation on the tarnishing reaction. (e) Effect of small additions of cadmium chloride on the protective action of silver chloride. (f) Anodized films of silver chloride as the solid electrolyte. (g) Electrical contacts at the silver-silver chloride interface. (h) Test results of Ag/AgCl/AgI/I_2 batteries. (i) Shorting of solid electrolyte batteries by a common electrolyte. (j) Modification in cup-shaped cell assembly. (k) Fluoride cell systems. *Solid Electrolyte Battery Systems, Donald Smyth, Sprague Electric Co., North Adams, Mass. Final report. June 1, 1954—Nov. 30, 1956. December 26, 282 pp. $4.00. Order PB 131796 from OTS, U. S. Department of Commerce, Washington 25, D. C.*

Germanium-Silicon Alloys

An isothermal solidification technique was developed for preparing homogeneous germanium-silicon alloys in polycrystalline form for all the compositions and in single crystal form for the low silicon alloys. Theoretical studies were made on the rate of solidification and furnace conditions necessary to make homogeneous alloys. The energy gaps of the alloys were calculated from data on the temperature dependence of resistivity and infra-red absorption measurements. Calculations showed the energy gap to increase rapidly with the addition of silicon and approach the value for pure silicon at about 50 atomic per cent silicon. The mobilities of the low silicon alloys were found comparable to germanium, while those of polycrystalline, high silicon alloys were low. Alloy life times were low as compared with germanium. Semiconductor devices made of germanium-silicon alloys were shown to operate at temperatures higher than those of germanium. *Investigation of Germanium-Silicon Alloys: Final Report. C. C. Wang, Sylvania Electric Products, Inc. for Bureau of Ships, U. S. Navy, Feb. 1955, 48 pp, $1.25. Order PB 131422 from OTS, U. S. Department of Commerce, Washington 25, D. C.*

Semiconductors Devices Research Program

Silicon power transistors can be fabricated by diffusing impurities in from the surface to form the base and emitter regions. Of the number of impurities which can be used to form transistor structure, galium and phosphorus were most thoroughly studied. The simultaneous diffusion process was used for transistor fabrication in pilot experiments, and the effects of external variables upon this process were determined. Emitter, base, and collector contacts were made using titanium or tungsten support plates. The transistors were mounted in a hermetically sealed, welded package of low thermal resistance. The fabrication process, consisting of diffusion, lead attachment, etching, and packaging, is described. The characteristics of preliminary laboratory units and of twenty production prototype units made by the process are given, and the performance of the units in typical circuits is shown. The transistors are said to be capable of dissipating over 25 w at a mounting base temperature of 85 C and delivering large power at relatively high temperatures. *Semiconductors Devices Research Program, J. E. Keister, General Electric Co. for Wright Air Development Center, U. S. Air Force, July 1958, 151 pp, $3.00. Order PB 151201 from OTS, U. S. Department of Commerce, Washington 25, D. C.*

Antennas and Radomes

Seven topics in applied electromagnetic theory were investigated: (1) Surface waves and anisotropic propagation, (2) Techniques for measuring far field data at close distances, (3) Mutual coupling of slots in waveguide, (4) Radome survey, (5) Microwave filters, (6) Electromagnetic field in a half space, and (7) A new type of lens. *Topics in Antennas and Radomes, Alan F. Kay, Technical Research Group, New York. Final report Jan. 1958, 23 pp, microfilm $2.70, photocopy $4.80. Order PB 134992 from the Library of Congress, Washington 25, D.C.*

Analysis of Junction-Diode Capacitance

This paper is the result of an attempt to explore the possible uses for the capacitance found in pn junctions, and to analyze the various parameters which might be controllable in the design and manufacture of these junctions. The circuits used in obtaining data are but one of many possible arrangements for which the capacitance of the junction can be used. *Analysis and Applications of a Variable Capacitance Junction Diode, Lawrence Roesler, Air Force Institute of Technology, Dayton, Ohio. Thesis, Mar. 1958, 36 pp, microfilm $3.90, photocopy $10.80. Order PB 134835 from Library of Congress, Photoduplication Service, Publications Board Project, Washington 25, D.C.*

REPORT BRIEFS

Directional Glide Path

"Encouraging results" are reported from tests of a directional glide path which provides pilots with vertical guidance during an approach over rough terrain under the Instrument Landing System. In operation, the glide path utilizes a transmitter which energizes an antenna system from which a carrier and sidebands of 90 cps and 150 cps are radiated. Airborne equipment presents an indication for on-path, above-path, or below-path which is a function of difference in depth of modulation. The system was developed specifically to produce a straight path where rough terrain prevented effective use of either the equisignal or the null-reference glide paths. The system performed satisfactorily in tests over rough terrain, providing a path which terminates essentially when the aircraft reaches an altitude of about 30 feet above the runway. Long-term stability of path position was found acceptable. *A Directional Glide Path. (CAA Technical Development Report No. 336.) T. H. Bottoms, H. C. Hurley, L. N. Spinner, and J. W. Watt, Technical Development Center, Civil Aeronautics Administration, Feb. 1958, 23 pp, $0.75. Order PB 131742 from OTS, U. S. Department of Commerce, Washington 25, D. C.*

Study of Universal Function Generator

Design and development of universal function generators for use in analog computing circuits are discussed. In order to simulate operational characteristics of a weapon on an analog computer, several types of function generators are necessary. Circuitry for the elliptical function generator and the ring spring generator is presented. *Feasibility and Evaluation Study of A Universal Function Generator, E. H. Jakubowski, Springfield Armory, Mass. Oct., 1957, 12 pp, microfilm $2.40, photocopy $3.30. Order PB 134279 from Library of Congress, Washington 25, D.C.*

Transistor Admittance Measurements

This report covers the modifications of the Wayne-Kerr R. F. Admittance Bridge Type B-601, the test used, and precautions found necessary to measure transistor short-circuit admittance parameters. Measurements were made of several transistor types for their complex admittance parameters over the frequency range of 100 kc/s to 5 Mc/s. *Transistor Admittance Measurements in the 0.1 to 5 MC Range Using the Type B-601 Wayne-Kerr R. F. Bridge, G. N. Kambouris, Diamond Ordnance Fuze Labs., Washington, D. C., May 1958, 23 pp, microfilm $2.70, photocopy $4.00. Order PB 134634 from Library of Congress, Photoduplication Service, Publications Board Project, Washington 25, D. C.*

Defocus Characteristics of Microwave Reflectors and Lenses

The initial purpose of this contract was to investigate the on-axis and off-axis defocus characteristics of microwave reflectors with apertures of both the circular and the rectangular types. The investigation developed into three major tasks, namely: (1) Simulation of Fraunhofer radiation patterns in the Fresnel region by a defocusing technique; (2) Determination of phase errors in an aperture plane of any given reflector with an arbitrarily located primary source; (3) Determination of aperture-field distributions for defocused microwave lenses which included metal-plate lenses, homogeneous dielectric lenses, and the Luneberg lens. *Defocus Characteristics of Microwave Reflectors and Lenses, David K. Cheng, Syracuse University Research Institute, N. Y., Final Report. July 1, 1954–Sept. 30, 1956, Nov. 1956, 62 pp, microfilm $3.90, photocopy $10.80. Order PB 135189 from the Library of Congress, Washington 25, N. Y.*

Field Emission Cathode Ray Tube Development

The design, construction and preliminary testing of a cathode ray tube utilizing a field emission cathode constitute the subject matter of this report. Magnetic focusing of the field emission beam was investigated and experimentally demonstrated, but the chief emphasis of the work was placed upon electrostatic focusing. A detailed analysis of the corresponding electron optical problem was made. Based upon this analysis, a tube was designed, built, tested and demonstrated. Its performance indicates favorable possibilities for further development of such tubes, taking advantage of the attractive features of the field emission source. *Field Emission Cathode Ray Tube Development, Joseph W. Griffith, Winthrop W. Dolan, Linfield Research Institute, McMinnville, Ore. July 1958, 37 pp, $1.00. Order PB 151246 from OTS, U. S. Department of Commerce, Washington 25, D.C.*

VHF and UHF Balum Transformer

A transformer is described which may be used as a phase inverter, differential transformer, or as a balum transformer. Practical models have been built which operate nearly three decades of frequency with bandwidths approaching one kilomegacycle. *Very Wide Band Balum Transformer For VHF and UHF, T. R. O'Meara, R. L. Sydnor University of Illinois, Electrical Engineering Research Laboratory, Urbana, Ill., July 1957, 55 pp, microfilm $3.60, photocopy $9.30. Order PB 134615 from Library of Congress, Washington 25, D. C.*

REPORT BRIEFS

Phase Plane Analysis in Missile Control System

The application of phase plane analysis to a missile jet relay control system is reviewed, explained, and illustrated. Only a single lead network is considered under conditions in which aerodynamic damping is negligible. The assumption that all forces occur as step inputs is used to simplify analysis techniques and does not constitute a significant limitation on the application of this method for design purposes. An analytic method for the solution of phase plane plots is developed which reduces the time necessary to evaluate a system design by minimizing the necessity for construction of phase plane diagrams. A summary of general principles which may be used to optimize a jet relay control system is presented. *Project Vanguard Report No. 34: Application of the Simplified Phase Plane to the Analysis and Design of Missile Jet-Relay Control Systems, J. L. Hieatt, U. S. Naval Research Laboratory, Sept. 1958, 34 pp, $1.00. Order PB 151-059 from OTS, U. S. Department of Commerce, Washington 25, D. C.*

Heterodyne Generation of UHF Local Oscillator Signals

Investigation of the possibility of heterodyning a BFO with a fixed frequency oscillator to obtain a beat frequency signal in the 400- to 1000-mc range (for use as a local oscillator in a superheterodyne receiver). Intermediate frequencies of 30 mc and 350 mc are considered. The results have shown that spurious responses from the mixer operation make this method impracticable for receivers of sensitivity greater than about minus 75 dbm. *Heterodyne Generation of UHF Local Oscillator Signals, Hugh Gottfried, Sylvania Electric Prod Inc., Electronic Defense Lab., Mountain View, Calif. May 1956, 17pp. Order PB 134833, from Library of Congress, Washington 25, D.C., microfilm $2.40, photocopy $3.30.*

Pulsed Traveling Wave Tubes

Two cases are considered in this study. The first is the case where rf is pulsed and the electron beam kept on for a period considerably longer than the length of the pulse. The second is the case where the beam is pulsed and the input rf signal applied for a considerably longer time than the pulse width required. *Pulsed Traveling Wave Tubes, Gordon S. Kino, Levinthal Electronic Products, Inc., Palo Alto, Calif., Oct. 1955, 17 pp, microfilm $2.40, photocopy $3.30. Order PB 135259 from Library of Congress, Washington 25, D.C.*

"L" and "T" Type Dissipative Network Design

An arbitrary load is perfectly matched over a prescribed broad frequency-band to a constant-resistance generator by means of a linear, passive, reciprocal, dissipative two-terminal pair network which is composed of an ideal transformer in tandem with an L-, π-, or T-pad of lumped elements. The problem of designing the matching network to dissipate a minimum of power is considered and solved in a number of cases. An analytic method of determining the limitation on the optimum matching is presented in the case of an L-type matching network employed so that a designer is able to predict the best possible performance for any given load. *Design of "L" and "T" Type Dissipative Networks for Broadband Matching of an Arbitrary Load, Marian Tsai Wang, Microwave Research Institute, Polytechnic Institute of Brooklyn, N.Y., Thesis, Aug. 1957, 87 pp, microfilm $4.80, photocopy $13.80. Order PB 135095 from Library of Congress, Washington 25, D.C.*

Last Days of Sputnik II

The track of Russia's Sputnik II, or Earth Satellite 1957 Beta, between April 1, 1958 and April 14, 1958, the day of its disintegration, is traced in an Air Force report which analyzes the Soviet artificial earth satellite's final two weeks of orbit. This preliminary study is based on all positional observations available to Project Space Track prior to May 22, 1958. The purpose of this Air Force activity is to track artificial earth satellites and space vehicles. Observations were collected from observers and stations in all parts of the world. They include such data as positions of the satellite on the celestial sphere and velocity in the line of sight, obtained with direction-finding antennas and Doppler-effect measuring radio receivers used while the satellite transmitters were active; visual observations made with and without optical equipment; and radar and photographic reports. In addition to these observations, which are presented in catalog form, the study includes descriptive reports dealing with the decay-phenomena as observed during the last phase of the re-entry from ships and islands in the Caribbean. Added in an appendix is a short summary on the decay of Sputnik I (Satellite 197 Alpha) produced in December 1957, shortly after the satellite's end. *Project Space Tracks The Orbital Motion of the Earth Satellite 1957 From 1 April 1958 to its Decay 14 April 1958, G. R. Miczaika, E. W. Wahl, Air Research and Development Command, U. S. Air Force, June, 1958, 47 pp, $125. PB 151249 from OTS, U. S. Department of Commerce, Washington 25, D.C.*

RUSSIAN TRANSLATIONS

Nonlinear and Parametric Phenomena In Radio Engineering

Part 15

A. A. Kharkevich
(Translated by J. George Adashko)

Chapter 2

Generation of Oscillations

22. Delay Nonlinearity

In Section 20 we investigated the steady state of an oscillator in which the growth of the self-oscillation amplitude was limited by the nonlinearity of the triode characteristic $I_a = f(U'_g)$. This characteristic expresses the relation between the instantaneous value of the anode current and grid voltage. Therefore, even if the voltage applied to the grid is purely sinusoidal, the ac component of the anode current is nonsinusoidal in principle.

The voltage on the tank circuit (and consequently on the grid) is practically sinusoidal only because of the filtering action of the tank circuit itself. The change to the quasi-linear form of equation consists of formulating an equation for the first harmonics of the current and voltage and introducing an average slope (transconductance) defined as the ratio of the amplitudes of the first harmonics of the current and voltage.

A nonlinearity is an essential feature of a self-oscillating system. It is possible, however, to design an oscillator on a different basis, by intro-

ducing into the self-oscillating system a nonlinear parameter whose value depends, not on the instantaneous values of the current or voltage, but on the effective (or maximum) values. A nonlinearity of this type is called a delay nonlinearity.

An example of a device with a delay nonlinearity is a thermistor. The resistance of a thermistor depends on its temperature, and the temperature is determined by the balance of power, namely the power liberated in the thermistor in the form of Joule heat and the power dissipated by the thermistor to its ambient by convection and radiation.

The time rate of the heat exchange between the thermistor and the ambient is characterized by a time constant which increases directly with the heat capacity of the thermistor and inversely with the heat conduction to the surrounding medium. The time constant is on the order of several or even several dozens of seconds, i.e., it is much longer than the period of high-frequency oscillation.

Therefore, if the thermistor is heated with a high-frequency current the thermistor temperature cannot follow, within a single period, the time variations of the instantaneous power, but remains constant to a high degree of accuracy. We can therefore assume that the resistance of the thermistor is a function of the effective amplitude (and not of the instantaneous value) of the current or the voltage.

It is quite important that this is attainable to any degree of accuracy (since it is quite easy in practice to make the time constant rather large). This signifies that the resultant self oscillations are sinusoidal to an accuracy that is as high as desired. This is a substantial feature of systems with delay nonlinearities.

Let us now consider an oscillator which differs from the one previously discussed in that the triode is assumed to be ideally linear, i.e., its characteristic is assumed to be linear with a constant transconductance S_m. The nonlinearity required to limit the amplitude is introduced into the system by including in the tank circuit an active resistance in the form of a thermistor with a time-dependent (and hence amplitude-dependent) resistance R_T.

Thermistors can be of either metal or of semiconducting material. The resistance of the former increases with temperature and that of the latter diminishes with temperature. The former can be connected in series with a tank circuit while the latter must be connected in parallel. We shall assume in either case that the resistance R_T represents the equivalent series resistance of the tank circuit.

We can thus use the complex form of the quasi-

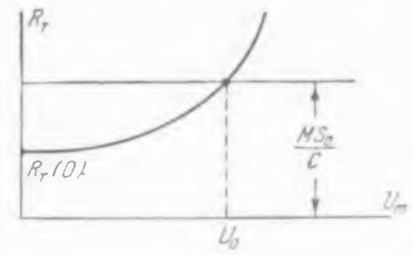


Fig. 74. The steady state amplitude of oscillations in a tank circuit using a thermistor can be determined with a graph like this one. R_T represents the equivalent series resistance of the tank and $R_T(O)$ is the thermistor resistance in the absence of oscillations.

linear equation of Sec. 20, rewriting it as

$$\omega_0^2 - \omega_0 + j\omega \frac{1}{L}\left(R_T - \frac{MS_0}{C}\right) = 0$$

The frequency of an oscillator containing a thermistor described by this relation is always ω_0 for all amplitudes. It consequently does not change while the oscillations are being established. The self-excitation condition is written as

$$R_T(0) < \frac{MS_0}{C}$$

where $R_T(0)$ is the thermistor resistance in the absence of oscillations. This resistance depends only on the ambient temperature. The steady-steady amplitude is found from the equation

$$R_T(U_m) = \frac{MS_0}{C}$$

The thermistor characteristic $R_T(U_m)$ must naturally be known. The equation can be solved graphically as shown in Fig. 74. The fact that it is possible to obtain steady-state sinusoidal self-oscillations with the aid of a delay nonlinearity is of great importance.

First, in many cases it is essential to have a good waveform, free of harmonics. Second, the presence of harmonics causes frequency shifts. The smaller the Q factor of the tank circuit, the more noticeable this effect. The use of delay nonlinearity makes it possible to obtain sinusoidal oscillations ever in the case of a low-Q tank circuit. The latter is particularly important in RC oscillators (see Sec. 27), in which combinations of capacitances and resistances only are made equivalent to aperiodic tank circuits.

23. The Phase Plane

In the usual graphic representation of oscillatory

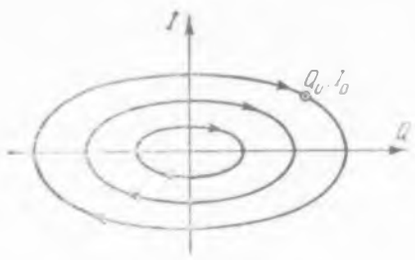


Fig. 75. A phase portrait for a linear lossless tank circuit.

phenomena in any system, all the time varying quantities (such as currents and voltages) are expressed by suitable time functions. Plots of these functions are called oscillograms.

It is possible, however, to proceed in a different manner, namely to choose as the rectangular coordinates the instantaneous values of the variable quantities which jointly define the state of the system. We thus define a certain space, in which each point represents the state of the system at a given instant of time. This space is called the phase space.

The number of dimensions of the phase space depends on the number of differential equations of the system. We know that to solve an n'th order equation it is necessary to specify, as initial conditions, the values of the function and of its derivatives up to order $n-1$, i.e., a total of n independent quantities.

We shall deal essentially with second-order equations. In this case, the number of dimensions of the phase space is two, i.e. the phase space becomes in this case a phase plane. Oscillating phenomena in a system described by a second-order equation can be represented by diagrams in the phase plane.

Let us examine by way of an example the free oscillations in a linear lossless tank circuit. The differential equation for this case is

$$L\frac{dI}{dt} + \frac{1}{C}\int I\,dt = 0 \qquad (1)$$

or

$$\frac{d^2Q}{dt^2} + \omega_0^2\,Q = 0 \qquad (2)$$

The solution of this equation is

$$Q = M \sin \omega_0 t + N \cos \omega_0 t \qquad (3)$$

where M and N are arbitrary constants determined from the initial conditions. For the current we have

$$I = \frac{dQ}{dt} = M\omega_0 \cos \omega_0 t - N\omega_0 \sin \omega_0 t \qquad (4)$$

Let us take the current and the charge to be the coordinates of the phase plane, and let us express one quantity directly in terms of the

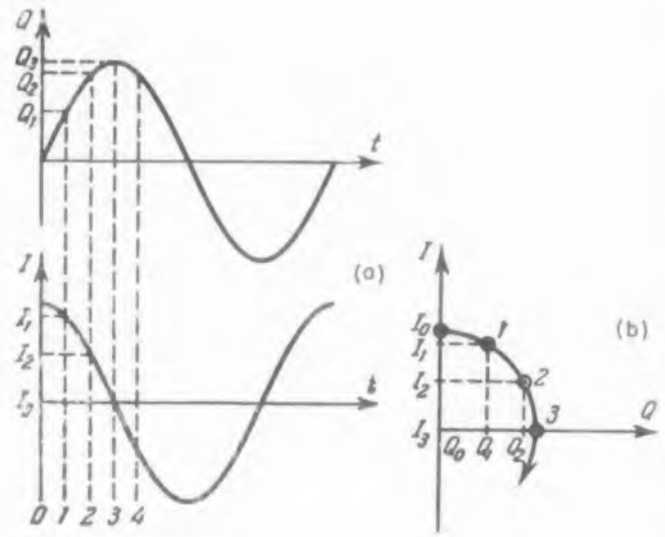


Fig. 76. Charge and current oscillograms (a) of a linear, lossless tank circuit, and how the phase trajectory is derived from them (b).

other, i.e., let us eliminate the parameter t. For this purpose we divide eq (4) by ω_0, square it, and add it to the square of (3). This yields the equation

$$\frac{1}{\omega_0^2} I^2 + Q^2 = M^2 + N^2$$

which is the equation of a family of ellipses (Fig. 75).

Note that by changing the scale, for example, by plotting $\omega_0 Q$ instead of Q along the abscissa we can obtain a family of circles. Each point on one of the ellipses represents the state of the system at a given instant of time (since the coordinates of the point are instantaneous values of the current and voltage). This is why the point on the diagram is called the representative point.

This point moves with time, describing a line called the phase trajectory. If a periodic process is plotted in the phase plane, the phase trajectory will be the closed contour covered by the representative point during one period.

A family of phase trajectories representing the oscillations possible in a given system, is called the "phase portrait" of a given system. Thus, Fig. 75 is the phase portrait of a linear lossless tank circuit.

The coordinates used in Fig. 75 are Q, and $I = dQ/dt$. With such a choice of coordinates the representative point moves clockwise, as noted in Fig. 75.

The phase portrait of Fig. 75 was obtained analytically. Let us show how to plot the phase portrait from oscillograms.

Fig. 76a shows the charge and current oscillo-

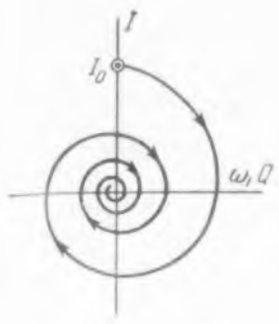


Fig. 77. The phase portrait of a lossy tank circuit with damped oscillations

grams. If we read the instantaneous values of Q and I (i.e., the ordinates of the corresponding curves) at the specific instants marked on the diagram and use these ordinates as coordinates of the representative point on Fig. 76b, we can plot the phase trajectory.

$$\omega_1 = \sqrt{\omega_0^2 - \alpha^2}$$

where $\omega_1 = \sqrt{\omega_0^2 - \alpha^2}$ is the natural frequency.

Let us determine the current

$$I = \frac{I_0}{\omega_1} \epsilon^{-\alpha t} (-\alpha \sin \omega_1 t + \omega_1 \cos \omega_1 t)$$

If the damping factor α is small, it is possible to neglect the first term in the parenthesis and assume

$$I \cong I_0 \epsilon^{-\alpha t} \cos \omega_1 t \qquad (7)$$

To eliminate the time t from (6) and (7), we write the relation between the current and the charge in polar coordinates. We put

$$I = I_0 \epsilon^{-\alpha t} \cos \omega_1 t = \rho \cos \theta$$

$$\omega_1 Q = I_0 \epsilon^{-\alpha t} \sin \omega_1 t = \rho \sin \theta$$

Hence we put

$$\rho = I_0 \epsilon^{-\alpha t} \qquad \theta = \omega_1 t$$

hence

$$\rho = I_0 \epsilon^{-\frac{\alpha}{\omega_1}\theta}$$

This indeed is the polar equation of a phase trajectory that represents a converging logarithmic spiral (Fig. 77). For other initial conditions we obtain other spirals. All these will fit one inside the other and will converge at the point $I = Q = 0$. Each spiral represents a damped oscillation. A family of spirals with different initial conditions forms the phase portrait of a lossy tank circuit. The construction confirms that the representative point moves clockwise.

We shall now explain the role of the initial conditions. As is known, the initial conditions for a second-order equation of type (2) are the values of the function Q and of its first derivative dQ/dt at the instant assumed to be the start of the time reference (in particular, at $t = 0$).

Consequently, a specification of the initial con-

RUSSIAN TRANSLATIONS

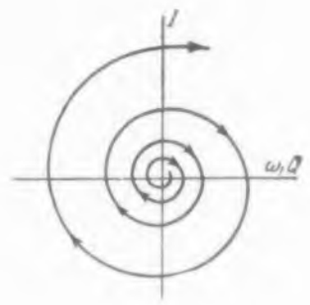


Fig. 78. The phase portrait of a tank circuit with negative damping.

ditions determines the initial coordinates of the representative point. Fig. 75 shows the free oscillations in the form of an ellipse passing through the point whose coordinates Q_0 and I_0 represent the initial conditions.

Let us turn now to a lossy tank circuit. The equation of such a tank circuit is of the form

$$\frac{d^2Q}{dt^2} + 2\alpha \frac{dQ}{dt} + \omega_0^2 Q = 0 \qquad (5)$$

A solution of this equation for the initial conditions

$$Q(0) = 0, \quad I(0) = I_0$$

is of the following form

$$Q = \frac{I_0}{\omega_1} e^{-\alpha t} \sin \omega_1 t \qquad (6)$$

To conclude this section, let us consider still another tank circuit in which the damping becomes negative as the consequence of feedback. Such a system is described by an equation that differs from (5) only in the sign of the term for the first derivative of the charge with respect to time. A solution of the equation is given by (6) and (7), and the equation of the first trajectory is given by (8); it is merely necessary to reverse the signs in all three formulas.

This means that we have oscillations with exponentially rising amplitudes, and the phase trajectory is an evolving unwinding spiral (Fig. 78). Were the system really linear, the amplitude would increase without limit. This would correspond to an unbounded increase in the radius of the spiral.

24. Phase Portraits of Oscillators

In the preceding section we used examples of linear systems. Yet we are interested in the phenomena occurring in oscillators which are known to be nonlinear systems, since no steady state self-oscillations are possible in a linear system.

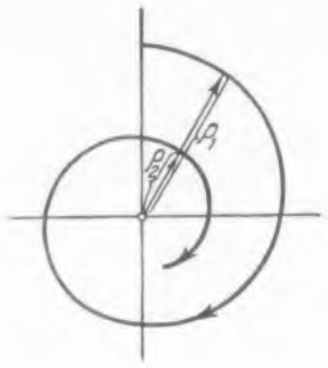


Fig. 79. The phase portrait of an oscillator showing only two values of φ corresponding to a θ change of 2π.

Our next task is to plot the phase portraits of oscillators. We start with an oscillator with soft excitation, this being the simpler case. The phase portrait should give a complete picture of the possible operating modes of the oscillator, both steady state and transient under all initial conditions.

We shall not derive the equations of the phase trajectories. We shall confine ourselves merely to a qualitative discussion. For this purpose we explain first how attenuation can be represented on the phase plots.

For a simple tank circuit we have the following equation of a spiral

$$\rho = I_0 \, e^{-\frac{\alpha}{\omega_1}\theta}$$

Let us take two values of the radius ρ corresponding to a change of 2π in the value of θ i.e., radii of two neighboring turns of the spiral (Fig. 79)

$$\rho_1 = I_0 e^{-\frac{\alpha}{\omega_1}\theta}, \quad \rho_2 = I_0 \, e^{-\frac{\alpha}{\omega_1}(\theta + 2\pi)}$$

and let us determine the ratio of these radii

$$\frac{\rho_1}{\rho_2} = e^{\frac{\alpha}{\omega_1} 2\pi} = e^{\alpha T} \cong e^{\alpha d}$$

where d is the attenuation of the tank circuit.

Thus the radius of the spiral changes from turn to turn as a geometric progression, whose denominator depends on the attenuation. The same applies also to an evolving spiral. (This is the property of a logarithmic spiral. In the case of an Archimedean spiral, the radius varies as an arithmetic progression.)

Let us now consider the phenomena in a soft generator. In the initial self-excitation stage, when the oscillations are still small, the phenomena can be described with satisfactory accuracy by the linear equation (2) of Sec. 17. If the self-excitation condition is satisfied, the attenuation factor is negative and the self excitation process

RUSSIAN TRANSLATIONS

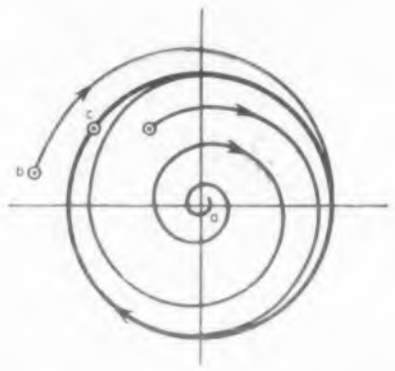


Fig. 80. The phase portrait of an oscillator with self excitation. The closed contour represents the steady state (the limit cycle). The points *(a)*, *(b)*, and *(c)* represent three ways of starting oscillations.

is represented by an evolving spiral as in Fig. 78.

As the amplitude increases however, the nonlinearity comes into play. Its influence manifests itself in that the absolute value of the attenuation becomes smaller. The radius of the spiral increases at a slower rate. Finally an energy balance is reached.

In this case the attenuation becomes equal to zero, and the amplitude no longer increases. The representative point now describes a closed contour in the form of an ellipse (or a circle, if the scale is properly chosen). This is exactly the steady state of the oscillator.

If the initial conditions specified for the oscillator are represented by a certain point outside the contour corresponding to the steady state mode, the damping will be positive, and the representative point will move along a winding spiral, whose radius diminishes slower and slower until the trajectory begins winding on the same contour of the steady-state mode.

All this is shown in Fig. 80, which represents the phase portrait of an oscillator with self excitation. The closed contour that represents the steady-state periodic oscillations (heavy line of Fig. 80) is called in oscillation theory the limit cycle.

The phase portrait of Fig. 80 is characterized by the fact that any phase trajectory, no matter where it begins, winds up in the final analysis on the limit cycle. This means that any disturbance to the steady-state mode is automatically equalized after the cause of the disturbance is removed. Under such conditions the limit cycle is called stable. It can be readily seen now that the three methods of establishment of oscillations, shown in Fig. 73, correspond in Fig. 80 to the following initial points on the phase trajectory, *a)* at the origin, *b)* outside the limit cycle, and *c)* on the limit cycle.

Let us now turn to a hard oscillator. This case

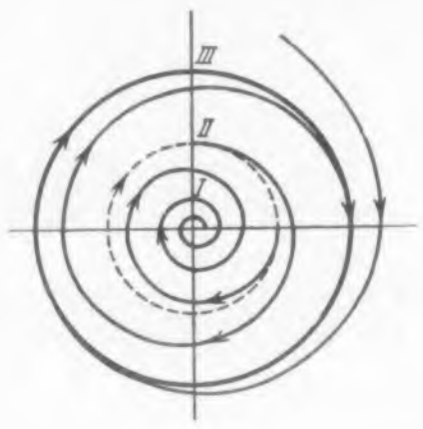


Fig. 81. The phase portrait of a hard oscillator showing the regions—inside the unstable cycle *(I)*, between the stable and unstable cycles *(II)*, and outside the stable cycles *(III)*.

differs from the one just considered only in that the attenuation is positive with small amplitudes and the phase trajectories wind towards the origin. There exists an amplitude for which the attenuation vanishes the first time. This value of the amplitude corresponds to its own limit cycle.

However this cycle is unstable. The phase trajectories do not wind towards it, they evolve away from the limit cycle, either inside towards the origin or to the region outside the unstable limit cycle. In this region the attenuation is negative and the amplitude increases until the attenuation again vanishes. There, a second limit cycle is produced, which now is stable.

The difference between the stable limit cycle and the unstable one, from the point of view of the phase plots, is that the phase trajectories move towards the stable cycle and move away from the unstable one. This is illustrated by the phase portrait of a hard generator shown in Fig. 81.

The phase plane can be broken up into three regions; *I*—inside the unstable cycle, *II*—between the stable and unstable cycles, and *III*—outside the stable cycles. No self-excited oscillations will be launched if the initial conditions are represented by a point in region *I*. They will be launched, however, if the initial point lies in region *II* or *III*.

The difference between the last two cases is that in the former case the amplitude will build up to a steady-state value, and in the second it will diminish to this value. The difference between a soft and hard oscillator, represented by Figs. 80 and 81, was explained previously by Figs. 70 and 71 and by Figs. 56 and 57. It is useful to compare all three pairs of diagrams, for they are different representations of the same relations.

(To be continued)

E. Brenner

Bandwidth Reduction for Transmission of Radar Signals

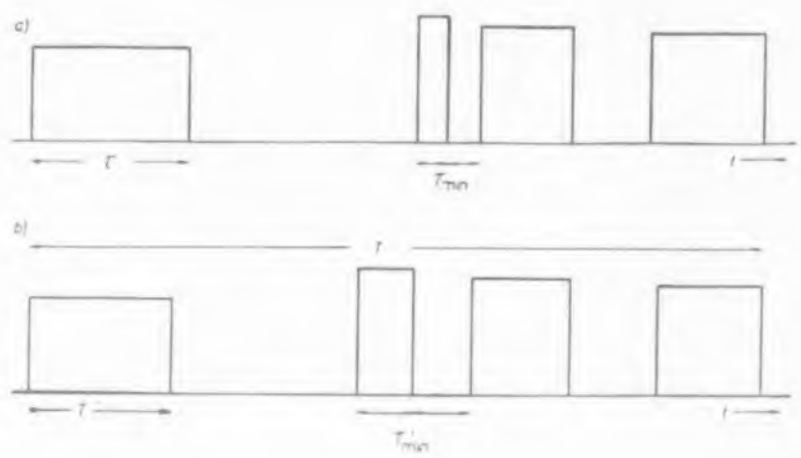


Fig. 1. (a) Pulse train of a radar signal (b) Effect of frequency compression in (a)

USING storage techniques, it has already been shown that the bandwidth for the transmission of signals from panorama radars can be reduced by a factor of about 100 to 200 kc for harbor control and to 50 kc for air communication safety. These techniques are based on the recognition of the information content of the radar signal (See *ED*, German Abstracts, Sept. 1, 1957). It is possible to compress the information into an even narrower band, the eventual goal being 4 kc, the band of ordinary telephone channels.

The information of the radar signals is contained in the duration and spacing of pulses

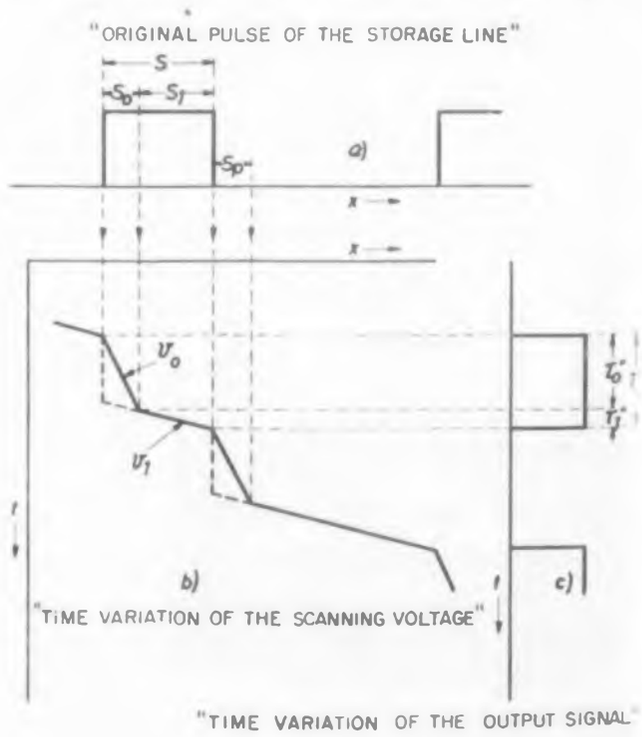


Fig. 2. Scheme for pulse stretching using a storage tube and a scanning beam with variable-slope deflection voltage.

own in Fig. 1a. The lowest frequency component of the signal, f_{min}, is the reciprocal of the tational speed of the antenna. The largest frequency, f_{max}, is determined either through the ration of the shortest pulse or the shortest "no lse" interval, whichever is the shorter time. noting this interval by τ_{min}, the maximum freency, $f_{max} = 1/(2\,\tau_{min})$.

The compression of the bandwidth beyond at has already been described above, depends stretching the shortest pulse (or "silent") inval to τ_{min} as shown in Fig. 1b. Choosing the ear relationship

$$\tau^* = a\,\tau + b \tag{1}$$

e original signal can be reconstructed at the ceiving end by using the inverse transformaon

$$\tau = \tau^* \cdot a - b/a \tag{2}$$

Denoting by T the transmission time of a line the picture and defining the compression ratio results in

$$p = T/\tau_{min} \tag{3}$$

$$k = \tau^*_{min}/\tau_{min} \tag{4}$$

nd

$$n = \frac{1 - mk/p}{1 - m/p} \tag{5}$$

$$b = \tau_{min} \times \frac{k - 1}{1 - m/p} \tag{6}$$

here m is the number of picture elements per ne. Evidently $k_{max} = p/m$, corresponding to $= 0$ and $b = T/m$, represents the limiting value f the compression ratio since in that case all ulses are equal in length, all information is lost nd checkerboard pattern is obtained.

The linear transformation from τ to τ° can be ccomplished by using a scanning beam whose orizontal deflection is controlled by two speeds s shown in Fig. 2. During the writing interval here exists on the storage line a charge distribuion which in the x-coordinate corresponds to the riginal, uncompressed signal. A pulse of length is transformed into a pulse of duration τ°, by ontrolling the speed of the scanning beam as ndicated in Fig. 2b. The lengths s_o is chosen to orrespond to the shortest original time interval τ_{min}.

The maximum frequency compression which ppears to be practical is below 10, the value 8 b ng typical.

The original paper also includes detailed deription of the apparatus used for the signal ompression.

Abstracted from an article by H. Meinke and A. Rihaczek, Nachrichtentechnische Zeitschrift, *Vol. 11, No. 8, August 1958, pp 398-404.*

GERMAN ABSTRACTS

E. Brenner

Transmission of Speech

WHEN a message is transmitted by means of pulse-amplitude modulation (PAM), a train of pulses with pulse spacing $2T$ is used to represent the signal if the highest significant frequency component in the message is $1/2T$. The message is reconstructed without distortion when the PAM signal is passed through a distortionless low pass filter with cut-off frequency $1/2T$. Since transmission using pulse code modulation (*PCM*) is particularly insensitive to noise in the communication channel, information from the PAM is encoded into binary signals. For this purpose it is necessary to subdivide the amplitudes into discrete levels and transmit the PCM signal through a channel whose cut-off frequency is at least $(\log_2 m)/2T$ if m levels are used. The use of discrete steps results in signal distortion which is generally described by a distortion factor k, where

$$k = \frac{1}{(m^2 - 1)^{1/2}} \qquad (1)$$

if it is assumed that all amplitudes in the original message are equally probable.

While a small value of m, when used in Eq. 1, results in a large value of k, the ease with which speech can be understood is not related to this "distortion factor" in a simple manner.

In order to investigate this feature of PCM, a device with the step-type transfer characteristics shown in Fig. 1 can be constructed. Even if only one step is used, words and sentences can be understood with surprising consistency. While this has been explained by noting that the information contained in the zero crossings of the speech signal (frequency modulation) is preserved with the one-step transfer characteristics, it is also true that the harmonic amplitudes in the output due to the signal are larger than the distortion components generated by the limiting.

If more than one step is used, it is found that optimum values of step intervals ($x_1, x_2, \ldots, y_1, y_2, \ldots$) correspond to each situation. These values become less critical as the number of steps is increased. In general, an even number of steps gives better results than does an odd number. When the

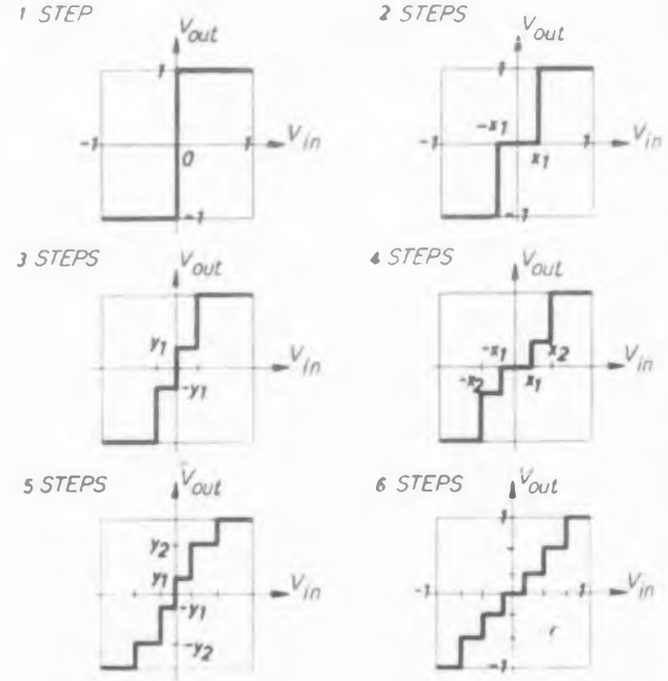


Fig. 1. Step-type transfer characteristics used to investigate the effect of levels of PAM signals which represent a spoken message.

step transfer curve has only four steps (see Fig. 1) even meaningless syllables are understood with 65 per cent success, although Eq. 1 indicates a distortion factor of 26 per cent.

Abstracted from an article by K. Kuepfmueller and W. Andrich, Nachrichtentechnische Zeitschrift, *Vol. 11, No. 8, August 1958, pp 389-392.*

Automatic Speech Recognition

A SURVEY of the published literature which deals with the automatic recognition of spoken speech reveals four motivations for investigation of the problem. The first of these is the narrower frequency band which can be used in transmission; thus the Vocoder (H. Dudley, *Jour. Acoust. Soc. Amer.*, 11, 1939, p 169) makes possible the transmission of speech within a 50 cps band and 40 db signal/noise ratio while ordinary telephone transmission requires a 3100 cps band with 48 db signal/noise ratio. Sound-code telegraphy requires only a 15 cps band and 10 db signal/noise ratio with correspondingly greater loss in "personalized" secondary information concerning the speaker.

Second application for automatic speech recognition devices lies in the area of input devices for automatic computers. While a digit recognition apparatus has been constructed at RCA, it cannot as yet be termed fully successful because it must be readjusted to recognize the speech "peculiarities" of individual speakers. The problem of the automatic typewriter forms the third class of potential applications and the transcribing of speech for the deaf is the fourth class.

Three approaches to the problems can be distinguished. The first of these is the analysis of the frequency spectrum of spoken language. While a great deal of progress on vowels has been made, the spectrum of a consonant is determined to a great extent by the vowels which bracket it. A second approach deals with the search for the information bearing elements of speech. A third line of investigation is concerned with the physiological process of speech and the corresponding coding.

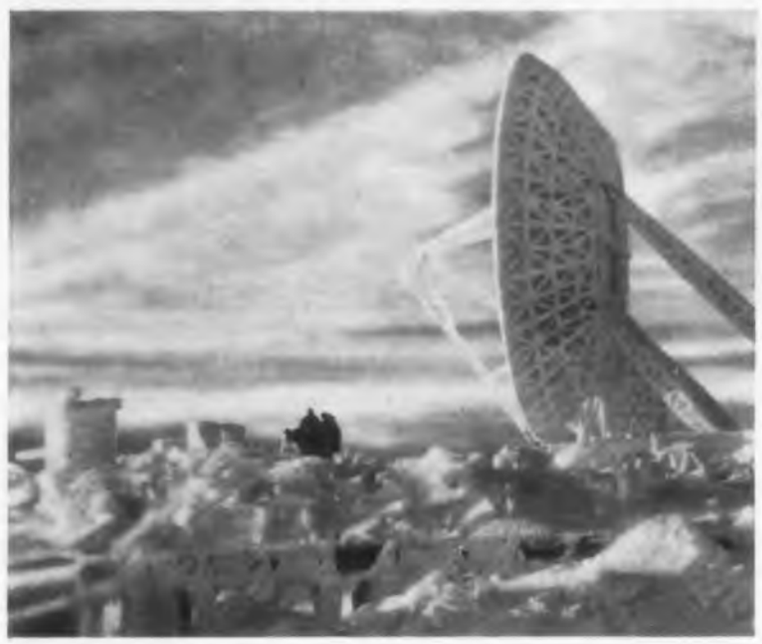
The original paper includes a brief summary of the 43 references which are cited

Abstracted from an article by K. Steinbuch, Nachrichtentechniache Zeitschrift, Vol. 11, No. 9, September 1958, pp 446-454.

WESTERN ELECTRIC PHOTO

WHITE ALICE

DEW LINE



POLE VAULT

OFFICIAL U.S. AIR FORCE PHOTO

TEXAS TOWERS

MEETINGS

Calendar of Events

March

31-2 9th Symposium on Millimeter Waves, New York, N.Y.*

April

1-29 World Meteorological Organization, 3rd Session of Congress, Geneva, Switzerland

2-3 Electrically Exploded Wires Conference, Boston, Mass.

2-4 Association for Computing Machinery, Cleveland, Ohio

5-10 5th Nuclear Congress, Engineers Joint Council, Cleveland, Ohio*

6-8 3rd Annual Astronautics Symposium (AFOSR), Washington, D.C.

6-9 16th Annual British Radio and Electronic Component Show, London, England

8-10 AIEE Southern District Meeting, Atlanta, Ga.

9-11 Southeastern Section, American Physical Society, New Orleans, La.

12-19 1st World Congress of Flight, Las Vegas, Nev.

13-15 Hydraulics Conference (ASME), Ann Arbor, Mich.

13-17 29th Annual National Packaging Conference (AMA), Chicago, Ill.

14-15 Electrical Heating Conference (AIEE), Philadelphia, Pa.

14-15 Conference on Industrial Instrumentation and Control, Chicago, Ill.

16-18 Southwestern IRE Regional Conference and Electronics Show, Dallas, Tex.

16-30 Engineering, Marine, Welding, and Nuclear Energy Exhibition, London, England

17 Current Developments in the Production of High Vacuum Symposium, London, England

18-22 27th Annual Meeting ASTE, Milwaukee, Wisc.

20-21 Techniques in Electronic Instrumentation (IRE), Philadelphia, Pa.

20-22 1st Annual Southeastern Regional ISA Conference & Exhibit, Gatlinburg, Tenn.

21-22 Technical Conference on Electronic Data Processing (IRE), Cincinnati, Ohio*

22-24 AIEE East-Central District Meeting, Akron, Ohio*

28-30 13th Annual Power Sources Conference, Atlantic City, N.J.

29-1 AIEE Empire District Meeting, Syracuse, N.Y.

May

3-7 Symposium on Electrode Processes, Philadelphia, Pa.

4-6 11th National Aeronautical Electronics Conference (IRE), Dayton, Ohio

5-7 URSI Spring Meeting (PGI, PGIT, PGGT), Washington, D. C.

5-7 7th National Conference on Electro-Magnetic Relay, Stillwater, Okla.

6-8 1959 Electronics Components Conference (IRE, AIEE, EIA, WCEMA), Philadelphia, Pa.

6-8 7th Regional Technical Conference and Trade Show (IRE), Albuquerque, N. Mex.

11-12 Symposium on Industrial Uses of Radioisotopes, Atlanta, Ga.

11-13 National Power Instrumentation Symposium, Kansas City, Kan.

11-13 National Symposium (PGMT, IRE), Boston, Mass.

11-13 2nd Annual Joint Conference on Automatic Techniques, Chicago, Ill.

18-20 5th Annual National Symposium on Instrumental Methods of Analysis, Houston, Tex.

18-20 Electronics Parts Distributors Show, Chicago, Ill.

19-21 AIEE Middle Eastern District Meeting, Baltimore, Md.

25-27 National Telemetry Conference (IAS, ISA, AIEE, ARS), Denver, Colo.

25-29 International Convention on Transistors and Associated Semi-Conductor Devices, London, England

June

1-3 National Symposium on Microwave Theory and Techniques (IRE), Cambridge, Mass.

3-5 Armed Forces Communications and Electronics Assoc., Annual Meeting, Washington, D.C.

4-5 3rd National Conference on Production Techniques (IRE), San Mateo, Calif.

8-11 Semi-annual Meeting, American Rocket Society, San Diego, Calif.

10-12 2nd International Symposium on Gas Chromatography (ISA), East Lansing, Michigan

15-18 Summer Meeting, Institute of Aeronautical Sciences, Los Angeles, Calif.

15-20 1st International Conference on Information Processing, Paris, France

16-18 International Symposium on Circuit and Information Theory (IRE), Los Angeles, Calif.

17-27 International Plastics Exhibition, London, England

21-26 Summer and Pacific General Meeting AIEE, Seattle, Wash.

24-26 2nd Nuclear Instrumentation Symposium, Idaho Falls, Idaho

29-1 National Convention on Military Electronics (IRE), Washington, D.C.

*Items described herewith.

9th Symposium on Millimeter Waves, March 31-April 2*

Engineering Societies Bldg., New York, N.Y. Sponsored by IRE with the support of the AFOSR, Office of Naval Research, and the U. S. Army Signal Research & Development Laboratory the event will be held without a charge for admission or registration. As in the past, recognized authorities will summarize the present state of the art and recent outstanding advances will be presented by research workers from university, industrial, and government laboratories throughout the world. Further information may be obtained from: *The Microwave Research Institute, Polytechnic Institute of Brooklyn, 55 Johnson Street, Brooklyn 1, N.Y.*

MEETINGS

5th Nuclear Congress, April 5-10

Public Auditorium in Cleveland, Ohio. Theme: For Mankind's Progress. Sponsored by more than thirty leading engineering, scientific and management groups, forty sessions are to be held. Features of the meeting will be engineering papers dealing with advances in reactor technology and the use of radioactive materials, a trade show, the ATOMFAIR, talks devoted to problems of industrial management in the nuclear field and papers devoted to laboratory problems in radioactive materials. For information: *Engineers Joint Council, 29 West 39th St., New York 18, N.Y.*

Technical Conference on Electronic Data processing, April 21-22

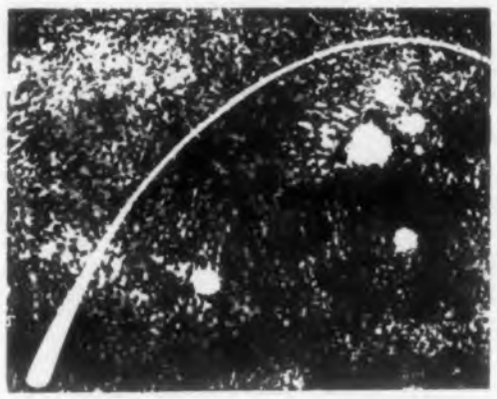
Enginering Society Bldg., Cincinnati, Ohio. Conference Theme: Electronic Data Processing. Papers to be presented on applications of data processing to such fields as communications, radar, computers, missile technology, chemical engineering, machine tools, and nucleonics.

AIEE East-Central District Meeting, April 22-24

Sheraton Hotel, Akron, Ohio. To be held in conjunction with the 11th Annual AIEE Rubber and Plastics Technical Conference, there will be a program of more than 50 technical papers and discussions. A special symposium on "Heating for Plastics Extrusion" has been scheduled together with such topics as: industrial heating and lighting; automation; computers; communications; high voltage cables and transmission; electric drive equipment; relaying and distribution; static components; nylon tire cord processing; rubber processing; standards for the rubber and plastics industry; its atmospheric contamination problems; and its use of new machines and processes; magnetic amplifiers, transistors, and semi-conductors.

Paper Deadlines

May 1: Deadline for papers to be presented at **WESCON, Aug. 18-21** to be held in San Francisco, Calif. Required are 100-200 word abstracts, together with complete texts or detailed summaries which should be sent to *Dr. Karl R Spangenberg, WESCON, 60 West 41st Ave., San Mateo, Calif.*



Bendix YORK

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GUIDED MISSILE ELECTRONICS

ELECTRONIC ENGINEERS

MECHANICAL ENGINEERS

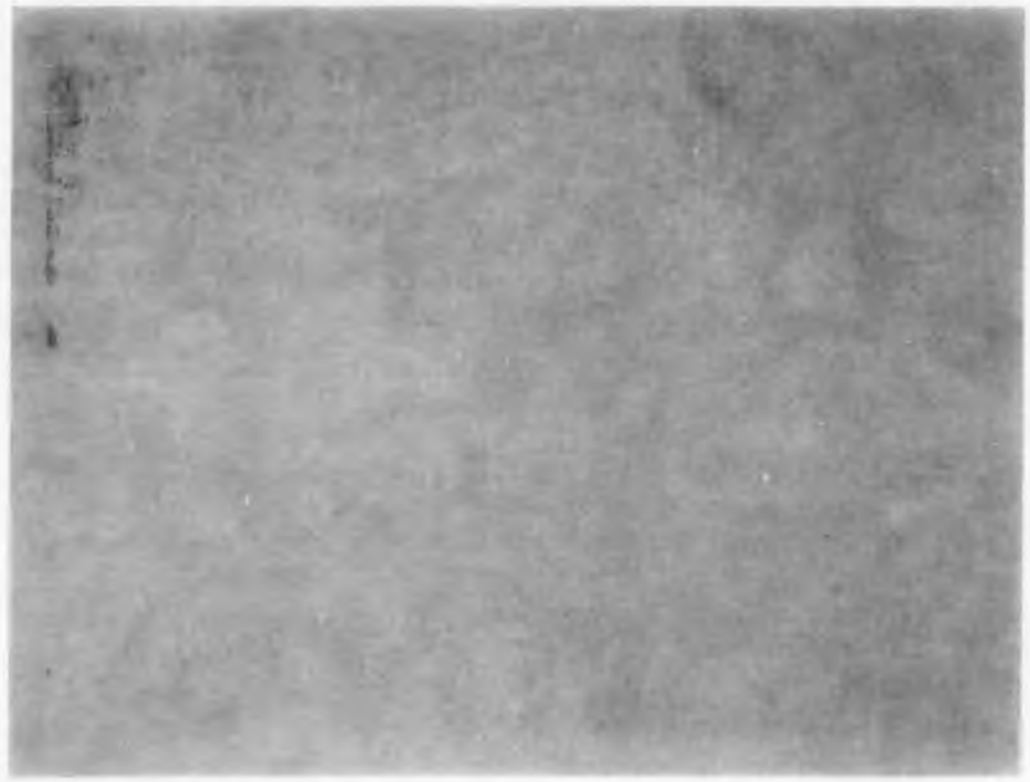
Here is your chance to prove your ability doing *important* work on missile fuzing, beacons, guidance, packaging and related test equipment. We have key openings that offer you the opportunity to move ahead rapidly in your profession. At Bendix York, you benefit from the advantages of a small company atmosphere in a growing division of one of the nation's largest engineering and manufacturing corporations. Also, you'll enjoy the "good life" in our beautiful suburban community. Good salaries, all employee benefits.

Drop us a card, briefly stating your education & experience. We'll act immediately to get together with you and talk it over.

ADDRESS:
PROFESSIONAL PLACEMENT
DEPT. D

Bendix
AVIATION CORPORATION
York Division
York, Penna. York 47-2611

CIRCLE 871 ON READER-SERVICE CARD



It's great to be proud of the place you work

To some engineers, a job is a job is a job. But it doesn't have to be. It *can* be a career to take pride in, the way the engineers and scientists at Autonetics do.

These young men have already made Autonetics a leader in electronics and electromechanics. For example, they designed the inertial navigation systems for the USS Nautilus and Skate and the monopulse radar system for the Air Force's F-105.

These same young men now are working on new developments—an even more advanced inertial navigation system for the first nuclear-powered Polaris-carrying submarines... the guidance and control systems for the Minuteman and GAM-77 missiles... and many more.

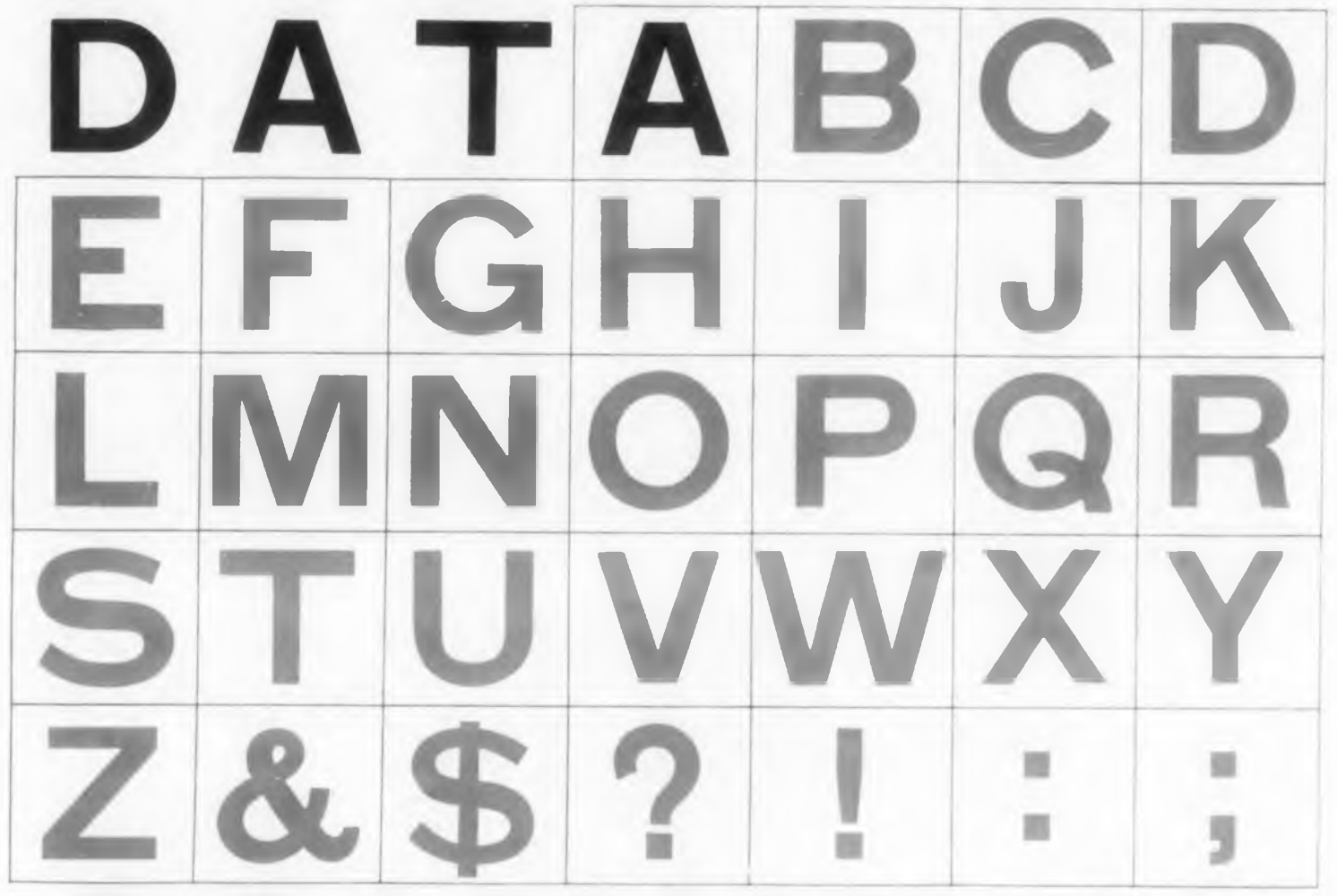
Today at Autonetics there is room for engineers and scientists who want to have a part in these history-making activities. Please send your resume to Mr. V. D. Benning, 9150 East Imperial Highway, Downey, California.

Autonetics
A DIVISION OF NORTH AMERICAN AVIATION, INC.
Downey, California

INERTIAL NAVIGATION / ARMAMENT CONTROL / FLIGHT CONTROL / DATA PROCESSING

Among the achievements of Autonetics' young men: the first successful airborne all-inertial navigation system... first navigation system accurate enough to guide the USS Nautilus and Skate on their historic voyages beneath Arctic ice... first successful automatic star tracking by an inertial navigation system during daylight flight... first completely maneuverable, inertially stabilized gyro platform... first successful completely automatic landing system for supersonic missiles and aircraft... first transistorized portable digital computer with "big computer" capabilities.

You can explore new areas at IBM in



COMMUNICA

Creative people at IBM are hard at work on a problem that has vexed man since the dawn of history—communication with his fellow beings. The rapid transmission of precise data is vital in this fast-moving age. One group of engineers and scientists at IBM is working on multiplexing techniques to channel data. This data has to be made available at maximum speed at desired times and places. Another group is developing computer systems that will control complete warehousing or industrial operations. For the military, IBM is designing a computer that will make available in real time, data concerning troop strength and dispositions. This important work needs imaginative people. If you want to be a part of this world of discovery and development, there are many opportunities at IBM.

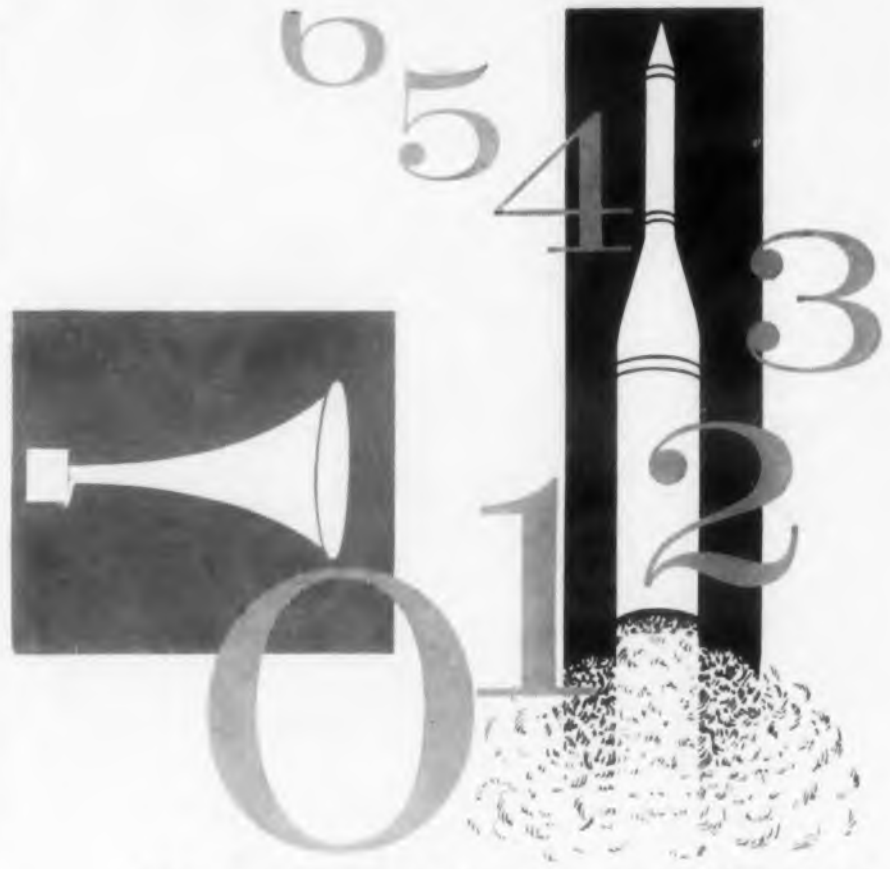
A NEW WORLD OF OPPORTUNITY. Both technical and administrative engineering careers offer parallel advancement opportunities and rewards at IBM. You will enjoy unusual professional freedom, comprehensive education programs, the assistance of specialists of diverse disciplines, and IBM's wealth of systems know-how. Working independently or as a member of a small team, your individual contributions are quickly recognized and rewarded. This is a unique opportunity for a career with a company that has an outstanding growth record.

IBM®

For details, write, outlining background and interests, to:
Mr. R. E. Rodgers, Dept. 555 D I
IBM Corporation
590 Madison Avenue
New York 22, N. Y.

INTERNATIONAL BUSINESS MACHINES CORPORATION

While in New York for the I.R.E. Show, you are cordially invited to visit the IBM booth and the IBM Product Display Center at IBM Headquarters, 590 Madison Avenue at East 57th Street.



At MOTOROLA in PHOENIX . . .
it's YOUR PROJECT all the way through

Ideas are the life-blood of an operation devoted exclusively to diversified electronics research, development and production. So it's logical, we think, for the project engineer to see his idea to completion . . . from design through construction through field testing (and sometimes, alas, back to the drawing board). The effectiveness of this *project approach* is illustrated by our achievements in military and industrial electronics. If you generate sound ideas and would like the opportunity to follow through on them . . . and if you like the idea of living beneath bright, sunny skies the year around . . . write to Mr. Kel Rowan, Department B-4

MOTOROLA

Western Military Electronics Center / 8201 E. McDowell Rd. Phoenix, Arizona

OPPORTUNITIES

Electronic Engineers, Mechanical Engineers, Physicists – SYSTEM ANALYSIS, DESIGN AND TEST – Radar ● Missile Guidance ● Navigation ● Combat Surveillance ● Communications ● Field Engineering ● Data Processing and Display – CIRCUIT DESIGN, DEVELOPMENT AND PACKAGING – Microwave ● Pulse and Video ● Antenna ● Transistor ● R-F and I-F ● Servos ● Digital and Analog
TECHNICAL WRITERS AND ILLUSTRATORS, QUALITY CONTROL ENGINEERS, RELIABILITY ENGINEERS
Motorola also offers opportunities at Riverside, California and Chicago, Illinois

CIRCLE 873 ON READER-SERVICE CARD

GENERAL DESCRIPTIONS OF SOME ASSIGNMENTS:

SYSTEMS ENGINEERS to analyze and design computer systems. Backgrounds required include analog to digital conversion; analyses and preparation of diagnostic programs; development of complex devices in servo-mechanisms or radar for advanced systems.

LOGICAL DESIGNERS with two to four years' experience outlining logical blocks. Previous computer experience desirable. Some experience in transistorized equipment specification helpful. Must have strong interest in the theoretical and practical aspects of checking means and various codes, redundancy, error detection and correction, information flow, and other factors.

SOLID STATE ENGINEERS AND SCIENTISTS to do applied research on precision linear circuitry employing solid state devices using analog to digital conversion techniques and sample data. Experience in feed-back amplifier design desirable. Also opening for engineers with experience in precision, low-level linear circuits employing solid state, to work on analog to digital conversion techniques.

CAREERS AVAILABLE IN THESE AREAS . . .
CIRCUIT DESIGN & RESEARCH
COMMUNICATIONS
COMPONENT ENGINEERING
COMPUTER ANALYSIS & DESIGN
CRYOGENICS
ENGINEERING PHYSICS
INERTIAL GUIDANCE
INDUSTRIAL CONTROL
INFORMATION THEORY
LOGICAL DESIGN
MATHEMATICS
OPTICS
PROGRAMMING
RADAR
REAL TIME STUDIES
SEMICONDUCTOR DESIGN
SOLID STATE DEVELOPMENT
SYSTEMS DEVELOPMENT

Qualifications: B.S., M.S., or Ph.D. in Electrical or Mechanical Engineering, Physics, or Mathematics — and proven ability to assume a high degree of technical responsibility in your sphere of interest.

A T 1 O NS:

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INDUSTRIAL CONTROL ENGINEERS to perform precision AC and DC electric measurements. Assignments in amplifier design, relay circuit logic, test equipment development, analog to digital conversion, and noise reduction.

CIRCUIT DESIGNERS to design transistor amplifiers, relay lines, transistor tube conversion circuits. Develop systems circuit specifications, perform circuit evaluation experiments and reliability criteria. Other openings in circuit design for magnetic devices.

MATHEMATICIANS to do digital computer programming, handle analysis-of-variance and multiple-regression type problems. Design experiments for wide variation of engineering applications. Knowledge of application of probability or game theory desirable.

ADVERTISERS' INDEX
April 1, 1959

◀ CIRCLE 326 ON READER-SERVICE CARD

CIRCLE 327 ON READER-SERVICE CARD ➤

April 1, 1959

ELECTRONIC DESIGN

HAYDEN PUBLISHING COMPANY, INC.
830 Third Avenue, New York 22, N.Y.

Typical RCA Ceramic-Metal Power Tubes utilize beam power design, and feature high-efficiency forced-air cooling.

RCA Ceramic-Metal Power Tubes

Known throughout industry and military services for high-efficiency operation and ability to withstand high voltages at ultra-high frequencies, RCA Ceramic-Metal Power Tubes are the answer for the designer who requires higher power in a smaller, compact tube design. No other power tubes in this class combine features such as: coaxial-electrode design; low-loss ceramic bushings between electrode contact surfaces; matrix-type cathode; extra-sturdy heater, low screen current, virtually no primary screen grid or control grid emission!

RCA Ceramic-Metal Power Tubes merit the attention of new equipment designers for a wide variety of applications. Your RCA Representative will be glad to discuss with you your requirements for RCA Ceramic-Metal Tubes and the availability of developmental types on a sampling basis.

Typical RCA Ceramic-Metal Power Tubes

Type No.	CW Service max Plate Input (Watts)	Pulse Service max. Peak Plate Input (Watts)	max Frequency for full Input (MC)	max. Plate Dissipation (Watts)
A-2582*	30	–	1215	25
A-2587*	–	3750	1215	25
6816	180	–	1215	115
A-2543-A*	–	9000	1215	115
A-2572*	1250	–	1215	600
A-2585*	–	64000	1215	600
7213	2500	–	1215	1500
A-2576-A*	–	180000	1215	1500
A-2545*	20000	–	400	10000
A-2581*	–	2000000	500	10000

*RCA Developmental Type—Available on Sampling Basis

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