AUGUST 15, 1957

ELECTRONIC DESIGN

Time rate of change meter . . . page 26

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ELECTRONIC DESIGN

Contents

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Editorial

This Age of Specialization

The days of the "all round" electronics engineer are past. Only yesterday an experienced engineer was expected to tackle almost any job that included vacuum tubes, resistors and capacitors. It is a tribute to the advanced state of our economy that this is no longer so. We have become a nation of specialists.

Yesterday's electronics engineer has been replaced by the vacuum-tube engineer, the transistor engineer, the analog computer man, the digital specialist, the capacitor engineer, the transformer and coil man, and a host of others.

Moreover, even these specialties have been divided into sub-specialties. The resistor engineer may design only power resistors and precision resistors or deposited types. The capacitor man may deal only in mica types, or paper, or electrolytics. The computer man may be strictly a circuits man, or a logic specialist, or a memory man.

Now, in the midst of this trend, in the midst of this age of super-specialization—we find an anomalous situation. The electronics engineer—the specialist—is being forced to branch out. Yesterday he designed for frequency response, gain, stability, signal-to-noise ratio. Today he must ask—"Can my system tolerate shock, vibration, salt spray, humidity, and altitude—can it take —60 C and +200 C?" The electronics specialist, it appears, must become a mechanical engineering specialist and a thermodynamics specialist, and rapidly too,—for in spite of the sweet talk, we are still in the midst of an arms race.

The electronics engineer is best capable of designing an instrument from an electronic viewpoint. The thermal design engineer can, no doubt, lay it out from the viewpoint of most efficient cooling, and the mechanical engineer is best able to insure resistance to shock and vibration. Certainly, compromises may have to be made, but teamwork is essential if we are to have optimum design.

Far too many prototypes have been junked because critical components overheated and no provision had been made for adequate cooling. Too many engineering dollars have been wasted because a system overheated at 23,000 feet, though it "worked fine" at sea level. We've thrown away too many precious hours building electronic gear that couldn't take vibration or shock.

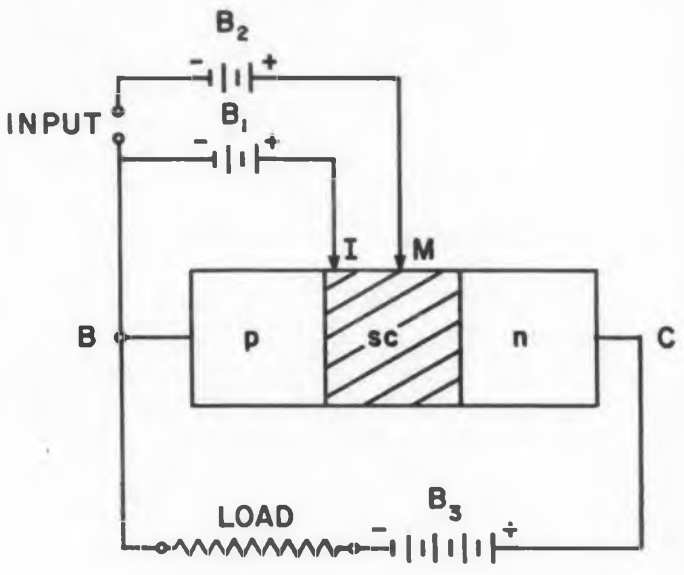
It is too much to expect the electronics engineer to be an expert on every phase of a system design. The day of the one-man project has gone. The time has come when we need teams of electronic, mechanical and thermal engineers on every major project.—GR

Engineering Review

For more information on developments described in "Engineering Review," write directly to the address given in the individual item.

The Spacistor; Revolutionary Transistor?

An estimated frequency limit of 10,000 mc, expected operation at 500 C, and an input and output impedance of 30 meg are some of the claims made by Raytheon Manufacturing Co. concerning their spacistor. Although still in the research stage, the spacistor would seem to promise a radical departure from conventional transistor design. However there is good reason to believe that the device is not quite so revolutionary as at first might seem, and that it might better be described as a step forward rather than as a startling departure from what has preceded it.



The spacistor is shown here schematically. The space-charge region of a p-n junction biased in reverse is indicated by the shaded area. A suitable electron emitting contact I is placed into the space-charge region. The contact I is connected to terminal B through a battery, which biases the contact negatively with respect to the potential of the underlying space-charge region. Note the potential of point I is still positive with respect to B. Electrons are emitted from this contact into the space-charge region where they are modulated by a field set up by M. The electrons flow to the n-side, through the load, and back to point I.

By avoiding the frequency limitations in the conventional transistor, due to the slow diffusion of minority carriers through the essentially field-free base region, the spacistor is theoretically capable of superior frequency preformance. Through utilizing the space-charge region in a reverse-biased p-n junction, a relatively high transit time can be achieved. As shown in the diagram, injector I and modulator M are the input points. Carriers emitted from I will travel rapidly in the space-charge region towards the collector C. Modulator M has two functions: varying the emission of injector I, and allowing the bias of I to be practically independent of the voltage B-C, thus keeping the output impedance desirably high.

The utilization of the space-charge region in a reversed-bias p-n junction is not new. In November of 1952, *Proceedings of the IRE* published an article by W. Shockley, then with Bell Telephone Labs., entitled "Transistor Electronics: Imperfections, Unipolar and Analog Transistors." The analog transistor in particular shows a resemblance to the spacistor. Called "analog," because of its analogy to the conventional vacuum triode, this transistor utilized a reversed-bias p-n junction to create a space-charge region, and thus layed some of the theoretical groundwork for low transit time devices. Modulation was accomplished by a p-type region, called the grid in accordance with the analog terminology.

The important difference of Raytheon's spacistor is the injection of carriers into the space-charge region by the emitter. Both the analog transistor and the field-effect transistor, which appeared at the same time, were limited in respect to field strength due to heat generated by the current flow. In the spacistor, where carriers are injected into the space-charge region, no current is necessary to establish the high electric field. Despite this important difference, the spacistor does not appear to have solved the problem encountered with similar devices. The theoretical frequency limit of 10,000 mc still remains quite theoretical; it might be possible even now to reach this upper limit but in the form of a minute vibration. The possibility of using new semiconductor materials with higher temperature ranges—silicon carbide was hinted—has met with equal scepticism from engineers experienced in the field. Apparently the fact that the spacistor does not depend on minority carrier lifetime does not therefore make it adaptable to other materials without other serious design considerations. The spacistor remains then as an important contribution in the field of transistor research, but Raytheon's estimate of three to five years before it reaches the market would appear to be a likely prediction.

Compared to a pinhead, the spacistor is shown attached to a transistor mount. The spacistor's four leads are: base (slanty crossbar); collector (wire directly under semiconductor block on right); injector (whisker sized wire on top left) and modulator (whisker sized wire on top right).

Engineering Review

From the depths of these caverns comes a sound unique in the musical world—that of a stalactite struck by a rubber-tipped plunger.

The Great Stalactite Organ

When four-year-old Robert Sprinkle bumped his head on a stalactite in Luray Caverns, Va., in June 1954, the nice deep tone of the rock fascinated him and his father, Leland W. Sprinkle, Sr., even more than the bump. The father, a physicist, was excited by the idea of creating a device to play musical selections on the stalactites. As the story goes, during the three years since then The Great Stalactite Organ has been created. Already of immense dimensions, the organ is still growing as more and more of the stalactites in the 64-acre caverns are being tuned.

The problems encountered in accomplishing the feat were many and various. The first consisted of whether and how a stalactite could be tuned. Sprinkle found only about two that were in tune naturally. A system of grinding the others had to be worked out, with aluminum oxide sanding discs rotated at high speed. Although the discs are strong enough to wear down tempered steel, the stalactites were hard enough to wear them out readily. English tuning forks were used for initial prospecting before precise tuning was done by a system of precision oscillators amplified so they can be heard above the grinding—which continued until the beats disappeared. Once tuned, stalactites stay tuned; air-conditioned by nature, they are maintained at a constant 54 F.

The over-all design of the instrument includes interchangeable octave blocks, which may be controlled by either a manual console or an automatic playing mechanism. The automatic player consists of a thin Mylar plastic belt with a pattern of holes melted into it by a soldering iron. As tiny paint brushes similar to a type used on IBM sorting ma-

chines slide through a hole, an electrical contact is established which triggers a relay. The relay, in turn, allows a storage capacitor to discharge through a long electric line into the surounding subterranean area, moving a solenoid-type plunger and sounding a stalactite. Volume changes as well as other tonal effects can be melted into the plastic tape, or if the manual console is used, these effects may be accomplished through a system of switches.

Among the numerous advantages of a stalactite organ is stereophonic sound. Probably no other organ in the world has more area in which to achieve its effects than in this cavern which has a reverberation time of approximately two seconds.

Portable Antenna Tower: Fabricated of lightweight magnesium for the Royal Australian Air Force by Magnesium Products of Milwaukee, this tower was demonstrated recently at the Milwaukee lake front. The tower, made in sections, is the telescoping type and can be cranked skyward to a height of 150 ft from the telescoped, or ground level, height of 12 ft. A 12-man crew can handle and erect a tower in two and a half hours. The complete tower, including guy wires and accessories, weighs 1400 lb. One man cranks the sections upwards into position and two men on a platform, 12 ft above ground, bolt the sections together.

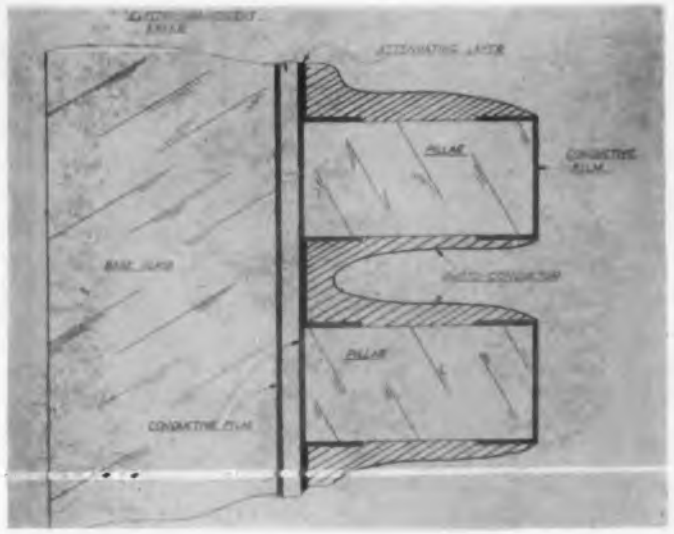
The towers will be used as microwave relay stations by the Australian Air Force as part of its communications network. The United States Air Force uses similar portable antennas, which are, however, only 100 ft high.

Electroluminescent Image Formation

For several years extensive research has been carried out in the field of electroluminescence (EL) with the fundamental goal being the development of image-forming devices. Recently three devices produced by the Sylvania Products Inc. in cooperation with Lincoln Lab. at MIT were demonstrated as the latest experimental EL innovations; they consisted of (1) an EL panel on which the position of a mobile dot of light can be manipulated electrically, (2) a display panel which reproduces optically and stores indefinitely the track of a mobile spot of light, (3) a panel which can reproduce optically a motion picture with good resolution and rapid response.

Type I is a 2 in.-square, flat plate made up of a horizontal array of linear conductors, an EL layer, and a vertical set of conductive strips. The strips are 3/64 in. wide with an insulating gap of 1/64 in. between strips. Upon application of a short ac pulse to each of two chosen strips at a different potential a voltage will exist across the EL layer at the point of intersection. This layer in the presence of the electric field will emit a dot of light at the particular point. All the 1024 squares can be lit individually.

Lighting of the squares must be initially accomplished by some triggering mechanism. One method is to focus a narrow beam of light on either the front or back of the element. The brightness frequency and ambient light conditions will affect the



Light coming from the right of the display panel will strike a cover glass and electroluminescent layer (both not shown) where dispersion will occur. In the presence of this light the resistance of the photo-conductor will rapidly decrease and present a very low resistance between the conductive end caps, which will then assume the same potential upon introduction of an ac voltage to the two electroluminescent layers.

The lighted square and the letter "H" are images which have been reproduced optically on a flat panel.

time required to trigger the element. Once triggered the element will continue to emit light even after the triggering source is removed.

The light storage device, Type II, is a display panel. A piece of conductive glass is used with an EL coating on which is cemented with melting glass sets of columns approximately 1/32 in. sq with a 1/32 in. spacing to adjacent columns, present a "waffle iron" effect. Black glass is applied to the webbing between individual columns. Each column has a conductive cap on both top and bottom and a photo-conductor layer for connections. A top conductor of perforated metal mesh or conductive glass is then cemented to the top conductive caps of the columns, joining them all. When ac power is applied to the two conductive coatings one below the electroluminescent layer and the other on top of the conductive caps and a spot of triggering light of short duration is applied to an individual column, either from front or back, the photo-conductor transmits ac power and the electroluminescent dot under the column lights up. The feedback of this light into the column is sufficient to keep the photo-conductor active so that the dot of light remains lit even after the triggering light is shut off. The black webbing prevents adjacent dots from lighting. Each dot will remain dark until triggered, and will remain lit after triggering.

The last type, a flat screen, consists of a conductive glass square coated with an EL layer, a photoconductive layer and an electrically conductive layer. By applying ac power to the conductive layers and by applying or projecting a light image or a picture to the back of the screen, the image or picture, consisting of thousands of dots of lights, is reproduced on the front of the screen.

Engineering Review

Radar Strip Recorder

A radar strip recorder which maintains the advantages of a PPI-scope presentation while eliminating most of the disadvantages is available. The radar strip recorder makes an actual photographic record of radar information on a slowly-moving strip of film. The film is 9-1/2 in. wide and is passed over a viewing screen so that the observer looks at a transparency approximately 9 x 12 in. in size. The transparency pictures the ground immediately aft of the airplane exactly as it looked to high-precision radar twenty sec previously. The film picture does not change, but rather the long strip of film is slowly wound from one spool to another. The speed of film travel can be controlled to correspond to airplane velocity. A permanent film record of the flight path of the airplane results; in addition, the pilot, navigator, or observer has at his command a precisely accurate picture of the ground below which is reliable day or night, in clear weather or cloudy overcast conditions. The system was developed by Hycon Mfg. Co. of Pasadena, Calif.

Automatic Flight Control

Virtually automatic control systems are directing the flight path of the nation's first supersonic bomber, the B-58 Hustler, and accurate release of its throw-away pods. These guidance systems can direct the plane through its autopilot with minimum supervision by a three-man crew. Production of the primary navigation and guidance systems for the new bomber aircraft was assigned to Sperry Gyroscope Company, Great Neck, N.Y., where these automatic systems for a wide range of missions were developed during the past several years by engineers from Sperry and the Convair Division of General Dynamics Corporation. Ten times as accurate as previous operational systems, the new equipment requires 37 per cent less space and weighs 20 per cent less than former systems.

◀ CIRCLE 7 ON READER-SERVICE CARD

The Moon Will Do

The powerful radar transmitter Diana developed a few years ago by the Army Signal Corps has been used recently in the testing of Vanguard Minitrack stations. Signals transmitted from the radar and reflected by the surface of the moon have been received by one of the tracking stations at Blossom Point, Md. Purpose of the tests is to perfect a technique by which the operation of all of the Western Hemisphere satellite tracking stations can be tested as soon as they have been completed and placed in operation.

The receiving equipment being used in the tests is the Mark II Minitrack being designed by the Naval Research Lab. for use by volunteer radio tracking stations. However, the equipment must be modified for the test because the Diana transmitter operated at 151 mc instead of the 108 mc Minitrack freq used in the satellite tracking system.

Breaking Through a Ham Barrier

An amateur station in California was in two-way 144-Mc radiotelegraph communication with another 2600 miles away in the Hawaiian Island of Oahu, a distance heretofore considered impossible on that frequency. No all-water path of greater than about 700 miles has been covered previously. Both stations used the maximum power allowed, one kw input to the final amplifier stages of the home-built transmitters, and highly sensitive low-noise receivers. The Hawaiian station employed a huge antenna array consisting of four 24-ft Yagi-type bays arranged in a box formation. A 13-element 24-ft Yagi array was used at the West Coast station.

The exact nature of the propagation medium which permitted station W6NLZ in Palos Verdes Estate and KH6UK at Kahuku to remain in contact for over one hour has not been definitely established, but the stable quality of the signals received at both ends of the circuit indicates that exceptionally stable weather conditions over the Pacific may have been the responsible factor.

CIRCLE 8 ON READER-SERVICE CARD ➤

Engineering Review

Talos Joins the Fleet

Talos, the Navy's long-range surface-to-air guided-missile will form the major armament of the light cruiser USS Galveston now undergoing conversion to a guided-missile cruiser at the Philadelphia Naval Shipyard. The Galveston is expected to go to sea in April, 1958. A year later, two other cruisers, both armed with Talos, are scheduled to rejoin the fleet. The first nuclear-powered cruiser Long Beach will also be armed with Talos.

According to Rear Admiral F. [illegible] Withington, Chief of the Bureau of Ordnance, Talos has consistently demonstrated a remarkable high degree of reliability and accuracy even at its longest range. Due to this reliability, the Navy is making the first direct shipboard installation of Talos in a first-line cruiser without the intervening steps of evaluation installations in experimental ships. The streamlining of the development process has saved considerable funds and has advanced the availability of Talos as a fleet weapon.

Research to Establish Specs

Reliability engineering research studies to supply criteria for selecting and establishing realistic specifications for electronic components have been initiated for the Army Signal Equipment Support Agency, Fort Monmouth, N.J. The 12-month 300,000-dollar contract was assigned to Battelle Institute, Columbus, Ohio.

Each group of components to be evaluated will be considered as a separate task. The general plan of research for each task will include: a survey phase during which information from contact with manufacturers and from the literature will be evaluated; an experimental phase to determine operational performance characteristics and an analysis and recommendation phase during which experimental data will be analyzed and specification limits established.

ansistor Sales Continue to Rise

Transistor sales during the first ve months of this year increased ubstantially over the corresponding 956 period according to RETMA. ales of the semiconductor device uring May also showed an increase s ver April and May of last year. Fac- fo ory sales of transistors in May totaled lig 055,000 units with a dollar value nd f 5,636,000 dollars compared with iss 774,000 transistors sold in April Ma alued at 4,880,000 dollars. Cumula- ect ve sales of these devices during the ye rst five months of this year totaled rm 954,300 valued at 25,128,000 dollars n t s against 3,626,000 transistors worth ver),082,000 dollars sold during the cor- rm sponding period of 1956.

F.
au ### ome Radiation Detector
ent
h d The GARD, Gamma Atomic Radia- eve on Detector, is to be used principally is r s a family home survey meter under e fi mergency conditions of nuclear war- Tal are, or accidental contamination. The he i etector, announced by Sargent-Ray- stall ent Co., Oakland 1, Calif., works on Th e principle of gamma sensitive crys- pro ls that glow at various intensities of ls a amma radiation. These crystals are Tal asily viewed through the magnifying ns when GARD is held to the eye. here is no holdover of afterglow of hese crystals. A person using GARD an seek the safest area and will be mmediately aware of leaving a high tensity area. The unit weighs 2 oz sear nd measures 2 x 1-1/4 x 1 in. It is lecti eatherproof, fungusproof, shock- ecifi roof, and non-breakable.
s ha
Sign
Fo ### irways Modernization
n 30
ned Despite mild antagonism, the nio. ouse Interstate Commerce Commit- to e approved and sent to the House a sep e Airways Modernization Bill (S- esear 56). Apparently, the testimony of its surv dvocates was strong enough to allow n fro e Senate bill to pass untouched. If d fro e House accepts the committee rec- ed, a mmendation (and there seems no ine o ason why it should not), the bill will eristi to the President for his signature. ndati he next chore will be to get the $30- tal da dd million the Board will need to ficati et rolling.

Fair Weather Radio

A solar radio measuring 3/4 x 2 x 3 in. has bee introduced to the American public. Created by t Acopian Technical Co. of Phillipsburg, N. J., th radio contains what is claimed to be a powerfu lifetime solar battery, which can convert eithe sunlight or artificial light into electrical energy. Other features of the radio, which sells for $12.9 include a high Q, omni-directional ferri-loopstick and an earphone which is described as a sensitiv high impedance hearing-aid type. A high gai specially selected transistor, a specially selecte germanium diode, and a durable two-tone plasti case are qualities which should make this devic well worth the cost.

But for those midnight until dawn programs, i is advised that one pick a night with a full moo or else keep the lights burning; that is, of course if there happens to be one of those 115 v outlet handy in which to plug a lamp.

Fingertip Control: The problems involved in flying a supersonic missile from a ground command station have been described as being like trying to steer a car from a mile behind with a rubber steering column. To get the ground controller right into the driver's seat, Lockheed's Missile Systems Div. has recently completed two years of work on a "human engineered" command station. The command station will compensate for the loss of feel that plagues the long-distance missile operator by making it possible for him to know at a glance the speed, pitch, and acceleration of the missile. Lighting, color, readability, and arrangement of instruments were devised by a team of psychologists and engineers to best complement the human operator to increase his speed, decrease his mistakes, and give him information for his piloting job. The station will be used at Holloman Air Development Center, Alamogordo, N. Mex.

Washington Report

Herbert H. Rosen

Missile Electronics On the Upswing

The demise of the Navaho missile project, the ...tchout of B-52 procurement, and the curtailment ...overtime bode of impending changes in the air-...ft industry—particularly in the procurement of ...siles. In a meeting of aviation and electronic ...ustrialists, Air Force Secretary J. H. Douglas ...nted a dull picture for the future of the aviation ...ustry. At the same time, he forecast an increase ... electronics procurement from $750 million to ...3 billion for the year.

Behind these warnings and forecasts is the phase-... of aircraft in favor of the guided missile. ...uglas and AMC procurement chief, Gen. David ...ker (since retired from the Air Force), told the ...ustrialists that there just wasn't enough money ... the Air Force budget to support both. Therefore, ...e has to be reduced, and it looks like it will be ...planes.

However, the future is not as clear cut as it may ...pear initially. The Air Force is going to have to ...ry its same responsibilities with less money. ...is means that there is going to be a more sincere ...ort to correct some of the costly extravagances ...aracteristic of Defense production.

D. C. Sharp, Assistant AF Secretary for Material, ...de six points that indicate the areas the Air ...rce will keep under close scrutiny.

- Quality engineering rather than quantity engineering.
- Reduction of overtime (already in effect).
- Reduction in industry personnel.
- Questioning of executive compensation chargeable to Government contracts.
- Better methods for subcontracting to receive the lowest possible prices.
- Elimination of new Air Force furnished facilities.

Extra-ordinary DOD Authority Thwarted

The Defense Department's authority to bail out ...anufacturers in trouble has expired with the fiscal ...ar. Authority for extra-ordinary negotiations was ...ntained in the First War Powers Act of 1941, ...hich was extended for another year by the House ...thout benefit of a hearing. However, Senator ...Mahoney (D-Wyo.), has objected to this pro-...dure and is holding up similar Senate action until ...arings can be held. He claims the Act gives DOD ...o much negotiating freedom. Meanwhile DOD is ...ft with no law to take care of special procurement ...ergencies should they crop up.

"Raspberries"

Gentlemen:

This letter is a response to the reading of yo "Editorial" of V5 #10 May 15, 1957.

Engineers at the bar should not be regarded criteria for facts. The ideas presented here for t consumption of our professional group are ir tional, unscientific, and irresponsible. Your previo editorial carrying the message "Reduce the fun increase the efficiency" is also psychologically gross error.

Let us see the facts instead of your miscellaneo comments.

W. Merel, Dev. En
Walter Kidde Co.
675 Main Ave.
Belleville, N.J.

▶ Ideas in the first referenced editorial came fro some very responsible engineers. Your editor w not in a bar when he organized them into a colum

Helpful to Know

Dear Sir:

Your new "Ideas for Design" section of ELE TRONIC DESIGN is very worthwhile and I hope will be a permanent feature of your magazine. . .

Hugh R. Lowry, Mgr.
Application Engineering
Semiconductor Products De
General Electric Co.,
Schenectady, N.Y.

Can You Help?

Dear Sir:

Any help your readers could give us in locati a teflon socket for a 6199 type photomultiplier tu would be appreciated.

Joseph J. Nemecek, 7320
U. S. Naval Research L
Washington, D. C.

▶ If anyone knows, please notify Mr. Nemecek rect.

Letters to the Editor

Salaries a Problem?

Dear Sir:

The editorial and letters to the Editor in the May 15 issue require an answer. Recently I saw the Engineering Joint Council salary curves (published in Automatic Control—Reinhold Publishing Co.—May issue). I suggest that the two government personnel men whose letters were published in your May 15 issue take the EJC curves and draw in some curves for their own organization and send these with their letters. If the data shows that they deserve engineers they will have a better chance of obtaining them. If they have less than average opportunity, then they should expect less than average response and from less than average engineers.

Your editorial expresses a very good thought—give R & D contracts to the competent—however the logical conclusion from the presentation is that all R & D should go to establish companies—and therefor the engineers should take what they condescend to pay. Do you infer that such companies as Ramo-Woodridge would never have been allowed to start? After all, if we are going to keep the engineers in line we hadn't better let anyone get away with anything or they will all try.

On the other hand, the incompetence exhibited in some equipment, both government and civilian is a crime as well as being beyond belief—especially in work that people try to do for themselves. As long as jobs go to the lowest bidder this will usually be true. The competent are not starving for jobs and bidding below true value to obtain them.

So, while your basic idea is very good and very important—I think that you let it get a bit out of hand.

John M. Graham, P.E.
2607 St. Charles Rd.
Bellwood, Illinois

It does not necessarily follow from our editorial that only "established" companies should get R and D work. We used the word "responsible." A one-man company might best serve the interests of the government. However, the procurement officer, under our prevailing policies, would be less subject to criticism by placing a contract with a company having the most help available, irrespective of how many engineers or what qualifications were needed.

Meetings

Aug. 28-30: AIEE Pacific General Meeting

Pasco Senior High School, Pasco, Wash. The te nical sessions will cover power generation, nuc onic and radiation instruments, human engineeri wire communication, transmission and distributi nucleonics, industrial power systems, radio co munication, substations, industrial power rectifie television and aural broadcasting, space heati and air pollution, safety, magnetic amplifiers, flig test instrumentation, and relaying. For more deta write to L. P. Reinig, 1704 Bldg., 100-K Ar General Electric Co., Richland, Washington.

Aug. 29-30: Fourth Annual Symposium on Co puters and Data Processing

Albany Hotel, Denver, Colo. Sponsored by t Denver Research Institute. Technical papers components, devices, systems organization, analy techniques, and design techniques will be p sented. For further information write to J. Marsh Cavenah, Electronics Div., Denver Research In tute, University of Denver 10, Colo.

Sept. 4-6: Special Technical Conference on Mo netic Amplifiers

Penn Sheraton Hotel, Pittsburgh, Pa. Sponsored the AIEE and the IRE. The program's four sessio will deal with New Circuits and Techniques, Ana sis and Design, and Applications. For more inform tion, write to D. Feldman, Bell Telephone Labs.

Sept. 8-13: Second Annual Course on Investme Castings

MIT, Cambridge, Mass. Sponsored by the Inve ment Casting Institute. Lectures, laborato exercises and demonstrations will be offered investment materials; melting; gating, riseri solidification and heat transfer; metal and all systems; defects in castings; and consideration new investment and allied processes. For furth information, write Harry P. Dolan, Investme Casting Institute, 27 E. Monroe St., Chicago 3,

Sept. 9-13: Twelfth Annual Instrument-Automati Conference and Exhibit

Cleveland Auditorium, Cleveland, Ohio. Sponsor by the ISA. Organized under the unifying them "Instrumentation for Systems Control," the confe ence will open with formal sessions devoted to da handling and instrument terminology. Followi these there will be individual workshop sessions limited discussion groups covering such topics

aircraft and missiles (excluding propulsion), wind tunnels, flight propulsion systems, process industries, power generation and distribution, meteorological, nuclear, medical, geophysical exploration and general industrial laboratories. Some 100 papers will be presented at the technical sessions. There will be about 500 exhibits. For details of the technical program write to Herbert S. Kindler, Director of Technical Programs, ISA, 313 Sixth Ave., Pittsburgh, Pa.

Sept. 17-18: RETMA Symposium on Numerical Control Systems for Machine Tools

Ambassador Hotel, Los Angeles, Calif. For details write to RETMA, Room 650, 11W. 42nd St., New York 36, N.Y.

Sept. 17-21: Institute of High Fidelity Manufacturers Show

Morrison Hotel, Chicago, Ill. For further information, contact Bernie Merems, 509 Madison Ave., New York, N.Y., or Howard Alexander, 75 E. Wacker Drive, Chicago, Ill.

Sept. 24-25: Sixth PGIE Symposium on Industrial Electronics

Morrison Hotel, Chicago, Ill. Sponsored by the IRE Professional Group on Industrial Electronics and AIEE. The main theme for the conference will be the characteristics, use and integration of transducers into complete systems to measure and control complete processes. For further details, write to J. N. Banky, 628 West 18th Street, Chicago, Ill.

Oct. 9-12: 1957 Convention of the Audio Engineering Society

New York Trade Show Bldg., New York, N.Y. Between 50 and 60 papers will be presented. Covered will be topics in such fields as disc and tape recording, reception, components and systems, noise control and acoustics. The New York High Fidelity Show, sponsored by the Institute of High Fidelity, will accompany the Convention. More information may be obtained from G. K. Dahl, 230 West 41st St., New York 36, N.Y.

Oct. 16-18: AIEE Conference on Computers in Control

Chalfonte and Haddon Hall Hotels, Atlantic City, N.J. Sponsored by the AIEE Committee on Feedback Control Systems. The conference will stress the role of analog and digital computers in automatic control, both as design tools and as components of systems. For more information, write Prof. J. G. Truxal, Dept. of Electrical Engineering, Polytechnic Institute of Brooklyn, 99 Livingston St., Brooklyn 1, N.Y.

Oct. 16-18: 1957 IRE Canadian Convention and Exposition

Automotive Building, Exhibition Park, Toronto, Canada. Sponsored by the Canadian Sections of the IRE. For information write to Grant Smedmor, IRE Canadian Convention, 745 Mt. Pleasant Rd., Toronto 7, Canada.

Oct. 17: SPE Regional Technical Conference

Hotel Carter, Cleveland, Ohio. Sponsored by the Cleveland-Akron Section of the Society of Plastics Engineers. The theme for the sessions will be "Polyethylene—Properties and Uses." For details, write E. J. Haskins, Zenith Plastics Co., 1009 Rockwell Ave., Cleveland 14, Ohio.

Oct. 31-Nov. 1: Third Annual Technical Conference of the Professional Group on Electron Devices, IRE

Shoreham Hotel, Washington, D.C. For more information, write W. M. Webster, RCA Semiconductor Div., Somerville, N.J.

Nov. 6-8: Tenth Annual Conference on Electronic Techniques in Medicine and Biology

Boston, Mass. Sponsored by ISA and AIEE. Further details and advance programs may be obtained from H. S. Kindler, Director of Technical Programs, Instrument Society of America, 313 Sixth Ave., Pittsburgh 22, Pa.

Nov. 6-8: Third Aero-Com Symposium

Hotel Utica, Utica, N.Y. Sponsored by the IRE Professional Group on Communications Systems. The conference will deal with systems, equipment design, techniques, antennas, spectrum conservation, air traffic control, management and other topics. For the presentation of confidential material, there will be a classified session on Nov. 8. For more information, write to R. C. Benoit, 138 Riverview Pkwy., Rome, N.Y.

Nov. 11-13: Third Annual Instrumentation Conference

Biltmore Hotel, Atlanta, Ga. The theme of this conference will be "Instrumentation for Data Handling" with special symposiums on electronic instrumentation as applied to medicine and the sales and purchasing aspects of electronic instrumentation. Papers should be submitted to Lamar Whittle, Federal Telecommunications Lab., 1389 Peachtree St., N.E., Atlanta, Ga. For more information write B. J. Dasher, School of Electrical Engineering, Georgia Institute of Technology, Atlanta, Ga.

Nov. 13-14: Mid-America Electronics Convention

Municipal Auditorium and Hotel Muehlebach, Kansas City, Mo. Sponsored by the Kansas City Section of the IRE. There will be exhibits and twelve tech-

nical sessions. Approximately thirty papers will deal with medical electronics, airborne electronics instrumentation, engineering management, electronics in nucleonics and a diversity of other subjects. Persons who want to submit papers should contact the Technical Papers Chairman, MAECON, 5109 Cherry St., Kansas City 10, Mo. The deadline for submissions is Aug. 15. For more information write Richard L. Clarke, 425 Volker Blvd., Kansas City 10, Mo.

Nov. 13-15: Eighth National Conference on Standards

St. Francis Hotel, San Francisco, Calif. Sponsored by the American Standards Association. Emphasis will be on standards as a key to progress and profits. Sessions will cover radiation exposure, electronics, industrial preparedness, motion pictures and television, purchasing, company standards, technical communications, government standards and safety. For more information, write to D. E. Denton, ASA. 70 E. 45th St., New York 17, N.Y.

Dec. 9-12: Seventh Eastern Joint Computer Conference and Exhibit

Sheraton-Park Hotel, Washington, D.C. Sponsored by the IRE, Association for Computing Machinery and AIEE. "Computers with Deadlines to Meet" will be the central theme. Papers will be presented on record keeping, materials handling, traffic, deadline data reduction, communication, flight simulation, and other computer deadline areas. For more details, write to Malcolm B. Catlin, Council for Economic and Industry Research, Inc., Arlington 2, Va.

Jan. 6-8: Fourth National Symposium on Reliability and Quality Control

Hotel Statler, Washington, D.C. Sponsored by the IRE, ASQC and AIEE. Covering fields of reliability. For detailed information, contact Richard M. Jacobs, RCA Bldg. 108-2, Moorestown, N.J.

Paper Deadlines

Nov. 1: Deadline for papers to be presented at the 1958 **IRE National Convention.** The convention will be held March 24-27 at the Waldorf-Astoria and the New York Coliseum, New York, N.Y. Prospective authors should submit a 100-word abstract and a 500-word summary. Both must be in triplicate with the title of the paper and the name and address of the author. The technical field in which the paper falls must also be indicated. Only papers not published or presented prior to the convention will be considered. Military or company clearance must be obtained before submittal. Address all material to Dr. George L. Haller, Chairman, 1958 Technical Program Committee, IRE, 1 E. 79th St., New York 21, N.Y.

VTVM Survey-I

Sol D. Prensky

ADVANCES in recent years have resulted in the evolution of a wide variety of improved forms of vacuum-tube (or electronic) voltmeters. Many different circuits are employed in advanced-type instruments to obtain a specially-desired kind of performance. This three part survey analyzes a representative cross-section of VTVM's to aid the designer in choosing a meter best suited to his needs.

Along with the development of new refinements, there has also been an increasing acceptance of the time-tested circuit arrangements for general-purpose applications. The arrangement of rectifier-plus-balanced-bridge, d-c amplifier circuit has proven itself very satisfactory for service VTVM's. The same can also be said for the laboratory workhorse VTVM instrument which provides high-sensitivity a-c measurements, by use of a well-standardized arrangement of stabilized multi-stage a-c amplifier-plus-rectifier circuit.

Many of the newer types emphasize refinements in the manner in which measurements are presented, rather than changes in basic circuit design. Such refinements include extensions to more sensitive ranges, incorporation of peak-to-peak calibrated scales, and automatic range selection. Other innovations involve more basic changes in circuitry, such as provision for a digital form of presentation, intensive development of d-c to a-c input conversion, improved d-c amplifiers and new circuitry for transistor voltmeters.

In order to prevent the large quantity and diversity of models from overshadowing the significance of basic circuit-design development, the article is divided into three parts according to major use and price-class. The meters are further identified in each group by circuit type.

Part I, the ***Laboratory Group***, covers a wide variety of instruments desirable for laboratory use, without being too specialized in their voltage-measuring function. Models in this group incorporate various types of multi-stage amplifiers and fall in a price class above $150. Part II, the ***Service Group***, usually employs a dual triode for a balanced bridge, and is widely used for general-purpose maintenance measurements. Instruments in this group are usually priced at less than $150. Part III has a catch-all designation, ***Special Group***, and includes the more specialized types. These would undoubtedly find use in either service or laboratory work but they are separated from these groups to emphasize their more special features.

Specifications for the models listed in the ***Service and Laboratory Groups*** are tabulated in 12 columns for easy comparison. In the ***Special Group*** important characteristics and special applications are listed under one head "circuit-features." Although some might not be considered as strictly vacuum-tube voltmeters, they all definitely do belong in the overall class of electronic current or voltage measuring instruments. Part III is so all inclusive that space limitations make it necessary to limit listings to a reasonable number of representative instruments.

Circuit Type

The last column of the tabulation lists circuit design features and places each meter in one of four general circuit types. Circuit types 1 and 2 employ d-c amplification and circuit types 3 and 4 a-c amplification.

Circuit Type 1: This circuit is a straight d-c amplifier and is generally used in a symmetrically balanced

LABORATORY METERS

Manufacturer	Model & Price	DC Scales: Voltage Range	DC Scales: Impedance Megohms	DC Scales: Accuracy Per Cent	DC Scales: Resistance Ranges—Ohms (CS) = Center of Scale	AC Scales: Voltage Range	AC Scales: Impedance Megohms	AC Scales: Accuracy Per Cent	AC Scales: Freq. Range	Power Tube Compliment	Accessories	Circuit Design Features
Acton Labs. Main Street Acton, Mass.	815A $400	0.1—1000 (9 ranges)	100	±2	Rx0.1—Rx10 Meg. (9 ranges) 10 (CS)	0.1—300 (8 ranges)	10	±3	15 cps to 100 mc	AC (1) 5157 (1) 12AX7 (2) 12AV7 (2) 9006	Provided: AC, DC and resistance probe.	Type 2. Circuit: Also current scales from .001 ua to 100 ma. Independent zero sets. AC supply voltage completely regulated as well as DC.
	810 $245	1—1000 (7 ranges)	100	±2	Rx1—Rx1 Meg. (7 ranges) 10 (CS)	1—300 (6 ranges)	7 2 μμf	±3	10 cps to 700 mc	AC (2) 6AU6 (1) 6AQ5 (1) 201-C (1) 2D21	Provided: AC, DC and resistance probe.	Type 2. Circuit: Frequency response flat within ± 1 db 10 cps to 700 mc. Regulated DC supply for ohms measurement. No Zero shift with range change any sales.
Ballantine Labs. Boonton, New Jersey	300 $210	—	—	—	—	.001-100v (5 ranges)	.5 30 μμf	±2 at any pt scale	10 cps to 150 kc	AC (1) 6J7 (2) 6SJ7 (1) 6AL5 (1)OA2 (1) 6X5	Provided: Amplifiers Output Jack and AC output control. Available: Voltage multipliers, decade amp., shunt resistors.	Type 3. Circuit: Amplifier flat within 1 db from 10-150 Kc.
	302C $245	—	—	—	—	.0001—1000v (7 ranges)	2 25 μμf	±3 (5 cy to 100 kc)	2 cps to 150 kc	BATT. OP. (5) 1U4 (1) 1R5	Provided: Amp. output jack with AC output control. Available: Voltage multipliers, shunt resistors.	Type 3. Circuit: Amplifier flat within 0.5 db.
	320 $425	—	—	—	—	.0001—320 (13 ranges)	10 25 μμf	±3	5 cps to 500 kc	AC (4) 5654 (2) 6U8 (1) 12AV7 (1) OA2 (1) OB2 (1) 5651 (1) 5V4G	Provided: Mean Sq. output; monitor jack. Available: Voltage multipliers.	Type 3. Circuit: Has built-in voltage calibrator. Reads true RMS.
Comm. Measurements Lab. Inc. 350 Leland Ave. Plainfield, N.J.	1520 $215		—	—	—	.0005—300 (6 ranges)	11 25 μμf	±2	15 cps to 250 kc	AC (4) 6AK5 (1) 5651 (2) 6J6 (1) 6X4 (1) 6AQ5	Provided: Amplifier output jack.	Type 3. Circuit: Flat within ½ db 10-400 Kc w/inverse feedback. Line voltage changes of ± 10 per cent. Does not impair accuracy.
Control Devices Inc. 8299 E. Nine Mile Rd. Van Dyke, Mich.	PTM-7 $625	—	—	—	—	.1—300 (6 ranges)	5 35 μμf	±2	5 cps to 125 kc	AC (1) 6X4 (2) 6AL5 (1) 6C4 (4) 6AK5 (1) 5651 (4) 12BH7	Remote Reset.	Type Circuit: Meter will respond immediately to an impressed signal as fast as 2.5μsec rise time and hold it with less than 1 per cent decay in ten minutes until reset.
Daven Co. Rt. 10 Livingston, N.J.	20B	—	—	—	—	.0005—500 —60+40 db (6 ranges)	2 18 μμf	±3	10 cps to 300 kc	AC (1) 5879 (1) 6AL5 (2) 6AH6 (1) OA2	Available: High Gain preamp.	Type 2. Circuit: Usable freq. up to 600 kc: resetable reference pointer use meter as null indicator; Log scale, accuracy rating is maximum error at any part on scale.
DuMont Labs. Inc. 760 Bloomfield Ave. Clifton, N.J.	405 $265	.1—1000 (8 ranges)	21	±2	Rx1—Rx1 Meg. (8 ranges)	.1—300	—	±1 db	10 cps to 300 kc	AC (1) 5879 (2) 6AH6 (1) 6AL5 (1) OA2	High Gain preamp. available. Frequency Response Curve.	Type 2. Circuit: Usable freq. response up to 600 kc: Resetable reference pointer; use meter as null indicator; Log Scale, accuracy rating subj. to FR curve maximum error at any of scale.
Federal Tele. & Radio Co. 100 Kingsland Rd. Clifton, N.J.	FT-URV $603	—	—	—	—	.02—500 (11 ranges)	.1 at 100 kc .003 at 300 mc		10 cps to 1000 kc	AC (1) 12AV7 (1) 6AN8	High Gain preamp. available.	Type 2. Circuit: Mirror scale knife edge pointer on linear scale meter accuracy same as 20B.
General Radio Co. 275 Massachusetts Ave. Cambridge 39, Mass.	1800B $415	0.01—150 (6 ranges)	10	±2	—	0.1—150 (6 ranges)	25 3.1 μμf shunt	±2	15 cps to 500 mc	AC (2) 9005 (2) 991 (1) 6SU7 (1) 6C4 (1) 6SL7 (1) 6AT6 (1) 6X5 (1) 3-4	Coaxial connector performance plots beyond 100 mc. and terminating resistor included. Available are voltage multipliers.	Type 2. Circuit: Excellent stability and accuracy with wide frequency range. Regulated power supply.
	1800B $225	0.2—500 (6 ranges)	111	±3	—	0.1—150 (5 ranges)	7.7 10 μμf shunt	±3	15 cps to 150 mc	AC (1) 6AL5 (1) 6SU7 (1) 6X4	Provided: Probe for r-f measurements; multiplier (1500 volts max) for audio and ultrasonic frequencies.	Type 2. Circuit: Shielded probe. Single zero adjustment.

LABORATORY METERS

Manufacturer	Model & Price	DC Scales: Voltage Range	DC Scales: Impedance Megohms	DC Scales: Accuracy Per Cent	DC Scales: Resistance Ranges—Ohms (CS) = Center of Scale	AC Scales: Voltage Range	AC Scales: Impedance Megohms	AC Scales: Accuracy Per Cent	AC Scales: Freq. Range	Power Tube Compliment	Accessories	Circuit Design Features
B. M. Harrison Labs. Inc. 80 Winchester St. Newton Hgh., Mass.	733 $174.50	—	—	—	—	.0005—500 (6 ranges)	20 25 μμf	±3	15 cps to 250 kc	AC (1) 5879 (2) 6AH6 (1) 5726/6AL5W (1) OA2WA (1) 2A12	Provided: Amp. output.	Type 3. Circuit: Freq. Resp. Flat .25db to 250,000 n stability ± 1 per cent for line voltages 105-125 v 50-400 cy.
Hewlett-Packard Co. 275 D. Page Mill Road Palo Alto, Calif.	400AB $200	—	—	—	—	0.003 to 300 (11 ranges)	10 25 μμf	±2 20 cy to 100 kc	10 cps to 600 kc	AC (3) 6CB6 (1) 6AH6 (1) 6BK7 (1) 6AX5 (1) 6W6 (1) OB2	Available: Capacitive divided for voltage to 22 kv-shunt resistors for current measurement.	Type 3. Circuit: Freq. Response flat within 3 per cent to 600 kc. line voltage variation of ± 10 per cent included in accuracy specs.
	400D $225	—				0.001—300 (12 ranges)	10 15 μμf	±2 20 cy to 1 mc	10 cps to 4 mc	AC (6) 6CB6 (1) 6AX5 (1) 6AU5 (1) OB2	Amplifier output terminals provided; available are HV extension to 25 KV.	Type 3. Circuit: Input cathode follower feeds 4-stage (pentode) AC amplifier using approximately 56 db of feedback in midrange and resulting in high long-term stability.
Instrument Elec. Corp. 90 Main St. Pt. Washington, N.Y.	247B $297	—	—	—	—	.5—15v (10 ranges)	50 15 μμf	±2	10 cps to 50 kc	AC (1) 5879 (3) 6AU6 (1) 6X8 (1) 6BQ7A (1) 6X4 (2) 6AQ5 (1) 5651 (1) 43PL		Type Circuit: Amp-Rectifier Meter protected against burnout; anti vibration tube mount; special freq. response features.
Metronix, Inc. Waterford, Conn.	571 $205	0.1—1000 (7 ranges)	120	±2	—	0.2—300 (6 ranges)	10 1.2 μμf	±3	20 cps to 1000 mc	AC (1) EA-52 (2) 12AU7 (1) CRM600-4 (1) 6X4 (1) OB2	Provided: Diode probe for AC measurement DC probe.	Type 2. Circuit: Freq. response flat within 1 db over range.
Millivac Instru. Corp. 444 Second St. Schenectady, N.Y.	MV17C	0.001—1000 (13 ranges)	6 to 100 mv 60 to 1000v	±3	—	—	—	—		AC (1) 6J7 (2) 6sj7 (1) 6X5 (2) NE-2	Provided: Test Leads available: DC shunt box and DC multipli. box for Hi-Z input.	Type 4. Circuit: Can be furnished with DC output sufficient to drive recorder.
	MV22B	—	—	—	—	0.00003 to 1000 (14 ranges)	1— 20 μμf (10 Meg. & 6 μμf with probe)	±3-1/2	20 cps to 10 mc	AC (12) 6AK5 (1) 6V6 (1) 6SN7 (1) 5Y3	Provided: Test Leads available: 10:1 cap. divider probe.	Type 3. Circuit: Extended freq. range to mc obtained by wideband video freq. amp. Instead of peaking coils amp. uses 12 (6AK5) tubes.
RCA Camden, N.J.	LV10 $250	1—1000 (7 ranges)	100	±3	Rx1—Rx1 Meg. (7 ranges) 20 (CS)	1—300 (6 ranges)	15 2 μμf	±3	18 cps to 700 mc	AC (1) 5751 (1) 201C (1) 6X4 (1) 6AL5	Provided: AC probe DC, ohms, common test leads. Available: 30kv DC probe; 1500v AC adaptor. Type N probe to coaxial cable.	Type 2. Circuit: Freq. Response 18 cps to 700 mc ± 1 db. Line voltage may vary ± 15 per cent without impairing accuracy db scale.
Southwestern Ind. Electronics 2831 Post Oak Rd. P. O. Box 13058 Houston 19, Texas	R-1 $620	0.001—1000 (7 ranges)	10	±1	Rx1—Rx10⁶ (7 ranges)	0.001—1000 (7 ranges)	10 20 μμf	±3	10 cps to 100 kc	AC (9) 12AU6 (1) 6AS7 (1) 5U4 (1) 5651 (1) 12AU7	Provided: DC amplifier output terminals gain 12 or 200; 6 or 100	Type 1 & Type 3. Circuits: Freq. response flat ½ db to 100 kc. zero drift: less than 1 per cent per hour on voltage ranges; less than 3μ per hour on mv range.
Waveforms Inc. 333 Sixth Ave. New York 14, N.Y.	520A $200	—	—	—	—	0.001—300 (12 ranges)	10 24 μμf	±3	10 cps to 2 mc	AC (4) 6AK5 (1) OA2 (1) 6X4	Output jack included for amplifier output; db scales —60 to +50 dbm.	Type 3. Circuit: Four-stage AC amplifier plus full-wave bridge rectifier. Amplifier gain of 1000 (60db) at 0.001 volt range and output voltage of 1 volt rms.

form. Amplifier gain stability is greatly improved by feedback, especially when more than one stage of amplification is used. Grid current, which is an inherent characteristic of the input tube, is not changed essentially by a feedback, as is sometimes believed.[1] In spite of grid-current limitations of around 10^{-11} amp., many special applications using electrometer type tubes are in commercial use. When the single-stage balanced-bridge is preceded by a rectifier, it becomes a Type 2 circuit.

Circuit Type 2: A rectifier plus a single-stage balanced-bridge d-c amplifier make up this circuit. It is widely used for providing a combination of a-c and d-c volt ranges. It can be readily adopted to resistance and peak-to-peak ranges, especially for service work. When used for laboratory a-c measurements, this circuit is capable of covering frequency range up to 300 mc, if maximum voltage sensitivity is not a prime consideration. The non-linearity of the rectifier limits accuracy in low-voltage measurements. Lowest full scale range is usually 0 to 1 v, if the wide-frequency capability is retained.

Circuit Type 3: Particularly suitable for measuring small a-c voltages. This type employs an a-c amplifier-plus-rectifier circuit. It has wide use in audio and low frequency applications where it is often provided with logarithmic meter-indications. For laboratory use, it appears most often in an arrangement having a frequency-compensated, constant-impedance input for a multi-stage a-c amplifier, with large amounts of feedback to stabilize gain and expand band-width. Shunt capacitance in the input circuit is fairly high, but generally acceptable for applications up to 10 mc. Lowest

full-scale ranges are usually around 0 to 10 mv. Overload protection is obtained from the buffer action of the amplifier.

Circuit Type 4: This type uses a modulator for conversion of dc to ac, plus a rectifier circuit. It is capable of very high d-c voltage sensitivity at a high input impedance. With chopper d-c to a-c conversion, only a narrow frequency response of the a-c amplifier is required, since it need cover only the driver frequency as expanded by the rate of the d-c input variation. Use of large amounts of feedback in the multi-stage a-c amplifier allows improvement of stabilized gain and higher input impedance. In a pH application, input impedance can be made to exceed 100 megohms.

When a modulator of the capacity type is used for d-c to a-c conversion, an input impedance as high as 10^{15} ohms is achieved and measurement of very small voltages from a high-resistance source can be made. Current measurements in the μμ amp range are attainable. At measurement levels of around 100 mv, zero stability of this circuit becomes better than that of the chopper-type.

The less common galvonometer-type modulator allows measurements full-scale as low as 0 to 10 μ amp at a 50 ohms input resistance, with long-term stability of ±0.2 mv.[1]

Special Group

Specialized applications of voltage measurement by electronic means, and many novel circuit types are included in this group. Examples cited are described in greater detail in the references.

- Digital VTVM displays the readings on a 3, 4 or 5 digit counter operated by a servometer.[2]
- Automatic range-switching feature replaced manual operation of the range switch.[2]
- Electrometer type of VTVM is capable of measuring d-c currents in the μμ amp range using special low grid-current electrometer tubes, with an input resistance of over one hundred million megohms.[3]
- Transistorized VTVM with its low battery-power consumption and compact construction is well adapted to field work. The meter is also free from the disturbing "beating" found in 60 cycle powered meters.[4]

Other examples to be found in the Special Group include voltage-calibrated oscilloscope presentation; the null detector, the tuned VTVM, and the built-in VTVM for compact panel mounting.[5]

References

1. The Modern Valve Voltmeter, Gerald Hitchcox, *British Communications & Electronics*, May 1956.
2. New Easy-to-Read VTVM's, Robert F. Scott, *Radio Eelectronics*, April 1956.
3. Sensitive Electrometer VTVM, ELECTRONIC DESIGN, March 15, 1956.
4. Ultra-Sensitive A-C Transistor Voltmeter, ELECTRONIC DESIGN, April 15, 1956.
5. Using Built-in-VTVM's, Jay Salz, ELECTRONIC DESIGN, April 1955.

Potter

Model 905
Digital Magnetic Tape Handler

(75 inches per second with 3 msec starts and stops)

Meets all requirements for speed and convenience in processing large quantities of digital data

The Potter Model 905 is the result of the most extensive study of data-processing requirements. It combines high speed with complete reliability and easy accessibility to all wiring and parts. The Potter machined bronze head with precisely aligned gaps provides dimensional stability and minimizes digital drop-outs caused by oxide pickup.

Tape widths:

- A – ¼" (2 or 3 channels)
- B – ½" (6 or 7 channels)
- C – ⅝" (up to 8 channels)
- D – ¾" (up to 10 channels)
- E – 1" (up to 13 channels)
- F – 1¼" (up to 15 channels)

Speed combinations:

- J – 30 and 7.5 inches per second
- K – 60 and 15 inches per second
- L – 75 and 18.75 inches per second
- X – Special (speeds up to 75 inches per second in ratios of 2 to 1, 3 to 1 and 6 to 1 are available on special order. Other speed combinations can be accommodated.)

Start time:	3 milliseconds
Stop time:	3 milliseconds
Reel sizes:	8" or 10½" standard NAB reels. Adaptors for other types can be provided.
Control:	Front panel pushbuttons or remote control contact closure and pulses.
Weight:	100 pounds
Dimensions:	Panel, width . . . 19"; height . . . 24½" Depth behind panel . . . 13½" Depth in front of panel . . . 3½"
Power Requirements:	110 to 120 volts, 60 cps, 400 watts.

For more information, write, wire or phone your Potter representative or the factory.

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CIRCLE 21 ON READER-SERVICE CARD FOR MORE INFORMATION

Time Rate of Change Meter

VERY slow time rate of change is measured by this electromechanical computer. Designed originally to provide rapid computation of the erection time of gyros, the instrument can be used for computer ramp rate operation or generation, dc amplifier drift rate measurement, contact potential change recording, and gyro drift and precession indication. Accuracy of the time-rate-of-change meter is two per cent.

The Deltameter, manufactured by Milgan, Inc., Dept. ED, 15506 S. Lakewood Blvd., Paramount, Calif., samples a voltage pulse at time t, stores the sample until time $t + \Delta t$, when it again samples the voltage being measured, compares the two samples

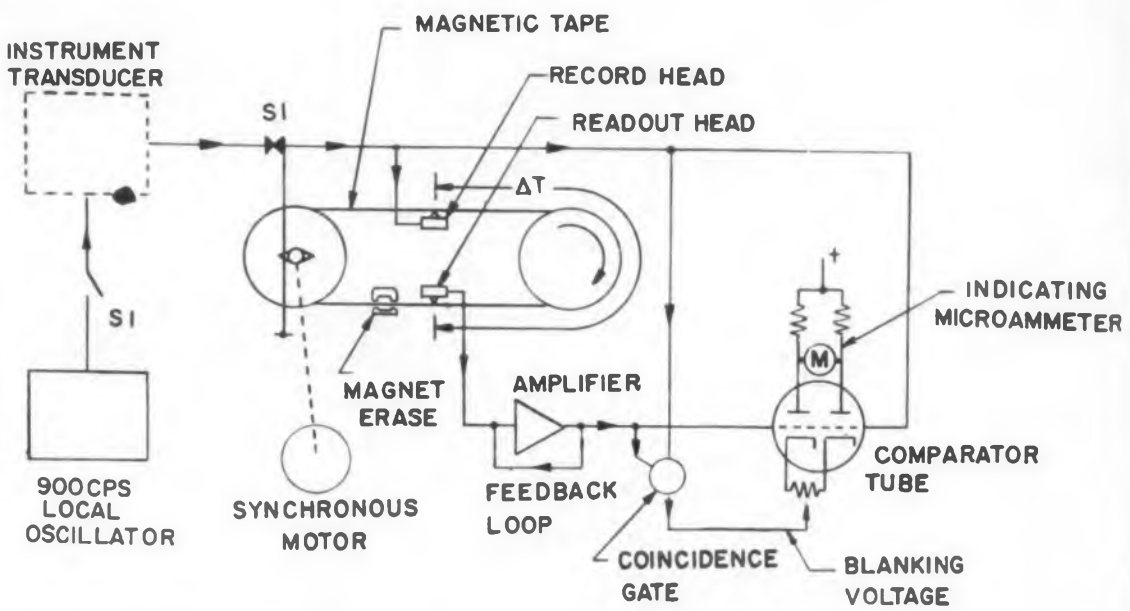

Fig. 1. System diagram of the Deltameter. To measure small changes in voltage, one signal is recorded and Δt later fed to the comparator tube via the readout head. A new signal is simultaneously recorded and fed to the other grid of the comparator. The difference in amplitude between the old and new signals is revealed by the microammeter.

nd shows the algebraic difference between he two. A controlled time interval Δt be- ween the two samples provides the other arameter necessary to calibrate the meter n values of dE/dt. In operation, a syn- hronous motor drives a short loop of mag- etic tape at a rate determined by the char- acteristics of the variable under observa- tion. As in Fig. 1, a commutator on the mo- tor shaft synchronizes the time of recording a pulse on the tape 180 deg from the read- out station and simultaneously applies a second voltage pulse from the source through an attenuator to one of the com- parator tube grids. The readout head picks up the first pulse at the same time.

After the tape passes the readout head, it is demagnetized by a permanent magnet to prepare it for the next cycle. Sampling rate is optional, and may be set for intervals of 1/2 sec to one or more hours. With ex- tremely long sampling intervals like these, the commonly used device of charging a ca- pacitor is not practical because of leakage; but the magnetic tape fulfills this function adequately.

At the time for comparing pulses from different time eras a coincidence tube re- moves a blocking bias from the comparator only while *both* pulses are present. Such protection permits enough sensitivity for the detection of small differential voltages, but saturation will not occur as the result of the full magnitude of either signal being applied to one grid when the two pulses do not coincide exactly. A 6BE6 tube with two control grids shielded from each other is used as a gate. Unless the grids are excited together, the comparator tube is biased nearly to cutoff. With the arrival of pulses on both grids of the 6BE6, the tube draws normal plate current, reducing the bias voltage on the comparator and permitting it to respond to voltages on its grids.

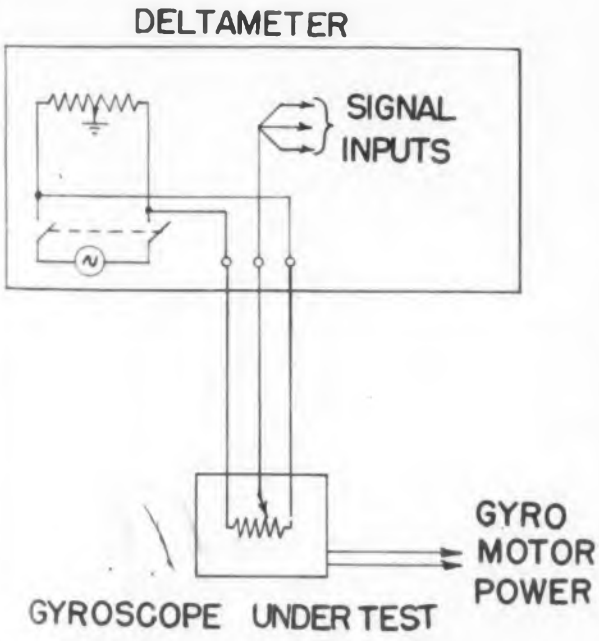

Fig. 2. Block diagram of gyro- scope test setup. An internal 900 cycle oscillator is used to excite the gyro potentiometer.

The Deltameter will handle input signals over the range of two to 25 mv at 20 to 20,- 000 cps, with standard sampling time inter- vals from 0.1 to 10 sec. Longer intervals are available on special order; the interval is a function of the magnetic tape speed and length. Input impedance to the device is 5.5 K at 1000 cps and the cathode follower output impedance is 1 K. Five v output may be used to drive a meter or feed a recorder or control system. Weighing 18 lb and measuring 12-1/2 x 7 x 9-3/4 in., the instru- ment may be rack-mounted.

An extension of the operating principle of the Deltameter permits computing the total elapsed time a repetitive operation will con- sume. The meter may be simply calibrated to read total time, even if the rate of change with respect to time is not really linear. Consider a gyroscope being precessed 20 deg from the vertical and allowed to return of its own volition. The meter might indi- cate a differential voltage equivalent to a precession rate of 5 deg per minute. That point would then be marked *four minutes*, and other points similarly located. If the rate of change is not linear, each point may be located by timing the total precession from different starting points and marking the points empirically. A few points marked on the scale are usually sufficient for rea- sonably accurate interpolation.

For operation during gyro testing the procedure follows that given above. The instrument is powered by the 115 v line, and a potentiometer and its wiper are con- nected to the three panel jacks as in Fig. 2. The operator precesses the gyro to the spe- cified limit, releases it and immediately the meter indicates the total time that would elapse before the gyro returned to its nor- mal position.

An internal 900 cps oscillator with suf- ficient output to excite low impedance dc potentiometers or other passive trans- ducers is included in the Deltameter. The ac signals from synchros are fed directly into the input without using the local oscil- lator.

For further information on this time-rate- of-change meter, turn to the Reader's Serv- ice Card and circle **425**.

Second of two parts. This series was designed to present practical design methods for transistor-resistor-capacitor filter networks. Part I included a brief but adequate review of modern network synthesis; and described the Negative Impedance Converter method of synthesis. The NIC scheme is attractive because it can be used for any number of complex poles without too much algebraic effort, and because the active and passive portions of the network are isolated. Positive feedback must be used, however, and the resultant sensitivity is poor.

The RL-RC method uses negative feedback, with a consequent better sensitivity and stability. In this article the RL-RC Synthesis method is given in sufficient detail to permit immediate exploitation by the engineer.

RC Transistor Network Design—II

Isaac M. Horowitz
Polytechnic Institute of Brooklyn

THE METHOD of RL-RC synthesis[1,2] involves the use of negative feedback and therefore results in better sensitivities than the Negative Impedance Converter method described in Part I of this series. The block diagram of Fig. 1 and eq. (1).

$$F(s) = \frac{I_o}{E_i} = \frac{y_{21a}\, y_{21b}}{y_{22a} + y_{11b}} \tag{1}$$

are used as starting points. The short circuit transfer admittance of A is y_{21a}; y_{22a} is the short circuit output admittance of A; and y_{11b} is the short circuit input admittance of B. A breakdown is made:

$$y_{22a} + y_{11b} = \frac{s^2 + 2\xi\omega_n s + \omega_n{}^2}{s + \omega_n} = s + \omega_n - \frac{2\omega_n s\,(1-\xi)}{s + \omega_n}, \tag{2}$$

and we pick

$$y_{22a} = s + \omega_n \text{ and } y_{11b} = \frac{-2\omega_n s\,(1-\xi)}{s + \omega_n}$$

In this case the B box of Fig. 1 is *not* the negative of an RC structure as in the NIC method. It is instead an RL structure, and may be realized by transistors, resistors and capacitors. The optimum design technique for the synthesis of a single complex pole pair has been developed and the results are presented here in sufficient detail to permit immediate use by the engineer.

First the model of the active element or elements is considered, in Fig. 2. The single transistor in the common emitter connection has the parameters:

$$G_1' = \frac{1-\alpha}{r'_e}, G_2' = \frac{r_e}{r_e'\, r_c}, G_3' = \frac{r_b}{r_e'\, r_c}, g = \frac{\alpha}{r_e'} \tag{3}$$

where

$$r_e' = r_e + r_b\,(1-\alpha)$$

The transistor pair consisting of a common collector connection followed by a common emitter connection (Fig. 3) has the following parameter values:

$$g = \alpha_2/r'_{e2},\ G_1' = \frac{(1-\alpha_1)\,(1-\alpha_2)}{r'_{e2}} + \frac{1-\alpha_1}{R} + \frac{1}{r_{e1}}$$

$$G'_2 = \frac{1-\alpha_1}{r_{c2}}, G_3' = \frac{r_{e2} + r_{b2} + r'_{e1}}{r_{c2}\, r_{e2}} \tag{4}$$

providing $r'_{e2} \gg r'_{e1}\,(1-\alpha_2)$, $r_{e1} \ll r_{c1}\,(1-\alpha_1)$, $R \gg r'_{e1}$, $r_{e2} \gg (r_{e1} + r_{b2})\,(1-\alpha_2)$.

The ideal transistor, from the viewpoint of this synthesis procedure would have $r_e = r_b = 0$, $r_c =$ infinity. The non-ideal nature of the transistor imposes limitations on realizable Q's, as will be seen.

For realization of $\frac{E_o}{E_i} = \frac{K}{s^2 + 2\,\xi\omega_n s + \omega_n{}^2}$, the network prototype is shown in Fig. 4. The highlighted portion is the transistor(s) contribution to the network. Obviously it is necessary that $G_1 \geq G_1'$, $G_2 \geq G_2'\, G_3 \geq G_3'$. The degree in which G_1 exceeds G_1' is a measure of the sensitivity of G_1 to that part of it due to the transistor. Thus if $G_1 = 5\,G_1'$, then if G_1' changes by x per cent, the change in G_1 is x/5 per cent. We make the following definitions:

$$\beta = \frac{g}{G_1'},\ (\beta \text{ is the short circuit current gain}),$$

$$\mu = \frac{G_1}{G_1'},\ \int_2 = g/G_2,\ \int_3 = g/G_3. \text{ (Therefore } \mu_{min} = 1, \tag{5}$$

$$\int_{2\,max} = g/G_2',\ \int_{3\,max} = g/G_3').$$

The values of μ, $\int_2$ and $\int_3$ are up to the designer and are chosen by him according to the sensitivities desired due to environmental conditions, and tolerances permitted in the specifications. A design example will later illustrate the choice of these parameters. For the most efficient design in terms of gain sensitivity, they should however be chosen so as to satisfy the following inequality with the equal sign:

$$Q^2 = \frac{1}{4\xi^2} \leq \frac{\int_2 \int_3}{4\,(\int_2 + \int_3)}\left(\frac{1}{\int_3} + \frac{\mu + \beta}{\mu \int_2 + \beta}\right) \tag{6}$$

If (6) is satisfied with the inequality sign, the sensitivities may be improved up to the point that eq (6) is satisfied with the equal sign. Let us investigate eq (6) to find whether there is an upper limit on the Q realizeable by this method. If sensitivity is sacrificed for the sake of large Q, $\mu = 1$ and eq (6) becomes

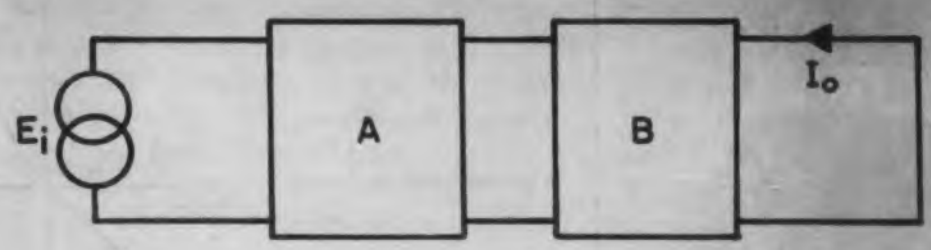

Fig. 1. Partitioning of circuit: The ratio of I_{out} to E_{in} is a function of the short circuit-transfer, output and input admittances of *A* and *B*.

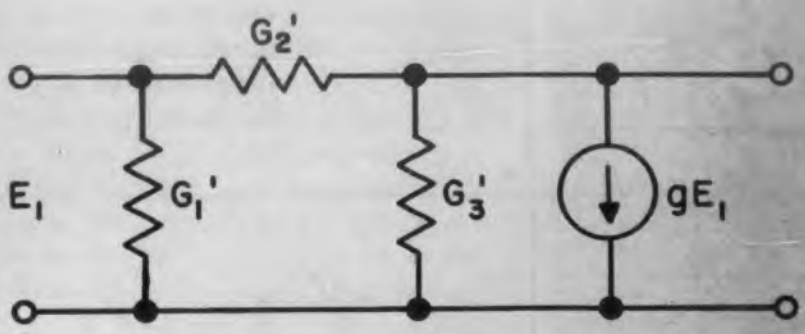

Fig. 2. General active structure of a low frequency transistor model.

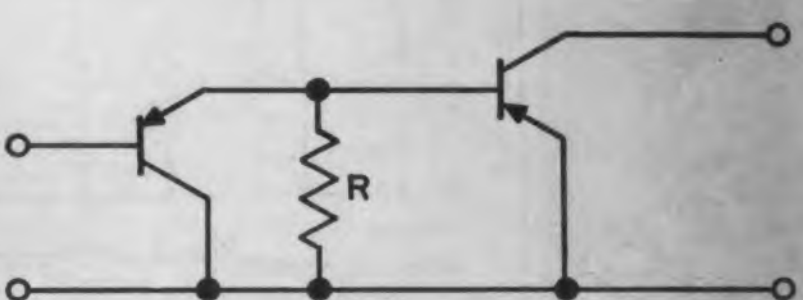

Fig. 3. Simple dual transistor amplifier.

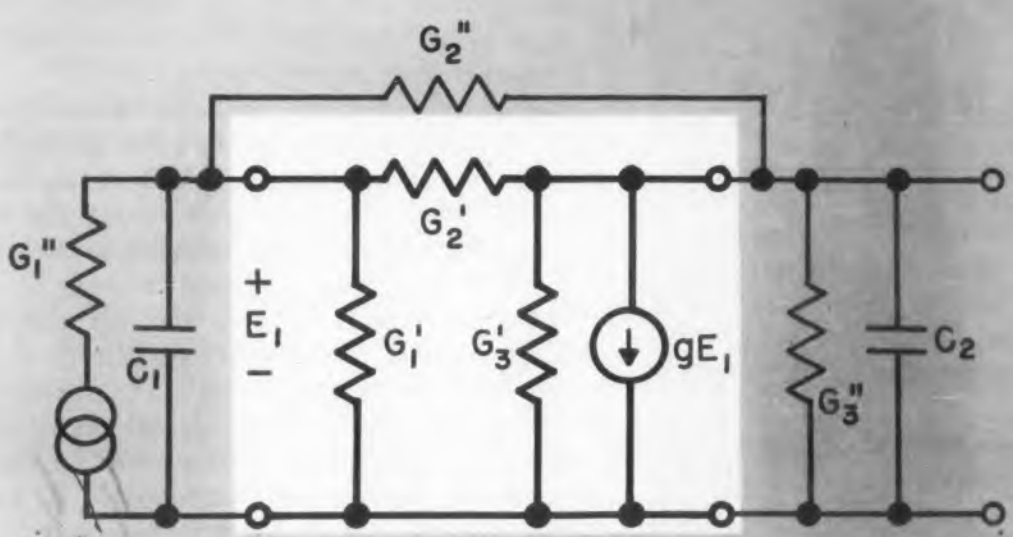

Fig. 4. Network prototype of the synthesis of $K_s^2 + 2\xi\omega_n s + \omega_n^2$. The highlighted area represents the transistor(s) contribution to the network.

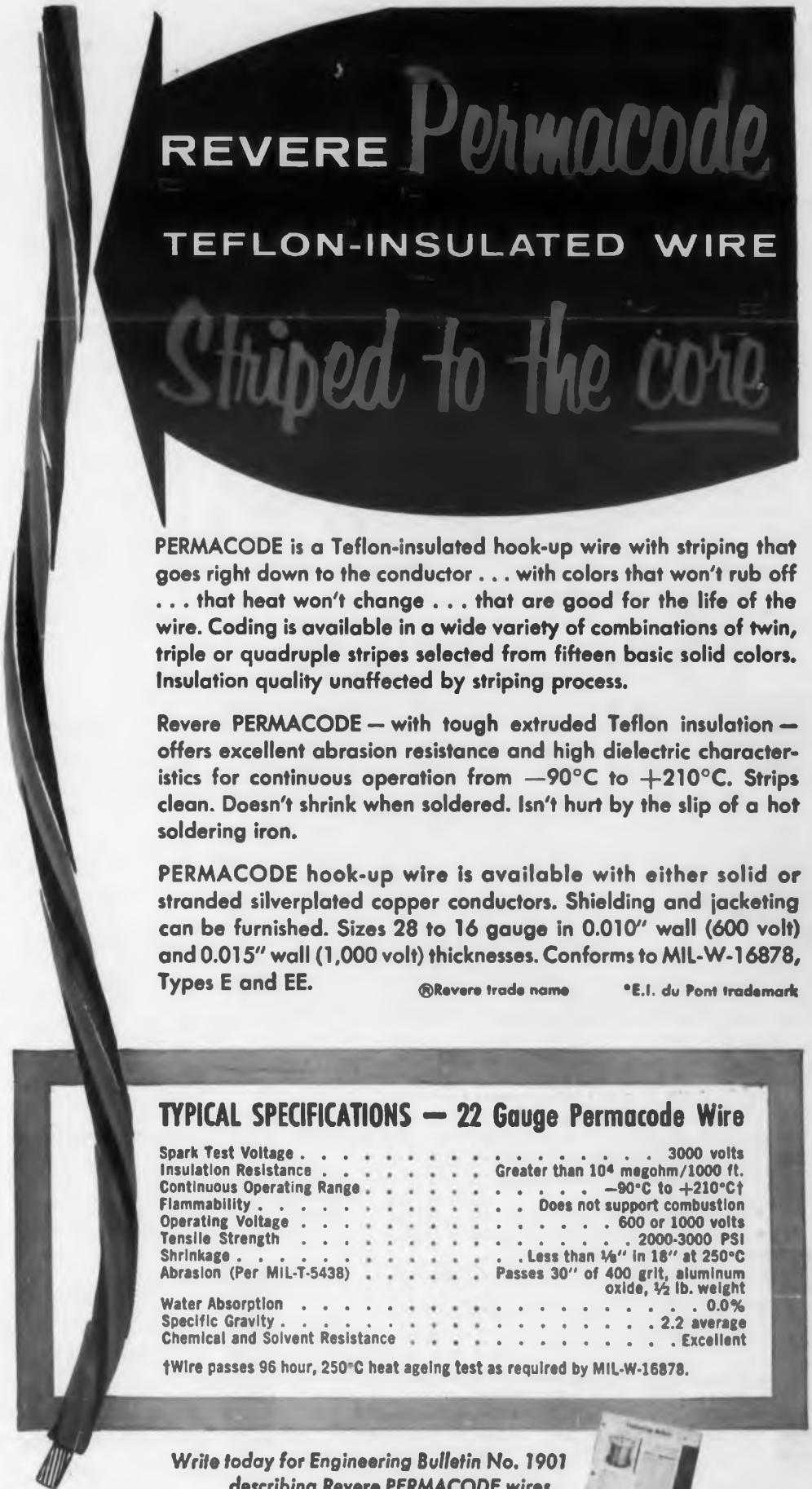

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Table 1 — Values of elements of Fig. 4.

$C_3 = 1$ F. $G_3 = v_2 \xi \omega_n$, $G_2 = \xi \omega_n (2 - v_1 - v_2)$, $g = \dfrac{v_3 \omega_n}{v_1 \xi}$,

$$G_1 = \frac{\omega_n (v_3 - 1 + v_1 v_2 \xi^2)}{v_1 \xi \left[\dfrac{\left(\dfrac{1}{v_1 \xi} - v_2 \xi \right)}{(2 - v_1 - v_2) \xi} - 1 \right]}$$

$$C_1 R_1 = \frac{v_3 (v_1 \xi)^{-1} - \xi (2 - v_1 - v_2)}{\omega_n^2 (v_3 - 1 + v_1 v_2 \xi^2)}$$

When (6) is satisfied with equality sign, $v_1 = 1$, $v_2 = \dfrac{\int_2}{\int_2 + \int_3}$, $v_3 = \xi^2 \dfrac{\int_2 \int_3}{\int_2 + \int_3}$. The impedance level of the network may be raised by any desired amount, say m, by multiplying the value of every resistance by m and dividing the value of every capacitance by m.

Table 2 — Sensitivity of pole at $s_o = -\xi \omega_n + j \omega_n \sqrt{1 - \xi^2}$ to variations in element values. ($S_k^{s_o}$).

Element	Real part of $S_k^{s_o}$	Im. part of $S_k^{s_o}$
G_3	$-0.5\, v_2 \xi \omega_n$	zero
C_3	$\xi \dfrac{\omega_n}{2}$	$-0.5\, \omega_n$
g	zero	$0.5\, \omega_n$
R_2	$0.5\, \omega_n (1 - v_2 + v_3^{-1})\, \xi$	$-0.5\, \omega_n$
G_1	$-0.5\, \omega_n (v_3 - 1)(v_3)^{-1} \xi$	zero
C_1	$0.5\, \xi \omega_n$	$-0.5\, \omega_n$

$$Q^2 \leq \frac{\int_2 \int_3 \beta}{4 (\int_2 + \int_3)(\int_2 + \beta)} \qquad (7)$$

By adding more transistors it is possible to obtain $\beta >> \int_2 >> \int_3$ leading to $Q^2 \leq 0.25 \int_3$. This in practice leads to Q's in the order of 15 unless special methods are used to reduce G_3'. In order to eliminate the bias conductance as a factor in determining $\int_{3max}$, the collector current may be supplied through a separate transistor.

The element values of the network of Fig. 4 are given in Table 1. The pole sensitivity (for the pole at $-\xi\omega_n + j\omega_n\sqrt{1-\xi^2}$) to each circuit element has been calculated and is given in Table 2. The table suggests that C_1, C_3 or R_2 may be used to align the circuit for correct center frequency (assuming a band pass design), followed by the adjustment of G_1 or G_3 for correct bandwidth.

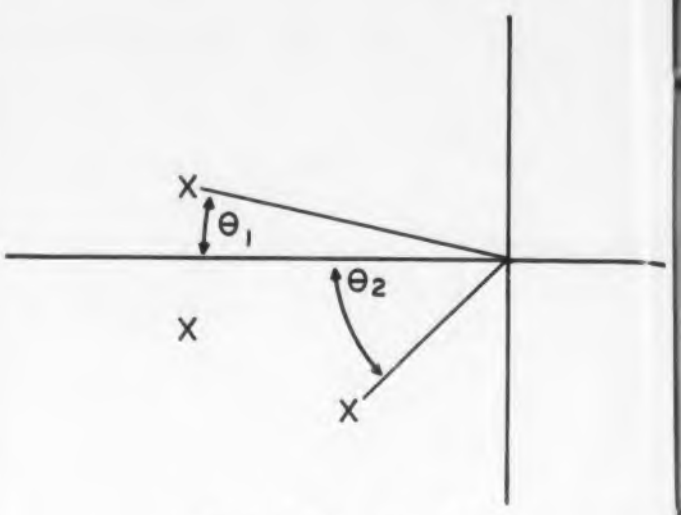

Fig. 5. The sum of the two angles shown is less than 90 deg. for RL-RC synthesis.

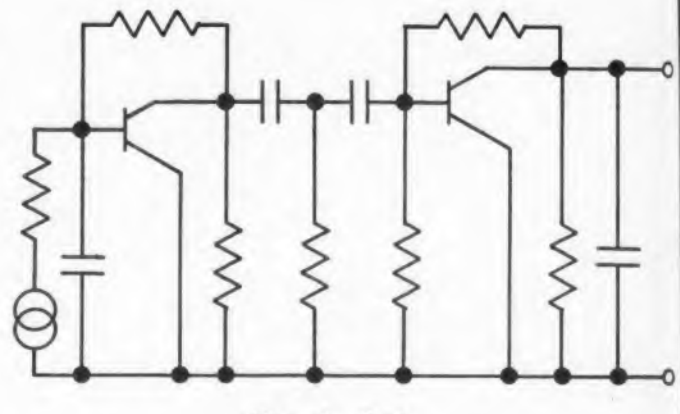

Fig. 6. Prototype network for two complex pole pairs.

The RL-RC method may also be used for two pairs of complex poles providing that the total angle in Fig. 5, $\vartheta_1 + \vartheta_2 < 90$ deg. In order to realize total complex pole angles more than 90 deg, the RL-RC design philosophy may be extended to the RL-RC-RL structure. It may be proven that any two pairs of complex transfer function left half plane poles may be realized in such a structural form. The network of Fig. 6, is a typical result. The previous limitations on Q_{max} due to the non-ideal nature of transistors (and tubes) apply here as well. Another way of realizing higher-order functions is to cascade single pole-pair structures with transistors in between for isolation purposes.

Design Example

The use of the data of Tables 1 and 2 is now illustrated by consideration of a typical design problem. The specifications call for a bandpass filter (in-

volving only one pole-pair) with a center frequency of $2\pi 100$ rps and a bandwidth of $2\pi 20$ rps. The maximum tolerable drift in center frequency is 2 per cent. The maximum imaginary part of Δp_0 is 4π. The maximum tolerable drift in bandwith is 5 per cent. The maximum real part of Δp_0 is π.

■ **Design.** Design is attempted by means of a common collector connection followed by a common emitter, with the typical parameter values:

$$r_e = 30,\ r_b = 500,\ r_c\ (1.5)\ 10^6,\ \beta = 60.$$

Let us assume that operating conditions are such that a maximum change of 20 per cent in each of these transistor parameters may be expected. The design will be made on the assumption that all the shifts in the pole positions due to the parameter variations are in the same direction. More careful analysis may permit very considerable relaxation of this point. Study of the G_1', G_2', G_3' parameters in relation to r_e, r_b, etc., suggests that the variations in g', G_1', G_2', G_3' may be as much as 20, 40, 40 and 30 per cent. If no external resistors are added to the emitters g' is g. It will be found that G_2'' will completely swamp out G_2' and therefore the variation in $G_2 = G_2' + G_2''$ is negligible. Using Table 2 and assuming $\int_2 \sim \int_3$ (this is usually the optimum choice), the contributions of the variations in g', G_1', G_3' to Δp_0 are:

Parameter	Real part of Δp_0	Im. part of Δp_0
g'	zero	20π
G_1'	2π	zero
G_3'	1.5π	zero.

Accordingly, in order to satisfy the specifications with respect to drift in center frequency, the sensitivity of g to g' must be less than 0.2. This is achieved by adding resistance externally to the emitter of approximately 5 times the nominal value of emitter resistance. To satisfy the specifications with respect to bandwith, the sensitivity of G_1 to G_1', G_3 to G_3' must be reduced in each case by a factor not less than 4. Now $\int_{3max}$ is approximately 2000. Therefore we choose $\int_3$ as 500. From eq (4),

$$\frac{\mu \int_2 + \beta}{\mu + \beta} \leq \frac{\int_2 \int_3}{4\,Q^2\,(\int_2 + \int_3)}, \text{ leading to } \mu \leq \frac{1.5\beta}{500}$$

A reasonable value for β is about 2500, and therefore $\mu \sim 7.5$. The voltage gain at the center frequency is about 6.5 for an output load of approximately 75,000 ohms. The above represents a rough first approximation in order to obtain the tentative design values.

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1. Synthesis of Active RC Transfer Functions, I. M. Horowitz, Polytechnic Institute of Brooklyn, MRI Research Report R-507-56, PIB-437, Nov. 8, 1956. Brooklyn, N. Y.
2. Active RC Transfer Function Synthesis by means of Cascaded RC and RL Structures, I. M. Horowitz, Polytechnic Institute of Brooklyn, MRI Research Report R-583-57, PIB-503.

For further information circle 400.

Servo Amplifiers at High Ambient Temperatures

P. M. Thompson and J. Mitchell

Defense Research Board,
Ottawa, Canada

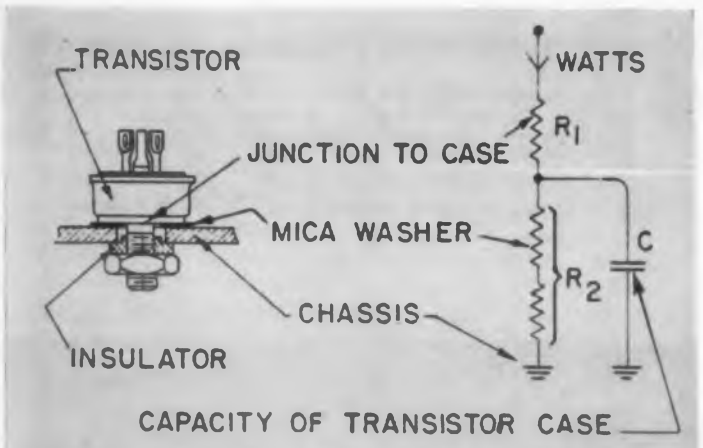

Fig. 1. Equivalent circuit of heat path from junction to chassis.

SINCE airborne equipment requires operation at high ambient temperatures, special considerations must, as such, be given to the design of equipment to be used under this condition. The procedures to be set forth below describe the design of a three-stage push-pull germanium transistor amplifier which delivers 3 w to a 400 cps servo motor. These procedures can be and have been utilized in designing other equipment.

Temperature Considerations

The maximum safe junction temperature for the readily available types of germanium transistors is between 90 and 95 C. If the ambient temperature is to be 85 C, the junction temperature must not be permitted to exceed this point by 5 or 10 deg.

An effective heat path from the transistor junctions, and minimum power dissipation (both mean power and peak instantaneous power) are conditions which will keep the temperature rise to low values. Peak instantaneous power is considered because most of it is dissipated at the collector junction where it can do the most harm. The thermal time constant of the junction may be quite short.

The difference between the ambient and junction temperature may be kept small by having a good thermal path from the junction and by holding the power dissipation to a low value.

Electrical network theory may be used to treat heat conduction. The thermal equivalent of Ohm's Law is

$$\frac{\text{Temperature Difference (deg C)}}{\text{Thermal Current (Watts)}} = \text{Thermal Resistance}$$

where thermal resistance is in degrees centigrade per watt.

The equivalent circuit for the heat conduction path from the collector junction to a chassis is shown in Fig. 1. The chassis is an infinite heat sink, or thermal ground, and the transistor case is a capacity (C). This capacity prevents rapid fluctuations in temperature, but has no effect on the mean temperature. The value of the junction to case thermal resistance, R_1, can often be found from the manufacturer's data. R_2 consists of a mica washer and a component due to the chassis.

This circuit is only an approximation but will lead to a conservative rating of the transistor.

The peak junction temperature is a function of both the peak and mean dissipations and is given by

$$\text{Junction Peak Temperature} = \text{Mean Watts} \times R_2 + \text{Peak Watts} \times R_1$$

The case temperature is calculated from the following:

$$\text{Case Temperature} = \text{Mean Watts} \times R_2$$

Switching methods and the use of an unfiltered, full-wave rectified power supply may serve to keep the mean power dissipation low. Since the switching methods are made difficult by the type of load

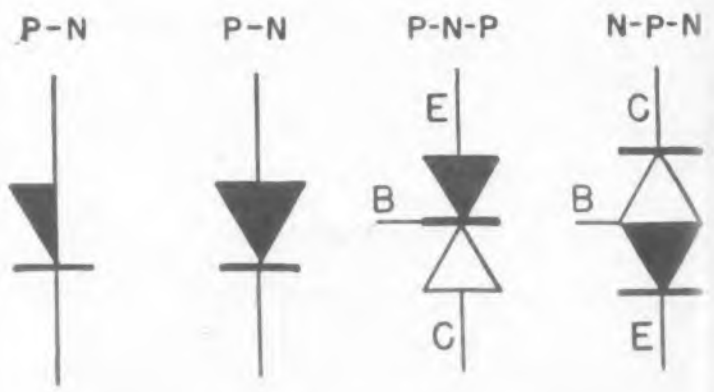

Fig. 2. Symbols for point junction transistors.

an induction motor presents, use of a power supply will be investigated with regard to the effect it has on the dissipation of the collector of an ordinary Class B amplifier.

Consideration will first be given, however, to the use of an ordinary supply.

With a sine wave output at maximum amplitude each collector will swing from zero to twice the battery voltage and the current will flow for 1/2 cycle. The peak value of the power will be about one-half the battery voltage times the peak current.

The use of an unfiltered supply will permit current flow when the collector voltage is almost zero and the power dissipation is negligible. This is only the case at maximum output.

In the typical design the maximum value of mean power dissipation for the supply is 1/2 w, and for the rectified supply 1/3 w.

In the case of the peak instantaneous power dissipation the maximum value is the same for both types of supply, namely 1.5 w. (If switching techniques had been used to obtain a low mean dissipation, the maximum peak dissipation could be as high as 5 or 6 w.)

With these values for power dissipation the rise in temperature of the junction over the chassis may be calculated. The value of R_1 is for an H5 transistor. R_2 is a 2 mil mica washer. For the unfiltered supply the temperature rise is 4.6 C, and for the ordinary dc supply 5.3 C. (For switching techniques the same treatment would yield a rise of 12 C).

Design will then be made on the basis of the unfiltered supply which is perhaps the easiest to obtain and would give the lowest junction temperature (90 deg. for the 85 C ambient).

Designing the Amplifier

The three stage amplifier design will now be considered. Design for aircraft will emphasize efficiency, reliability, and stability at the expense of some gain. The amplifier, furthermore, must be able to withstand the leakage current at 90 C.

For economical reasons direct rather than transformer coupling shall be used. A transformer input, however, is utilized to protect the transistors. The symbols used for various transistors are indicated in Fig. 2, with the junctions appropriately labeled.

Initially, three transistors are coupled directly from the collector to base beginning with a pnp, followed by an npn, followed by another pnp in order that their complementary characteristics may be used, as in Fig. 3. It is expected that the gain of this amplifier will vary with current and consequently feedback is applied. Introduction of R_1 will not affect the current gain but will control and reduce the voltage gain. The input impedance is increased, however, and is dependent upon the current gain. The value of R_1 may be computed on the basis of peak current and peak voltage. If the

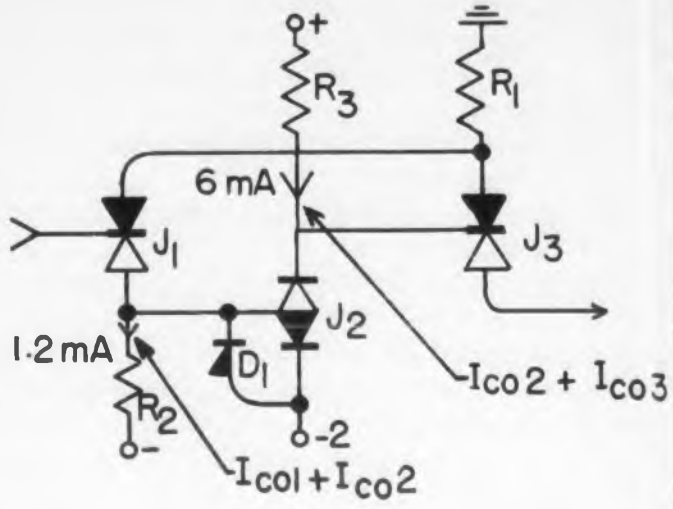

Fig. 3. R_1 reduces the voltage gain and increases the input impedance. Diode D_1 prevents the base of J_2 from going too far negative. R_2 and R_3 draw off a current greater than the maximum leakage current.

supply voltage for the 3 w amplifier is 26 v peak, the peak output is 250 ma. This value will approximate the peak current in R_1. If a peak input voltage of 1 v is selected this will then be the peak value of voltage across R_1. R_1 will then be 5 ohms.

An emitter voltage for J_2 must be chosen which will keep the collector dissipation low and at the same time prevent J_2 from saturating. Inspection of the characteristics of various suitable transistors for J_2 and J_3 indicates that -2 v for the emitter of J_1 will suffice.

Maximum values of the leakage current which the transistors can be relied upon not to exceed are the following: for J_1, 200 μa; J_2, 1 μa; J_3, 5 μa.

The method used in dealing with these leakage currents should be employed in negative feedback amplifiers only. The resistors R_2 and R_3, connected

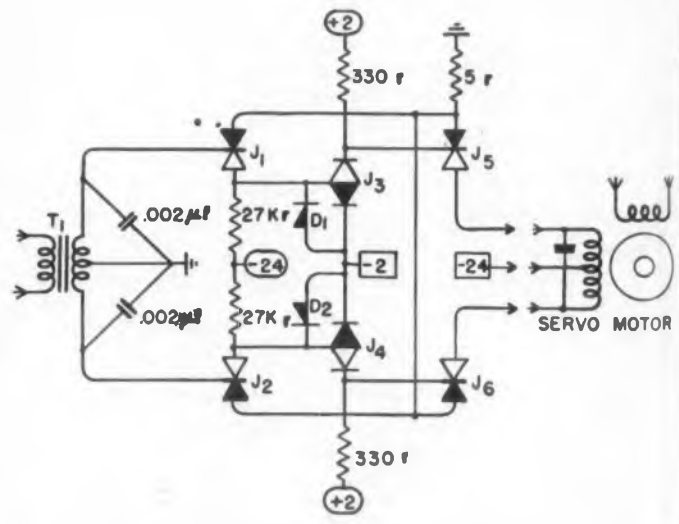

Fig. 4. The complete circuit in push-pull.

to negative and positive supplies, draw off a current greater than the maximum I_{co} (1.2 ma and 6 ma in the example). Diode D_1 prevents the base of J_2 from going so negative that the emitter junction would break down. Design is complete when two circuits are used in push pull, as illustrated in Fig. 4 R_1 may be shared by the two halves since only one-half of the circuit is conducting at a time.

One difficulty encountered is the appropriate choice of an npn transistor. A transistor with a thermal resistance from collector to case of about 4 mw/deg C is selected which would be rated at about 300 mw. It should have an α better than .96 at 30 ma, and an I_{co} less than 300 μa at 95 C. A transistor of this type is not difficult to make. A photograph of the completed unit is shown in Fig. 5.

Fig. 5. The complete servo amplifier unit.

Conclusion

It is possible to design transistor servo amplifiers to operate at ambient temperatures close to the maximum storage temperature of their transistors if both the mean and peak power dissipated at the junctions are kept low. Provision must also be made to handle the high leakage currents. An approach of this sort is not limited to servo amplifiers but may be applied to many other economical and reliable designs where transistors are used at high ambient temperatures.

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Long delay measurements with an accuracy of ±.01 per cent.

Pulse Timer

TIME delays as long as 10,000 μsec are measured with an accuracy of ±.01 per cent. "Jitter"—an inherent problem in many long-delay circuits—is less than 0.001 μsec. Measured delay time is presented in numerical form by a combination of decade counters and a digital dial.

The TL1 Model PT-244 Pulse Timer is a paired trigger generator which provides a fixed and a delayed pulse. It incorporates the circuit design used in the Hazeltine Model 1754 Precision Time Measuring Equipment and is manufactured by Telectronics Laboratory, Inc., Westbury, L.I., N.Y. A crystal controlled oscillator produces 10 μsec pulses for both fixed and delayed pulse outputs.

A short gate in the fixed pulse circuit selects one pulse for the fixed marker (Fig. 1). The same 1

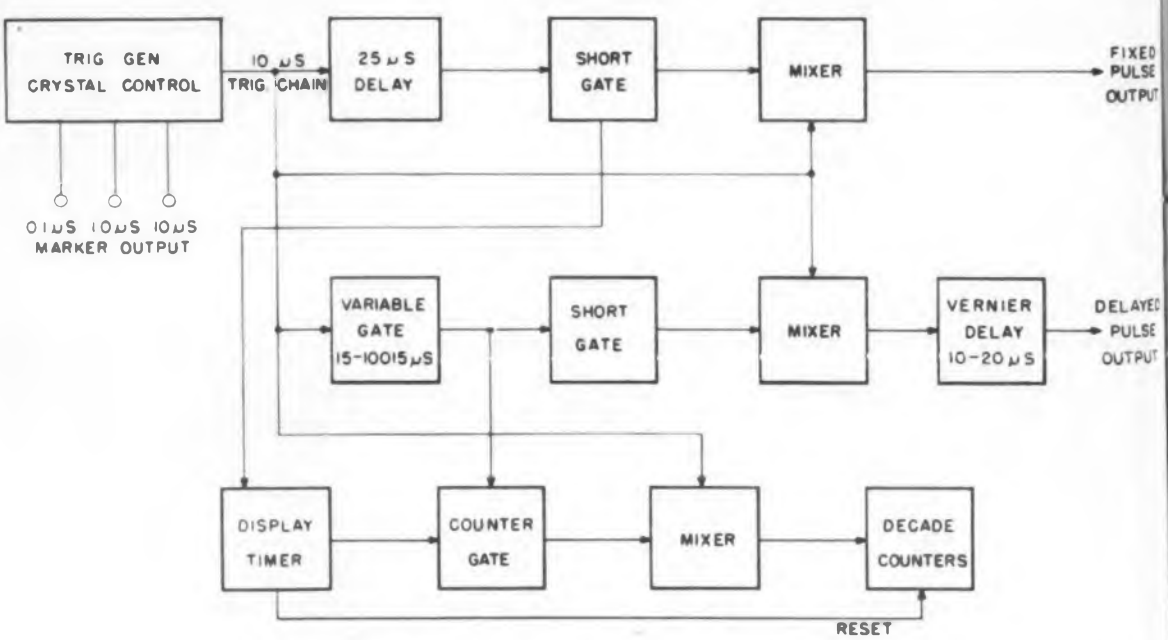

Fig. 1. Fixed pulse and delayed pulse both originate from one trigger chain.

μsec trigger chain feeds the delayed pulse circuit. When the required number of 10 μsec triggers are received, one is selected for the output. It triggers a phanastron circuit to provide vernier control between the 10 μsec intervals of the trigger chain. Extremely low jitter is obtained since only the gate is subjected to long delay and not the pulse itself.

Time Display

Delay time is measured by feeding the 10 μsec trigger chain to decade counters which are gated to count the number of 10 μsec triggers between the fixed pulse and the delayed pulse. Decade counters provide a reading in tens of μsecs. A vernier delay control with a digital dial gives the delay reading to ± 0.01 μsec.

A simplified application of the timer shown in Fig. 2 illustrates its independence from the scope used to display the pulses. With the delay controls set at zero, the scope positioning controls are used to place the fixed pulse (Input No. 1) at a convenient point on the CRT. The fixed pulse is used as a reference for zero time and the delayed pulse to trigger the scope. When the scope is switched to the output of the delay network (Input No. 2), the pulse from the delay network is positioned in the spot previously occupied by the fixed pulse from the Pulse Timer. This is accomplished by adjusting the delay controls on the Pulse Timer, since it is this output which syncs the scope.

Time between the two pulses observed on the CRT is read directly from counters and a digital dial on the Pulse Timer. Since positioning on the scope is relative rather than absolute, accuracy is determined only by the timer and not dependent on scope characteristics.

For further information on the Pulse Timer, fill out Reader's Service Card and circle 426.

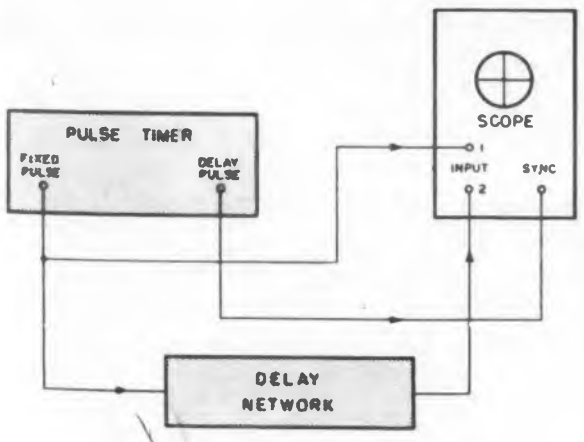

Fig. 2. Accuracy of time delay—displayed by the timer—is independent of the scope.

The first part of this article appeared June 15 on page 38. It described the role of standards and gave some of the basic considerations for accurate measurements of mass, length, and time. This second part covers derived standards, precise physical constants and fundamental physical constants. It also includes a bibliography for further study or reference.

Basic Standards for Science and Industry II

R. D. Huntoon, Assoc. Director
National Bureau of Standards
Washington, D. C.

Derived Standards

From the three primary standards mass, length, and time, and the units which define them, the associated physical laws define the derived standards.

Force. The first derived unit to claim attention is the unit of force, the newton, defined as the force required to give a mass of 1 kc an acceleration of 1 meter/sec.^{2} One cannot keep a force on the shelf to look at but one can compare a force with the attraction of the earth on the mass standard.

Acceleration of Gravity Being Redetermined

The force of attraction of the earth on a mass gives it an acceleration of g meters/sec^2; so any force measured by comparing it with the attraction of the earth for a mass, m, will have the magnitude

$$F = mg$$

It appears then that the mass standard can be used as a force standard if the value of the transfer constant g is well known. G varies from place to place and from time to time by a slight amount; but its precise measurement today is the basis of our "force standard." We measure forces by comparing them with the earth's attraction for mass and refer the latter to the mass standard.

The acceleration due to gravity, g, is known today with a precision of about 2-3 parts in 10^6 but with an absolute accuracy which is in doubt by as much as 10 to 15 parts per million. All values are referred to some particular spot on the earth by means of transfer measurements which have considerably greater precision (of the order of 1 part per million or better).

The reason for the uncertainty lies in the fact that only three precision determinations have been made until very recently and all three by the same method. They are therefore subject to the same hidden and unknown systematic errors.

All the major national standardizing laboratories are engaged in redeterminations of this important constant. At the N.B.S., we are now engaged in a remeasurement by two methods quite different from those previously used. No results are available as yet.

Current. The unit of current, the ampere, is defined as the current which, when flowing in two parallel wires of infinite length separated by a distance of one meter, gives rise to a force of 2×10^{-7} Newtons per unit length when in free space.

To accomplish the experimental determination, wires are wound upon coils of measured dimensions, and the force between the coils is measured. To measure the force, one balances it against a mass involving g.

The standard current of 1 ampere can be established with a probable error of about 2 in 10^6, neglecting the uncertainty in g. Recent measurements just completed at the National Bureau of Standards indicate that there is further uncertainty of about 10 ppm as yet unexplained. The results from two basically different configurations of the coils disagree. Thus, the ampere may have an uncertainty in its absolute value approaching 15 parts per million when the uncertainty in g is taken into account.

One cannot keep an ampere on the shelf, so it becomes necessary to reproduce it at will without the necessity of repeating the complicated standardizing experiments. This is done by standards of resistance and voltage.

Resistance. The unit ohm in this case is defined with the aid of the relation

$$Z = \omega L$$

where Z is an alternating current impedance, ω is an angular frequency, and L is the inductance computed from the geometric disposition of the conductors composing the inductance. Adjustments are so made in the defining geometry that one ampere through one ohm will liberate energy at a rate of 1 Newton-meter per second, or one watt. This sets the size of the ohm.

The establishment of a standard ohm thus involves measurements of length and time. The ohm does not involve g; and when realized, it is a material standard which can be kept on the shelf.

The standard ohm can be established to about 5 parts in 10^6 in terms of the units of mass, length and time.

Volt. The volt unit is defined with the aid of Ohm's Law such that

$$I = \frac{V}{R}$$

One ampere through one ohm gives a potential difference of one volt. The actual potential difference of certain standard cells is determined in terms of the standard current and resistance. Subsequently the standard ampere can be reproduced by adjusting the current through a standard resistance until the standard potential difference (referred to the standard cell) is established.

A typical situation which occurs similarly in other fields arises with respect to the electrical standards, and deserves mention. Once a resistor is selected as a standard, others just like it can be produced with a precision of about 1 in 10 million. Similarly, standard cells can be made in terms of the initial standard of about 1 in 10^6.

Thus, a standard current can be reproduced with an uncertainty of about 1 in 10^6 although its absolute value will have a greater uncertainty.

Thus there are a group of standards at N.B.S. which can be reproduced with greater precision than their absolute values in terms of the primary standards of mass, length and time can yet be determined. For this reason, all certifications of standards submitted to N.B.S. for calibration are made in terms of standards "as maintained at the National Bureau of Standards." Thus, all measuring equipment referred to N.B.S. for calibration will be mutually consistent with a precision greater than we now know the absolute values of the electrical standards we use. As our knowledge improves, this improvement automatically transfers to our certified values.

Precise Physical Constants

Having a set of standards of mass, length, time, force, resistance and current (or voltage) it becomes feasible to turn to the measurement of physical constants. Because of the convenience of measurement and the state of the art, some of these can be measured today with great precision.

Velocity of Light—c. This fundamental constant of great importance to all of science has been the object of extensive repeated determination. It appears that the value obtained early in the 20th century by Michelson and others was in error. The problem is essentially that of measurement of velocity, the measurement of a length and of a time. The most recent values indicate

$$c = 2.997928 \times 10^{10} \text{ cm/sec}$$

with a probable error of 1 or 2 ppm.

Rydberg Constant, $R\infty$. This constant of fundamental importance in Spectroscopy and Atomic Structure is in principle the determination of a wavelength and as such involves only length measurements and a pure number, the number of waves in a given length. Thus only one primary standard, that of length, is involved. It is interesting to note that the values obtained

$$R\infty = 1.0973731 \times 10^5 \text{ cm}^{-1}$$

has an uncertainty of about 1 in 10^7, the error with which waves have been compared with the standard meter bar.

Fine Structure Constant, α. This is a dimensionless constant involving certain relationships among atomic spectra and hence in principle does not involve any of our standards but does require that those which are incidentally used in the process are consistently related to another with a precision equal to that of the precision of the determination. It is presently known to be

$$\frac{1}{\alpha} = 137.0371$$

with an uncertainty of about 3 in 10^6.

Atomic Mass of the Proton, m_p. This is another dimensionless constant which may appear at first sight to be misleading. It is the mass of the proton on a physical scale of atomic masses so established that the value for O^{16} is given the precise value 16. Thus, it is determined in a different system of units and is later related to the MKS set through other measurements. To measure m_p in this system of units, it is only necessary to compare the masses of enough elements in precision mass spectrographs to arrive at a proper value for the ratio of the masses.

The presently accepted value is

$$m_p = 1.0075957 \; amu$$

with an uncertainty of 1 ppm. Here, again, when present standards are involved incidentally in the measurement, they must be internally consistent to avoid error in the final result. They need not however be in absolute accord with the definitions of the units.

Resonance Constants. There are three other physical constants which have not to date been measured with such precision as those just discussed but which form a second rank of precision and which make use of high frequency resonance techniques for their measurement. These may be referred to as the "resonance constants."

Gyromagnetic Ratio of the Proton γ_p'. (Uncorrected for diamagnetism.) In this determination, the electrical units and standards are directly involved—a point which is important to bear in mind, for this is the only physical constant we will discuss which does directly involve these units in the sense of depending upon their absolute values. The gyromagnetic ratio is measured by means of the relation

$$\omega = \gamma_p' B$$

where ω is an angular frequency and B is the

strength of a magnetic field. B is measured by the relation

$$F = BIL$$

where F is the force on a coil, I is the current in it, L is the effective length of conductor in the magnetic field B. F is measured with the aid of a mass, so

$$F = mg$$

and g is involved in the result. The angular frequency ω has been determined by nuclear resonance absorption. A small sample of water is placed in a strong magnetic field B and the energy absorbed by the precessing nuclei is detected in a small radio frequency coil surrounding the sample. The frequency for maximum absorption is the one measured. The result for γ_p' is

$$\gamma_p' = 2.67523 \times 10^4 \text{ sec}^{-1} \text{ gauss}^{-1}$$

with an uncertainty of 22 in 10^6.

Cyclotron Resonance of Electron ω_e/ω_n'. Here again, the concern is with a ratio not involving the primary standards. Two experiments are performed in the identical magnetic field B which must remain constant during both measurements. The precession frequency of protons is measured as described for the measurement of γ_p'. The resultant value is labeled ω_n'. Next, electrons are allowed to describe circular orbits in this same field, and the frequency with which they traverse these circular orbits is measured. The value is written ω_e. The ratio of these two is the value needed. Its presently accepted value is

$$\frac{\omega_e}{\omega_n'} = 657.475$$

with an uncertainty of about 12 ppm. This value can also be deduced from other experiments and combined with the theoretical value of the anomalous moment of the electron to give this ratio with an uncertainty of about 1 in 10^6.

Cyclotron Resonance of the Proton. Finally, the same experiment as just indicated is done using a proton instead of an electron to give the corresponding frequencies of ω_n' and ω_c. The observed result is

$$\frac{\omega_n'}{\omega_c} = 2.79268$$

with an uncertainty of 20 in 10^6.

Fundamental Physical Constants

By describing the determination of the precision constants and the resonance constants it is possible to show how the values of the fundamental constants can be obtained with quite good precision; although in most cases they cannot be measured very well directly.

The fundamental constants whose values are sought are

e — charge on electron

m — mass of electron

h — Planck constant

N — Avogadro's number

F — Faraday

m_p — mass of proton

$\frac{e}{mc}$ — ratio of charge to mass of electron (emu) and other combinations.

To find these values the following relations which exist among the constants should be noted:

$$R_\infty = \frac{2\pi^2 me^4}{ch^3}$$

$$\alpha = \frac{2\pi e^2}{ch}$$

$$\gamma_p' = \frac{4\pi \mu_p'}{h}$$

$$\frac{\omega_c}{\omega_n'} = \frac{eh}{4\pi mc} \cdot \frac{1}{\mu_p'}$$

$$\frac{\omega_c}{\omega_n'} = \frac{eh}{4\pi m_p c} \cdot \frac{1}{\mu_p}$$

Solving these equations for e, m, m_p, h and eliminating μ_p, the magnetic moment of the proton, we have:

$$e = \frac{\alpha^3 c}{4\pi R \gamma_p' \omega_e/\omega_n'} = (4.8029 \pm 0.00013) \times 10^{-10} \text{ esu}$$

$$m_e = \frac{\alpha^3}{4\pi R (\gamma_p')^2 (\omega_e/\omega_n')} = (9.1084 \pm 0.00046) \times 10^{-28} \text{ gm}$$

$$h = \frac{\alpha^5 c}{8\pi R^2 (\gamma_p')^2 (\omega_e/\omega_n')^2} = (6.6252 \pm 0.0003) \times 10^{-27} \text{ erg sec}$$

$$m_p = \frac{\alpha^3 (\omega_n/\omega_c)}{4\pi R (\gamma_p')^2 (\omega_e/\omega_n')^2} = (1.67241 \pm 0.00005) \times 10^{-24} \text{ gm}$$

$$F = m_p \gamma_p' (\omega_c/\omega_n') = 9652.2 \pm 0.3 \text{ emu erg}^{-1}$$

$$\frac{m_p}{m_e} = \left(\frac{\omega_n'}{\omega_c}\right)\left(\frac{\omega_e}{\omega_n'}\right) = 1836.12 \pm 0.046$$

$$\frac{e}{m_p c} = \gamma_p' \left(\frac{\omega_c}{\omega_n'}\right) = 9579.4 \pm 0.3 \text{ emu gm}$$

$$\frac{h}{e} = \frac{\alpha^2}{2R \gamma_p' (\omega_e/\omega_n')} = (1.37943 \pm 0.00003) \times 10^{-17} \text{ erg sec esu}^{-1}$$

The values of the physical constants obtained in this way are not "adjusted best values" as usually found tabulated, and they should not be so used. The point in getting them this way here is to illustrate the chain of measurement from the primary standards to the important physical constants. Proper adjustments for "best values" lead to small differences but this does not alter the essential argument.

It is most important to note the key role played by γ_p'. The transition from the primary standards to the electrical standards is the first link in the chain. The gyromagnetic ratio γ_p' provides the second link from the microscopic world of working standards (electrical) to the miscroscopic world of atomic physics whose constants we seek to determine.

In comparison to some of the other constants, γ_p' has been the recipient of relatively little effort. The National Bureau of Standards is engaged in a new determination of this important constant.

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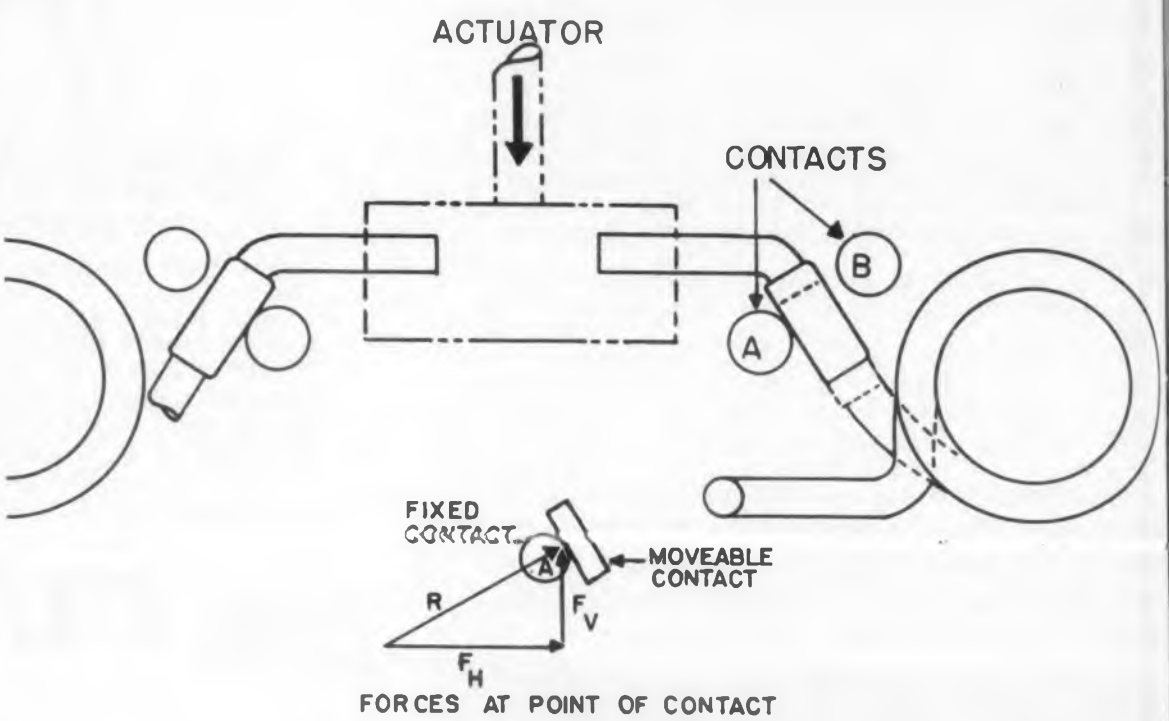
Wedge Contact Relay

WORKING on an entirely new principle—*wedge action*—this solenoid actuated relay features lower contact resistance to small currents, automatic contact cleaning, and high shock and vibration resistance. The 24 karat gold contacts employed are arranged for six-pole double-throw operation.



Double-Pole, Double-Throw Wedge Action Principle. *A* and *B* are fixed contacts. The moving contact is supported at both ends, giving greater resistance to vibration than conventional cantilever contact arrangements.

How It Works

The "wedge action" principle was developed by Electro Tec Corp., P.O. Box 667, Ormond Beach, Fla., to provide relay characteristics not possible by conventional design. The operation of the Mark II Relay can be shown by referring to the sketch.

The terminology, "wedge action," is descriptive of the type of motion involved. In the case of a wedge being driven between two fixed members, the pressure against the sides of the opening increases as the wedge travels forward. This same type of action is created in the Mark II Relay. Referring to the vector diagram, it will be noted that the resultant force "R" beween the contacts after engagement is greater in magnitude than the actuating force. At any instant it is equal to the vector sum of the horizontal and vertical components.

As the actuator travels downward the moving contact moves down. However, due to the force applied upon engaging the stationary contact, it is displaced slightly to the right. This means that as the moving contact travels downward the force between it and the fixed contact is increased so that not only a wiping action occurs but also an increased pressure results. This "wedge action" is extremely important in removing contaminants from the contact surfaces, reducing resistance to micro-level currents, and in rendering the relay highly shock and vibration resistant.

After contact is made, the vertical motion of the actuator continues. This "over-travel" action is a factor which enables the "wedge action" to occur. In the course of "wedge action" not only does cleaning of the contact surfaces occur, but burnishing takes place which polishes the surface and resists further destruction of these areas. An important result of "wedge action" is the fact that the positive contact pressure established enables the relays to switch extremely low currents and low voltages with high reliability.

The moving contact is supported at both ends, thereby eliminating the undesirable effects of a cantilever which is present in most current designs.

Characteristics

The Electro Tec relay, designated Mark II, is designed for continuous duty and is rated for operation from —65 to 200 C. It will withstand 30 g vibration from 5 to 2000 cps and is shock resistant to 100 g's. The contacts carry 2 a into a resistive load. Coil voltage is 26.5 v dc, or other values on order. The entire relay is hermetically sealed and meets or exceeds specifications MIL-R-5757C and MIL-R-25018, Class C, Type II, Grade 3.

Weight of the relay is only 4.7 oz, and its overall dimensions are 1-7/8 in. diam x 1-7/8 in. high including soldering lugs.

For additional information on this product, fill out the Reader's Service Card and circle 427.

DC Overpotential Testing

Victor Wouk
Engineering Director
Beta Electric Division of Sorensen & Co.

The use of high voltage dc for checking the insulation characteristics of electronic components has advantages over ac testing. Less destructive, the dc method can also be used to anticipate component failures by the proper interpretation of resistance characteristics. Improved reliability results.

Virtually all electronic components and equipment are subjected to one or more insulation strength tests during fabrication by the manufacturer, and, in any company well organized for reliability and quality control, in "incoming inspection," as well as often in the end product. In these tests, variously called hipot tests, overpotential tests, overvoltage tests, insulation tests and dielectric strength tests, the item under test is subjected to an electrical stress greater than the anticipated operating voltage, with the assumption that if the component passes this test the probabilty of its performing adequately in its normal operating circumstances will be high.

On new equipment, twice the rated ac voltage plus 1000 v is applied for a period of a few seconds up to one minute, as a standard test. For maintenance tests on equipment that has been in service, often 150 per cent of the rated operating voltage will be applied for one minute.

None of these ratings has any particular intrinsic significance. It is not true that an item that stands "twice rated voltage plus 1000 v" will *not* fail when operating at rated voltages. The test was achieved as a standard of comparison after much discussion and compromises. Original suggestions ranged all the way from "133 per cent of rated voltage" through "3 times rated voltage plus 1000 v." The present test was accepted as indicating a high degree of probability that the component would operate satisfactorily in its application, if it passed the test.

Any other test that will indicate acceptance with equal probability of the unit not failing subsequently would be just as valuable as the ac test.

The advantages of testing with dc instead of ac are many, but the adoption of dc testing has been slow, probably because 1. It is felt intuitively that an item of electronic equipment to be operated under ac conditions should be tested with ac, and 2. until recently it was simpler and less expensive to obtain very high voltage ac with simple transformer techniques, than with dc, which previously required expensive rectifier equipment.

Today, low-cost, compact, reliable dc test equipment in the high voltage (3 to 30 kv) very high voltage (30 to 300 kv) and ultra high voltage (300 kv and above) ranges render dc testing feasible, even at voltages as high as 600,000 v dc.[1]

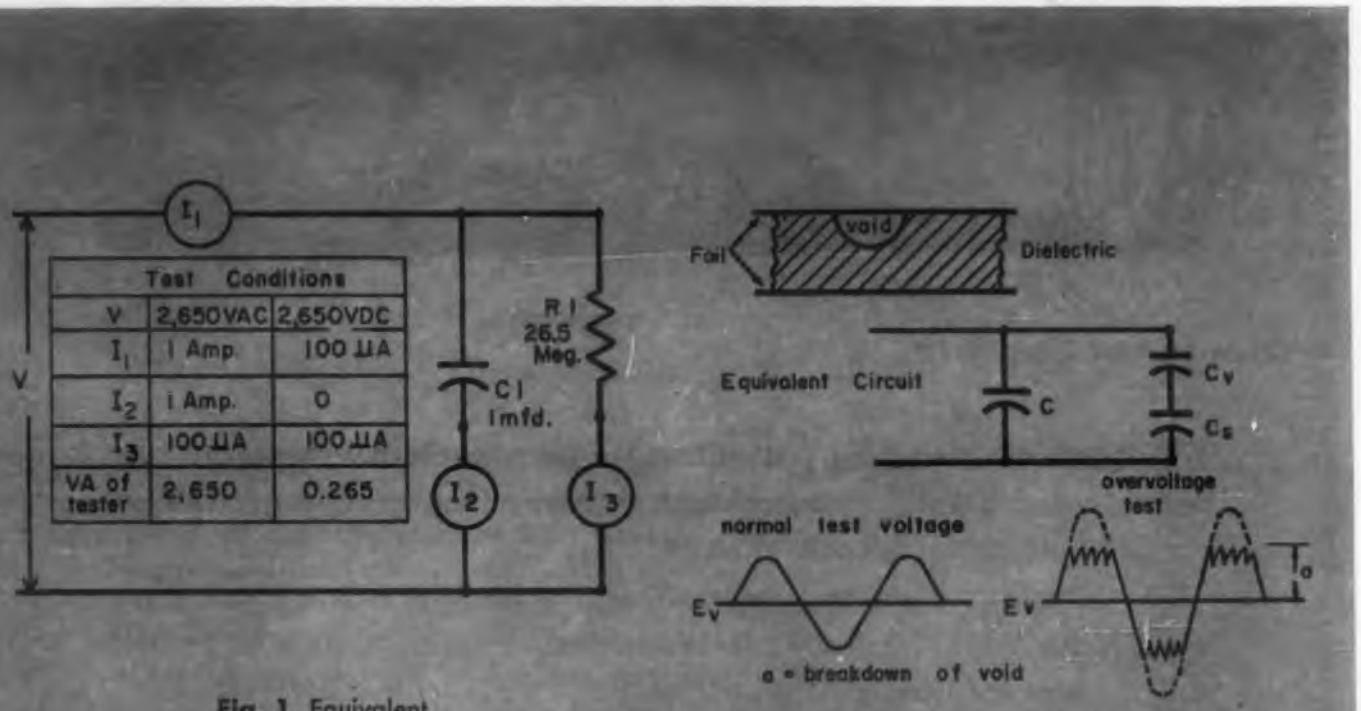


Fig. 1. Equivalent circuit of capacitor under test.

Fig. 2. Equivalent circuit of and test voltages across void in insulation.

IN THE "hipot" test, the overvoltage applied to a capacitor, transformer, insulator or cable under test is dc rather than ac. The major advantages of dc insulation testing are direct indication of leakage resistance and the fact that dc test equipment is much smaller than ac in higher voltages:

With modern insulating materials, the leakage resistance is generally of the order of tens or hundreds of megohms. The leakage current is masked in a capacitance circuit by the capacitance currents that flow, because in most modern insulation the power factor or the loss factor is very small. Fig. 1 illustrates some of these properties: capacitor C1 under test has leakage resistance R1. Unusual voltages and capacitances are employed for emphasis. The ratio of capacitance current to leakage current—almost 10,000 to 1—indicates that the insulation resistance would be extremely difficult to determine with ac.

With dc, on the other hand, after the initial current surges that charge the capacitance, and dielectric absorption, the leakage current indicates the resistance. The resistance is an excellent indication of the insulation condition.[2, 3, 4, 5] This is the most important advantage of dc testing; it indicates *quantitatively* the status of the insulation, in comparison to ac tests which are essentially "go, no-go" tests. Referring to Fig. 1, the ac test equipment would have to provide 2650 va, whereas in dc testing only 0.265 va are required. In these low ratings, this is not particularly serious. But consider the case of a 1 μf filter capacitor rated at 25 kv for a transmitter application. In this particular case, an ac test with approximately 51 kv would result in almost 20 amp flowing, with a required test capacity in the transformer of 1000 kva. The dc leakage current

to be expected might be of the order of 1 ma maximum, with a corresponding volt-ampere rating of the dc test equipment of 51 va.

It is because of this particular aspect of the problem, which when applied to power cable problems where the capacitance might be 8 μf and the test voltage 250 kv, and with the resultant kva required for test purposes in the mega-va range, that dc overpotential testing equipment has been developed to replace ac tests in many power industry applications.

Test Time Not Critical

The duration of voltage application is not as critical with dc as it is with ac. Moreover the dc tests are often considerably less destructive for equally searching tests. As an example, there is a radar equipment manufacturing company where a rigid quality control program had been instituted in the incoming inspection department. Capacitors which had been previously tested by the capacitor manufacturer at "twice rated voltage plus 1000 volts" for one minute, were subjected to a similar test at incoming inspection at the radar plant. Prior to shipment of the finished product an identical test was again applied. Again, prior to installation at the customer's site, another ac hipot test was applied. It was found that a particular capacitor was failing in the field at an unpleasant rate, although it had met all the tests satisfactorily.

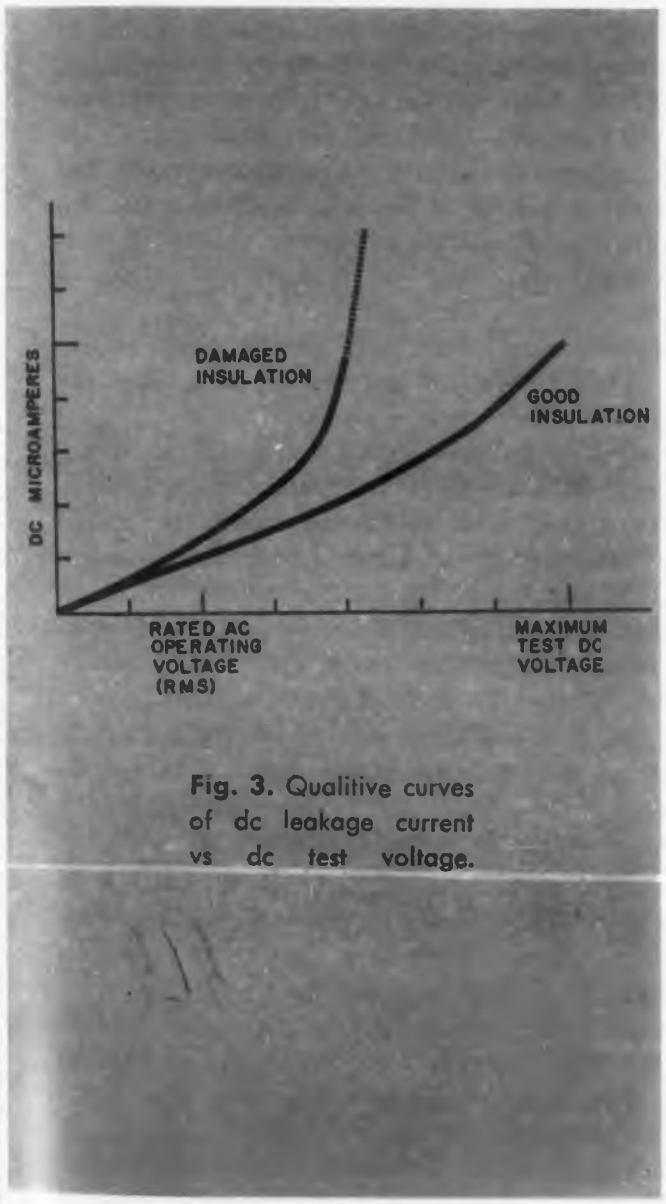


Fig. 3. Qualitive curves of dc leakage current vs dc test voltage.

During one particular production run, it was learned that the capacitors, when replaced in the field with units that were shipped directly from the manufacturer, encountered a considerably lower failure rate. It was perceived that excessive testing was causing damage; incoming and outgoing inspection with high voltage ac overvoltage tests were eliminated. Capacitance checks and dc overpotential tests were substituted, and this particular difficulty disappeared.

We can understand this phenomenon by referring to Fig. 2, which represents a section of a capacitor, where there may be a void. The equivalent circuit is illustrated by the main capacitance C, shunted by the series connection of capacitance C_v represented by the void, and the balance of the material with which it is in series, C_a. Let us assume that the circumstances are such that with normal rated voltage, the peak voltage across capacitor C_v never exceeds the breakdown voltage of the void, which is considerably lower than the breakdown voltage of the same volume when occupied by insulating material. The breakdown voltage is slightly above the normal operating voltage. Under normal operating conditions, the void will not break down, and there will be no deleterious products.

On the other hand, referring to the curves of Fig. 2, it can be seen that several breakdowns could occur during the course of one ac cycle, as the voltage across C_v starts to exceed the breakdown voltage. It has been well established[7] that it is the various ozone, ultraviolet, and other chemical effects of the electrical discharge in the void that eventually softens the insulating material and causes breakdown.

In this way, a good design which would operate for a long period of time under normal operating voltages was "tested to death" in a test which did not indicate anything wrong with the equipment, and during the course of the test damaged the insulation, so weakening it that there was subsequent failure during normal operation.

Breakdown Anticipation

An important factor discovered in the use of dc overpotential testing has been the frequent ability to *anticipate* incipient breakdowns.[2, 3, 4, 5] This is done by plotting the dc resistance, or leakage current, vs the applied test voltage, and looking for a "knee" in the curve. Fig. 3 illustrates typical data obtained with good and bad insulating material.

In Fig. 3 it is apparent that for good insulation the leakage current rises linearly with applied volt-

age beyond the normal operating voltage. Near the end of the test voltage range the current may begin to rise more rapidly. This indicates that the resistance is comparatively constant over the normal operating range, and drops somewhat near the maximum test voltage.

With poor insulation the rise of current may again be linear over some range of the applied voltage. But what is most important is that a "knee" develops in the curve, and the current begins to rise very rapidly as a function of voltage. If this happens it is an indication of incipient breakdown.

Insulation Resistance

Fig. 4 illustrates typical current vs time with dc applied to a dielectric material, the dc voltage being fixed. The current initially varies rapidly with time.[8] The components of capacitance current and irreversible dielectric absorption die out comparatively rapidly. The reversible absorption current decays slowly, and often will be of the order of magnitude of the true leakage current. Considerable time must often be spent in waiting for the current reading to stabilize. It is for this reason that some tests arbitrarily cut off at one minute to determine the nominal relative leakage resistance. Although the current read on the leakage indicating meter is a serious function of time, after a while the reading does level off, and a reproducible value is obtained. The length of application of the test voltage will not affect the "true" leakage, nor, in general, will it affect the degree of damage—if any—done to the insulation during test.

Equivalent Dc to Ac Test Ratio

Ratios of dc-to-ac breakdown voltages as high as 2.5 to 1 and as low as 1.2 to 1 have been reported in the literature.[2, 3, 4, 5] For motors and generators, i.e., rotating equipment, however, a ratio of 1.6 has been tentatively recommended.[9]

If a test with ac on a generator coil has been established at 10,000 v rms, the test with dc is 16,000 v. There is nothing magical about the 1.6 ratio. It is something that was determined empirically, and represents a test which, if withstood by the equipment, indicates a high probability of no subsequent failure. This value is a compromise between a lower test voltage, which will permit many more items to be accepted, which may nevertheless fail subsequently, and a higher test voltage, which may be more costly due to the larger number of items that may be rejected.

Operation Failure Anticipation

It has been reported[3] that by recording the leakage current at a specific test voltage over a period of years a trend in leakage can be noted.

Thus, referring to Fig. 5, one sees a typical trend as reported for the insulation in a particular generator. It can be seen that for the first few years, at a given test voltage, the leakage current is comparatively constant, rising very slowly. After a number of years, as the insulation is deteriorated due to thermal cycling, occasional electrical overvoltages, and accumulated moisture the insulation resistance tends to drop. When the rate of rise becomes excessive, as at point X, indicating a possible extrapolation to very high current at point Z, or, if the resistance is plotted, extrapolation to zero resistance, then it can be expected that the insulation will fail at time Y.

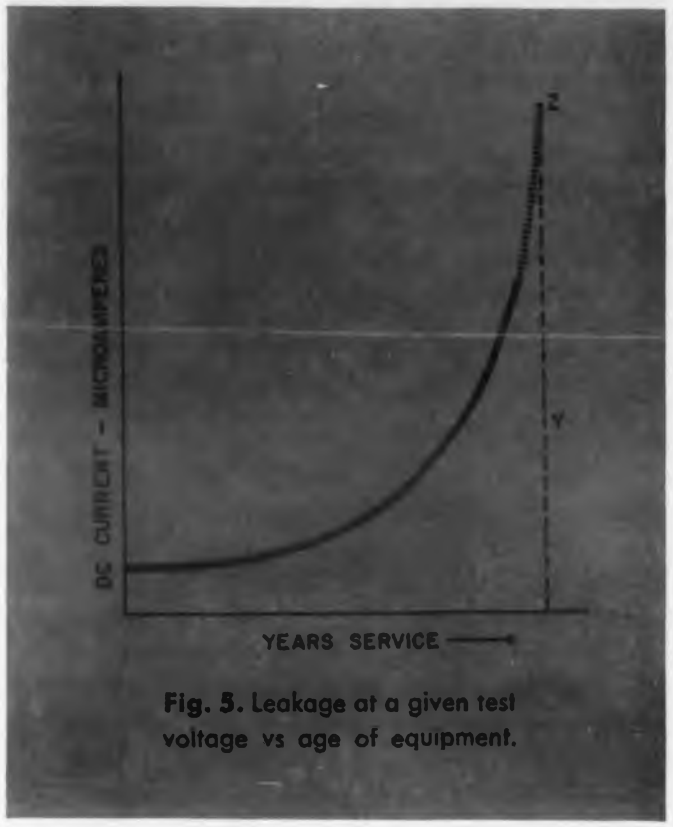


Fig. 5. Leakage at a given test voltage vs age of equipment.

It is obviously better to rewind or repair equipment in which failure is anticipated, than allow the equipment to fail when in service.

An obvious parallel application in the radio engineering field would be the testing of certain important tubes, such as power amplifiers in the output stages of broadcasting systems, and recording, let us say, the g_m for *fixed* operating conditions as a function of time. If these values were plotted as a function of time, a curve like the one for resistance of Fig. 5 would be obtained. The tube could be removed from service during a maintenance test and replaced at the proper time.

Capacitor Testing

A simple check at a single value of test voltage is not necessarily a good dc test for checking characteristics of capacitors, as is illustrated in Fig. 3. If a capacitor is designed for operation in the thousands or tens of thousands of volts range, then a resistance check at 500 volts, which is common in many industries, is far from adequate since it is obvious that the resistance varies with voltage. For prediction of probable reliability, the variation of resistance with voltage is sought. By testing with dc and

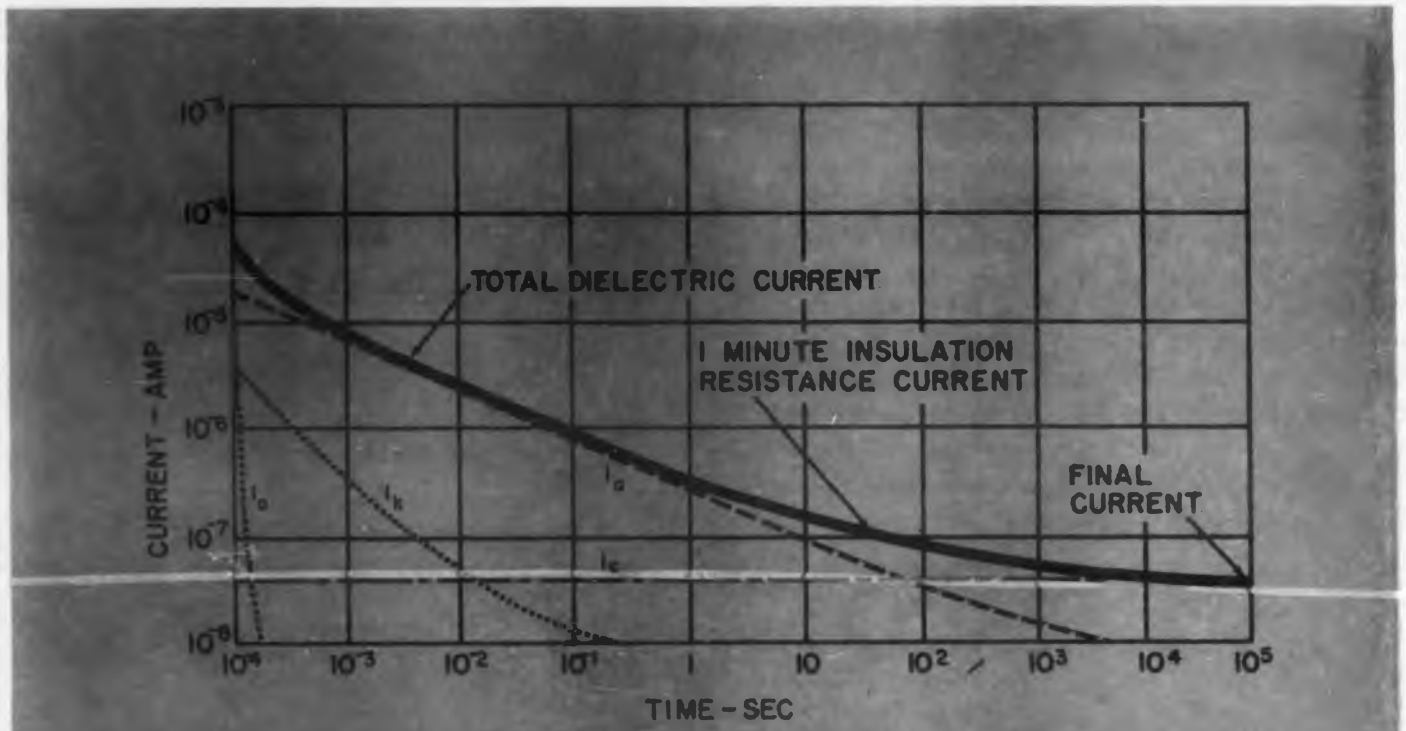


Fig. 4. Leakage current variation with time, with constant dc voltage applied. Curve labled I_d is the charging current, I_a = reversible absorption current, I_b the irreversible absorption current, and I_c leakage conduction current.

getting the curve of voltage and current, one can look for a "knee" in the curve to indicate possible voltage breakdown or probable failure.

In large volume production of capacitors, this would be a time-consuming operation, since several minutes often have to be allowed to pass, before the correct leakage current is determined. Sampling from batch lots is one solution however.

DC Testing Equipment

Typical test equipment when checking capacitors should include the following units:

- A line voltage stabilizer. This is because the indicated current can vary enormously with small line voltage changes, if the capacitance is high.
- Automatic output shorting mechanism. Since a capacitor is being charged, it is recommended that a device be included in the power supply that automatically shorts the output to ground when the high voltage is turned off.
- Jig interlock. A provision should be made for an interlock on the test jig or cage so that the item under test must be properly enclosed before high voltage can be applied.
- Zero-start interlock. It is also recommended that a device be incorporated to insure that the high voltage control is at zero before the high voltage can be applied. This prevents unexpectedly high voltages from being applied to the item under test.

Conclusion

Dc overpotential testing has in the power engineering field resulted in more reliable operation of equipment. Similar techniques should be introduced in the electronic industries field with regard to checking the insulation of electronic components for possible failure, and improve the reliability of performance by utilizing components of which the probability of failure is low.

References

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3. "Techniques and Examples of High Voltage DC Testing of Rotating Machine Windings," Sidway & Loxley, AIEE Technical paper #53-318.
4. "Diagnoses of AC Generator Insulation Condition by Nondestructive Tests," A. W. W. Cameron; AIEE Transactions, Sec. T2-59, Vol. 71, (1952).
5. Testing Electrical Insulation of Rotating Machinery with High Voltage DC," G. Leslie Hill; AIEE Technical paper #53-3.
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9. "Proposed Guide for Insulation Maintenance for Large Alternating Current Rotating Machinery," AIEE Report #56, dated May 1954, Page 8, Item 5, 32.

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CIRCLE 36 ON READER-SERVICE CARD FOR MORE INFORMATION

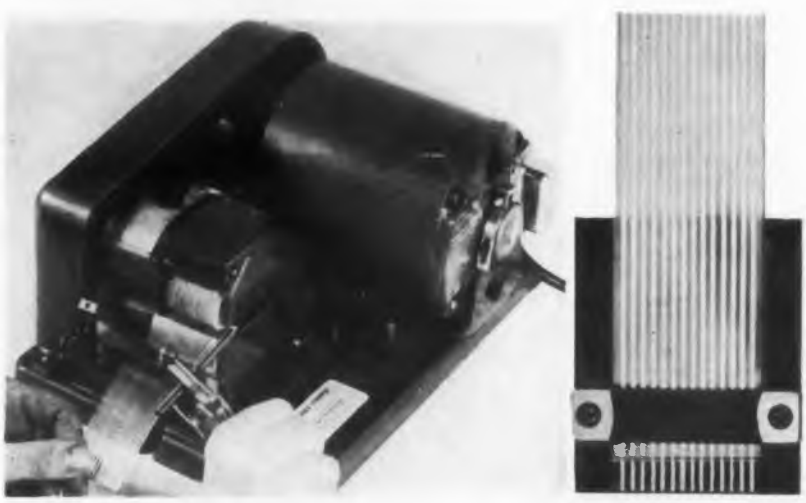
Rolls of standard cable in tape form

Cable in Tape Form

DESIGNED for automatic assembly operation, this flat cable requires no individual handling of separate wires. All conductors are stripped simultaneously because they are all flat and in the same plane. All conductors can be dip soldered simultaneously to printed wiring boards or printed wiring connectors. Major labor savings are possible, since all conductors are handled as one unit through stripping, positioning for termination and soldering.

Weight and size are but a fraction of standard round insulating cable. The new flat, flexible, ribbon-like multiconductor cable, which comes in rolls up to 1000 ft long, is desirable for aircraft, missiles, mobile equipment, portable devices, or wherever space and weight are important. It is particularly applicable to computers or telephone systems where there are many multiple interconnections.

Tape Cable, registered trademark of the manufacturer, Tape Cable Corp., 790 Linden Ave., Rochester 10, N.Y., has flat cop



Stripping all conductors at once is accomplished with a fiber wheel stripper (extreme left). Techniques for splicing, soldering to boards and connectors may call for removing insulation other than at extreme ends. One variation of a strain relief clamp is shown at near left.

Tape Cable is designed to work with standard connectors such as those made by Elco.

per conductors 0.0015 in. thick imbedded in a uniform transparent polyester film insulation. This design results in a cable having minimum cross section area, minimum interconductor capacitance, high tear strength, high flex life, and high resistance to chemical attack.

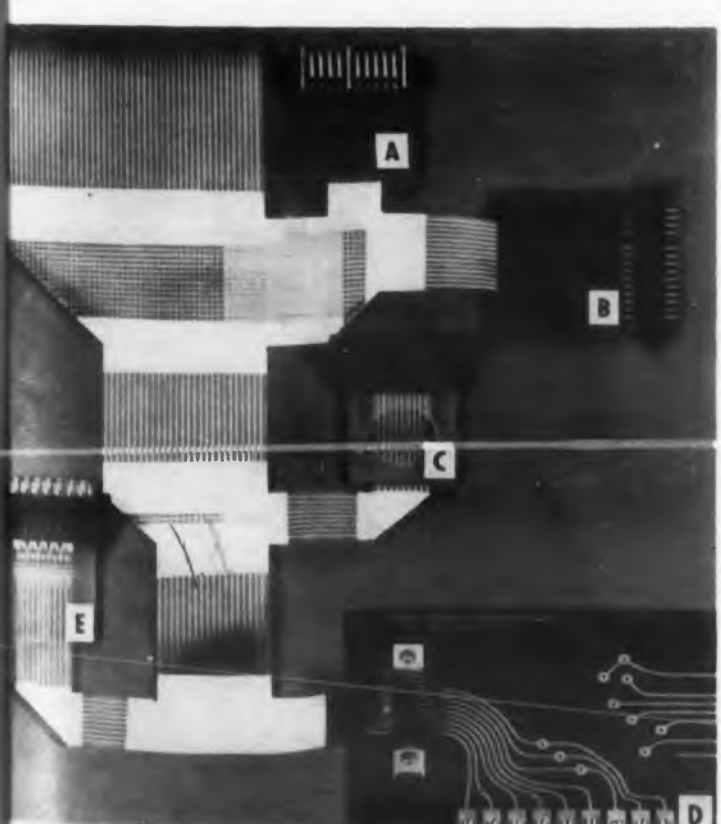
Conductors have 0.100 in. center-to-center spacing in accordance with the recommended RETMA grid pattern for printed wiring, Nine standard sizes are avilable, having 9, 14, 17, 21, 27, 30, 36, 40 or 50 conductors. The standard conductor is 0.0015 x 0.030 in. This gives Tape Cable a high conductor density, 1160 conductors per cross-section square inch as compared with only 225 for ordinary cable having no. 22 wire insulated with 0.010 in. wall. A 100 ft roll of 50-conductor tape cable weighs only 2-1/2 lb. This is a saving of 85 per cent in copper over conventional cable having round conductors of the same current handling capacity.

Since interconductor capacitance is less than 5 μμf per ft between conductors, the new cable is ideal for high frequency applications. Grounding alternate conductors will reduce the interconductor capacitance to under 1 μμf per ft in free air. Because of the large heat dissipating characteristics of flat conductors, each conductor in Tape Cable has a conservative rating in free air of 1 amp. It is interesting to note that a conservative rating of 300 v is achieved with a maximum cable thickness of only 0.011 in.

Because the cable is so thin, it has a high flex life. It has been successfully used in applications requiring continuous flexing on a radius of 1/4 in. The mechanical strength of the cable, as in the case of printed wiring, is in its insulation. Tests indicate a tensile strength of 80 lb per inch of width. To take full advantage of this high tensile strength, which is greater than that of the soldered connections, a strain relief should be used in termination. Several varieties of strain reliefs have been designed and are available.

All or any number of the conductors in a single cable may be stripped rapidly and easily in one operation by a pair of opposing high speed glass fiber wheels. Two or more cable ends can be brought together, dip soldered and insulated with tape to form a splice. Harnesses can be made by expanding this technique.

For more information on this product, turn to the Reader's Service card and circle 428.



Cable harness. *A* is a 9-contact Tape Cable plug with rubber sleeve, wedge strain relief and cinch connector. *B* shows a 14-contact Tape Cable plug with rubber sleeve, wedge strain relief and Amphenol connector. *C* is a 9-contact Elco plug and connector. *D* shows a 9-contact printed circuit board, with bar strain relief and Tinnerman nuts for making wire connections. *E* also illustrates a 9-contact Elco plug and connector.

Here's your guide... to better wiring with one-third the work

This new bulletin gives you the facts . . . and complete how-to-do-it instructions for wiring your product with PANEL CHANEL® raceways. All steps are fully illustrated. PANEL CHANEL does the wiring job with one-third the work . . . and even greater reductions in cost. PANEL CHANEL is relatively new . . . but it is already the standard wiring method used by hundreds of leading electrical and electronic equipment manufacturers for their products.

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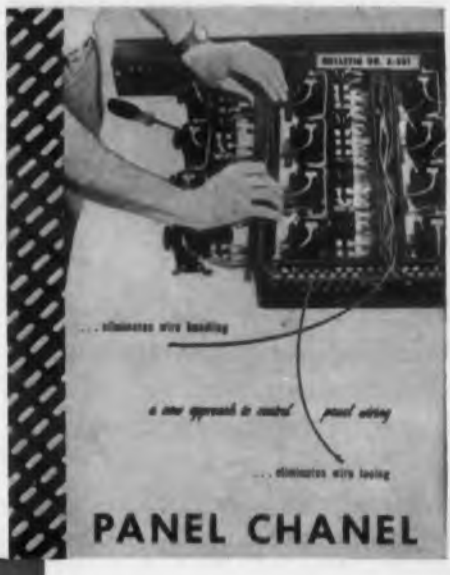


Panel Chanel®

STAHLIN BROTHERS, INC. • 103 MAPLE STREET
Belding, Michigan

CIRCLE 52 ON READER-SERVICE CARD FOR MORE INFORMATION

Flux Density Nomograph – V

Martin Berger
Minitran Corp.
5 Oliver St.
Newark, N. J.

THIS NOMOGRAPH–the last of a five-part series on transformer design–relates flux density, frequency, voltage, number of turns, and core sizes. Flux density is fixed at 10 kilogauss and frequency at either 60 or 400 cps; but relatively simple (usually mental) calculations can convert results to other flux densities and frequencies.

Three voltage scales are drawn to the right of the "Turns" scale. Each of these corresponds to a particular "Core" scale on the left. Illustrative examples are the following:

Examples of Use

Example 1. *An EI-375 square stack transformer is to operate at 10 kilogauss when excited with 115 v, 400 cps. How many turns shall be used for the primary?*

Laying a straightedge from the EI-375 mark on the 400 cps side of the "Core Type–Flat Stampings" scale to 115 v on the "Volts–Flat Stampings" scale, the line drawn crosses the "Turns" scale at 800 turns.

Example 2. *A toroidal inductor of 4000 turns wound on a Magnetic Metals core of case size No. 7 is to operate at 25 v, 400 cps. At what flux density will it be operating?*

Laying the straightedge from the No. 7 mark on the 400 cps side of the "Core Type–Toroids" scale through 4000 on the "Turns" scale gives a reading of 125 v per 10 kilogauss read from the "Volts–Toroids" scale. Since the actual coil voltage will be only 25 v, the toroid will be operating at

$$\frac{25}{125} \times 10 = 2 \text{ kilogauss.}$$

Basic Considerations

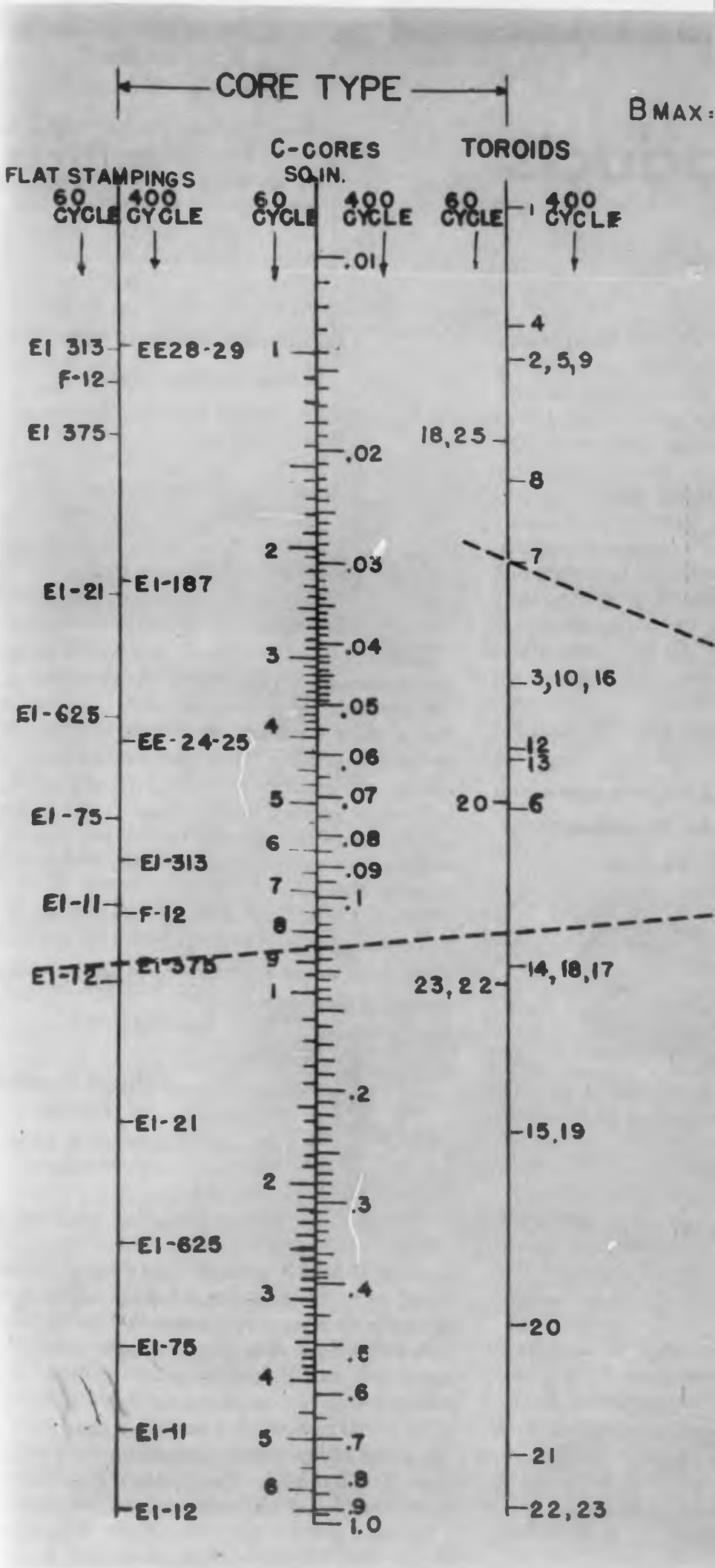
As shown in example 2, this nomograph is not limited to 10 kilogauss; neither is it limited to 60 or 400 cps, nor to square stacking. When using the nomograph for quantities other than the foregoing it is only necesary to bear in mind that

1. Relation of the factors involved are in accordance with the formula: $B_{max} = \frac{KE}{N f a}$

where,

K = constant of core size
a = cross sectional area of core
f = frequency
N = no. of turns
E = volts

2. Flux density is directly proportional to the reciprocal of frequency. (Thus, answer to Example 1 would be 200 turns at 1600 cps.)
3. Flux density is directly proportional to the reciprocal of the number of turns.
4. Flux density is directly proportional to the reciprocal of core cross-sectional area. (Thus, answer to Example 1 would be 400 turns for a ¾ in. stack of EI-375.)


CORE TYPE
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FLAT STAMPINGS
60 CYCLE
400 CYCLE
C-CORES
SQ. IN.
60 CYCLE
400 CYCLE
TOROIDS
60 CYCLE
400 CYCLE
EI 313
F-12
EI 375
EI-21
EI-625
EI-75
EI-11
EI-12
EE28-29
EI-187
EE-24-25
EI-313
F-12
EI-375
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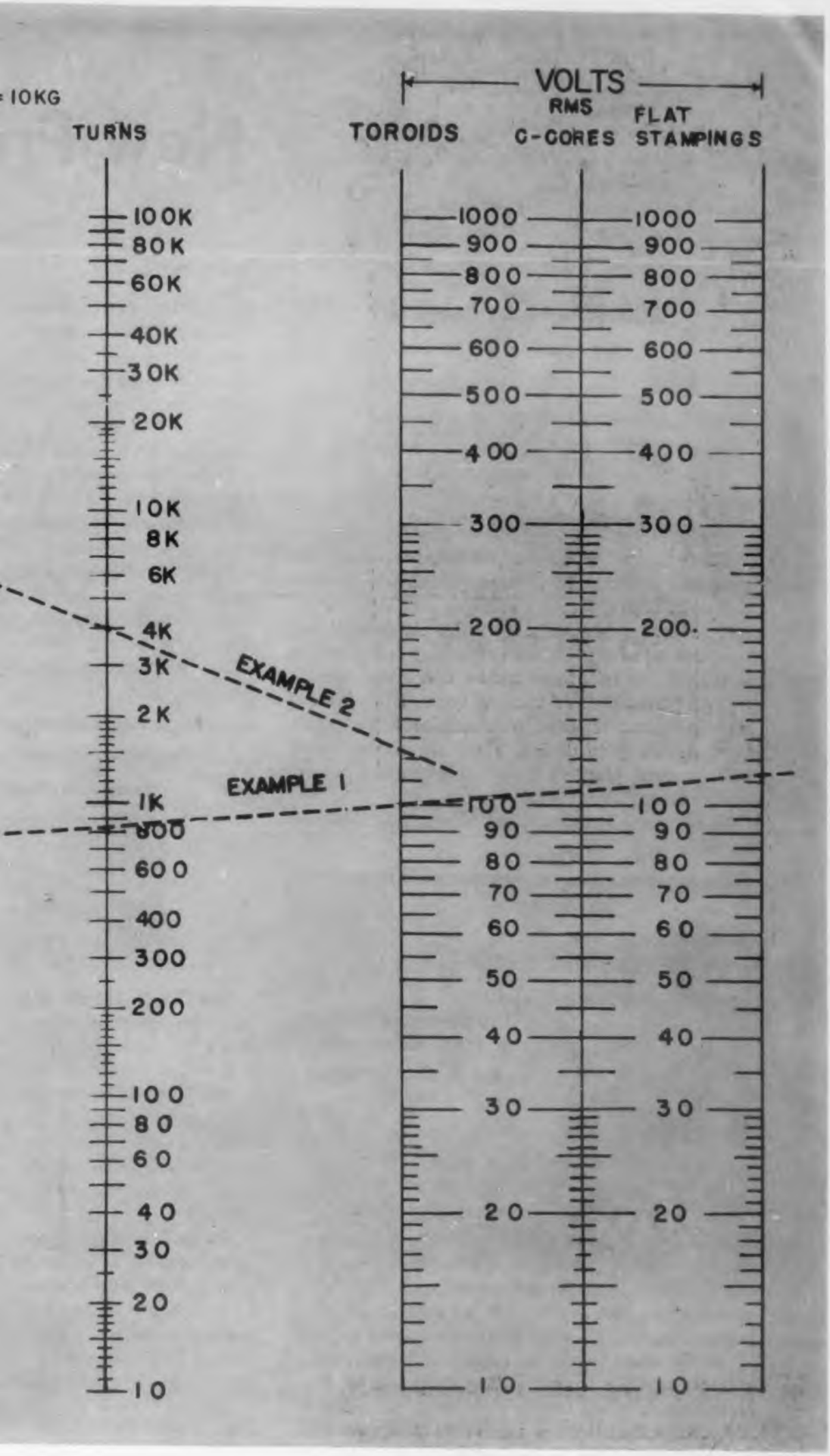
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EXAMPLE 2
EXAMPLE 1
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RMS
TOROIDS
C-CORES
FLAT STAMPINGS
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900
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700
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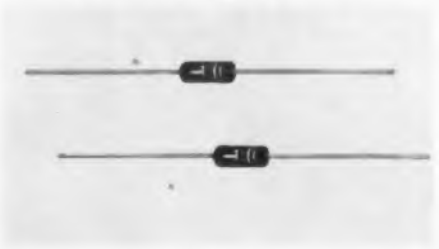
New Products

Silicon Diodes for Computers

No Derating to 150 C



These silicon diodes were designed especially for computer service and other applications requiring fast switching. Operating voltages extend to 200 v, and no derating is necessary up to their maximum temperature of 150 C. With switching times as fast as 0.3 μsec or less, these diodes can often directly replace germanium or vacuum types. High inverse resistance and forward conductance allow maximum flexibility in design. They are encased in a subminiature glass package to withstand severe environmental conditions.

Transitron Electronic Corp., Dept. ED, Melrose 76, Mass.

CIRCLE 39 ON READER-SERVICE CARD FOR MORE INFORMATION

Programmed Current Pulse Generator

For Testing of Digital Devices

Model 1020 is a packaged system providing precisely controlled, fully programmed current pulses for the research development and production testing of digital systems and components. Operating at 525 v dc, two current drivers deliver negative pulse currents to 3 a from source impedance as high as 20,000 ohms, while two deliver positive pulse currents to 4.5 a from a voltage-type source. Programming is based on an eight step, periodically repeated pattern with a maximum step repetition frequency of 200 kc. Pulse repetition frequencies of up to 400 kc may be obtained through incorporation of both a primary and a controlled delay secondary pulse during each step. The program may be automatically stopped at any one or two of its eight steps and made to repeat the scheduled pulse up to 2000 times. In addition, any one or two adjacent step pairs may be repeated up to 1000 times.

Primary or secondary pulse width is continuously adjustable from 0.5 to 50 μsec. Linear and exponential rise time is continuously variable from 0.08 to 2 μsec, while exponential fall time is continuously variable from 0.15 to 2 μsec. Output amplitude is highly stabilized, remaining constant over duty-factor extremes, and at average output current levels approaching ±0.5 a.

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

CIRCLE 40 ON READER-SERVICE CARD FOR MORE INFORMATION

Traveling Wave Tube Amplifiers

Permanent-Magnet Focused

The HA-28, HA-29, HA-30, and HA-31 forward wave amplifiers are all permanent-magnet focused and have the respective frequency ranges of 4 to 8, 2 to 4, 2 to 4 and 1 to 2 mc. The general characteristics of each unit except the HA-30 are: small signal gain of 30 db (min), power output of 10 mw (min), noise figure of 25 db (max) and net weight of 3.75 lb. The HA-30 has a power output of 1 w (min), noise figure of 30 db (max) and net weight of 5 lb.

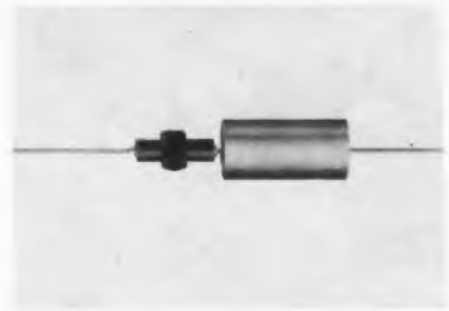
Elimination of the solenoid and its associated supply results in a weight reduction by a factor greater than 10. Focusing is accomplished by arranging high coercive force ceramic magnets in a periodic structure. Each unit operates over its indicated frequency range without the necessity of any electrical or mechanical adjustments.

Huggins Labs., Inc., Dept. ED, 711 Hamilton Ave., Menlo Park, Calif.

CIRCLE 41 ON READER-SERVICE CARD FOR MORE INFORMATION

Component Encapsulation

Custom-machined Epoxy



Called N-Capshells, these encapsulations are custom machined of polyester or epoxy materials, and are available open-ended or with one end closed. Entry holes for leads are provided in the closed end when specified. Their use eliminates the use of molds, and reduces rejection rate and patch time because of molding imperfections. They are less expensive than the extruded or molded type of case and can be supplied in any quantity without tooling or setup charges.

E.P.M. Corp., Dept. ED, 675 Harbey St., Brooklyn, N.Y.

CIRCLE 42 ON READER-SERVICE CARD FOR MORE INFORMATION

Voltage Regulator Diodes

Available in 10 to 100 V Range

These 10 w voltage regulator or zener, diodes are stated to be the first commercially available zener diodes to incorporate a large area diffused junction. This diffused junction offers extremely low dynamic impedance and permits closely controlled characteristics. Standard units are available in the range of 10 to 100 v, with tolerances of 5 and 10 per cent. The range of low voltage values, together with long time stability, make the voltage regulator especially suitable for transistor and mag-amp circuitry.

Hoffman Electronics Corp., Dept. ED, Semiconductor Div., 930 Pitner Ave., Evanston, Ill.

CIRCLE 43 ON READER-SERVICE CARD FOR MORE INFORMATION

Germanium Fusion Alloy Transistors

Available in JETEC-30 Package

The below pnp germanium fusion alloy transistors have been included in the JETEC-30 standardized package. New computer types have been designated 2N425, 2N426, 2N427 and 2N428. These vary in alpha cut-off frequency and beta but have been designed to meet the great bulk of the computer requirements. Two radio frequency types, the 2N416 and the 2N417, will replace respectively the previous types 2N113 and 2N114 having alpha cut-off frequencies of 10 and 20 mc respectively. Audio output types include 2N359, 2N360 and 2N361 for class A or B output use and differ in the gain groupings for which they are tested. Type 2N138B, which is appreciably smaller than the JETEC-30 standardized package, is also available for class A or B useage. Audio frequency amplifier types include 2N362, 2N363, and 2N422. The first two are drivers for output stages while the 2N422 is a very low noise amplifier unit. In addition to these, types 2N130A, 2N131A, 2N132A and 2N133A are available in the same extra small package as the 2N138B.

Raytheon Manufacturing Co., Dept. ED, 55 Chapel St., Newton 58, Mass.

CIRCLE 45 ON READER-SERVICE CARD

Etched Metal Nameplates

7 Min Delivery

A product called Fotofoil solves short run problems for nameplates, panels, schematics, and templates by permitting delivery in 7 min. No darkroom or photographic equipment is required. The kit contains all necessary chemicals and equipment to produce quality etched, anodized nameplates and panels in your own plant. Fotofoil is available in a variety of colors and in standard thicknesses from 0.003 in. It consists of a metal, coated with a light sensitive ink which, after processing, becomes alkali, acid and waterproof. The bit is used for photo template work.

Miller Dial & Name Plate Co., Dept. ED, 4400 N. Temple City Blvd., El Monte, Calif.

CIRCLE 46 ON READER-SERVICE CARD

CIRCLE 47 ON READER-SERVICE CARD ➤

ONE TEN°

Tung-Sol Horizontal, Vertical Deflection Tubes

Tung-Sol's complete complement of horizontal and vertical deflection tubes—engineered to the industry's most exacting standards—will insure maximum performance of the Magic Mirror **One-Ten°** and every other picture tube on the market, 110° or 90° deflection.

The Magic Mirror One-Ten° Aluminized Picture Tube

The Magic Mirror **One-Ten°** the brand-new 110° deflection picture tube, is designed by Tung-Sol to meet the most exacting specifications and performance requirements of manufacturers of portable and lightweight cabinet and table TV sets.

The Magic Mirror **One-Ten°** is being produced in types 17BZP4 and 21DAP4. The 17BZP4 is 12 9/16 inches long (three inches shorter than standard 90° tubes), possesses a 155 square-inch viewing area and weighs but 10 pounds. The 21DAP4 is 14 11/16 inches long, has a 262 square-inch area and weighs 20 pounds.

The Magic Mirror **One-Ten°** needs no ion-trap magnet. It is aluminized by the same unique method that has earned for all Tung-Sol picture tubes their reputation among set manufacturers for pictures of outstanding quality.

For additional information write Sales Dept., Tung-Sol Electric Inc., Newark 4, N.J. Sales Offices: Atlanta, Ga.; Columbus, Ohio; Culver City, Calif.; Dallas, Tex.; Denver, Colo.; Detroit, Mich.; Melrose Park, Ill.; Newark, N. J.; Seattle, Wash.

TUNG-SOL®
ELECTRON TUBES
SEMICONDUCTORS

TUNG-SOL ELECTRIC INC., NEWARK 4, N. J.

TUNG-SOL®

CIRCLE 49 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Germanium Diodes

High Conductance and Quick Recovery

This series of germanium point-contact diodes features a combination of both high conductance and quick recovery. As a result, they make possible advanced, higher speed circuits in which recovery from a forward pulse must be achieved in a minimum of time. Their low forward voltage drop combined with the fast recovery make them ideal for transistorized computer circuits and similar applications.

All types are packaged in a one piece, fusion-sealed glass envelope, impervious to moisture and other contaminants. Actual size, diode glass body: 0.265 x 0.105 in. max. Specifications: piv up to 100 v, forward current up to 100 ma, back resistances of 1 meg, and recovery to 100 k in 1 μsec when switched from 30 ma to 35 v.

Hughes Products, Dept. ED, International Airport Station, Los Angeles 45, Calif.

CIRCLE 50 ON READER-SERVICE CARD FOR MORE INFORMATION

Phase Voltage Converter

Single Phase to Three Phase

This converter changes single phase, 115 v, 60 cps to three phase, 230 v, 60 cps. Frequency is held constant within a fraction of a cycle. Intake and exhaust air vents are located in lower halves of end-bells, making the converter drip proof. Heavy duty grease sealed ball bearings produce very little noise. Equipped with vibration dampeners, the machine can be used to change phase and voltage for sound track equipment if placed a few feet away from recording equipment. Five models are available ranging from 500 to 2500 w. The durable aluminum alloy frame houses capacitator starter as well as both output and input receptacles, and is about 10 in. high without carrying handle and weighs 39 lb.

Kato Engineering Co., Dept. ED, 1415 First Ave., Mankato, Minn.

CIRCLE 51 ON READER-SERVICE CARD FOR MORE INFORMATION

FREEZE-UP of solenoid-controlled valve in airborne system at −65°F can choke off vital air supply. Manufacturer faces tight contract delivery schedule.

SPECIAL HEATING unit custom-designed and delivered by G.E. in 5 days enables stock valve to function properly, saves customer time, money.

AIR VALVE OPERATING AT −65°F SHOWS HOW . . .

General Electric Specialty Heating Maintains Component Temperature

When components must be kept at operating temperature, G-E specialty heating equipment does the job! Thermal conditioning applications ranging from hydraulic and electronic components to tiny test instruments have all been solved by experienced G-E heating engineers.

LET US ANALYZE YOUR HEATING PROBLEM. Whether it's fast delivery on a prototype or quantity production, General Electric can provide specialty heating products engineered to your specific component needs.

FOR MORE INFORMATION contact your local General Electric Apparatus Sales Office or send coupon.

General Electric Company
Section C220-12, Schenectady 5, N. Y.

Please send bulletin GEA-6285A, G-E Specialty Heating Equipment

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Name.....

Position.....

Company.....

City..... **State**.....

Progress Is Our Most Important Product

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CIRCLE 37 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Matched PNP, NPN Transistor

For Symmetrical Circuits

Selected matched pairs of pnp and npn transistors are available for use in complementary symmetry circuits. The pairs, labelled the SMP Series are matched in five contiguous beta categories and have a wide variety of applications in transformerless Class B push-pull output stages, dc coupled amplifiers and balanced modulators.

General Transistor Corp., Dept. ED, Jamaica, L.I., N.Y.

CIRCLE 55 ON READER-SERVICE CARD

Transistorized Frequency Meter

10 Cps to 100 Kc

A transistorized frequency meter, designed to measure frequency in the range from 10 cps to 100 kc with an accuracy of 2 per cent regardless of wave shape down to a 1 per cent duty cycle, is available. Seven full volt ranges of 100, 300, 1 kc, 3 kc, 10 kc, 30 kc and 100 kc are provided. Minimum input voltage is 0.1 v rms and maximum 120 v. The instrument measures 8-3/4 x 5-3/4 x 4 in.

Teletronics Lab., Inc., Dept. ED, 54 Kinkel St., Westbury, L.I., N.Y.

CIRCLE 56 ON READER-SERVICE CARD

Beam Power Tube

For Receiver Output Stage

The 6DS5 is a beam power tube of the seven pin miniature type designed for use as a class A amplifier in the audio ouput stages of TV and radio receivers. Having high power sensitivity and high efficiency, the 6DS5 in cathode-bias circuits can deliver a maximum-signal power output of approximately 3.6 w with a peak af grid no. 1 voltage of 9.2 v.

The structure of the 6DS5 is designed to permit cool operation of grid no. 1 with the result that grid emission is minimized. Because of this feature, the 6DS5 can be used with cathode-bias and a relatively large value of grid no. 1 circuit resistance.

Radio Corporation of America, Dept. ED, Electron Tube Div., Harrison, N.J.

CIRCLE 471 ON READER-SERVICE CARD

CIRCLE 58 ON READER-SERVICE CARD ➤

Quick-Filming Aviation Brushes

Immediate High-Altitude Protection

These quick-filming aviation brush grades require no sea level break-in filming run. The brushes are scaled and are ready for immediate service at practically any altitude within the scope of modern equipment. The immediate filming feature has not entailed any sacrifice of other essential brush characteristics. Greater stability in such factors as brush temperature, field current and commutation is maintained under a wide range of speed, load, temperature and altitude variations. Improved commutation combines with low friction coefficient to reduce brush operating temperatures materially. The special quick-filming treatment of the brushes is non-corrosive and lends itself readily to silver-soldering rivet connections where needed.

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

CIRCLE 59 ON READER-SERVICE CARD

High-Temperature Oscillograph

For Flight-Test Recording

Specifically developed for flight-test recording at high temperatures, the Type 5-122 is explosion-proof and operates from —65 to +250 F at altitudes up to 120,000 ft. The instrument has a crash-resistant magazine with a safety shutter which automatically closes when the magazine is removed from the oscillograph. The 5-122 will record up to 26 channels at writing speeds in excess of 12,000 ips. To get this, a matching series of high-temperature, high-performance galvanometers were designed.

Design permits normal operation of the instrument during constant acceleration of 15 g in any direction. The company reports that no damage to the instrument will result from constant accelerations of 25 g. Including a fully-loaded magazine, the instrument weighs 80 lbs and takes up a space 11 x 8 x 18-1/2 in. The power requirement for the oscillograph is 200 v, 400 cps, three-phase.

Consolidated Electrodynamics Corp., Dept. ED, 300 N. Sierra Madre Villa, Pasadena, Calif.

CIRCLE 60 ON READER-SERVICE CARD

◀ CIRCLE 58 ON READER-SERVICE CARD

New Products

Miniature Power Pentode

High Power With Low Plate Voltage

The EL84/6BQ5 is designed fo the output stages of low-distortion amplifiers with relatively low-voltage power supplies. A pair in push-pull will deliver 17 w at 4 per cent harmonic distortion, without feedback in Class AB operation, with 300 v B+ supply. As a single-ended output stage, one tube delivers 5.7 w at 1 per cent harmonic distortion, without feedback. Plate dissipation is 12 w which is achieved in an envelope only slightly taller than that of conventional miniature tubes.

Amperex Electronic Corp., Dept. ED, Special Purpose Tube Div., 23 Duffy Ave., Hicksville, L.I., N.Y.

CIRCLE 63 ON READER-SERVICE CARD

Transistor Header Machine

Produces Metal-Flanged Stems

A transistor header machine produces quality metal-flanged stems for transistors and similar components at a rate of up to 800 units per hr. Incorporating twelve heads with individual upper and lower molds, the unit differs from the standard all-glass subminiature stem machine in that each head position utilizes a precise die that correctly positions and holds the metal flange or ferrule.

Kahle Engineering Co., Dept. ED, 1400 Seventh St., North Bergen, N.J.

CIRCLE 64 ON READER-SERVICE CARD

Miniaturized Bezel Assembly

For 3 In. CRT

To achieve brilliant edge lighting of engraved graticules for 3 in. cathode-ray tubes, these assemblies are miniaturized prototypes of similar components formerly available only for larger sized units. Assembly consists of die cast aluminum bezel finished in matte, baked enamel surface, green plastic light filter, precision engraved scale calibrated graticule, heavy neoprene tube cushion and twin receptacles for pilot bulbs.

Jan Hardware Mfg. Co., Inc., Dept. ED, 75 N. 11 St., Brooklyn 11, N. Y.

CIRCLE 65 ON READER-SERVICE CARD

◀ CIRCLE 62 ON READER-SERVICE CARD

Silicon Rectifiers

For Electrostatic Precipitators

These oil-immersed silicon rectifiers are claimed to have numerous economies in operation and maintenance and to greatly extend precipitator rectifier life. Units are available with rated output of 70 kvp and 500 ma. Field tests have shown that units operate with a rectifier efficiency of 96 per cent as compared with 80-85 per cent usually associated with tube sets. Present indications are that the units will last as long as the precipitator itself. When compared with selenium, the units are substantially smaller and hermetically sealed, have high conductance and power-handling ability, and allow greater circuit efficiency and higher temperature stability, with no voltage drop resulting from aging. In addition, the units can be immersed in oil or askeral, along with the power transformer.

Research-Cottrell, Inc., Dept. ED, Bound Brook, N.J.

CIRCLE 66 ON READER-SERVICE CARD

Vernier Potentiometer

Resolution of 0.1 Per Cent

Having a 3 terminal construction for use in circuits having a common ground, the Type 49-A vernier potentiometer provides the advantages of the vernier type at a price comparable to helical potentiometers. The Type 49-A provides a single knob control of two resistance decades. Two turns of the control knob cover the full range of the device. Standard resistance ranges are 1000, 10,000 and 100,000 ohms; accuracy is ±5 per cent of full scale resistance; linearity is ±0.5 per cent; resolution is 0.1 per cent; power rating is 4 w when used as a potentiometer and 20 ma when used as a rheostat. Frequency range is from dc to 10 kc. No disassembly is required for mounting. The complete unit mounts like a panel meter and uses only 2 x 2 in. of panel space with 3 in. projecting behind the panel.

Research Instrument Co., Dept. ED, P.O. Box 9168, Portland 16, Ore.

CIRCLE 67 ON READER-SERVICE CARD

CIRCLE 68 ON READER-SERVICE CARD ➤

New Products

Seven Subminiature Tubes
26.5 V Heaters

Seven subminiature tubes designed with 26.5 v heaters for a variety of military and commercial applications have been developed. This feature, while providing equitable heater voltage distribution, eliminates transformers and the need for series stringing. The group includes a double diode (type 5903), a medium mu ultra triode (type 5904), three pentodes (types 5905, 5906 and 5907), and two pentode mixers (types 5908 and 5916). Four of the tubes, types 5904, 5905, 5907, and 5908, are designed for operation with 26.5 v on plate and screen elements as well as on the heater. The resulting circuitry permits the elimination of several components and parts normally required for tube operation. They are capable of high temperature operation—175 C ambient, bulb temp rate to 220 C.

Sylvania Electric Products Inc., Dept. ED, 1740 Broadway, New York 19, N.Y.

CIRCLE 71 ON READER-SERVICE CARD

Toggle Switches
Have Safety Feature

A series of three-position toggle switches have safety catches to hold the toggle lever in a set position and a pull of approximately 0.109 in. is required to release the lever for movement. One of the new switches, designated 111AT, has two basic switching units in each assembly, while the other, designated 115AT, has four switching units. All switching units have spdt.

Among other features of the switches are compact design, positively driven switch actuators, and sturdy construction. Electrical ratings include: inductive, 10 a at sea level and 6 a at 50,000 ft; resistive, 10 a; motor, 6 a. The basic switching units used in the switches are listed by Underwriters' Labs. for: 10 a at 125-250 v ac; 1/2 a at 125 v dc; 1/4 a at 250 v dc.

Micro Switch, Dept. ED, Div. of Minneapolis-Honeywell Regulator Co., Chicago & Spring Sts., Freeport, Ill.

CIRCLE 72 ON READER-SERVICE CARD

◀ CIRCLE 70 ON READER-SERVICE CARD

Cleaning Solvent

For Magnetic Tapes

Safety solvent, Tecsolv No. 928, for cleaning magnetic tape is low in toxicity, has no flash point, and shows no more action on the magnetic oxides than carbon tetrachloride which it replaces. The solvent is slightly slower evaporating than carbon tetrachloride, but sufficiently fast for the purpose. It is available in containers as small as a half-pt to 55 gal drums.

Tecct, Inc., Dept. ED, Cortland Ave. & Erie St., Dumont, N.J.

CIRCLE 74 ON READER-SERVICE CARD

Crimping Tools

Strip Insulation and Cut Wires

Two hand tools will effectively crimp solderless terminals and connectors to, strip insulation from, and cut wires from 22 through 10 gauge. The copper plated ABC-100 model crimps standard terminals and connectors, while the ABC-200 model, plated in bright cadmium, crimps insulated terminals and connectors. An insulation stripper and wire cutter, as well as crimping jaws, are incorporated in both models. In operation, the stripper may also be used as a wire gauge.

Electrix Terminals & Connectors, Inc., Dept. ED, 990 E. 67 St., Cleveland 3, Ohio.

CIRCLE 75 ON READER-SERVICE CARD

Distributed-Constant Delay Lines

0.2 to 1 μ Sec Delay

Distributed-Constant Delay Lines are housed in an impregnated waxed rigid cylinder with tinned solid axial leads. The lines have a time delay of 0.2 to 1 μsec. They are of a geometry that is well suited to requirements for point-to-point wiring and printed board applications. Principal applications are in color television receivers, computers, test equipment, and telemetering equipment. A few of the desirable features which they incorporate are inherent uniformity and economy.

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

CIRCLE 76 ON READER-SERVICE CARD

CIRCLE 77 ON READER-SERVICE CARD ➤

DU PONT

ELECTRONIC DESIGN NEWS

LATEST PROPERTY AND APPLICATION DATA ON TEFLON® tetrafluoroethylene resins

Impedance-matching weather protection of Du Pont TEFLON® tetrafluoroethylene resins featured in new variable-polarization K-band antenna

Du Pont TEFLON tetrafluoroethylene resins are uniquely qualified as materials for making the matching devices and radome used in the feed system of the new Diamond K-brand antenna. The 16,000 mc radar signal passes through an impedance-matching and weatherizing system based on components of a TEFLON resin, and is reflected from the accurate parabolic dish. The .027" wall of the radome matches the horn to space.

No other material could compare with TEFLON resins for this highly critical electronic application. They are unaffected by outdoor weathering and have so little moisture absorption that their dielectric constant remains unchanged under all humidity conditions. The very low dielectric constant of TEFLON resins gives the material its excellent matching characteristics. They are rated at 2.1 from 60 cycles through the super-high frequency range and have a power factor of under 0.0003 from 60 cycles to over 10,000 mc, so that the loss figure in transmission is very low. Dirt has no tendency to stick to the naturally "slick" surface. TEFLON is unaffected by heating to 260° C.

With this system, the plane of polarization can be varied a full 90° by Faraday rotation. Use of a TEFLON resin overcomes the impedance-matching problem. Moreover, no orienting effects are produced by radomes of this resin. VSWR of the antenna is less than 1.2: 1 over the required ±1% frequency band.

For your own designs, you are invited to take a closer look at the many outstanding advantages of Du Pont TEFLON tetrafluoroethylene resins in electronic applications. The coupon will bring you details.

RADOME of a TEFLON resin matches impedance of feed horn to space and provides protection against weather. Wave-guide impedances at input and output of ferromagnetic rotator in the feed are matched with minimum insertion loss by internal cones of a TEFLON resin. (Made by Diamond Antenna and Microwave Corp., Wakefield, Mass.)

Tapes made of TEFLON® tetrafluoroethylene resins provide high dielectric strength

Tapes made of TEFLON resins are strong, smooth and easy to handle. They have a dielectric strength of 500 to 4,000 volts, depending on thickness. Arc resistance is high, too; no carbonized path is formed by a surface arc. Tapes of TEFLON resins make high-grade electrical insulation which "snugs down" easily, conforms to sharp corners and odd shapes, and becomes tighter as temperature rises.

TEFLON®

is a registered trademark...

TEFLON is the registered trademark of the Du Pont Company. It should not be used as an adjective to describe a product of another concern, nor may this registered trademark be used in whole, or in part, as a trademark for any product.

SEND FOR INFORMATION

For additional property and application data on Du Pont TEFLON tetrafluoroethylene resins, mail this coupon.

E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Dept.
Room 18815, Du Pont Building, Wilmington 98, Delaware

Please send me more information on Du Pont TEFLON tetrafluoroethylene resin. I am interested in evaluating this material for_____

*Name*_____

*Company*_____ *Position*_____

*Street*_____

*City*_____ *State*_____

*Type of Business*_____

In Canada: Du Pont Company of Canada (1956) Limited, P. O. Box 660, Montreal, Quebec

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FOR EVERY SYSTEM APPLICATION

KEARFOTT offers the systems manufacturer the most complete line of precision made components available anywhere. Quantity production enables quick deliveries and reasonable prices.

SYNCHROS—Transmitters, Control Transformers, Resolvers, Repeaters, and Differentials in Bu Ord Sizes 8, 11 and 15. High Accuracy and environmental resistance.

SERVO MOTORS—High torque, low inertia Servo Motors, Inertial and Viscous damped Servo Motors, in Bu Ord Sizes 8, 11, 15, 18 and 23.

TACHOMETER GENERATORS—Available as damping generators, rate generators and integrators. They feature high output to null ratio and extremely linear outputs. Temperature stabilization may be provided.

GYROS—Directional, floated rate integrating, free, vertical, and spring restrained rate gyros for all airborne navigation, stabilization or fire control applications.

Bulletins giving physical and technical data of the various Kearfott Products will be sent on request. The Kearfott organization is available to assist in the development and manufacture of other precision components you may require.

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Midwest Office: 23 W. Calendar Ave., La Grange, Ill. South Central Office: 6211 Denton Drive, Dallas, Texas
West Coast Office: 253 N. Vinedo Avenue, Pasadena, Calif.

CIRCLE 78 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Miniature Tantalum Capacitors

Diameter of 5/64 in.

Two new sizes have now been added to the Tan-O-Mite line of Series TW electrolytic capacitors. Designated sizes S and T, the case dimensions are 3/16 in. length by 5/64 in. diam; and 5/32 in. length by 5/64 in. diam respectively.

The six sizes of the entire line provide a capacitance range of approximately 0.1 to 60 μf, and the two smallest capacitors now offered have a capacitance range of up to 4 μf. Tan-O-Mite capacitors, insulated with a Mylar plastic sleeve, 0.002 in. thick, are also available. This sleeve increases the diameter and length slightly. Insulated capacitors find application in confined, tight locations where metal parts of different potential could possibly touch the capacitor as a result of shock or vibration.

Ohmite Mfg. Co., Dept. ED, 3629 Howard St., Skokie, Ill.

CIRCLE 79 ON READER-SERVICE CARD FOR MORE INFORMATION

Instrument Shunts

50 Mv Range

Light weight instrument shunts are available in the 50 mv operating range. The MS-91586 shunts are furnished in current ratings ranging from 30 to 150 amp and are designated as the MSA type. MS-19587 units have current ratings ranging from 170 to 600 amp and are identified as MSB while the MSC type shunts are made to MS-19588 and are provided in ampere ranges from 800 to 1200 amperes.

Janco Corp., Dept. ED, Burbank, Calif.

CIRCLE 80 ON READER-SERVICE CARD FOR MORE INFORMATION

Sealed AC Relay

400 cps 6PDT

A Class 11 6PDT relay with built-in full wave rectification is hermetically sealed into one unit. Rectification affords operation that closely approaches direct current from all frequencies up to and including 400 cps, thereby making possible contact combinations to 6PDT in this miniature relay. Other advantages include increased operating sensitivity, higher contact pressures, reliable operation through much wider variation in voltage or current, and quiet operation, free of ac hum. Can be furnished to conform with military specifications. Dimensions of the container, less 20 pin miniature plug-in header and mounting studs are 2-3/8 in. L, 1-23/32 in. W, 1-7/32 in. H.

Magnecraft Electric Co., Dept. ED, 8350D W. Grand Avenue, Chicago 51, Illinois.

CIRCLE 83 ON READER-SERVICE CARD

Single-Turn Potentiometer

10-30,000 Ohms

This 1 5/16 in. diam single-turn potentiometer, Model 130, meets military specifications NAS-710 environmental humidity requirements, and will operate in a temperature range of −55 C to +85 C. The unit has a standard resistance range from 10 ohms to 30,000 ohms, with a standard tolerance of plus or minus 3 per cent. It has a life exceeding 1,000,000 revolutions. As many as 11 additional taps can be supplied to meet nearly all specific location requirements within 36 deg of each other, on the rear of the unit.

Spectrol Electronics, Dept. ED, Div. of Carrier Corp., 1704 S. Del Mar Ave., San Gabriel, Calif.

CIRCLE 84 ON READER-SERVICE CARD

CIRCLE 85 ON READER-SERVICE CARD ➤

Do YOU Seek Definite Improvement in • • •

☐ **Evacuation of Lighting, TV or Radio Tubes**

☐ **Purification of Germanium, Selenium and Silicon . . . and Crystal Growing**

☐ **Vacuum Curing of Transistors, Diodes and other Semi-Conductors**

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Kinney®

HIGH VACUUM

for work in the low micron region

KINNEY Simplex and Duplex Single-Stage Oil Sealed Mechanical Pumps afford a choice of 9 models with displacements from 13 to 780 cfm and ultimate pressures to 10 microns (McLeod). Compound Pumps in 4 sizes – 2.0 to 46.0 cfm – develop ultimate pressures to 0.2 micron (McLeod).

for high pumping speed in the low micron region

KINNEY Mechanical Booster Pumps in 4 models with displacements from 30 to 5000 cfm. These revolutionary Pumps produce a clean, dry vacuum in the 0.2 micron (McLeod) range or better without use of cold traps or baffles. Widely used in metallurgical and electronic work.

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KINNEY complete High Vacuum Systems embrace a comprehensive selection of Evaporators, Furnaces, Curing Ovens, High Vacuum Pumping Systems and Power Units. KINNEY-built equipment reflects the know-how of extra years of experience in High Vacuum technology.

Write for bulletins on new developments in KINNEY Pumps and High Vacuum Systems.

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CIRCLE 87 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Broadband Absorber

Reflection of 0.1 Per Cent

Type 12CM broadband microwave absorbent material for simulating free space conditions indoors is available with a maximum of 0.1 per cent reflection above 8400 mc. Other absorbers are available with a maximum of 0.1 per cent reflection at lower microwave frequencies. Maximum reflection of the standard 12CM broadband absorber remains less than 2 per cent from 2500 to 8400 mc and less than 1 per cent over the same frequency range for a selected 12CM material.

The B. F. Goodrich Co., Dept. ED, 800 Second Ave., N.Y. 17, N.Y.

CIRCLE 88 ON READER-SERVICE CARD

Electron Beam Tube

Measures Weak Magnetic Field

An electron beam tube with wide applications in analysis of weak magnetic fields has been developed. This tube is 20 in. long and has a constricted mid-section for convenient positioning of the test samples.

Multi-Tron Laboratory, Inc., Dept. ED, 4624 W. Washington Blvd., Chicago, Ill.

CIRCLE 89 ON READER-SERVICE CARD

Voltage Regulator

Corona Type

Corona type regulators with current ratings up to 4 ma are produced in T6-1/2 and T9 envelopes in voltage ranges below 3500 v. Suggested applications for high current corona type voltage regulators include klystron power supply, high beam current synchroscopes, laboratory oscilloscopes, radar display units, air conditioning units, and magnetron oscillators.

The Victoreen Instrument Co., Dept. ED, Components Div., 5806 Hough Ave., Cleveland 3, Ohio.

CIRCLE 90 ON READER-SERVICE CARD

Stainless Steel Containers

Eliminates Breakage in Transport

A stock container of all stainless steel, for transporting aircraft parts, delicate instruments and radium isotopes as well as liquids and radio tubes, is available in three standard sizes; namely, 1, 2, and 3 in. diam with lengths from 2 to 12, 3 to 12 and 3 to 12 in. respectively. Each container is equipped with two 0 rings which accords a double seal to the unit. The wall can withstand 250,000 lbs external pressure and 100,000 lbs internal pressure.

DSC Machine Co., Inc., Dept. ED, 23 Bertel Ave. in Mt. Vernon, N.Y.

CIRCLE 91 ON READER-SERVICE CARD

Coolant Dielectric

For Airborne Equipment

A chemical coolant-dielectric, trademarked OS-45, for airborne electronic equipment which may be pumped at temperatures ranging from —65 to 400 F consists of silicate ester-based fluid. It reportedly solves the complex problem of cooling miniaturized and black-boxed electronic equipment.

Monsanto Chemical Co., Dept. ED, 1700 S. Second St., St. Louis 4, Mo.

CIRCLE 92 ON READER-SERVICE CARD

RF Choke Coils

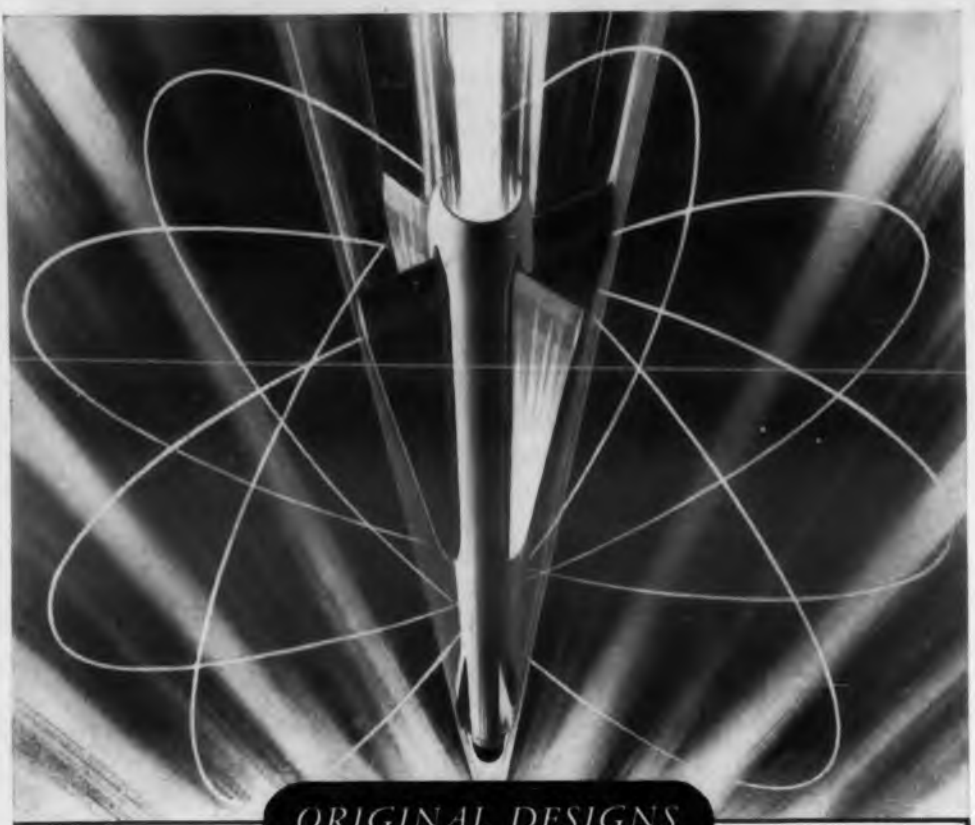
0.15 to 22 μH

A standardized series of molded rf choke coils is available in 23 items with inductance values from 0.15 to 22 μh. Coils measure 0.156 in. diam x 0.375 in. length. All are hermetically encapsulated in molded alkyd to provide a high degree of environmental protection. This sub-miniature series is one of six standardized rf choke coil series available for off the shelf delivery. There are 150 coils in the six series—each has exactingly defined electrical parameters.

Delevan Electronics Corp., Dept. ED. East Aurora, N.Y.

CIRCLE 93 ON READER-SERVICE CARD

CIRCLE 94 ON READER-SERVICE CARD ➤



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MINIATURE THERMAL RELAYS

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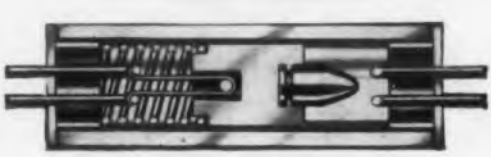
99.99% PLUS RELIABILITY

EXACT SIZE



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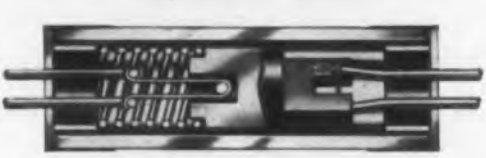


NORMALLY CLOSED

EXACT SIZE

Our complete environmental testing laboratory samples and certifies daily production.

New NORMALLY CLOSED RELAYS NOW AVAILABLE. Hermetically sealed by an exclusive process of bonding metal headers to high thermal, shock resistant glass housings. Designs are based on the "fuse burnout" principle and will open or close a circuit *positively* in 0.1 second or other delay times. They can also be safely used as a "squib" or timing mechanism.

Relays have been qualification tested for high performance and are being used extensively on current production missiles and complex electronic equipment.

Withstand extreme conditions of temperature (−100°F to +450°F), shock (250 G's), vibration (20-3000 cps at 40 G's), and precise electrical characteristics with the added feature of visibility.

WHAT ARE YOUR REQUIREMENTS?

Write TODAY for new Brochure containing detailed characteristics and specifications.

NETWORKS ELECTRONIC CORPORATION

14806 OXNARD STREET, VAN NUYS, CALIFORNIA

Original designs for highest reliability in glass housed miniature Relays and Resistors for all purposes.

SEE US AT WESCON BOOTH 1214

CIRCLE 95 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

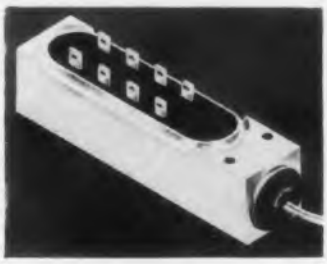
Pre-Amplifier

For Meter Movement Recorders

The M-10, is a dc amplifier with chopper stabilization which is specifically designed as a preamplifier for use with recorders of the meter movement type. Ten mw input produces a 1.5 v output across a 1500 ohm load with 1 per cent linearity, less than 1 per cent zero drift, and 2 per cent accuracy from dc to 2 cps. The unit operates from 115 v 60 cps consuming 15 w.

Mandrel Industries, Dept. ED, Ind. Instruments Div., 5134 Glenmont Dr., Houston, Texas.

CIRCLE 96 ON READER-SERVICE CARD FOR MORE INFORMATION



Squib-Actuated Switch

Actuation Time: 1 msec.

A switch has been developed for special applications which is actuated by a squib, or tiny explosive charge. Encased in a metal housing, 1/2 x 1/2 x 2-5/32 in., the switch provides four sets of contacts which can be furnished in any combination of normally open and normally closed positions, as desired. It is unaffected by vibration of 100 g amplitude from 20 to 2000 cps, and is not damaged by shock acceleration of 15,000 g in any direction. Tests at a sweep rate of 50 μsec per grid square reveal a complete lack of contact bounce.

Insulation resistance between open contacts at 500 v is 5 x 11^{11} ohms. Contact resistance, closed contacts at 1 to 10 amp, is 4 v 10^{-3} ohms. Current capacity of contacts is 10 amp continuous, and 100 amp for 100 msec. Actuation time for the carbon bridge switch is less than 1 msec, and for the wire bridge it is from 2 to 4 msec. Delay actuation can be furnished, if desired, with a corresponding change in dimensions. Firing energy for the actuating squib is 500 ergs with the carbon bridge, and 5000 to 30,000 ergs with the wire bridge. The switch is sealed to permit potting in wax or resin compounds.

Atlas Powder Co., Parke Thompson Ordnance Section, Dept. ED, 9404 Watson Rd., St. Louis 19, Mo.

CIRCLE 97 ON READER-SERVICE CARD FOR MORE INFORMATION

Induction Motor

Single Coil

A single coil 2 pole induction motor, Type P, is available in various stacks and horsepower ratings from 1/300 to

1/50. Free speed is 3400 rpm; load speed 3000 rpm. The motor is designed for 115 v, 60 cycle operation.

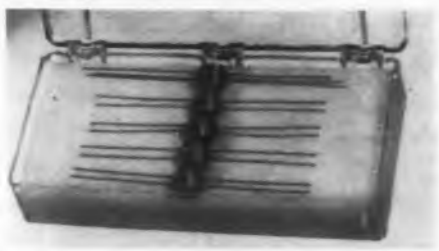
Heinze Electric Co., Dept. ED, 685 Lawrence St., Lowell, Mass.

CIRCLE 100 ON READER-SERVICE CARD

Transformer Kit

Miniature Pulse Type

Model KA-4 consists of five subminiature, metal cased, hermetically sealed Mil T-27 type pulse transformers. The transformers measure 1/2 in. OD by 3/8 in. long. They use ferrite



toroidal cores with pig tail mountings for dip soldering operations. Typical applications for these units are impedance matching, blocking oscillators, and isolation. Custom designing services to meet particular circuit requirements are available for this size unit.

C B S Electronics Co., Inc., Dept. ED, 2601 North Howard St., Philadelphia 33, Pa.

CIRCLE 101 ON READER-SERVICE CARD

CIRCLE 102 ON READER-SERVICE CARD ➤

New Products

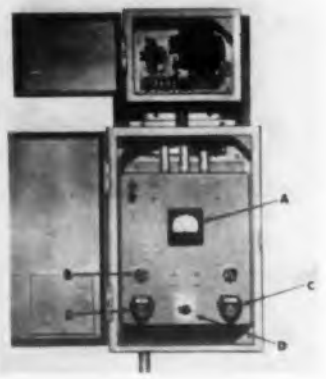
Wire-Reinforced Fuse Clips

100 Per Cent Electrolytic Copper

These wire-reinforced fuse clips and jaws are made of 100 per cent electrolytic copper. Steel wire reinforcing produces the necessary grip on fuses to withstand excessive vibration and shock. The clips are available in the following sizes: 30 a, 250 v; 30 a, 600 v; 60 a, 250 v; 60 a, 600 v; 100 a, 250 v.

Ilsco Corp., Dept. ED, Cincinnati 27, Ohio.

CIRCLE 105 ON READER-SERVICE CARD FOR MORE INFORMATION



TorqueTrol

Detects Torque Change

Machines can operate unattended when they are supervised by TorqueTrol, which detects any increase of torque due to jamming, tool wear or faulty lubrication. In addition, tool feed may be automatically controlled or the work strokes of the machine counted. TorqueTrol consists of current and voltage transformers and an electronic control unit, which constantly monitors the load on the motor-driven machine and the torque in the drive-shaft. A relay trips when the pre-set load level is reached, sounding an alarm and stopping the machine. A built-in time delay, adjustable from 0 to 10 sec is optional; this will allow the relay to operate only if overload is sustained for the selected period. The unit constantly monitors load on motor-driven machine, responds in milliseconds to stop abnormal overload long before human operator can make a move toward stop button. Meter A indicates instantaneous load level. Pointer moves up-scale with increasing load or torque until trip level is reached, whereupon relay turns on red light B, sounds alarm and stops machine. Sensitivity is set by Control D. Reset button C resets TorqueTrol after load or torque has decreased to normal level. Test button E permits calibrating or checking TorqueTrol without stopping machine.

Electronic Control Corp., Dept. ED, 1573 East Forest Ave., Detroit 7, Mich.

CIRCLE 106 ON READER-SERVICE CARD FOR MORE INFORMATION

Nylon Batting

High Shock Absorption

The ability of a material, called Ny-Sul-Loft, to absorb shock and vibration is demonstrated with two glasses of matter. A self-supporting batting, it is made of nylon fibers with other characteristics useful for thermal insulation, liquid and gaseous filtration, padding, and packing applications. As a shock absorber, the material has advantages because of its ability to soften an impact while recovering to its normal shape without undue force. As a padding medium, the material is desirable because of its light weight and permanent resilience.

The fabric batting possesses all of nylon's properties including being anti-fungus, anti-mildew, rapid drying, and resistant to alkalies and most acids. Since it will withstand continuous temperature of 300 F, it can be laminated or stitched by a process utilizing heat treatment. The material can be used independently of supporting substances in most applications. It can be die cut and impregnated with any chemical compatible with nylon. The material is made by crimping nylon fibers and then permanently locking them together by a patented chemical-thermal process. The fiber crimp gives the fabric added tensile strength and loft as well as imparting to it permanent resilience. The material is produced in a range of weights from 2 to 8 oz per sq yd. It is available in any width up to 55 in.

Star Woolen Co., Dept. ED, Cohoes, N.Y.

CIRCLE 108 ON READER-SERVICE CARD FOR MORE INFORMATION

Insulating Liquid

Dries to Natural Rubber

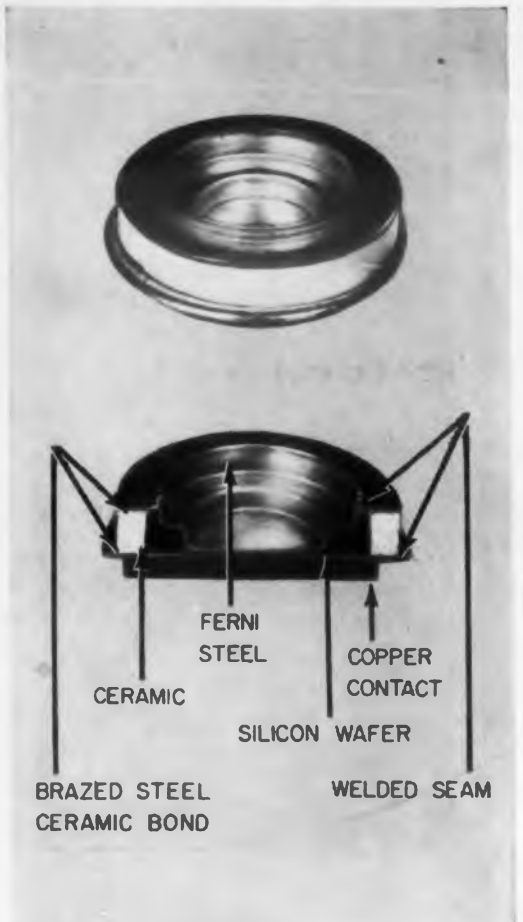
A liquid rubber has been developed that can be sprayed or painted on to insulate chassis against shocks and shorts. When the product dries, it forms a rubber coating that prevents arcing between components and weatherproofs antenna terminals, wires, and mounts. The product resists salt and sea air, many kinds of acids and withstands heat from −20 to +200 F. Available in green, grey, red, black, and transparent, and comes in 2 oz bottles with brush applicator and in half pint and pint size cans.

Rubber Magic, Inc., Dept. ED, 4312 Third Ave., Brooklyn 32, N.Y.

CIRCLE 109 ON READER-SERVICE CARD FOR MORE INFORMATION

DESIGNER'S

HERMETICALLY SEALED silicon cell is mounted on a standard stud assembly for ease in mounting to almost any type of heat sink. The selected heat sink may be either forced-air or liquid-cooled as desired by the user. Positive contact on both sides provide efficient heat transfer.



ACTUAL SIZE view shows G-E silicon rectifier cell hermetically sealed to better protect the silicon wafer from moisture or other contaminants.

New G-E silicon cell provides more output, greater flexibility for large DC power

A new power-sized silicon rectifier is now available from the General Electric Company with cell ratings up to 140 amperes. In the field of electronics there are many types of applications such as filament power supplies, and power supplies for computers, radar, etc., for which this will be ideally suitable. It offers the advantages of lightweight, small size, high efficiency, and higher operating temperature as compared to other types of semiconductor rectifiers.

The basic part of the G-E silicon rectifier is the cell enclosure as shown in the cutaway view above. The specially processed silicon wafer is enclosed in a hermetically sealed package of ceramic and welded ferni steel. This same construction has been adequately field tested in 4 years of successful performance totalling over 35,000 KW of our high-power germanium rectifier components.

The package is intimately bonded to a threaded stud to provide a simple yet thermally efficient method of mounting the rectifier assembly to a proper heat sink (see fig. 1163340). Because of this design, it is now possible to obtain an effective heat transfer junction on single-plate type cooling fin.

Complete application information is available through your local G-E Apparatus Office or check coupon for bulletin GET-2689.

Packs 2.2 hp in

General Electric combination d-c motor-tachometer unit has high power in small space, plus extremely fast response

This General Electric d-c motor-tachometer combines—in one compact, space-saving unit—great power and extra-fast response to control signals. It's a natural choice for automatic machines that are subject to rapid acceleration, frequent starts, stops, reversals, and widely fluctuating loads.

For example, the 200-volt model shown is less than 15 inches long and only 5.16 inches in diameter. Yet it delivers 2.2 horsepower, when externally cooled, to

GENERAL ELECTRIC

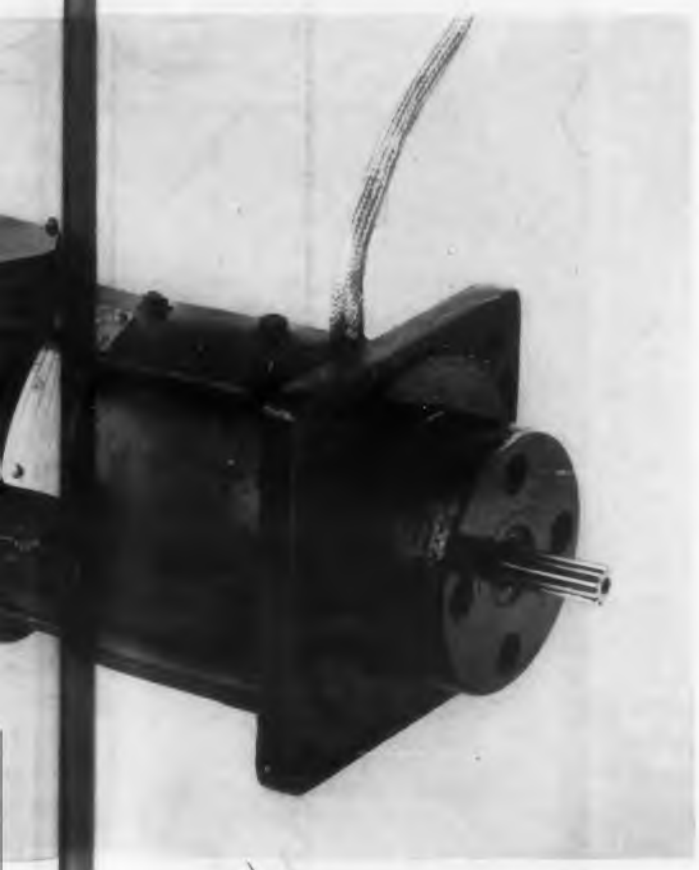
5.16-in. diameter

drive a ground radar antenna in a missile guidance system. In this case, the motor moves the radar antenna up or down, clockwise or counterclockwise, fast or slow, depending on the missile's track and speed.

The motor's speed of response is such that, at no load, it reaches 63 per cent of its rated speed of 5500 rpm in only .014 seconds from standstill. When blower-cooled, it delivers 2.65 lb-ft of torque throughout the entire shaft-speed range from standstill to 4500 rpm. Stall torque is 10 lb-ft.

This motor can be supplied with or without shaft-coupled tachometer-generator that is used for feedback control signals.

Available in two frame sizes, the motor features all-angle operation, can be powered by any d-c control power supply, and is applicable to practically any servo system. For more details on your application, see your nearest Apparatus Sales Office.



POWER-PACKED General Electric motor-tachometer-generator set features high power, small size, fast response. Model shown—rated 2.2 hp, 5500 rpm, 200 volts d-c, with Class B insulation—measures under 15 inches in length, only 5.16 inches in diameter.

For your design problems . . .

General Electric energy storage capacitors supply minimum inductance or low-cost joules

To meet the increasing needs of the electronics industry, General Electric has expanded its line of energy storage and discharge capacitors to include a new low inductance model. Shown at right in the photo the new unit is rated at 100 kv .25 uf, and will ring at 2.5 mc. The inherent low inductance of this unit means such advantages as maximum energy transfer to low inductance loads, extremely steep current rise, and simpler "crowbar" circuitry.

The existing standard type of G-E energy storage capacitor (shown at left in photo) is rated at 20 kv 7.5 uf and will ring at 200 kc. This standard model offers maximum joules at lowest cost.

BOTH CUSTOM DESIGNED AND STANDARD RATINGS AVAILABLE

Both models are available either in standard ratings or custom designed for your circuit problem. The standard model has applications in atomic energy research projects, photographic equipment, discharge welders, and several other energy storage uses.

The low inductance model has similar applications, and is ideal in high frequency pulse circuits where an optimum rise time is essential. The use of Pyranol* impregnant in all energy storage units provides a relatively small, lightweight, stable capacitor which has a life consistent with the application involved.

CONSULT G-E CAPACITOR EXPERTS

General Electric invites you to discuss your application needs for energy storage units with capacitor specialists like Doug Warner who is shown in the photo.

With more than 20 years of G-E electronics experience, Doug probably will be able to come up with ideas that will solve your particular circuit problems. His recent paper, "The Application of Large Capacitors for Use in Energy Storage Banks," is available now. Simply write for Capacitor Facts No. 4, GET-2698. Additional information on Energy Storage and Discharge Capacitors from 2000 to 6000 volts, may be obtained by writing for Bulletin GEC-1357.

*Registered trade-mark of General Electric Co.

GENERAL ELECTRIC COMPANY, APPARATUS SALES DIVISION, SECTION B667-37
SCHENECTADY 5, NEW YORK

Please send me the following:

√ for reference only × for planning immediate project

☐ GEC-1357—Energy storage capacitors
☐ GET-2689—High-current silicon rectifiers
☐ GET-2698—Capacitor Facts No. 4

For information on other products, contact your nearest G-E Apparatus Sales Office.

NAME.....

COMPANY.....

CITY..... STATE.....

CIRCLE 112 ON READER-SERVICE CARD FOR MORE INFORMATION

FANSTEEL

S·T·A

SOLID TANTALUM

CAPACITORS

Here Are The Sizes Available

	CATALOG NUMBER	CAPACITY IN MFD*	WORKING VOLTAGE	SURGE VOLTAGE
100 SERIES	STA-155	3.5	10	12
	STA-160	2.0	15	18
	STA-165	1.5	20	24
	STA-170	1.2	30	36
	STA-175	1.0	35	42
200 SERIES	STA-255	17	10	12
	STA-260	11	15	18
	STA-265	8	20	24
	STA-270	6	30	36
	STA-275	5	35	42
300 SERIES	STA-355	70	10	12
	STA-360	45	15	18
	STA-365	35	20	24
	STA-370	23	30	36
	STA-375	20	35	42

*Standard Capacity Tolerances are minus 15%, plus 25%.

NOW AVAILABLE IN PRODUCTION QUANTITIES

FANSTEEL 1907 1957 Golden Anniversary of Progress

C376A

Write for bulletin 6.112

FANSTEEL METALLURGICAL CORPORATION

North Chicago, Illinois, U. S. A.

SEE US AT WESCON Booth Nos. 1221-1222

CIRCLE 113 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

DC to AC Power

60 Cps, ±1 Cps

These units generate 117 v at 60 cps ±1 cps from dc sources. Models are available for 6, 12 and 27.5 v operation. They contain a precision frequency power vibrator which operates over a wide dc input voltage range with accurate frequency maintenance. The output can be both resistive and inductive to include recorder motors and control circuits.

James Vibrapowr Co., Dept. ED, 4050 N. Rockwell St., Chicago 18, Ill.

CIRCLE 114 ON READER-SERVICE CARD FOR MORE INFORMATION

Strain Indicators

High Sensitivity

This strain indicator is made in two sensitivities. ZT-301 has a sensitivity of over 1,000 ohms per gram of tension, continuously repeatable up to 2 lb maximum strain. ZT-302 has a sensitivity of over 1,000,000 per gram of tension, continuously repeatable up to 40 grams maximum. The units may be connected in series to double the sensitivity and in multiple to increase the accuracy. No amplifier or expensive accessories are required, the indicators being rated at 0.25 w and will feed into a recorder, meter, scope or relay. The size of the unit is 7.25 in. long, has a 3/16 in. OD. The Zirco-Tet sensing element is enclosed in a rubber tube for moisture protection which is sealed at both ends, and equipped with combination strain and electrical connections. The Model ZT-302 when attached to a man's chest with adhesive tape will continuously analyze respirations with a resolution of 0.001 gram. Temperature range of the units listed is –65 to 150 F as is often required in expansion for control of preloading.

Clark Electronic Labs., Dept. ED, Box 165 Palm Springs, Calif.

CIRCLE 115 ON READER-SERVICE CARD FOR MORE INFORMATION

Pin Straightener and Wiring Plug

Precision Machined

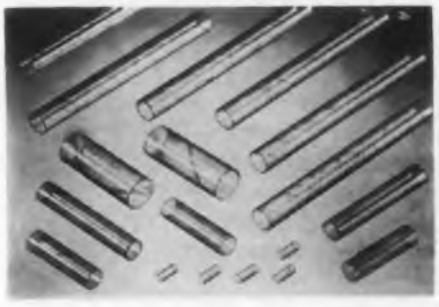
A 27-hole tube pin straightener, JE-31, has No. 303 stainless steel inserts with holes of 0.043 in. diam, equally spaced and perfectly aligned in two pin circles. The holes are countersunk to prevent undue strain on glass tube buttons, and an extra hole aids in speedy insertion of the tube. The JE-24, a 26-pin socket wiring plug, is designed especially for use with sockets which are receptive to Burroughs beam switching tubes, types 6700-6701. The plug features No. 420 stainless steel pins of 0.038 in. diam which have the same alignment, in two circles, as the holes in the JE-31 tube pin straightener. The inner ring of pins protrudes beyond the outer ring for easy insertion, and the semihemispherical tips prevent marring of socket contacts. All pins are permanently set in a die cast housing.

Star Expansion Products Co., Dept. ED, 142 Liberty St., New York, N.Y.

CIRCLE 119 ON READER-SERVICE CARD FOR MORE INFORMATION

Thin-Wall Coil Forms

Wide Range of Sizes



Mylar thin-wall coil forms have been developed as a solution to insulating problems where space is at a premium. Wall thicknesses of from 0.002 to 0.01 in. can be supplied. The Mylar tubes are highly resistant to moisture, solvents and chemicals and have high dielectric strength. They provide the greatest tensile strength that any plastic film can afford according to the manufacturer. The tubes will neither dry nor brittle with age. Because of their dimensional stability, the coil forms are ideal for compact assemblies. For large work, the film can be combined with or wound over conventional materials to improve their dielectric characteristics. The manufacturer will fabricate to any id, od, or length.

Precision Paper Tube Co., Dept. ED, 2035 West Charleston St., Chicago 44, Ill.

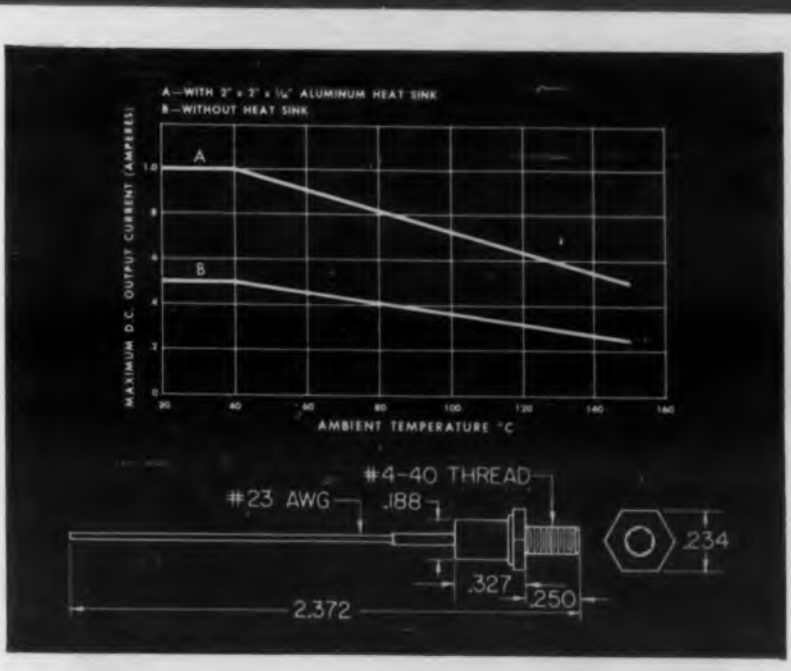
CIRCLE 120 ON READER-SERVICE CARD FOR MORE INFORMATION

FANSTEEL

Silicon

RECTIFIERS

For Extreme Miniaturization



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1907 FANSTEEL 1957 · Golden Anniversary of Progress ·

CIRCLE 121 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Floated Rate Gyro

Damping Ratio: 0.1 of Critical

Model 55,000 rate gyro was designed for an accuracy of better than +1/2 per cent of full scale while it is being subjected to severe vibration environment. The floated rate gyro can be supplied in a variety of maximum rate ranges from 1 to 1000 deg per sec. This gyro incorporates an inductive signal pickoff, which provides a higher power signal output than has previously been available in this size rate gyro. The power signal output enables the use of minimum gimbal displacement, consequently yielding high natural frequency. Standard gimbal displacement is ±0.75 deg. The gyro is completely filled with flotation fluid. The flotation fluid serves to reduce the load on the gimbal bearings, to insulate the gimbal bearings from shock and vibration, and to provide damping.

Damping ratio is maintained without a heater to within 0.1 over the temperature range of −55 to +85 C.

Norden-Ketay Corp., Dept. ED, Commerce Rd., Stamford, Conn.

CIRCLE 124 ON READER-SERVICE CARD FOR MORE INFORMATION

Nonlinear and Decimal Code Disks

For Analog-to-Digital Shaft Angle Encoders

High-accuracy disks for nonlinear and decimal codes are available. Patterns for trigonometric functions, logarithmic functions and other nonlinear codes can be produced, providing the original data can be placed on IBM punched cards. Decimal code disks are being manufactured having any number of divisions to and including 100,000. These nonlinear and decimal code disks can be mounted in the standard 6 and 9 in. encoder housings.

The Baldwin Piano Co., Dept. ED, Industrial Sales Div., 1801 Gilbert Ave., Cincinnati 2, Ohio.

CIRCLE 125 ON READER-SERVICE CARD FOR MORE INFORMATION

Pull-type Solenoid

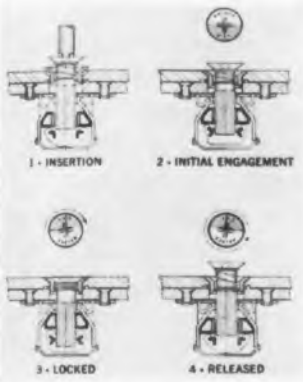
Low Friction Loss

With operating temperature range of −65 F to +100 F, the solenoid provides efficiency and low plunger friction loss.

Operating voltage of the solenoid is from 6 to 100 v dc with plunger operating under side force of 8 to 10 g. At 3 amp, 100 v dc, and 78 F, force is 1.3 lb with stroke .03 in. At these same conditions force is .8 lb with stroke .06 in., and .4 lb with stroke .125 lb.

Carruthers & Fernandez Inc., Dept. ED, 1501 Colorado Ave., Santa Monica, Calif.

CIRCLE 127 ON READER-SERVICE CARD FOR MORE INFORMATION



Stressed-Panel Fastener

Withstands 7000 lb Shear

The QAF is a quick-action stressed-panel fastener that will withstand high shear and tensile loads, lock positively in less than one-half torque-free turn and compensate automatically for sheet separation resulting from warpage or deformation in the panels being secured. The device is intended for use on structural load-carrying panels in aircraft, guided missiles and other applications where quick access to service areas is required. The fastener exceeds the strength specifications of NAS no. 547. The fastener is vibration-proof and has a tensile load capacity of 4000 lbs in the NAS 547 no. 1 size. The wedge action of the split nut assures 100 per cent crest-to-root thread engagement between the stud and nut halves. The ultimate shear load capacity of the fastener is approximately 7000 lbs in the no. 1 size. The fastener is strip-proof and cannot be cross-threaded. The nut halves float inside the receptacle before engagement and the screw is centered automatically. Flag action provides a visual indication the fastener is engaged but not locked. The stud protrudes from the panel until it is in the locked position. The fastener may be used on hinged, curved panels.

It can accommodate an included angle of 140 deg between fasteners. The new fastener is available currently in a 1/4 in. diam stud size and is designated as the QAF-4841. This conforms to NAS 547 for Size No. 1, Class A. Type I fasteners.

Waldes Kohinoor, Inc., Dept. ED, Special Products Division, 47-16 Austel Pl., Long Island City 1, N.Y.

CIRCLE 128 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Square-Face CRT

Large Raster Size, Short Tube Length

The 3-1/2 in. square-face design of the type 41HAP single-gun electrostatic focus and deflection cathode ray tube provides a raster size almost as large as that of a 5 in. tube of conventional round design. Overall length of 11-1/8 in. provides an additional design advantage. The tube has highly sensitive D1D2 and D3D4 deflection plates. Angle alignment between the D1D2 and D3D4 traces are held to within 1 deg. Deflection factors are held to within 10 per cent with low pattern distortion. Grid cut-off bias is held to within 25 per cent. A gun which draws negligible focusing electrode current is employed.

Electronic Tube Corp., Dept. ED, 1200 E. Mermaid Lane, Philadelphia 18, Pa.

CIRCLE 132 ON READER-SERVICE CARD FOR MORE INFORMATION

Printed Circuit Relays

Minimum Input Power

Class II Printed Circuit Relays are especially adaptable to low voltage sensitive applications where reliability is important and for requirements where one relay must perform a number of switching functions with minimum input power. They can be furnished with resistance to shock, vibration and temperature variation in compliance with military specifications.

Available for dc operation, any voltage to 230 v. also with full wave rectification for operation from 20 to 400 cps. Furnished with a variety of contact combinations; snap action contacts, time delay, and heavy current contacts.

Magnecraft Electric Co., Dept., ED, 3350D W. Grand Ave., Chicago 51, Ill.

CIRCLE 133 ON READER-SERVICE CARD FOR MORE INFORMATION

Nuclear Powered Timer

μsec to 40 hr Range

Given the trade name of Betachron, this Nuclear Powered Electric Timer has a shelf and use life of over 25 yrs and is capable of reliably operating over wide ranges of temperature, acceleration and vibration. The timer is suitable for use in weapon and missile systems where time delays from the μsec range to 40 hrs are required with an accuracy of ±3 per cent.

Capable of delivering energy pulses up to 250,000 ergs, it is supplied encapsulated in a metal case and provided with standard connectors at the output. A timer for fixed time intervals is supplied in a cylindrical metal case 2-1/2 in. diam, 1-7/8 in. long. A switch, located within the case, initiates the time delay. Depending upon the application, either a snap action, pull wire, or external electrical signal type switch can be supplied without changing the physical dimensions of the unit.

The heart of the timer is a nuclear battery which has been in production by the company for the last few years. This battery converts nuclear energy directly into electrical energy. It is made with current ratings from 50 to 5000 μμa and equilibrium voltages in the order of 10000 v. Battery performance is not affected by environmental conditions, shelf and use life are not charged by short circuiting.

Universal Winding Co., Dept. ED, P.O. Box 1605, Providence, R.I.

CIRCLE 135 ON READER-SERVICE CARD FOR MORE INFORMATION

Rotary Switch

Use up to 60 Mc

This rotary switch for use up to 60 mc consists of 9 completely shielded decks with 10 positions, one pole per deck. All contacts and wipers are of coin silver and all metal parts are silver plated brass. The wiring of this switch is all done with Micro-dot cable and all leads are terminated in Micro-dot connectors. The entire switch exclusive of shaft is 3 x 3 x 6 in. The use of sectional shielding and rf grounding fingers in conjunction with the outer case results in good rf characteristics.

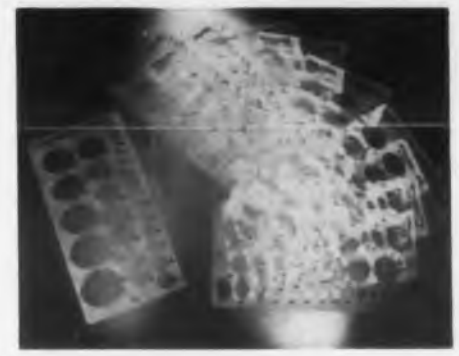
The Daven Co., Dept. ED, Livingston, N.J.

CIRCLE 136 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Ellipse Templates

Set of Ten



The No. 70 Ellipse Series comprises 10 templates from 150 to 60 deg in increments at 32nds from 1/4 to 1/2 in., 16ths from 9/16 to 1-1/2 in., and 8ths from 1-5/8 to 2 in. 50 and 60 deg templates contain 27 ellipses each; from 1/4 to 1/2 in. in 32nds, 9/16 to 1-1/4 in. in 16ths, and 1-3/8 to 2 in. in 8ths. Size and center lines are detailed for permanence on the negative side of the 0.030 matte finish plastic. Actual size of each template is 5 x 9-7/8 in.

Rapidesign, Inc., Dept. ED, Box 592, Glendale, Calif.

CIRCLE 141 ON READER-SERVICE CARD FOR MORE INFORMATION

High Gain Transistor

For Audio Amplifiers

A high gain germanium pnp audio power transistor is now in full scale production with the JETEC designation 2N385A. The transistor has current gains up to 250 at 0.5 a collector current, 125 at 2 a collector current, and 50 at 3 a collector current. It has a maximum collector dissipation of 25 w and a maximum junction temperature of 95 C.

The 2N285A is designed to be used in high gain audio and hi-fi amplifiers. Because of its high gain it is especially useful in feedback circuits. There are also numerous applications for high current switching circuits such as static inverters and power oscillators, and for servo amplifiers and motor control circuits.

Bendix Aviation Corp., Dept. ED, Red Bank Div., 201 Westwood Ave., Long Branch, N.J.

CIRCLE 142 ON READER-SERVICE CARD FOR MORE INFORMATION

Strain Gage Power Supply

6 or 10 v Source

The model PSG-3 provides three individual 6 or 10 v sources for 120 or 350 ohm strain gages. The PSG-3 is especially designed for use with the model 111 series broadband dc amplifiers in dc strain gage systems. The three power supply units are contained in a single chassis which fits standard 19 in. rack mounts. The chassis requires 3.5 in. of vertical space and 19.5 in. behind the front panel, which includes space for the mating connector and cable. The latitude of adjustment provided by a screw-driver control is ±1 v for either the 6 or 10 v setting. Push-button switches on the front panel allow sequential measurement of the output voltage from each channel by an external voltmeter.

Major specifications are as follows: Voltage output, 6 or 10 v; voltage adjustment resolution, 0.05 per cent; output ripple, 2 mv peak to peak; output noise, less than 5 μv with the supply ungrounded and feeding a grounded 350 or 120 ohm bridge; insulation resistance to ground, greater than 1000 meg; capacity to ground, less than 500 μμf per channel; load resistance, 120 or 350 ohm nominally; internal impedance, less than 15 ohm; regulation, essentially the same as the ac source; power required, approximately 5 va per channel.

KIN TEL, Dept. ED, 5725 Kearny Villa Rd., San Diego 11, Calif.

CIRCLE 144 ON READER-SERVICE CARD FOR MORE INFORMATION

Control Relay

For Printed Circuits

Series GP has 1/8 by 1/32 in. solid lugs which when inserted into the printed circuit board give the relay considerable rigidity. Coils are available in standard ac and dc voltages up to 115 volts. The same frame and printed circuit feature is available in the series PC as a sensitive plate circuit relay. Sensitivity is about 130 mw per pole, pre-set at factory, and coils are available in 2500, 5000 and 10,000 ohms. Both relays use silicon steel or magnetic iron. Contacts are self-wiping 1/8 in. fine silver rated 5 amp for series GP and 2 amp for series PC, non inductive. Board is NEMA grade LE and all insulation is tested at 500 v ac minimum. Dimensions are 1 in. wide x 1-1/4 in. long x 1-3/4 in. high.

Hillburn Electronic Products Co., Dept. ED, 55 Nassau Ave., Brooklyn 22, N.Y.

CIRCLE 145 ON READER-SERVICE CARD FOR MORE INFORMATION

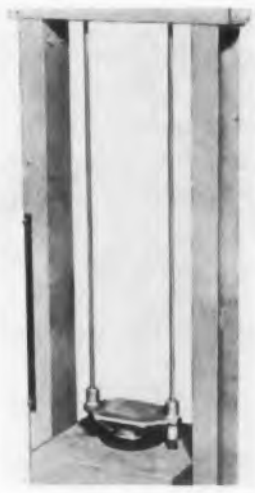
New Products

DC Power Supply
Weighs 10 Lb

This dc power supply, Model BP-200A, has two output ranges. The high range is from 125 to 300 v. The low range is from zero to 150 v, with 150 ma available throughout the range. A fixed supply of 150 v and 50 ma is available at all times, also. While in a standby position the B plus and bias voltage is disconnected while leaving the filament power on. The filament voltage consists of two windings of 6.3 v at 2 a. It can be arranged in series or parallel allowing 6.3 v at 4 a or 12.6 v at 2 a. The unit measures 3-3/4 x 7-1/2 x 7-1/2 in. and weighs only 10 lb.

Specific Products, Dept. ED, 21051 Costanso, Woodland Hills, Calif.

CIRCLE 148 ON READER-SERVICE CARD FOR MORE INFORMATION



Shock Tester
500 G Impact

This shock tester provides a means for testing very small, lightweight components to impacts of 500 g at time durations of 1 msec. Known as JOLTA-M-500, the unit consists of a heavy cast meehanite steel base, steel channel frame and precision machined, cast magnesium carriage and magnesium anvil. Totally reproducible shocks are achieved by use of a specially prepared mass of rubber to arrest the freely falling carriage and produce clean rebound. Designed especially for testing items such as diodes, transistors, relays, and micro switches, having a total weight of 8 oz or less, each machine is accurately calibrated for direct readings.

Jan Hardware Mfg. Co., Inc., Dept. ED, 75 North 11 St., Brooklyn 11, N.Y.

CIRCLE 149 ON READER-SERVICE CARD FOR MORE INFORMATION

Function Programmer

Handles 16 Separate Functions

This Programmer provides switching as well as potentiometer control of electrical and electronic circuitry in relation to time. Up to 16 separate circuit functions can be accommodated with 8 detachable function switch strips. In addition, a pulsing switch is provided for deriving pulses in 0.5 sec increments or any multiple of 0.5 sec. A speed-regulated dc motor with reduction gears causes the moving contacts to travel along the switch or potentiometer strips at constant speed. The travel time is 50 sec $\pm$0.1 sec. The direction of travel may be reversed by inversion of the dc input to the motor. The motor normally requires 350 ma. Input voltage may vary between 22 to 36 v. The timer may be stopped or reversed at any point. Individual circuit function strips or potentiometer strips may be removed and replaced without affecting the other strips already in place.

The timer has been tested for vibration up to 20 g between 20 and 2000 cps in three planes, acceleration up to 50 g in six directions and 100 g of shock for 1.3 msec in six directions. The unit has been subjected to extremes of temperature and simulated altitudes up to 80,000 ft.

Hubbard Scientific Labs., Inc., Dept. ED, 1292 E. Third St., Pomona, Calif.

CIRCLE 151 ON READER-SERVICE CARD FOR MORE INFORMATION

Synchro-Null LD 101

Zeroing Device

The Synchro-Null LD 101 is a zeroing device for rapid zeroing of synchros. It is applicable to 110 v 60 cps, 110 v 400 cps, and 26 v 400 cps synchros of all standard types and sizes. All leads are plainly marked for proper attachment to the synchro terminals. By simple positive switching it automatically selects proper test-circuit connections and the proper sequence of test circuits for the zeroing operation. It measures 19 x 7 x 7 in. and weighs 14 lbs uncrated.

Advance Industries, Inc., Dept. ED, Cambridge, Mass.

CIRCLE 152 ON READER-SERVICE CARD FOR MORE INFORMATION

HUGHES GERMANIUM DIODES

with high conductance and quick recovery, together

Never before have the properties of high conductance and quick recovery been combined to this extent in one diode. For the first time, Hughes offers this unusual combination in a new series of germanium point-contact devices. They have the famous glass package created at Hughes, the same rugged construction which enables all Hughes diodes to withstand shock, vibration, and severe environmental conditions. But inside there are changes. And these changes, painstakingly developed and meticulously introduced into the manufacturing process, impart to the diodes their unusual characteristics—make them fill a need long recognized in the industry.

APPLICATIONS:
These diodes make possible advanced, higher speed circuits in which recovery from a forward pulse must be achieved in a minimum of time. Their low forward voltage drop combined with the fast recovery make them ideal for transistorized computer circuits and similar applications.

SPECIFICATIONS AT 25° C

Type	Forward Voltage Drop @ 10mA	Maximum Reverse Current @ −50V	WIV	Forward Current @ +1V
HD-2762	0.80V	50μA	80V	20mA
HD-2763	0.80V	100μA	80V	20mA
HD-2764	0.67V	50μA	80V	50mA
HD-2765	0.67V	100μA	80V	50mA

All types recover to 100 Kohms in 1 μsec when switched from 30 mA forward to −35V reverse in the modified IBM "Y" test circuit.

If you plan to be in San Francisco for the Wescon show, please visit our booths (#2910-11 and #2912-13). Perhaps we can discuss the new diodes there and determine how to use them most effectively in your circuits. Or, if you prefer, ask for a visit from one of our sales engineers. Please write:

SEMICONDUCTOR DIVISION · HUGHES PRODUCTS · *International Airport Station, Los Angeles 45, California*

Creating a new world with ELECTRONICS

HUGHES PRODUCTS

HUGHES SEMICONDUCTORS

CIRCLE 153 ON READER-SERVICE CARD FOR MORE INFORMATION

IERC's FREE TUBE SHIELD GUIDE helps you improve electron tube reliability

—provides information you need to properly match over 1,400 sizes and types of electron tubes and heat-dissipating tube shields for best cooling, retention and protection against shock and vibration!

New 20 page IERC Heat-dissipating Tube Shield Guide has been carefully and accurately compiled in answer to many hundreds of Electronic Engineer suggestions and requests for just such a practical Guide. New design applications and retrofitting of electronic equipments with IERC Heat-dissipating Tube Shields (for the excellent cooling, extended tube life and reliability they provide) created the need for this type of professional information – plus another "first" for IERC – *the first reference manual of this type* to the electronic industry!

For a free copy, please send request on your company letterhead to: Dept. TSG.

International

electronic research corporation
145 West Magnolia Boulevard, Burbank, California

Heat-dissipating tube shields for miniature, subminiature, octal/power electron tubes

CIRCLE 163 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

DC Amplifier

For Pen-Motor Recorders

The Model 405 dc pen-motor amplifier features low drift, a voltage gain of 30,000, and an amplification technique which results in high stability. Power supply is self-contained and the 405 can be used with wire strain gages, load and pressure cells, acceleration transducers, thermocouples, etc. An attenuator is incorporated which permits inputs as high as 500 mv without overloading the instrument.

Allegany Instrument Co., Inc., Dept. ED, 1091 Wills Mountain, Cumberland, Md.

CIRCLE 164 ON READER-SERVICE CARD FOR MORE INFORMATION

Paper-pin Connectors

Draw-Pull, Screw-Locking and Hexagonal

Series MI, MI-SL and MH miniature precision connectors are available with solderless taper-pin terminals for use with AMP series 37 taper receptacles. The draw-pull and screw-locking versions have been designated Models MI-SDL and MI-SL-SDL, and are available in 7, 12, 14, 18, 20, 21 26, 34, 41, 50 and 75 contacts. Insulation resistance is over 100,000 meg with voltage breakdown between contacts at 2600 v ac rms. The hexagonal version has been designated Model MH-SDL and is available in 4, 5, 7 and 9 contacts. Voltage breakdown between contacts at 2100 v ac rms. Alkyd, Melamine and diallyl phthalate insulating bodies can be supplied for all models to meet MIL specifications.

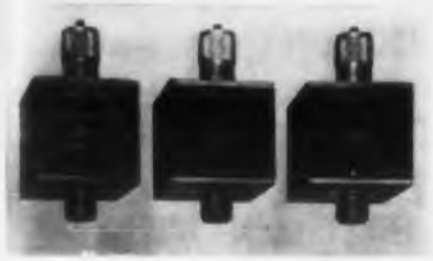
Design assures positive, dependable and quick wire assembly. Field interchangeability with existing U.S.C. solder-up miniature connectors is guaranteed together with full conformance to the latest applicable military specifications.

U. S. Components, Inc., Dept. ED. 454 E 148th St., New York 55, N.Y.

CIRCLE 165 ON READER-SERVICE CARD FOR MORE INFORMATION

Audio Low Pass Filters

7, 20 and 40 Kc Cutoff



Standard values of the Series F audio filters available from stock are 7 kc, 20 kc, and 40 kc cutoff. Attenuation is zero at low frequency, 1 db at cutoff frequency, 12 db per octave above cutoff. Connectors are standard AN PL-259 coaxial input and SO-239 coaxial output. Input impedance is 500 ohms; output impedance is 4000 ohms. Size is 2 cu in. Shells are extruded aluminum, color coded and marked.

Flow Corp., Dept. ED, 85 Mystic St., Arlington 74, Mass.

CIRCLE 168 ON READER-SERVICE CARD

VHF Signal Generator

3 v Output

A vhf power signal generator, provides sufficient amplitude to permit readings to be taken throughout the entire vhf band without further amplification. Designated as FT-SMIM, it will furnish a signal of at least 3 v throughout the 30-300 mc range, in six ranges, with an accuracy of ±1 per cent. Harmonic distortion is less than 4 per cent. Internal a-m modulation is 80 per cent, 100 cps, and external it is 0 to 80 per cent, 30 cps to 200 kc.

Federal Telephone and Radio Co., Dept. ED, 100 Kingsland Road, Clifton, N.J.

CIRCLE 169 ON READER-SERVICE CARD

CIRCLE 170 ON READER-SERVICE CARD ➤

New Products

Connectors

Cable-to-Chassis

Cable-to-chassis types have been added to the Micro-Ribbon series of connectors. Available in 14, 24, 36 and 50 contacts, these types feature cadmium-plated brass shells with clear chromate treatment, gold-over-silver plated contacts and diallyl phthalate dielectrics. Miniature in size, a mated pair of largest 50 contact size types occupy 3.7 cu in. At 5 a Micro-Ribbon connectors are rated at 700 v dc at sea level and at 200 v dc at 70,000 ft.

Amphenol Electronics Corp., Dept. ED, Chicago 50, Ill.

CIRCLE 156 ON READER-SERVICE CARD FOR MORE INFORMATION

Time-to-Pulse-Height Converter

Milli-Microsecond Intervals

The Model TH-300 Time-to-Pulse-Height Converter is designed to measure time intervals in the range 0.25 milli-μsec to 1 μsec. The instrument has in practice achieved resolution times in the order of 40 μμsec. Use of the unit requires that the time interval of interest be defined by a pulse occurring at the beginning and again at the end of the interval. Output of the instrument is a pulse whose final amplitude is proportional, within 1 per cent, to the time interval being measured. Readout may be accomplished either by a multi-channel pulse height analyzer or oscilloscope. Time-of-flight of nuclear particles, determinations of half-life in short-lived isotopes and the general field of fast coincidence studies are among the typical applications of this novel instrument. The instrument contains its own power supply, operating from 115 v ac, and is rack mounted, 19 x 8-3/4 x 14 in.

El Dorado Electronics Co., Dept. ED, 1401 Middle Harbor Rd., Oakland 20, Calif.

CIRCLE 157 ON READER-SERVICE CARD FOR MORE INFORMATION

Universal Stabilized Amplifier

Printed Circuit

The printed circuit universal stabilized amplifier, Model USA-3, is designed for application to instrumentation, control, and analog computation. The chopper-stabilized unit has open-loop dc gain of 10 million, output range of ±115 v. When used at a gain of 100, accuracy is maintained well beyond 1 kc. Bandwidth is inversely proportional to gain. Its long-term drift, noise and offset amount to less than 100 μv referred to the input. Power requirements are 15 ma quiescent at ±300 v, and 2 a at 6.3 v 60 cps. Complete oscillatory stability is obtained even with zero-resistance feedback and with as much as 500 mmf from output to ground. Safety against accidental grounding of the output is achieved in that no part ever exceeds its wattage rating. The printed-circuit board measures 7 x 2-1/2 in. and the amplifier connectio scheme is permanently etched into the board. The basic unit is designed for mounting in any desired fashion, and several types of modular packaging are available.

George A. Philbrick Researches, Inc., Dept. ED, 230 Congress St., Boston 10, Mass.

CIRCLE 159 ON READER-SERVICE CARD FOR MORE INFORMATION

Milliohmmeter

20 μohms to 1200 ohms

Model 47A milliohmmeter is designed for the measurement of low and very low resistances, covering a range from 20 μohms to 1200 ohms over seven decades. This is a portable direct-reading instrument, line operated with no batteries being required. Unlike other instruments of this type which use direct current, the model 47A milliohmmeter employs ac test currents at line voltage frequency. The power dissipated in the test specimen is very small, less than 1/8th of a watt in the worst case. The instrument uses the four terminal principle. It incorporates a self-calibration circuit which allows the accuracy of the instrument to be checked at any time in a matter of seconds. The instrument measures 7-3/4 x 8-1/2 x 12-1/2 in. and weighs 19 lbs. Accuracy is generally better than ±2 per cent of full scale.

Herman H. Sticht Co., Inc., Dept. ED, 27 Park Pl., N.Y., N.Y.

CIRCLE 160 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Arc Resistance Tester
10 Arc-current Steps

The Model ART-2 Arc Resistance Tester is used in measuring resistance of insulating materials to high-voltage arcs. The unit has the following arc-current steps: 10/8, 10/4, 10/2, 10, 20, 30, 40, 60, 80 and 100 ma. A built-in timer indicates arc resistance time. Readings are in five figures to 1/10 sec. Calibrating electrostatic voltmeters are built in and a milliammeter is provided with automatic switching to the proper range. Suppressed zero voltmeter is provided for extreme accuracy and the equipment is manufactured for operation by unskilled personnel.

Industrial Instruments, Inc., Dept. ED, 89 Commerce Rd., Cedar Grove, N.J.

CIRCLE 172 ON READER-SERVICE CARD

Short Circuit Analyzer
Tests 1200 Circuits Per Min

A circuit analyzer that uncovers short circuits enables tests of 1200 different aircraft electrical circuits in less than a min. Five seconds for every 100 circuits is required. In operation any multiple circuit assembly is plugged into it. The operator pushes the starter button and electric current is passed in rapid succession through each circuit in the assembly. As each circuit is checked, a light flashes on the panel board which is perforated with anywhere from 100 to 1200 small lights, each representing a single circuit. If all circuits are working properly, the checker stops automatically at the end of the test.

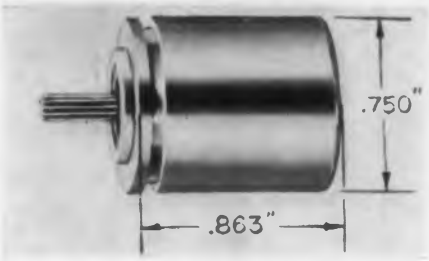
In locating a reversed or open circuit, the checker stops at that circuit and the light on the instrument panel board for that particular circuit remains on, rather than flashing off. An override switch allows the operator to continue the automatic testing of other circuits after he has recorded the trouble. The unit also determines immediately all of those circuits which are involved in the trouble.

Republic Aviation Corp., Dept. ED, Farmingdale, N.Y.

CIRCLE 173 ON READER-SERVICE CARD

Hi-temp Servo Motor

For Transistorized Operations



A smaller and lighter high temperature continuous duty servo motor for transistorized operations has been made available. Type 8-5001-02 measures 0.863 in. long x 0.750 in. od, weighs 1.2 oz., has an operating temperature range of from −65 to +125 C and meets MIL-E-5272. Voltage is 40/20 on control phase and 26 on fixed phase 400 cps. No load speed is 6500 rpm and still torque 0.15 oz-in. Furnished with synchro mount and pinion type shaft.

John Oster Mfg. Co., Avionic Div., Dept. ED, Main St., Racine, Wis.

CIRCLE 176 ON READER-SERVICE CARD FOR MORE INFORMATION

Oscillogram Reader

Accurate Data Reduction

Data reduction is accomplished by essentially a combination of operations and applications with this Oscillogram Reader. Either linear or non-linear calibration is possible without overlays. Curves may be quickly and accurately traced. Editing, notating and reading are all possible over the entire area of the exposed record. X and Y motions are separately inhibitable. Opaque and translucent oscillograms can be read in a point-to-point operation. Data is prepared for either plotting, typing, tape perforating or card punching. The equipment is incorporated into a desk-type console 54 in. wide and 59 in. high and constructed of walnut and formica panels on a metal frame. The 12 x 24 in. exposed reading area accommodates records 13 in. wide with a roll diameter of 6 in. Other technical specifications include a 40-400 count per in. resolution, total travel ±999 counts and accuracy calibrated to ±0.01 in.

Telecomputing Corp., Dept. ED, 16217 Lindbergh St., Van Nuys, Calif.

CIRCLE 177 ON READER-SERVICE CARD FOR MORE INFORMATION

THE BIG STICK

Since 1946, Martin engineering has placed special emphasis on the science of rocket and missile development.

It is because of this that Martin is now building a most potent and important weapon system—the ICBM Titan—an ocean-spanning missile to back up the traditional American policy of peace with honor: *"Speak softly and carry a big stick!"*

From this intercontinental peace protector to the world's first satellite launching vehicle now nearing completion, Martin engineering is pioneering the new age of missiles and rockets.

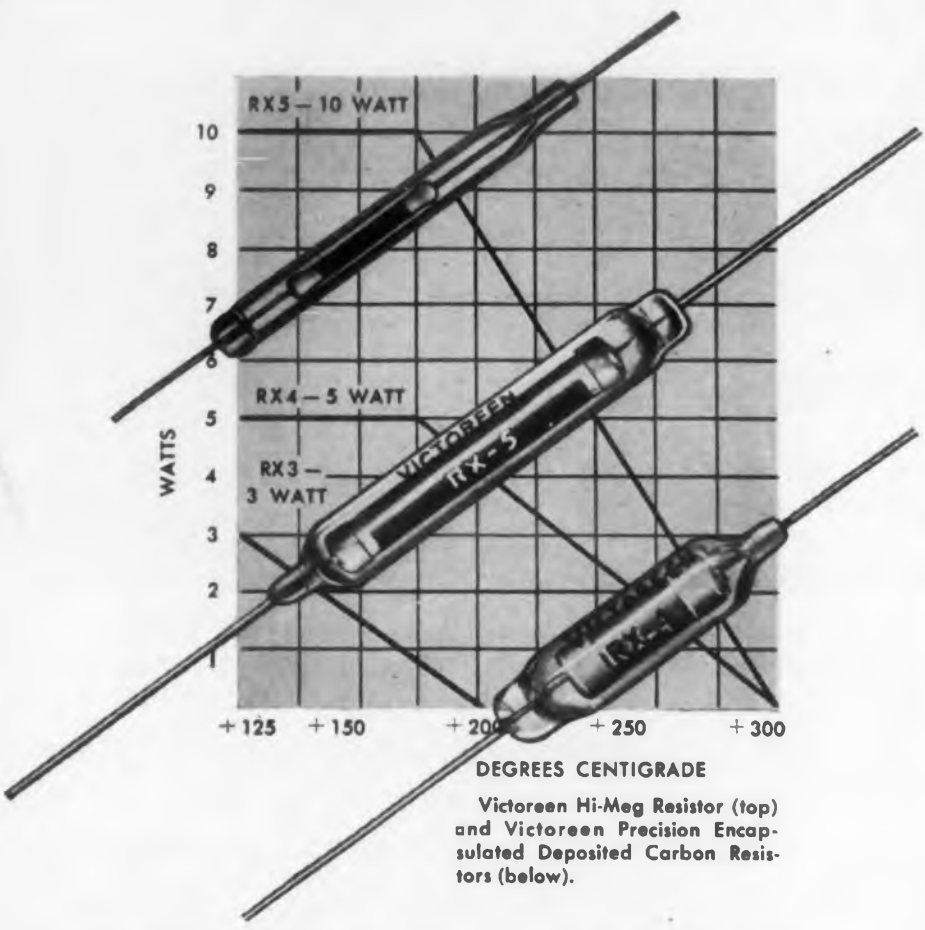
If you are on the watch for tomorrow, watch Martin today.

MARTIN

BALTIMORE · DENVER ORLANDO

It's just part of the Victoreen story . . .

HIGH STABILITY RESISTORS



Victoreen Hi-Meg Resistor (top) and Victoreen Precision Encapsulated Deposited Carbon Resistors (below).

High stability, exceptional accuracy and performance that easily exceeds the normal electrical specifications of MIL 10509C—even in high ambients to 300°C where more than normal life expectancy is required. That's the story, in brief, of Victoreen deposited carbon resistors.

Hi-Meg resistors have a carbon-coated glass rod element, the ends of which are banded with silver for best electrical contact.

Hi-Meg resistors are vacuum-sealed in a glass envelope treated with special silicone varnish to keep envelope moisture-free.

For the ultimate in accuracy, stability and long-time performance, *specify Victoreen precision resistors.*

AA-5423

For the full story on Victoreen deposited carbon or Hi-Meg resistors, write for your free copy of Form 3025A.

ATTENDING WESCON? Be sure to see Victoreen's engineers. They'll be waiting for you at Booth 407.

The Victoreen Instrument Company

Components Division

5806 Hough Avenue, Cleveland 3, Ohio

CIRCLE 180 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

670 Amp Power Junction

9.8 Per Cent Efficiency

Liquid-cooled germanium power junctions have been engineered for heavy power conversion. Six types are available in the range of 20 to 66 v rms. Conservatively rated at a maximum full load output current of 670 a, measured as rectified dc a per junction in three-phase operation, these low-density junctions provide 98.5 per cent efficiency and will appreciably lower the power consumption of rectifier equipment. Connected in a three-phase bridge circuit, six of these junctions will deliver 170 kw, 2000 a at 85 v.

The junction measures 5 x 3-7/8 x 3-3/8 in. and features a copper housing cast around special alloy steel tubing for maximum cooling. Re-circulation of the cooling medium over an internal cooling area of 52 sq in. in a volume of 48 cu in. provides a highly efficient heat exchanger, which makes it especially suited to the handling of heavy, continuous industrial loads. Water, oil, or other accepted coolants may be used.

International Rectifier Corp., Dept. ED, 233 Kansas St., El Segundo, Calif.

CIRCLE 181 ON READER-SERVICE CARD FOR MORE INFORMATION

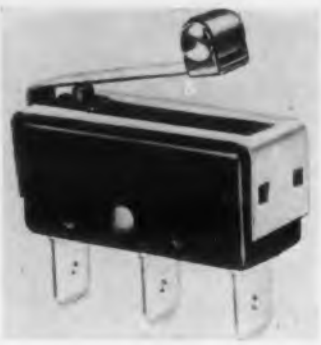
Temperature Transducer

Moisture Proof

For surface temperature measurement, the silastic overmold of the Strapon permits usage in the presence of radioactive fields, high humidity, water, alcohols, salts, oils, some acids, caustics and other substances that normally render temperature transducers ineffective. It is offered as a re-usable and flexible supplement to the RdF Stikon.

Arthur C. Ruge Associates Inc., Dept. ED, Cambridge, Mass.

CIRCLE 182 ON READER-SERVICE CARD FOR MORE INFORMATION



15 Amp Switch

3-Oz Actuation

Class 4 TyniSwitches are designed for ganging and have a choice of operating forces from 3 to 12 oz on the pin. They are available with solder, screw, standard spade or junior tab terminals. Underwriters' Lab. listed at 15 a, 125 to 250 v ac. Illustrated is the Class 4 SR-spring leaf and roller actuated model. There are three other models, BP-pin actuated, SL-spring leaf actuated and RR-rotary actuated.

Detroit Controls Corp., Dept. ED, TyniSwitch Dept., 800 Union Ave., Bridgeport, Conn.

CIRCLE 186 ON READER-SERVICE CARD FOR MORE INFORMATION

Vacuum Gages

Thermocouple and Ionization Types

The TG-025 is a single-station, panel-mounted thermocouple vacuum gage. It operates on two size D flashlight batteries contained within its housing. Two terminals are provided on the bottom of the instrument for connection to an external battery power supply. The range of the TG-025 from 0 to 1000 microns Hg of dry air pressure is covered on one non-linear scale, with 5 microns the smallest indicated marking. The pressure range from 0 to 60 microns Hg extends over more than half of the entire scale.

Another vacuum gage, the GIC-100, is an ionization type which gives continuous pressure readings on eight linear ranges from 1×10^{-8} to 2×10^{-12} mm Hg. This instrument has been designed to control, read, and degas any type of commercially available ionization tube. The emission control is variable over a continuous linear range from 25 μa to 20 ma and is regulated throughout the range to ±2 per cent. This enables the operator to control the sensing tube at a greatly reduced emission current, resulting in reduced ion pumping and x-ray effects. Tube degassing by both resistance and electron bombardment is provided. The degassing current is variable, and pressures can be read continuously while the tube is degassing.

Consolidated Electrodynamics Corp., Dept. ED, 300 North Sierra Madre Villa, Pasadena, Calif.

CIRCLE 187 ON READER-SERVICE CARD FOR MORE INFORMATION

It's just part of the Victoreen story...

an entirely **new**
concept in
power supply regulation with
CORONA TYPE VOLTAGE REGULATORS

Victoreen Corona type Voltage Regulators are approved by the military.

Superior voltage regulation and greatly extended current ranges—that's *part* of the Victoreen story. But it doesn't stop there. Use of these new glass or metal corona regulators means you can eliminate complex circuitry regulators. Fail-safe feature gives protection not afforded by other forms of regulators.

Improved Regulation results from new electrode structures and improved processing for greater dynamic resistance, greater protection, simplified circuits.

Improved Current Rating increases scope of applications.

Improved Life Expectancy results from even better processing, even more rigid selection of materials.

Improved Ruggedization means these regulators withstand more rigorous adverse environments longer.

AA-5421

Get the full story on the new Victoreen voltage regulators.

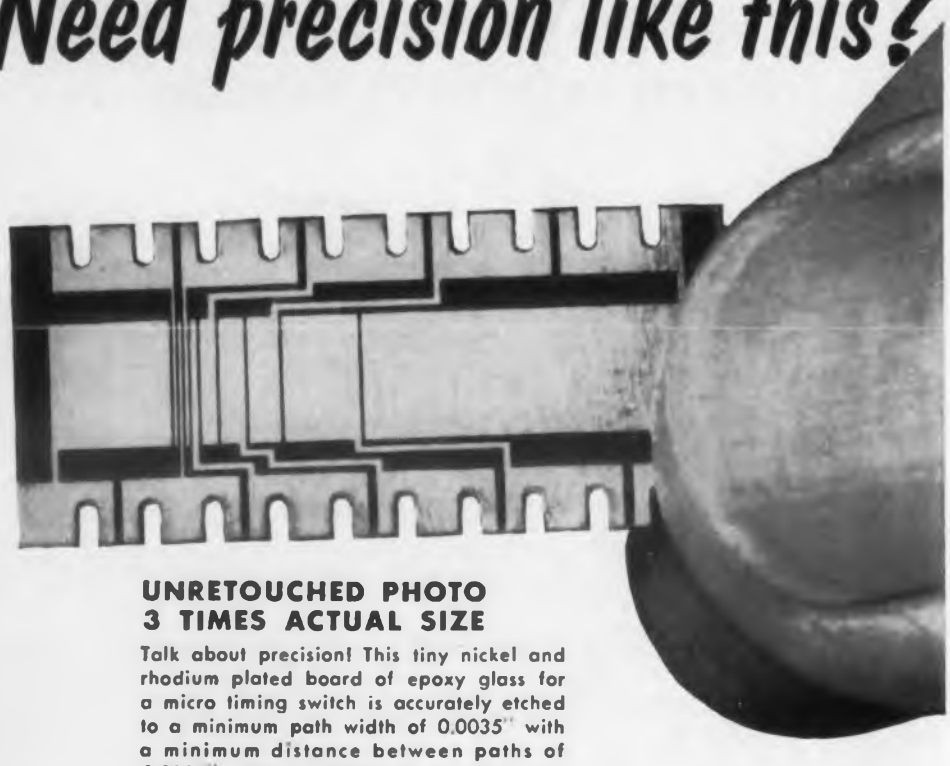
Write for your free copy of Form 3003-7 today.

ATTENDING WESCON? Be sure to see Victoreen's engineers. They'll be waiting for you at Booth 407.

The Victoreen Instrument Company
Components Division
5806 Hough Avenue, Cleveland 3, Ohio

CIRCLE 188 ON READER-SERVICE CARD FOR MORE INFORMATION

Need precision like this?



UNRETOUCHED PHOTO
3 TIMES ACTUAL SIZE

Talk about precision! This tiny nickel and rhodium plated board of epoxy glass for a micro timing switch is accurately etched to a minimum path width of 0.0035" with a minimum distance between paths of 0.0025". This is typical of precision production by the Bureau.

Let the Bureau solve your etched wiring problems

Whatever your needs in boards . . . routine or extraordinary . . . custom quantities or hundreds of thousands . . . the Bureau offers you the *complete service*. Bureau engineers are fussy about specifications. You get the accuracy and quality control you need. Bureau engineers appreciate deadlines. You receive delivery as ordered.

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- Drafting
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- Post Forming
- Custom Laminating
- Through-hole Plating
- Electroplating
  - Solder
  - Copper
  - Nickel
  - Rhodium
  - Gold
  - Silver

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FREE 8-Page Booklet No. 130

Come along on a photo tour of the Bureau's fully-equipped research laboratory and factory facilities for the quantity production of etched wiring boards.

Industrial Division

BUREAU OF ENGRAVING, INC.

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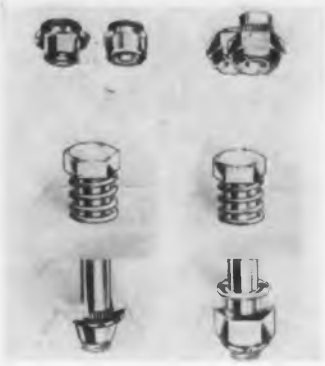
MINNEAPOLIS 15, MINN.

CIRCLE 190 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products



Miniature Clinch Nuts

Flush Mount in Thin Stock

The self-locking clinch nuts with a shank design that permits flush installation in stock as thin as 0.03 in. have been developed for applications having limited space allowances. Type NCFM clinch nuts are designed with special nylon locking inserts for temperatures up to 350 F, while Type LHCFM features an all metal nut with an elliptical crown locking device for use up to 550 F. Both types require only two shank lengths for flush mounting installation in material ranging in thickness from 0.03 to 0.06 or 0.06 and above. Thread sizes designed for both types of miniature clinch nuts are 2-56, 4-40, 6-32, 8-32, 10-24, 10-32, 1/4-20 and 1/4-28. The nuts are made of cadmium plated steel and meet applicable performance requirements of AN-N-5/AN-N-10 and MIL-N-25027.

Elastic Stop Nut Corp. of America, Dept. ED, Union, N.J.

CIRCLE 191 ON READER-SERVICE CARD FOR MORE INFORMATION

Teflon Cable Clamps

High Durability

These cable clamps fabricated from Teflon give excellent performance under the most severe service conditions according to the manufacturer. The clamps are tough and flexible besides having the insulating qualities of Teflon. The clamp is chemically inert, non-adhesive and heat resistant over a wide temperature range. It is immune to the effects of weathering and seasonal change even in installations where direct and constant exposure occurs. The clamp offers little friction and the water absorption is rated at zero.

Weckesser Co., Dept. ED, 5701 Northwest Hwy, Chicago 30, Ill.

CIRCLE 192 ON READER-SERVICE CARD FOR MORE INFORMATION

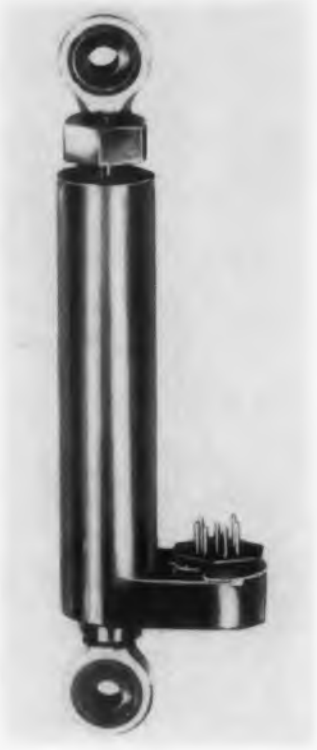
Rotary Lock Switch

20 Amp, 125 V

Capable of handling heavy loads, these switches, with silver plated contacts, are available in single pole quad break. Operated by turning a key in a Corbin pin tumbler lock, they assure that circuit control will be kept in the proper hands. Included in the line of 20 amp, 125 v switches are switches with flush plates and screw caps for switch control in locations exposed to dampness and other atmospheric conditions.

The Arrow-Hart & Hegeman Electric Co., Dept. ED, Hartford, Conn.

CIRCLE 196 ON READER-SERVICE CARD FOR MORE INFORMATION



Linear Variable Differential Transformer

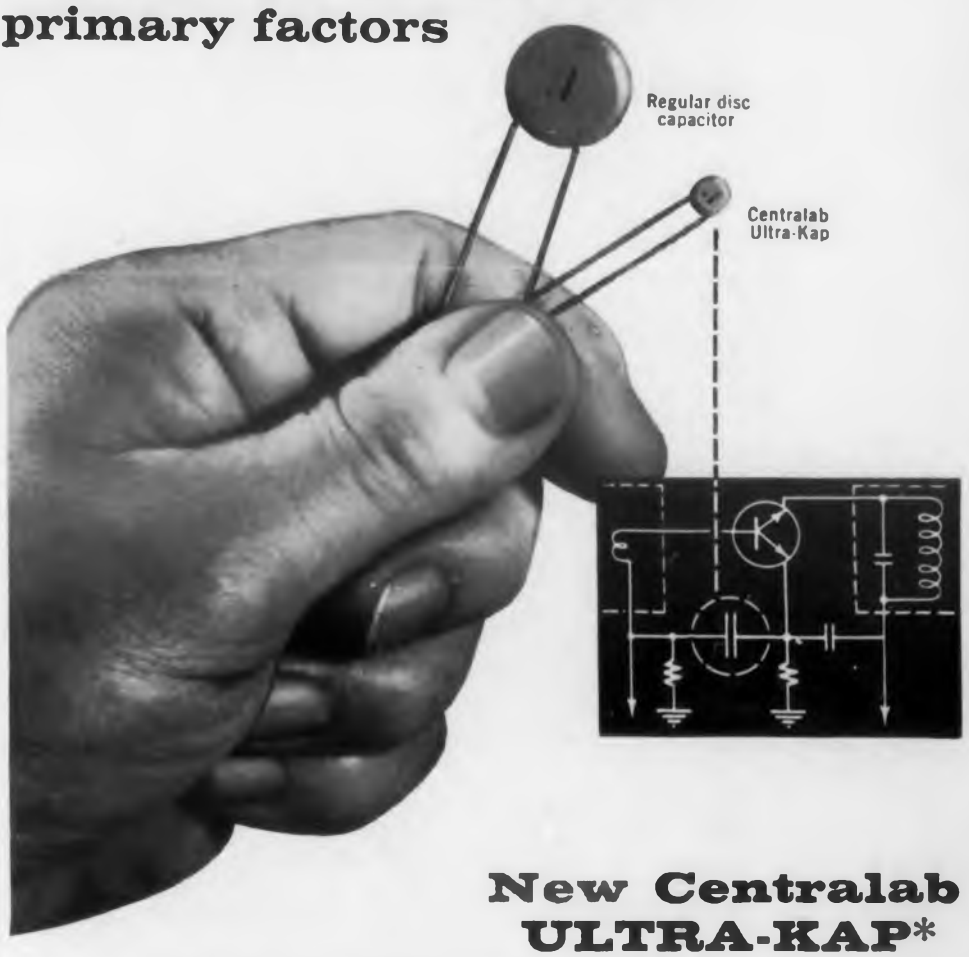
1.2 In. Linear Range

This linear variable differential transformer provides a core assembly which is completely separate from the transformer and is attached by the user to the source of motion. The unit offers a linear range of ± 0.6 in. from null position of core, total linear travel of 1.2 in., linearity within 0.5 per cent of nominal output at 0.6 in., and ambient temperature range of -65 to $+225$ F. The output, at 10 v cps input into a 0.5 megohm load, is 6.4 v at 0.6 in. displacement. The primary impedance is 90 ohms, the differential secondary impedance is 155 ohms. The complete assembly weighs 95 gms.

Schaevitz Engineering, Dept. ED, P.O. Box 505, Camden 1, N.J.

CIRCLE 197 ON READER-SERVICE CARD FOR MORE INFORMATION

In transistor applications where size and cost are primary factors



New Centralab ULTRA-KAP* outperforms much larger and higher-priced components

A radically new approach to a ceramic disc capacitor that combines unusually high capacity with small physical size.

Has stable capacity curve over wide temperature range. Capacity vs. temperature: ±25% over+10°C to +85°C.

Ideal for by-pass in transistorized applications.

Costs far less than electrolytic and tantalytic capacitors of equal or greater capacity.

DIAM.	MAX. THICKNESS	CAPACITY MFD.	TOLERANCE
1/4″	.156″	.22	GMV
3/8″	.156″	.56	GMV
9/16″	.156″	1.0	GMV
3/4″	.156″	2.2	GMV

Write us for further information. Or have the nearby Centralab representative tell you more. If you don't know who he is, ask us for his name.

*Trademark

Centralab

A DIVISION OF GLOBE-UNION INC.
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Milwaukee 1, Wis.

In Canada:
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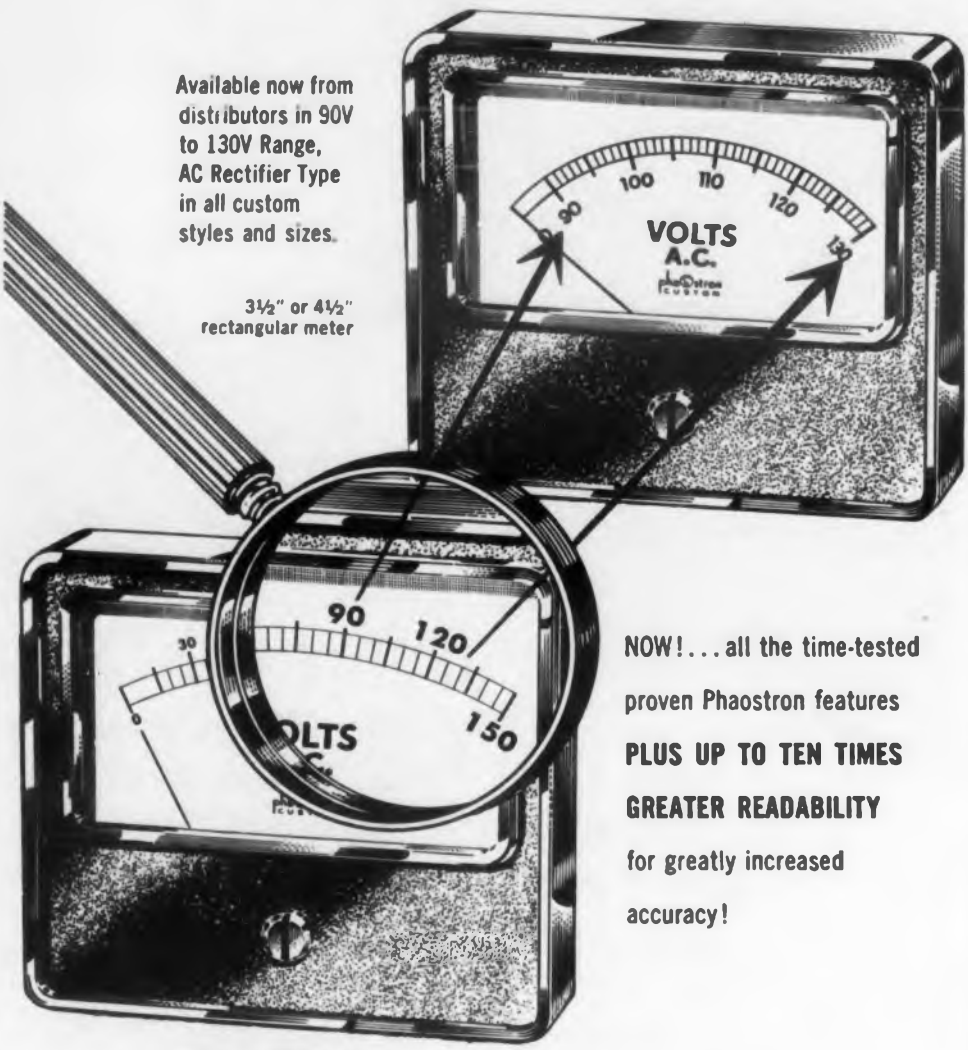
See us at the WESCON SHOW
August 20-23
San Francisco
BOOTH 2701

CIRCLE 198 ON READER-SERVICE CARD FOR MORE INFORMATION

NEW PHAOSTRON
EXPANDED SCALE AC Voltmeter

Available now from distributors in 90V to 130V Range, AC Rectifier Type in all custom styles and sizes.

3½" or 4½" rectangular meter



NOW!... all the time-tested proven Phaostron features **PLUS UP TO TEN TIMES GREATER READABILITY** for greatly increased accuracy!

2½" or 3½" square meter

6" rectangular meter

2½" or 3½" round meter

All meters available with illuminated dial on special order

Phaostron has squeezed down that under 90V portion of the scale, where you don't need it, and expanded the section where you need it most—between 90 and 130V. Precisely calibrated 1 volt scale increments provide greater reading accuracy. Wide frequency range—linearity—true rms reading and Phaostron craftsman construction.

Phaostron Custom Panel Meters, with expanded scale, 90V to 130V AC rms, are available in nine types at your Parts Distributor. For special requirements for AC or DC expanded scale meters, write to Product Development Dept. for practical recommendations.

PHAOSTRON

PHAOSTRON INSTRUMENT & ELECTRONIC CO., 151 PASADENA AVE., SOUTH PASADENA, CALIF.

CIRCLE 200 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Precision DC Power Supply

0.005 Per Cent Regulation

Model 301C power supply is primarily designed for laboratory functions where stability and regulation are a requisite. Specifications of the 301C are as follows: output voltage of 1.02 to 1012 v dc, output current of 0 to 400 ma, regulation vs line of 0.005 per cent or 1 mv for 10 per cent line voltage change, regulation vs load of 0.005 per cent or 1 mv for 200 ma load current change, stability of 0.005 per cent per hr after short warm up, voltage resolution of 0.5 mv at any output voltage via 0.11 v vernier, and a calibration accuracy of ±0.1 per cent or 2 mv.

John Fluke Mfg. Co., Inc., Dept. ED, 1111 W. Nickerson St., Seattle 99, Wash.

CIRCLE 201 ON READER-SERVICE CARD FOR MORE INFORMATION

Strain Gage Power Supply

Response of 0.2 Sec Max

Having tubeless construction, Model 562 provides a dc output of 5 v at 1 a, and an ac input of 105-125 v, single phase, 380-420 cps. The power supply has an excellent response time of 0.2 sec max, with a voltage regulation of ±0.1 per cent for line frequency of ±0.5 per cent from 20 per cent full load to full load.

The unit is hermetically sealed and has a glass seal color-coded header for identification. The duty cycle is continuous, with the controls for voltage adjustment potentiometer mounted externally. Dimensions are 5 x 5 x 4 in., and it may be mounted in any position. Weight of the unit is 6-1/2 lb.

Perkin Engineering Corp., Dept. ED, 345 Kansas St., El Segundo, Calif.

CIRCLE 202 ON READER-SERVICE CARD FOR MORE INFORMATION

Mechanical Limit Stop

For Servo Systems

The miniature mechanical limit stop may be directly incorporated into production servo systems without the need of special mounting hardware. Contained in a size 11 synchro housing, the limit stop is the lead screw type permitting a total travel of 40 revolutions. For ease of adjustment, it can be continuously set over its full range without removal from the mechanical system. Leaf spring stops protect delicate components and gears from jarring halts, without sacrificing the advantages of a positive mechanical stop.

Reeves Instrument Corp., Dept. ED, 207 East 91 St., New York 28, N.Y.

CIRCLE 206 ON READER-SERVICE CARD FOR MORE INFORMATION

5-Inch Oscilloscope

20 mv/in. Sensitivity

The Model 685 oscilloscope incorporates ac and dc amplifiers, dc to 750 kc response, and 20 mv rms per inch sensitivity. The medium band amplifiers and high pulse response rate permit accurate measurements in the study and interpretation of modulation, phase relations, voltage amplitudes and distortion. A maximum full screen vertical and 3 times full screen horizontal deflection is allowed without low or high frequency distortion on the screen. Vertical gain control provides a non-frequency discriminating 10 to 1 gain. Both vertical and horizontal attenuators are frequency compensated in decade steps from 1 to 1 through 1000 to 1. Vertical attenuator has a fixed voltage calibration of 0.1 v peak-to-peak.

The illuminated, calibrated screen is backed with a green filter to reduce incidental reflections and permit more accurate measurements. The illumination brightness is adjustable and an astigmatic focus control provides undistorted trace sharpness. An additional circuit feature is a dual fuse protection whereby both B+ and the line are fused for additional safety.

Hickok Electrical Instrument Co., Dept. ED, 10581 Dupont Ave., Cleveland 8, Ohio.

CIRCLE 207 ON READER-SERVICE CARD FOR MORE INFORMATION

ENGINEERED FACILITIES

FOR HIGH RELIABILITY RESISTOR PRODUCTION ONLY!

(Environmental production testing optional, but recommended)

- Hermetically Sealed Deposited Carbon Resistors
- Sealed Resistor Networks
- Encapsulated Precision Wire Wound Resistors

MEPCO INC., MORRISTOWN, NEW JERSEY

CIRCLE 208 ON READER-SERVICE CARD FOR MORE INFORMATION

#3 IN A SERIES

Puzzled *by that metal-joining problem?*

NORRIS-THERMADOR'S **NORTHAM** DIVISION WAS – on how to join NuMetal to cold rolled steel in accelerometer armature assemblies, with thicknesses ranging from .004 to .006. They succeeded with the help of a Weldmatic stored-energy welder... which may be the answer to your problem, too. *Write for complete literature.*

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CIRCLE 209 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Electron Tube Analyzer

Measures Transconductance

Electron Tube Analyzer, Model 725 features a true transconductance measurement to an accuracy of 3 per cent. Transconductance can be measured to 30,000 micromhos. Plate and screen voltages from 0-300 v are available. Grid and suppressor supplies cover ranges to ± 150 v. Plate currents up to 150 ma, screen currents to 50 ma, suppressor and grid currents have maximum current rating of 10 ma. Grid currents that are as low as 1 ua can be measured.

Laboratory for Electronics, Inc., 75 Pitts St., Boston 14, Mass.

CIRCLE 397 ON READER-SERVICE CARD FOR MORE INFORMATION

Magnetic DC Signal Amplifier

Powered by 28 V DC

Designated the Micromag MMO-528, this unit features a built-in transistor oscillator which generates its own frequency, enabling operation from a dc source. The unit is therefore free from the variations normally present when excitation is provided by an ac line supply. Input is electrically isolated from the output. A built-in voltage regulator eliminates the need for a separate power supply. Having a voltage gain of 500, the MMO-528 achieves 5 v dc output from 10 mv dc input signal. Designed for amplification of signals from thermocouples, strain gages and similar low-level transducers, the amplifier has virtually no zero drift and is temperature compensated from 0 to 60 C, which can be extended to 85 c on request. The unit is potted and hermetically sealed and is designed to meet MIL-E-5272A.

Magnetic Research Corp., Dept. ED, Sales Engineering Dept., 3160 W. El Segundo Blvd., Hawthorne, Calif.

CIRCLE 398 ON READER-SERVICE CARD FOR MORE INFORMATION

Non-linear Computing Component

Function of Two Variables

Called the Function of Two Variables, Model F2V provides an output voltage which is an arbitrary function of two independent varying input voltages. A family of curves is produced with smooth interpolation in both directions. This surface may be visualized as a tent with 36 poles where the height of each pole is individually adjustable between ±50 v. This computing component fills a need for an instrument capable of providing instantaneous solutions for problems in data reduction and computing involving functions of two variables. Extensions of the principles involved make possible functions of 3 or more variables.

Specifications include: Input range; x = 0 to +50 v, y= 0 to + 50 v. Output range; −50 to +50 v. Impedance; less than one ohm. Allowable load impedance, 30 K minimum. Power requirements; 300 v dc at 150 ma, 115 v ac 50-60 cps or 150 w. Rack mounted. Dimensions; 19 x 8-1/8 x 16 in.

George A. Philbrick Researches, Inc., Dept. ED, 230 Congress St., Boston 10, Mass.

CIRCLE 212 ON READER-SERVICE CARD FOR MORE INFORMATION

Swivel Positioner and Work Holder

Five Sizes, 5-1000 Lb Capacity

This redesigned PowRarm Work Positioner is now available for assembly, welding or bench positioning. All models operate on the ball point principle, and lock firmly in any position. With the use of various holding fixtures, many types of work can be held in any position the operator desires. The unit features an operating handle with a bakelite knob mounted well above bench top level. All steel parts are cadmium plated to eliminate rust and corrosion. A heavy duty finish has been applied, consisting of a zinc chromate primer with an aircraft gray enamel finish. Five models are available with rated holding power of 5 lb up to 1000 lb.

Wilton Tool Mfg. Co., Inc., Dept. ED, 9525 Irving Park Rd., Schiller Park, Ill.

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Magnetic Research Corp., Dept. ED, Sales Engineering Dept., 3160 W. El Segundo Blvd., Hawthorne, Calif.

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Wilton Tool Mfg. Co., Inc., Dept. ED, 9525 Irving Park Rd., Schiller Park, Ill.

CIRCLE 213 ON READER-SERVICE CARD FOR MORE INFORMATION

MICRO-BEARING ABSTRACTS

by **A. N. DANIELS,** *President*
New Hampshire Ball Bearings, Inc.

BEARING FITS AND FITTING PRACTICES

As shown in *Fig. 1*, the fitting of Micro-Bearings, like the fitting of larger ball bearings, chiefly involves the clearances between the inside diameter of the housing and the outside diameter of the bearing; the bore of the bearing and the shaft diameter.

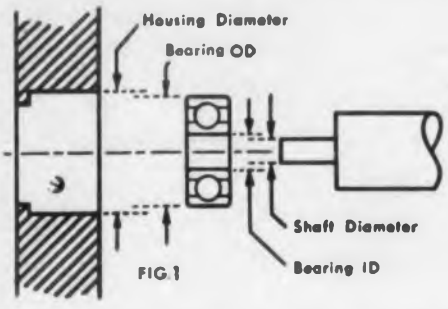


FIG.1

The achievement of the desired fit by dimensioning is illustrated in *Fig. 2*. The bearing ID is represented by the top blocks and the shaft OD is represented by the lower blocks. Such a block diagram could also be applied to housings and bearing outside diameters. In this block diagram, it will be noted, the bearing ID is represented by a .00015 tolerance with a similar tolerance for the shaft. A resulting fit of line to line to .0003 loose is shown.

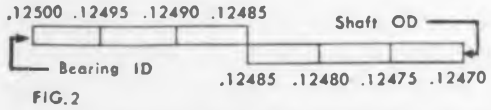


FIG.2

An interference fit not tighter than line to line is suggested for the following reasons:

1. *Difficulty in assembly.*
2. *Difficulty in disassembly. This is often more hazardous than the assembly operation and may result in total bearing destruction.*
3. *Reduction in radial play.*
4. *Danger of bearing ring conforming to possible poor geometry of mating shaft or housing.*

TOLERANCE DISTRIBUTION

The maximum .0003 loose condition shown in *Fig. 2* may be excessive in some applications. The fitting problem then resolves itself to reducing this extreme, and yet maintain the maximum tight fit of line to line. The looseness may be reduced by redimensioning the shaft to .12490/.12475 as shown in the block diagram, *Fig. 3*.

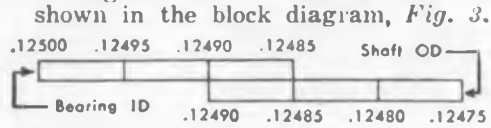


FIG.3

If the frequency distributions of shaft and bearing ID sizes were statistically normal, the modal fit of all parts would be 0.0001 loose. Accordingly, an insignificant percentage of parts would be mated to the extreme values, and for practical purposes could be ignored.

With regard to bearings' outside diameters and bores, however, normality of the distribution curve cannot be assumed. During the grinding operation, the "most metal tendency" tends to skew the frequency distributions for bearing ID's and OD's in the direction of most metal.

In grinding and finishing shafts and housings, similarly skewed distributions occur.

Operating on a modified probability distribution of tolerance is possible if the volume of parts is sizeable. But the approximate distribution of shaft and housing sizes must be verified if this method is to be used.

MATERIALS and SURFACE FINISHES

The ease of assembly is also affected by materials and finishes. The following factors must be considered:

1. *The galling characteristics, hardness and ductility of the materials involved.*
2. *Finish lay patterns produced by various tools and techniques used.*
3. *R M S surface finish values achieved.*
4. *Geometry of shafts and housings as regards out-of-roundness, taper, etc.*

The possible combinations of these elements in any single application are so numerous that their gross effect can only be ascertained by trial and error, or by a detailed study of operations on individual applications. A more complete discussion of fitting practices, including sizing methods and coding, is found in our design handbook.

New Products

Photomultiplier Preamplifier

For Driving Long Coax Cables

The photomultiplier preamplifier provides prewired photomultiplier socket and a stacked cathode follower having a 70 ohm output impedance mounted in a counter weighted aluminum box. The unit is particularly suitable for driving long coaxial cables with characteristic impedances between 65 and 78 ohms, such as RG6, RG11, RG12, RG59, and RG81. A slight modification will permit a match for 51 ohm cable.

Hamner Electronics Co., Inc., Dept. ED, P.O. Box 531, Princeton, N.J.

CIRCLE 217 ON READER-SERVICE CARD FOR MORE INFORMATION

Color Oscilloscope Kit

Flat to 5 MC

This oscilloscope, 3151, in kit or wired form, goes up beyond 9 mc and is flat through 5 mc for color-TV testing. The instrument, housed in a steel cabinet 13-1/4 x 8-3/4 in., features highly sensitive push-pull vertical and horizontal amplifiers; a 5 CP[1] tube with post acceleration; frequency compensated stepping attenuators for both the vertical and horizontal; focus, intensity and astigmatism controls, and output voltage calibration.

The vertical amplifiers are flat through 5 mc and ± 8 db through 9 mc. Sensitivity is 10 mv/cm, and there are frequency compensated stepping attenuators in the input, and push-pull pentodes in the output. The horizontal amplifiers are within ± 6 db through 500 kc, and feature a push-pull output. Frequency attenuated stepping attenuators in the input and a cathode follower assure an extremely clean linear horizontal trace. It uses a hard vacuum sweep with sufficient expansion to see color bursts clearly. Horizontal sensitivity is approximately 40 mv/cm.

Precise Development Corp., Dept. ED, 2 Neil Court, Oceanside, N.Y.

CIRCLE 218 ON READER-SERVICE CARD FOR MORE INFORMATION

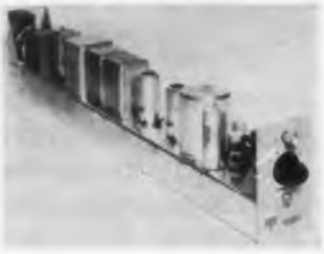
Ground Plane Antenna

3 Ft. Wide, Weighs 3 lbs.

An antenna for use at base station in two-way radio communications systems weighs one-tenth as much as similar antennas and is less than one-fourth in overall width. The model GPR ground plane antenna is available for operation at frequencies between 27 and 90 mc. Antennas are furnished factory tuned for operation within a 4 mc band. This antenna differs from other ground plant type antennas in that the vertical radiating element and the four ground plane members are base-loaded whips with an overall length of approximately 18 in. Thus the entire antenna assembly is only slightly more than 18 in. high and has an overall width of just over 3 ft. The shunt-base-loaded whips are joined together in a mounting fixture provided with six coaxial receptacles into which the five whips and the antenna transmission line are plugged. The entire assembly weighs less than three lbs and hence can be mounted on a much lighter antenna support. Tests indicate that the antenna is almost as efficient as conventional antennas with full length quarter-wave elements.

Tele-Beam Industries, Dept. ED, Atlas Peak Rd., Napa, Calif.

CIRCLE 222 ON READER-SERVICE CARD FOR MORE INFORMATION



DC Amplifier

Floating Input

This dc amplifier, featuring a true floating input, is offered for amplification of low-level signals from thermocouples, strain-gage bridges, and resistance-bridge transducers. In the Type 1-100C, input and output are isolated from each other and from ground. The amplifier, basically a carrier type, utilizes a 400 cps chopper modulator. The gain of this amplifier is continuously variable from 5 to 100 by means of a seven-position attenuator and a gain potentiometer. Linearity is 0.05 per cent of full scale. Long-term stability is ± 0.2 per cent of full scale, and long-term drift is less than ± 5 μv referred to the input. Input impedance is greater than 1.5 megohms, and output impedance is 60 ohms. Noise level is less than 5 μv peak-to-peak referred to the input.

Neff Instrument Corp., Dept. ED, 2211 East Foothill Blvd., Pasadena, Calif.

CIRCLE 223 ON READER-SERVICE CARD FOR MORE INFORMATION

CURRENT PULSE GENERATORS

pulse widths variable 1-40 usec current up to 2 amps peak

Model 5 — negative going pulses — Model 6 is similar, delivering positive going pulses

● **The Reflectone Model 5 high current pulse generator delivers negative going rectangular wave current pulses of variable duration, rise time and amplitude. Model 6 is similar, delivering positive going pulses.**

Each of these new pulse generators is a four stage unit — multivibrator, inverter-amplifier, cathode follower, and current amplifier. The design of the multivibrator stage permits the selection of any pulse width from 1-40 microseconds by either instrument controls or the use of two external trigger pulses.

The inverter amplifier stage provides a rise time range from .15-1.0 microseconds.

Output amplitude can be varied from 0-2 amperes. Input Requirements: Standard 0.1 microsecond pulses, negative, 13-30V.; +150V. DC, 2.03 amps; —150V. DC, .04 amps; 6.3V. AC, 10.6 amps.

Either Model 5 or Model 6 is available in a standard 19" relay rack mounting 5¼" high by 8" deep.

Write today for complete details or visit WESCON booth #2907
At WESCON, also see and *test* our line of power supplies.

A P P L I C A T I O N S

- precision measurement of core characteristics in magnetic logic circuits
- transistor testing
- high current for memory circuit testing
- high speed ferrite study
- switch core investigation

OTHER REFLECTONE PRODUCTS: integrators • differentials • couplings • power supplies • simulators • procedure trainers

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CIRCLE 224 ON READER-SERVICE CARD FOR MORE INFORMATION

MINIATURE CONTROL COMPONENTS

. . a WRIGHT specialty

SIZE 9 SERVO MOTOR TACHOMETER GENERATOR

Diameter: 7/8 inch
Input: 26V-400 cy.
Speed: 9500 RPM
Torque Rating: 0.25 oz.-inch
Generator Output: .33 V/1000 RPM

This two bearing motor-generator set illustrates Wright's exceptional capability for production of special small precision components and assemblies. You are invited to consult us on your next requirements for . . .

A. C. and D. C. Motors · Servo Tach Units
Synchros In All Categories
Gyro Motors · Tachometer Generators
And Related Components and Assemblies

MOTOR DIVISION

WRIGHT MACHINERY COMPANY
ESTABLISHED 1893 · DURHAM, N. C.
DIVISION OF SPERRY RAND CORPORATION

CIRCLE 226 ON READER-SERVICE CARD FOR MORE INFORMATION

Services for Designers

Wire and Rod Conversion

A conversion department for wire and rod is in operation at Techalloy Co., Inc., Rahns, Pa. Straightened and cut wire and rod in round, square, hex and other special shapes, with diameters from 0.002 in. to 1/2 in. or equivalent cross sections can be handled. Finished material can be cut in lengths from 2 in. to 12 ft. Various types of annealing and pickling equipment needed for special conversion of ferrous and nonferrous alloys are available.

Silicon Single Crystals

Thermosen, Inc., 361 West Main Street, Stamford, Conn., announces the availability of oriented single crystal silicon ingots grown to customer's required type and resistivity. Crystals average 60 grams in weight, but smaller crystals can be supplied when desired. Production is currently on a limited basis and priority will be given to customers requiring one or two crystals for research or small scale production.

Ultra-Thin Die Stampings

A new technique for the ultra-thin die stamping of special metals and alloys assure high production of delicate, close tolerance parts, while maintaining all the valued characteristics of the particular material used. This technique has been utilized in producing nichrome numbers for a gaseous, computer-readout tube. These 5/8 in. high numbers can be stacked within a single glass envelope, displaying individual digits from zero to nine, thus eliminating the need for separate tubes for each number. Another product of this ultra-thin stamping technique is a minimum-torque, vibrationless pigtail lead of Beryllium Copper, to eliminate frequency modulation of the control signal in a gyro. The pigtail is 0.001 in. thick and 0.017 in. wide, and is made in one of several possible shapes for torque limiting, high conductivity and high stress resistance. Other metals which have been stamped by this process include: Swedish iron, Alclad (aluminum clad iron), tantalum, molybdenum and super-thin sheets of plated ceramic.

For further information write: Be Cu Mfg. Co., Inc., 40 Kent St., Newark, N.J.

Centerless Grinding

Any cylindrical shape, in any material such as metal, ceramic or plastic, up to 1/2 in. diam, can be fabricated at a new custom centerless grinding department, equipped to do short run, development, experimental or production runs. Both infeed and infeed taper, as well as thrufeed grinding will be done on a jobbing or contract basis. Further information may be obtained from Electronic Parts Mfg. Corp., 508-25th St., Union City, N.J.

Irradiation Service

Radiation Applications Incorporated announces the institution of an industrial cobalt source irradiation service in Long Island City, N.Y., and the publication of a brochure describing radiation testing of materials, radiation effects and damage evaluations. Information about the use of nuclear radiation in industry and design and installation of a cobalt facility is also included. White Radiation Service Dept., Radiation Applications Incorporated, 342 Madison Ave., New York 17, N.Y.

CIRCLE 232 ON READER-SERVICE CARD FOR MORE INFORMATION

Custom Molding Service

Custom molding of B-stage phenolics, polyester glass and Scotchply epoxy glass laminates has been undertaken by Mica Insulator Co., of Schenectady, N.Y. A wide range of parts can be molded from these materials to rigid specifications. The company undertakes complete responsibility including design selection of the material, molding and necessary finishing operations.

B-stage phenolics are available with paper, canvas or linen backing. As thermosetting materials, they can be molded from sheet or macerated forms. Parts made from these materials feature excellent resistance to heat, and have good dimensional stability as well as high tensile, compressive and impact strength.

The polyester glass parts are molded to mat layups, roving or "gunk." They combine glass fibres and polyester resin, which, on the application of heat and pressure, cure to a rigid laminate with desirable dielectric properties, outstanding arc resistance and high structural strength. Scotchply epoxy glass laminates are light in weight, high in strength and stability and have good resistance to chemicals and electrical properties. Fiber orientation can be controlled to run in unidirectional, bidirectional or isotropic patterns to provide the desired physical characteristics imposed by specific applications.

ENGINEERS...

cross new frontiers in system electronics at The Garrett Corporation

Increased activity in the design and production of system electronics units like the one illustrated above has created openings for engineers in the following areas:

- **ELECTRONIC AND AIR DATA SYSTEMS** Required are men of project engineering capabilities to participate in the design and development of complete electronic control and air data systems for use in current and future high performance aircraft. Also required are development and design engineers with specialized experience in servo-mechanisms, circuit and analog computer design utilizing vacuum tubes, transistors, and magnetic amplifiers.

- **SERVO-MECHANISMS AND ELECTRO-MAGNETICS** Work includes the design and development of magnetic amplifier control devices and integration of components into finished systems. Servo-system analysis and performance prediction would be helpful. Complete working knowledge of electro-magnetic theory and familiarity with materials and methods employed in the design of magnetic amplifiers is required.

- **FLIGHT INSTRUMENTS AND TRANSDUCER DEVELOPMENT** Requires engineers capable of analyzing performance during preliminary design and able to prepare proposals and reports. Experience with sensitive aircraft instruments, servos, gyros, auto pilots and flight controls is desirable.

- **FLIGHT INSTRUMENTS DESIGN** Requires engineers skilled with the drafting and design of light mechanisms for production in which low friction, freedom from vibration effects and compensation of thermo expansion are important. These mechanisms frequently involve instruments, bearings, gears, bellows, diaphragms, cams, potentiometers, linkages and small electric motors.

- **HIGH FREQUENCY MOTORS, GENERATORS, CONTROLS** Requires electrical design engineers with BSEE or equivalent interested in high frequency motors, generators and associated controls. Experience in the field of aircraft motors and generators, servo-motors or high speed, high frequency machine tool motors helpful. The field of power supply and utilization equipment on modern aircraft and missiles provides excellent opportunities.

Send resume of education and experience today to:

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CIRCLE 559 ON READER-SERVICE CARD FOR MORE INFORMATION

New Materials

Performance of Filled Epoxy Resin Under High Humidity Conditions

IT IS well known that insulation resistance of epoxy resin systems under standard laboratory conditions of 25 C and 50 per cent relative humidity is so good that sizeable amounts of other materials may be added to the system without degrading the product to the point of uselessness. However, when such systems are given prolonged exposure to high humidity, performance is often unsatisfactory. The ability of moisture to wick along the resin-filler interface under some conditions has been reported. The intensifying effect that fillers have on galvanic degradation under high humidity has also been noticed. Hence, one of the components of a resin system whose action at high humidity would be most suspect is the filler.

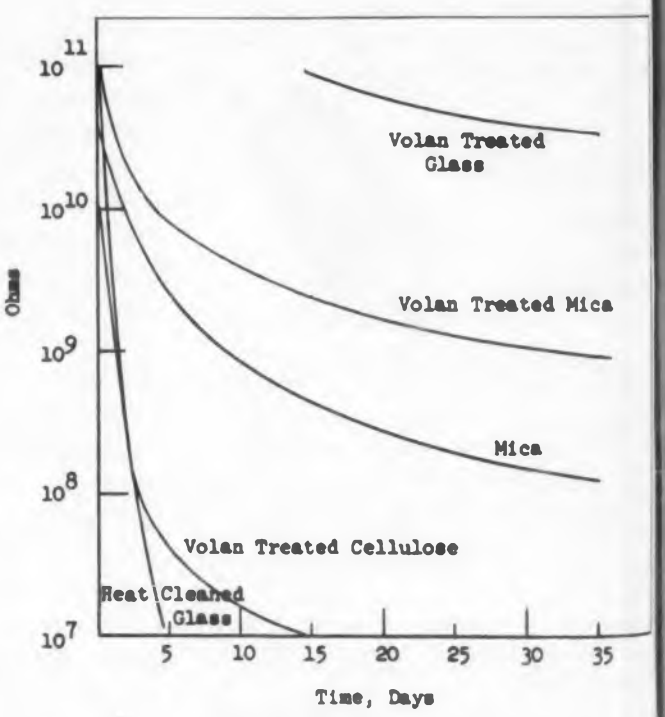
To investigate the effect of humidity on filled epoxy resin, resistance measurements were made at 500 v dc under the environmental conditions of 95 per cent at 140 F. The specimens were maintained in this environment by suspending them over a saturated K_2SO_4 solution in a forced draft oven at 140 $\pm$1.5 F. The set-up made it possible to make periodic measurements without disturbing the environment by connecting the bridge to the appropriate terminals outside the oven. The insulation resistance of each specimen was measured daily for a period of 35 days.

The resin used was Epon 828 cured with 14 phr of m-phenylenediamine. The proportion of filler used in each sample was 50 per cent by weight, and consisted of the following: a composition of glass fibre treated with a Volan surface finish (shredded 181-Volan-A cloth); Volan-A treated water ground mica; water ground mica; Volan-A treated alpha cellulose floc, and chopped glass fibers fired at 900 F. To apply the Volan finish to the mica and cellulose floc, they were suspended with rapid stirring in a 2 per cent aqueous solution of methacrylato-chromic chloride (Volan-duPont).

The results obtained are presented in the accompanying graph. It became apparent early in the investigation that resistance values greater than 10^{11} ohms were of questionable accuracy; therefore, no curves are given above this range. The control of unfilled Epon 828 cured with m-phenylenediamine is not shown since all values were above this range. The best performance was obtained from the Volan-treated glass, and it would appear that this filler gives a product whose performance is excellent. The next best result, obtained with the Volan-treated mica, proves this system to be acceptable for most applications where high humidity is involved. The untreated mica is measurably inferior to the Volan-treated mica and would probably be considered as marginally acceptable. The dismal performance of the other two systems is quite significant. It would appear that the Volan treatment has a tremendous effect on the resin-glass interface but little effect on the resin-cellulose interface.

The experiment shows that the addition of filler to a good epoxy resin polymer unquestionably impairs the performance of the system as an insulator under high humidity conditions; however, there are wide differences between fillers. The improvement in performance that in some cases results from the use of surface finishes would make it appear that this field is worthy of further investigation.

Abstracted from Effect of Fillers on High Humidity Insulation Resistance of Epoxy Resin Systems *by H. L. Parry, J. E. Carey, M. D. Anderson, Shell Chemical Corp., Union, N.J.*



The performance of an epoxy resin at 95 per cent relative humidity and 140 F is shown to differ widely according to the type of filler used.

Silicone Insulation
Pour Without Solvents

Identified as R-7501 and R-7521, these are pure silicone materials, pour freely without solvents, and cure to form void-free high temperature impregnations or encapsulations. At room temperature, the viscosity of R-7501 is 2500 centistokes; that of R-7251, 100 centistokes. Either can be thinned by warming to 175 F before application, and both can be blended in any ratio to achieve any intermediate viscosity.

Full curing is obtained with a peroxide catalyst and a step cure of 9 hrs at temperatures up to 390 F. Shelf life of the uncatalyzed resins is over a year, while pot life at room temperature of the catalyzed resins is over six months. Either of the resins may be used as a potting compound, or with a range of inorganic fillers.

The low viscosity and fully reactive nature of the resins enable them to thoroughly saturate and penetrate the most complex assemblies and to convert to solid, bubble-free insulation. When cured, they exhibit excellent dielectric properties moisture resistance, thermal conductivity and mechanical strength despite prolonged exposure to 400 F.

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

CIRCLE 245 ON READER-SERVICE CARD

Epoxy Resin Compound
High Heat Distortion

U-300 thermopoxy compound was developed for use on rotating field coils and other coils requiring a high degree of turn to turn bonding strength at elevated temperatures. It also is supplied in a consistency for dip application of electric apparatus where fairly heavy films are desired. The material is thixotropic and contains a filler. It is a single-component system which does not require a catalyst. It has a heat distortion rating of 150 C. Thixotropic properties assure that it will not flow during recommended curing operation. It is reported to have a high rate of heat-transfer and good moisture and chemical resistance. Tank or pot life is over 120 days.

The Sterling Varnish Co., Dept. ED, Haysville Bor., Sewickley, Pa.

CIRCLE 246 ON READER-SERVICE CARD

New Literature

Single-Phase Induction Motors 250

Construction features of drip proof and enclosed single-phase induction motors are discussed in Bulletin No. 1419. Three-fourths to 5 hp; frames 182, 184, 213, 215; 115/230 v; 60 cyc are covered in the four pages. Application data, types, ratings, frame sizes are indicated. Used for applications such as fans, blowers, pumps, air and refrigeration compressors, conveyors, masonry saws, sanding machines, hammer mills and other farm and general purpose applications. General Electric Co., Schenectady 5, N.Y.

Thermistor Catalog 251

Listing typical applications and circuitry, Bulletin T-100 gives specifications and characteristics of wafer, rod and bead thermistors. Each type is illustrated with diagrams and charts indicating models and their corresponding characteristics and size. A table shows the resistance ratio vs temperature to compute thermistor resistance at specified temperatures. The ten-page booklet contains special ordering information for standard thermistors and custom and special engineering application units. Gulton Industries, Inc., Thermistor Div., Metuchen, N.J.

Bridge Amp & Meter 252

Practical combination of strain gage switch and balance and indicator units are described in Bulletin No. 6 now available. You can preset both the balance and gain on six channels of two or four arm strain gage setups and bring in one after the other as fast as you can punch the channel selector buttons.

The bulletin also includes information on the excellent Weston meter movement on the front of the BAM-1 or dynamic signals from dc to 20,000 cps which are brought out on a dc oscilloscope. Ellis Assoc., Box 77, Pelham, N.Y.

Industrial Plastics Booklet 253

A new presentation booklet and plastics material guide has been made available. It features interesting graphic examples of plastic fabrication methods with illustrations of the types of products best suited to each method. An extensive chart, reprinted here, showing the characteristics of tough, rigid thermoplastics is also included. L. A. Darling Co., Plastics Division, Coldwater, Michigan.

MATERIAL

Chemical Type	Trade Name	Manufacturer
Acrylonitrile-butadiene-styrene copolymer	Cycolac	Marbon Chemical Co.
Acrylonitrile-butadiene-styrene rubber-resin blends	Kralastic	Naugatuck Chemical Co.
Cellulose acetate	Celanese acetate	Celanese Corp. of America
	Tenite acetate	Eastman Chemical Products
	Hercocel A	Hercules Powder Co.
Cellulose acetate butyrate	Tenite Butyrate	Eastman Chemical Products
Cellulose propionate	Forticel	Celanese Corp. of America
Ethyl cellulose	Ethocel	Dow Chemical Co.
	Hercocel E	Hercules Powder Co.
Ethylene (low pressure)	Grex	W. R. Grace Co.
	Hi-fax	Hercules Powder Co.
	Super Dylan	Koppers Co.
	Marlex 50	Phillips Chemical Co.
Fluorochlorocarbon	Fluorothene	Bakelite Co.
	Kel-F	M. W. Kellog Co.
Nylon	Plaskon Nylon	Allied Chemical and Dye
	Zytel	E. I. du Pont
Styrene, glass-filled	Fiberfil	Fiberfil Corp.
	Fibertuff	Koppers Co.
Styrene, modified	2155	Bakelite Co.
	Styron	Dow Chemical Co.
	Plio-Tuf	Goodyear Tire & Rubber Co.
	Dylene	Koppers Co.
	Lustrex	Monsanto Chemical Co.
Vinyl Chloride copolymers and blends	Exon	Firestone Plastics Co.
	Geon	B. F. Goodrich Co.
	Marvinol	Naugatuck Chemical Co.
Acrylics	Lucite	E. I. du Pont
	Plexiglas	Rohm & Haas

Cadmium Batteries 254

Results of tests run on the SILCAD battery have been released in bulletin by Dr. Paul L. Howard, Director of Technical Operations.

The bulletin entitled "The Silver-Oxide Cadmium Alkaline Secondary Battery" shows that this silver-cadmium battery is especially useful where longer life and low discharge rates are required, and where there is need for a great number of recharges. Yardney Electric Corp., 40-50 Leonard St., New York, N.Y.

Reluctance Amplifier Reprint 255

Reprint of article entitled "Reluctance Amplifier," Power in Small Package—is now available. Developed primarily for driving servo motors, its small size and light weight are desirable features which makes it especially useful to designers of mobile and aircraft equipments. The unit's power supply is self-contained. It has no drift or time lags. Response time is limited by use of 400 cps carrier.

The four-page brochure, RA-1, details operating characteristics and circuit diagrams of this amplifier, which derives its name from its output which is controlled by the electrical insertion of reluctance into one or another leg of a three-legged transformer. Servo Corp. America, 20-20 Jericho Turnpike, New Hyde Pk., N. Y.

Precision and Infrared Optics 256

Precision and infrared optics are topics for two available brochures. In Precision Optics Bulletin No. 0-104, six pages of photographs and captions describe expanded engineering and production facilities for designing and fabricating flat, cylindrical, prismatic, spherical, and aspherical components for recording oscillographs, fire control, photographic, projection, missile, ultraviolet and infrared uses.

Two-page Infrared Optics Bulletin No. 0-105 tells how infrared optics are produced from home-grown silicon crystals expressly for use in hyper-sensitive infrared systems. With graphs to illustrate, the properties and characteristics of silicon are discussed is some detail. Texas Instruments, Inc., 6000 Lemmon Ave., Dallas 9, Tex.

900 Frame AC Motor 257

Engineering bulletin on 900 Frame ac motor shows performance curves presented for both a 1 and 1-1/2 in. blower with accompanying engineering data on each. According to the bulletin, the 900 Frame units can be supplied as servo, fan or blower motors. Units in this series are also applicable in motor generator sets or servos with drag cup generators. Induction Motors Corp., 570 Main St., Westbury, L.I., N.Y.

THERMOPLASTICS CHARACTERISTICS

MECHANICAL: Toughness, Stiffness, Ductility, Hardness, Strength — PHYSICAL: Density, Service Temperature Limits, Flammability — ELECTRICAL: Power Factor, Dielectric Constant, Dielectric Strength, Volume Resistivity — GENERAL: Moisture Resistance, Optical

Toughness Notched Izod, ft-lb/in.			Stiffness Modulus, psi			Ductility Elongation, %			Hardness Rockwell			Strength Tensile, psi			Density cu in./lb.			Service Temperature Limits Deg F: Softening			Service Temperature Limits Deg F: Embrittling			Flammability Burning Rate			Power Factor			Dielectric Constant			Dielectric Strength volts/mil			Volume Resistivity ohm-cm			Moisture Resistance Absorption, %			Optical: Clarity			Optical: Colors		
Over 4	1 to 4	Under 1	Over 400,000	200,000 to 400,000	Under 200,000	Over 50	5 to 50	Under 5	Over 80M	80R to 80M	Under 80R	Over 8000	4000-8000	Under 4000	Over 32	18 to 32	Under 18	Over 212	175 to 212	Under 175	Under −40	−40 to 20	Over 20	Nil	Slow	Fast	Under 0.001	0.001 to 0.010	Over 0.010	Under 3	3 to 6	Over 6	Over 800	400 to 800	Under 400	Over 10^{16}	10^{13} to 10^{16}	Under 10^{13}	Under 0.1	0.1 to 0.4	Over 0.4	Colorless, transparent	Colored or translucent	Opaque	Many	Limited	None
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Ferrite Magnetic Materials 261

The availability of an 8-page illustrated bulletin called "Ferramics for General Applications up to 200 Megacycles" is announced. The publication fully describes the nature of ferrites, their advantages and limitations and method of production. It also contains a detailed comparison of ferramic bodies and their specific applications to the electrical and electronic industries. General Ceramics Corp., Keasbey, N.J.

Universal Relay Tester 262

Detailed specifications, including electrical and special characteristics, are given in 4-page brochure, now available. It includes methods-time measurement (MTM) production data, developed for production and industrial engineers, and an outlined dimensional drawing. Magnavox Co., Ft. Wayne 4, Ind.

Math and Chemistry Data Books 263

Several revised loose-leaf technical data books are available. "Lefax Manual of Mathematics" contains mathematical reviews, logarithmic tables, natural trigonometric functions, conversion tables, and functions of numbers. The trig, log, and other tables are accurate and reliable. With a binder, the book costs $4.25; with a pin cover, it is $2.25.

"Lefax Mathematical Tables" incorporates all formulas and tables needed to solve everyday problems in arithmetic, geometry, algebra, trigonometry, analytic geometry, and calculus. In a cloth binder, the book is $3.25, in a pin cover, $1.50.

"Lefax Chemical Hand Book" is a 224-page compilation of data on general chemistry, inorganic chemistry, organic chemistry, physical chemistry, and quantitative qualitative analysis. Complete in binder, the price is $3.75; in pin cover, $2.00.

"Handbook of Chemical Tables" is a complement of chemical tables covering the physical and thermodynamic properties of inorganic and organic compounds. The 320-page book costs $4.00 in a binder and $2.50 in a pin cover.

Offered free is a catalog listing over 2000 technical subjects. *For more information about these books, write directly to Lefax Publishers, 9th and Sansom Sts., Philadelphia 7, Pa.*

New Literature

Numerical Positioning Control 270

Bulletin GET-2675 has 14 pages describing functions of numerical positioning control. It gives a detailed breakdown of the three major elements—data input, director, and servo drive; lists features, and graphically illustrates each operation. General Electric Company, Schenectady 5, N.Y.

Industrial Coils 271

An informative eight-page booklet No. S-20 describing custom-made industrial coils is available. Replete with photographs of the manufacturing processes, this brochure explains the need for superior design, workmanship, materials and finish in the construction of vacuum impregnated coils. Stonite Coil Corp., Yardville 20, N.J.

Quality Control Testing 272

Complete facilities available in Environmental, metallurgical, chemical and quality control testing is covered in this 24-page brochure just released.

In indicates that industry's need for a modern, fully-equipped plant to serve all test requirements has been recognized. Burgoyne Testing Labs., 542 Main St., Westbury, L.I.

Modular Instrument Enclosures 273

Supplement 101-A introduces four modular enclosure types. Two vertical frames, a turret frame and a deep scope frame assembly are described. All are illustrated with photographs and dimensional diagrams. Prices are listed for each assembly. Amco Engineering Co., 7333 W. Ainslie St., Chicago 31, Ill.

Wire and Strip Alloy 274

Complete line of bobbins for use in the textile electrical manufacturing and metal working industries is included in catalog just released.

The 12-page catalog describes and illustrates standard and special bobbins made from various sources. National Vulcanized Fibre Co., Lestershire Spool Div., 1057 Beech St., Wilmington 99, Del.

Cooling Equipment 275

An eight-page colored brochure, entitled "What We Make" containing pictures and brief descriptions of a line of cooling equipment for electronic applications is now available.

At a glance this brochure shows the scope of the products and enginering services available. Rotron Mfg. Co., Woodstock, N.Y.

NEW DEVELOPMENT PROTECTS ELECTRONIC EQUIPMENT

General Electric Company has perfected miniature, *hermetically sealed* breakdown gaps that protect costly condensers, transformers, tubes, and other components from over-voltage conditions. These units are ideal for applications where, due to weight and size restrictions, normal operation is at maximum ratings.

The gaps are completely unaffected by altitude, humidity, temperature or foreign particles because they are *hermetically sealed*. Stainless steel electrodes are supplied for normal applications—tungsten electrodes for heavier duty. Choice of voltage ratings up to 6000v. available.

For further information, write ACCESSORY EQUIPMENT DEPARTMENT, General Electric Company, Bridgeport 2, Connecticut.

Progress Is Our Most Important Product

GENERAL ELECTRIC

CIRCLE 278 ON READER-SERVICE CARD FOR MORE INFORMATION

MINIATURIZED EQUIPMENT GROWS SMALLER STILL with

DAGE DM series RF Cable Connectors

half the size of standard BNC's

- Tiny but rugged, can withstand a cable pull of over 50 lbs.
- Twelve polarity groups—two and three lug
- Vibration-proof bayonet locking (MIL-C-5015)
- Teflon insulators permit use over wide temperature-range with low electric loss
- .002″ silver plate and gold flash affords excellent corrosion resistance

Dage Catalog 201-B gives full details with specifications on sub-miniature DMs. Write for your free copy.

DAGE ELECTRIC CO., INC. | 67 No. Second St. Beech Grove, Ind.

CIRCLE 279 ON READER-SERVICE CARD FOR MORE INFORMATION

High Temperature Insulation 280

"See what's super-new at super-temp" is the title of colorfully illustrated folder now available. A representative group of super-temp products are presented as well as a brief outline of the company itself, its new production and testing equipment, and its concept of service and quality. American Super-Temperature Wires, Inc., Winooski, Vt.

Copperply Wire 281

Specifications of Copperply wire are described in Bulletin 202, a new eight page booklet. Data includes charts of coating thicknesses for each wire size and salt spray resistance of each coating thickness. Tables list breaking loads, weight, resistance and other wire qualities. National-Standard Co., Niles, Michigan.

Analog Computer 282

Analog Computer Model 3000 is described in engineering data sheet now available. The computer's "building-block" design, problem-handling capacity, and accesories are discussed in a comprehensive, but easy-to-read manner. Complete prices, typical module combinations, and recommended computing facilities are also included. Donner Scientific Co., 888 Galindo St., Concord, Calif.

TENSION GAUGE is PRE-SETTABLE

For GO/NO-GO Tests of Springs and Contact Pressures

Speedy, one-hand operation and precise calibration over a range of 4 to 2500 grams, with adjustable zero setting, are the important features of GENALEX tension gauges. Designed for GO-NO-GO checking of spring tensions or other resistive forces, these gauges permit inspection or production testing by unskilled personnel.

To use this gauge: just preset the tension by turning the micrometer knob until the pointer shows the desired tension on the scale and apply the tip of the gauge-operating strip where force is to be checked. If the force being checked matches the gauge setting, the operating strip and the resisting element will move at the same time. Attention is focused on one point only—movement at the point of contact; there are no dials or scales to be read.

Six models are available, covering ranges of 4-24, 10-80, 50-250, 100-500, 200-1600, and 500-2500 grams. For detailed descriptive bulletin and prices, write: General Electric Company, Limited of England, c/o Imtra Corporation (U. S. Agents), 11 University Rd., Cambridge 38, Massachusetts.

CIRCLE 285 ON READER-SERVICE CARD FOR MORE INFORMATION

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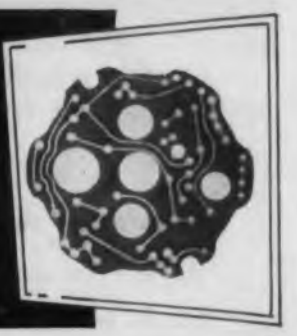
quality . . .
uniformity . . .
service . . .

GLASS for
HERMETIC SEALING
• EPOXY PREFORMS
• PRESSED CERAMICS

mansol CERAMICS CO.
140 LITTLE ST. • BELLEVILLE • NEW JERSEY
THORTON HEATH • SURREY • ENGLAND

CIRCLE 283 ON READER-SERVICE CARD FOR MORE INFORMATION

PRINTED WIRING by METHODE



With the newest and largest facility in the industry, Methode, long a leader in volume production, is now in position to give *special attention* to *short run* as well as large quantity printed circuit requirements

PROMPT QUOTATIONS—
DEPENDABLE DELIVERY—
RELIABLE PRODUCT—

Printed Circuit Handbook upon request

METHODE Mfg. Corp.
7447 W. Wilson Ave.
CHICAGO 31, ILLINOIS

CIRCLE 284 ON READER-SERVICE CARD FOR MORE INFORMATION

Volumetric Efficiency

SHOWN and described here is a demodulator circuit consisting of 4 toroids, 8 capacitors, 9 resistors and 4 diodes packaged in the smallest volume possible. Plug-in construction and hermetic sealing were required.

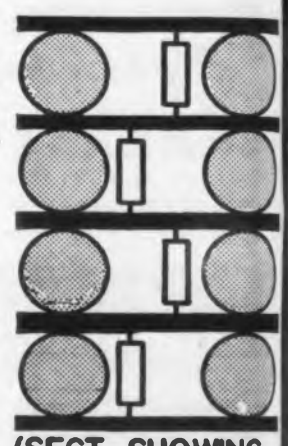
How It Was Done

The toroids were wound with leads brought out together on one side. Then the toroids were dipped in a rubbery compound to provide a cushion. Phenolic boards 0.032 thick, dimensioned to clear inside of the smallest std. mil. can which would clear toroid diameter, were fitted with eyelets at corners, and with four holes in the center to clear diode leads. Diodes were staggered inside the toroids, with leads brought out the four holes on top and bottom boards, and terminated at eyelets on top and header on bottom. Hopkins' oval and square subminiature capacitors were wired vertically between eyelets, and resistors were wired horizontally. Lead wires from Triad octal header were run to appropriate eyelets for input, output, and intermediate test points.

A 91 per cent space factor (measured) was achieved.

R. P. Sykes, Ramo-Wooldridge Corp., Inglewood, Calif.

Tightly Packaged Demodulator



(SECT. SHOWING DIODES)

Mold-in-Place Gaskets

Rubber gaskets are used for waterproofing electrical equipment, yet trouble is sometimes experienced when attempting to close a container and at the same time keep the gasket in the proper position. Other uses often involve complicated shapes, inaccessible locations, or expensive machining to retain the rubber gasket.

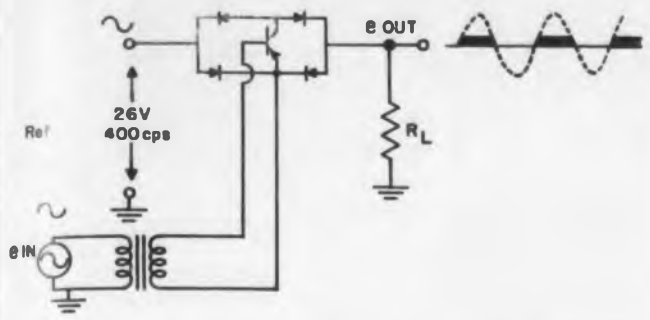
One way of preventing trouble and saving costs is to use the rubber formulations available as pourable materials (i.e. silicone rubber, room temperature curing type), actually to mold in place the shape gasket required. Adhesion to the base material can be excellent, and savings as well as easier maintenance can generally be expected. *Albert Geduld, Consultant, 135 Belmont St., Englewood, N.J.*

Servo Demodulator

It was desired to develop a demodulator for servo applications with the following characteristics: 1. Phase discrimination; 2. very low drift; 3. non-center-tapped load; 4. power or voltage gain; and 5. with only one dynamic control element required (tube or transistor).

Solution

The schematic shows a half-wave circuit utilizing a p-n-p transistor. The output voltage may vary as a half-wave rectified signal within the confines of the dashed lines (saturation limit equal to the reference supply). Assuming that the diodes have a very great back impedance, the circuit is essentially drift free; and nearly all of the load current



Schematic of Servo demodulator utilizing p-n-p transistor and four diodes.

is forced to flow through the transistor each half cycle (for zero signal).

The current leakage resulting from I_{co} will vary with temperature, but the leakage with zero input will be equal each half cycle. Thus, a 400 cps signal will appear across the load proportional to I_{co}; but the net dc will be zero.

Full-wave versions of this circuit (requiring twice as many components and a 180 deg reference phase) are also essentially driftless without having to match transistors.

The author has used this circuit several times, building a 40 w full-wave circuit utilizing two 6AS7 tubes in parallel, a 20 w full-wave circuit using two 2N174 transistors, and other lower power demodulators. For optimum efficiency and/or linearity a combination of self bias and fixed bias may need to be provided depending on the tube or transistor to be used.

Theodore L. Roess, Bell Aircraft Corp., Buffalo 5, N.Y.

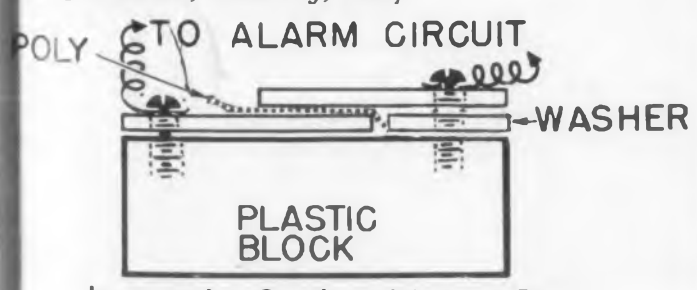
Inexpensive Temperature Indicator

The author had the problem of producing a cheap temperature indicator that could be used to warn of overloads, resulting in abnormal temperatures that could damage equipment.

The indicator that was developed is that shown. Two metal strips, overlapping each other and separated by a thin (0.002 in.) piece of polyethylene, were fastened to a block of plastic.

When the temperature exceeds the critical value, the polyethylene insulation melts, closing the alarm circuit. The polyethylene film can be readily replaced by lifting the spring leaf.

Harold Chapman, Jr., Plastics by Chapman, 1427 Oregon Street, Berkeley, Calif.



Inexpensive Overheat Warning Device

Ideas for Design

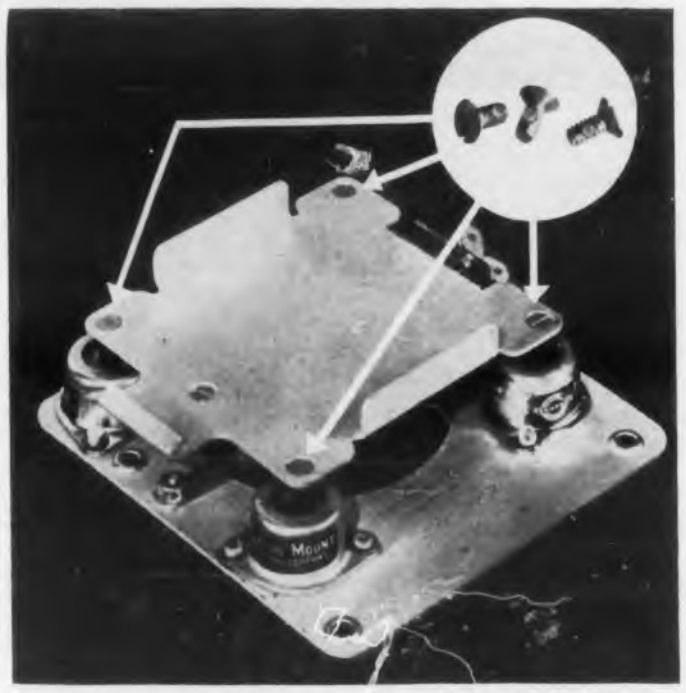
Nylon Screws Eliminate Lock Washers

By switching to self-locking nylon screws, a manufacturer of mounting bases for airborne electronic equipment saved assembly time on each base.

The mounting base shown isolates a delicate electronic anti-skid device in the nose wheel well of a jet fighter from the violent shock of 100 mph landings and armament firing, as well as the constant vibration of the 10,000 rpm turbine.

T. R. Finn & Co., Inc. of Hawthorne, N.J., the manufacturer, is now using Nylok self-locking flat head screws to secure the platform to the mounts. These screws have a nylon pellet inserted into the threads of the screw shank which bears against the threads in the mount stud. This produces a tight metal-to-metal fit between mating threads and prevents the screw from loosening or changing position.

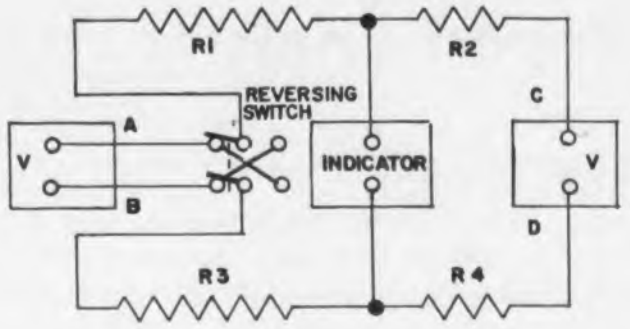
Because nylon is an elastic material, it tends to regain its original shape. Thus, these screws can be reused many times without losing their self-locking ability.



Mounting base using nylon self-locking screws.

Phase Determination

The author had the problem of checking, under load, the relative phase of isolated voltages which are either in phase or 180 deg out of phase. Examples are isolated transformer windings, servo references, and audio lines.



The circuit shown accomplishes the purpose very well. $R_1 = R_2 = R_3 = R_4$. If V_{AB} and V_{CD} are approximately equal, the indicator will light if AB is 180 deg out of phase with CD, with the switch in the position shown. It will not light if they are in phase. If the voltages are unequal, the indication will be dim for an in-phase connection and bright for an out-of-phase connection. A neon lamp may be used as an indicator for high voltage, high impedance circuits and an incandescent lamp for low-voltage low-impedance circuits. A vtvm may be used as indicator for low-level, high-impedance circuits. It will read high for out-of-phase and low for in-phase voltages.

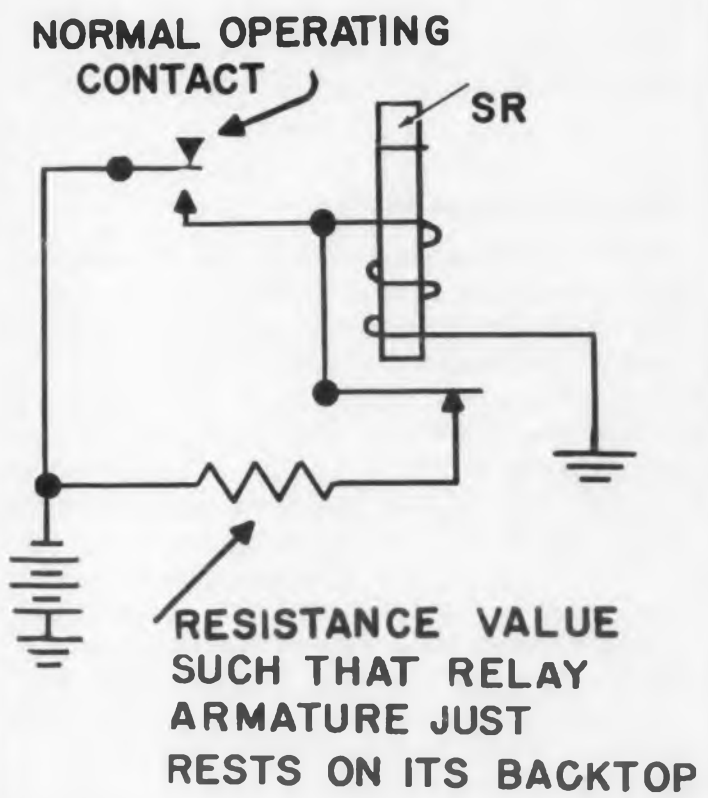
F. H. Goodenough, Eng., General Electric Co., Court St., Bldg. 4, Rm. 16, Syracuse, N. Y.

Fast-Operate, Slow-Release Relay

Shown is a circuit for accomplishing slow-release, fast-operating (slugged) relay characteristics.

A spare, normally-closed contact set, is connected through a resistor to provide a current equal to about 1/4 of operate current. Relay will operate unusually fast and release slowly.

A. W. Kaufman, Pacific Tel & Tel Co., 177 Post St., Rm. 701, San Francisco 4, Calif.



Report Briefs

Speech Frequency Control

An automatic amplitude control for speech frequencies is described which is characterized by unique circuitry in which two miniature vacuum tubes in conjunction with crystal diodes provide a dynamic control range of 35 db. Input amplitude variations over this range are reduced to approximately 1 db at the output with relatively little distortion. Modification of the speech wave insures that a maximum of the speech "intelligence" is transmitted. *PB 123077 Method of Automatic Amplitude Control for Speech Frequencies, Lyle R. Battersby, U. S. Signal Corps Eng. Labs., Ft. Monmouth, N. J. Library of Congress, Washington 25, D. C., Nov. 1954, 20 pp, microfilm $2.40, photocopy $3.30.*

Radiation from Slot Antenna

A rectangular waveguide terminating in the plane of an infinite ground screen and radiating into a half space has a ferrite slab located at the aperture. With a TE_{10} mode of 9365 mc sent through the waveguide the far-zone radiation pattern in the H-plane has been measured as a function of a transversely applied static magnetic field. It was discovered that for certain thicknesses of the ferrite slab the radiation lobe deviated considerably from the normal to the infinite screen with only small changes in the applied magnetic field. *PB 123945 Radiation From a Ferrite Filled Slot Antenna, D. J. Angelakos and M. M. Korman, Calif. Univ., Electronics Research Lab., Antenna Group, Berkeley, Calif. Library of Congress, Washington 25, D. C., Sept. 1955, 25 pp, microfilm $2.70, photocopy $4.80.*

Ceramic Magnet Studies

More than 700 magnets were prepared and measured during two years of studies. Data are provided in this report for processes for making the magnets, methods and results of physical measurements, and observations on theoretical aspects of magnetism in barium ferrite. Among a number of advances was the attainment of crystal orientations better than 93 per cent and residual inductions of nearly 4200 gauss. The energy product of barium ferrite was increased from about 1 million to over 3.7 million gauss-oersteds. Powder patterns were classified and a possible mechanism reversal was proposed. *PB 121865 A Study of Permanent Magnets of the Barium Ferrite Type, K. J. Sixtus, Indiana Steel Products Co., OTS, U. S. Dept. of Commerce, Washington 25, D. C., Aug. 1956, 53 pp. $1.50.*

Oscillating Crystals

An X-ray investigation of the crystal-structural basis for piezo- and ferroelectric activity in solids, with the aim of prediction and development of new crystals for frequency-control elements. The X-ray studies are coordinated with electrical, mechanical, thermal and optical measurements on the materials concerned. The program has been concerned with development of special X-ray diffraction apparatus and piezoelectric testing devices of adequate sensitivity for crystal surveys, a survey of possible new piezoelectric crystals, and X-ray diffraction studies of KH_2PO_4, $NH_4H_2PO_4$, $LiNH_4$ tartrate. H_2O and LiRB tartrate H_2O. *PB 123172 Stroboscopic X-ray Studies of Oscillating Crystals, R. Pepinsky, Penn. State Univ., University Pk., Pa. Library of Congress, Washington 25, D. C., Jan. 1953, 272 pp, microfilm $11.10, photocopy $42.35.*

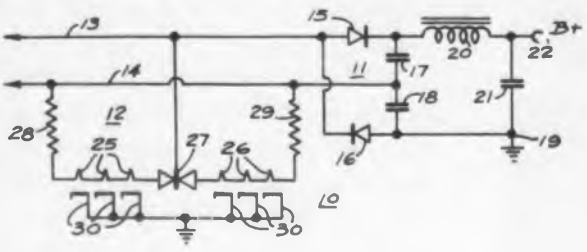
Coil Energy Reservoir

The power required to accelerate a pellet to very high velocity is enormous. It is not feasible, nor necessary, to deliver this power from a continuous source. The extremely short time duration and small duty cycle allow the use of a system in which the energy is accumulated at a very slow rate and discharged at a very high rate. The feasibility of using the inductance coil as an energy reservoir for such a system is discussed. Three systems are analyzed. The first system has the simplest circuit possible to transfer the energy from the field of one coil to the field of another. The second system is a modification of the first using the addition of a capacitor for improved performance. The third system employs a bank of capacitors as the energy reservoir, and serves as a standard for measuring the merit of the other two systems. *PB 124264 Inductance Coil as an Energy Reservoir for an Electromagnetic Accelerator, Charles R. Forbes and William S. Partridge, Utah Univ., Salt Lake City, Utah. Library of Congress, Washington 25, D. C., Aug. 1956, 50 pp, microfilm $3.30, photocopy $7.80.*

Permanent-Magnet Generators

A simple theory of the permanent-magnet generator is presented, based on an equivalent magnetic circuit and using the conventional synchronous machine constants. Steady-state and transient operation is analyzed, and the demagnetizing effect of a short-circuit transient is evaluated. The theory may be used for the prediction of machine performance and as the basis of an optimum design method. *PB 121862 Permanent-Magnet Generators, D. J. Hanrahan and D. S. Toffolo, U. S. Naval Research Lab., OTS, Washington 25, D.C., March 1957, 18 pp, $.50.*

Patents



Power Supply

Patent No. 2,780,736. G. C. Chernish. (Assigned to Sylvania Electric Products, Inc.)

Receiving tubes used in radio and television receivers are designed to operate with plate potential of 250 to 300 volts. In order to secure this voltage from 120 v commercial power lines, it has been necessary to use a transformer, rectifier and filter. A transformer is an expensive component and in seeking to avoid using one in the power supply, a voltage multiplier circuit has been restored to, using disk rectifiers. These rectifiers are relatively inexpensive as compared to a transformer. It was found, however, that receivers using a voltage multiplier circuit power supply were subject to many more tube failures than when using the transformer power supply. As a consequence receivers were again provided with the transformer power supply.

It was discovered that the reason for tube failures was caused primarily by excessive voltage between the cathode and the heater of the tube. In order to reduce this voltage, the patentee devised the circuit illustrated. The voltage doubler portion of the circuit is made up of the capacitors *17*, *18* and *21* with rectifiers *15* and *16* and a choke coil *20* connected as shown. The commercial power supply lines are the wires *13* and *14*. The heaters *25* of one group of receiver tubes are connected in series with a resistor *28* on the high voltage

side of the supply line and a rectifier in the low voltage side. Heaters 26 of a second group of tubes are in a similar circuit in parallel with the first. With the heater circuits illustrated in conjunction with the voltage multiplier portion of the power supply, the combined dc and ac potential difference between the heaters and the cathodes 30, does not exceed 200 v which is the maximum cathode heater voltage rating for tubes commonly used in receivers. Since the voltage between the heaters and the cathode does not exceed this maximum voltage, tube life is substantially increased.

Two other circuits are illustrated in the patent in which the heaters of all of the tubes in the receiver are used in one series string. In this circuit a capacitor of substantial value is connected across the heaters or the heaters and the series resistor.

Modulator

Patent No. 2,793,304. S. T. Martin. (Assigned to the United States of America)

The line type modulator devised by the patentee uses a gas discharge tube and a delay line connected at one end to the anode circuit of the tube. Pulsing of the tube causes ionization of the gas in the tube and initiates a discharge of the delay line. This generates a wave which travels to the other end of the line and is reflected toward the anode in the form of an inverse voltage wave. The inverse voltage wave causes the tube to draw inverse current due to positive ions in the decaying plasma. A reactive impedance is provided across the other and of the delay line which delays the application of the inverse voltage until the positive ion density in the plasma is reduced. As a consequence the amount of inverse current drawn by the tube is reduced.

Semi-Conductive Devices

Patent No. 2,793,331. J. J. Lamb. (Assigned to Sperry Rand Corp.)

An electronic control device is described which uses a semi-conductor. The semi-conductor is hermetically sealed within an envelope. Within the envelope there is provided a shunting circuit between the electrodes for shunting the current around the semi-conductor when the potential difference between the electrodes reaches a predetermined value.

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Patents

Single Stage Amplifier-Detector Amplifier

Patent No. 2,785,299. J. G. Spracklen. (Assigned to Zenith Radio Corp.)

The amplifier uses an electron-discharge tube having a cathode, a first control grid, an accelerating electrode, a second control grid, and an output electrode. An input circuit applies an amplitude-modulated *w* signal between one of the control grids and the cathode. This signal has a predetermined carrier frequency. Another circuit is provided between the other control grid and the cathode which circuit includes a resonant two-terminal load circuit. One of these terminals is coupled externally of the tube to the other control grid only. The load circuit has an impedance at the predetermined carried frequency greater than the reciprocal of the effective transconductance, at this predetermined frequency, of one control grid with respect to the other control grid. An amplified signal is developed which includes modulation components of the modulated wave-signal. Between the other control grid and the cathod there is a circuit for effecting separation the modulation components from he a plified signal and for supplying the sep rated modulation components to the oth control grid to modulate the electron flo to the output electrode in accordance wi the modulation components. An outp load circuit is coupled between the outp electrode and the cathode which utiliz the transconductance of the other contr grid with respect to the output electro for amplifying the modulation componen

Pulse Sharpening Circuits

Patent No. 2,793,303. H. Fleisher. (Assign to International Business Machines Cor

The pulse sharpening circuit uses a rec fier and an inductance in series and bias to be normally conducting. Input pulses a applied to the rectifier to interrupt the n mal current flow. A transistor has its emitt electrode connected to one terminal of t inductance. The base electrode is connect to the other terminal to bias the transist to substantially non-conducting conditi A load impedance and a source of potent connects the collector and the base el trodes. With this circuit the transistor ca

ducts and quenches the current flowing through the inductance due to the back electromotive force developed across the inductance when an input pulse is applied to the rectifier. This produces a sharpened pulse across the load impedance.

Method And Apparatus For Reproducing Magnetically Recorded Signals

Patent No. 2,785,233. A. A. Stuart Jr. (Assigned to Bendix Aviation Corp.)

The device described is for reproducing the signals recorded on a magnetic record such as a tape. As in such devices a magnetically permeable member is arranged to have the record pass in close proximity to the member so that it receives or responds to the flux on the record. A pick-up coil is carried on the member. The member is periodically saturated when it receives flux from the record to induce voltages in the pick-up coil corresponding to the signals.

Pulse Width Selecting Filter

Patent No. 2,784,310. E. W. Cowan. (Assigned to the United States of America)

The selecting filter rejects applied pulses which exceed a predetermined duration. This is accomplished with first and second delay lines. Characteristic impedance of the second delay line is a fraction of that of the first delay line. A pulse input circuit terminates the input side of the first delay line with the characteristic impedance of the line. The output side of the first delay line is terminated by an impedance including the second delay line in a fraction of the characteristic impedance. An open circuit is provided in the output side of the second delay line. The total delay time of the first and the second delay lines is a fraction of the predetermined duration.

Squelch Circuit

Patent No. 2,785,298. G. H. Menhennett. (Assigned to International Telephone and Telegraph Corp.)

A squelch biasing voltage is developed by using an input circuit which is responsive to noise energy. A generator is coupled to the input circuit which is responsive to noise voltage above a given level and generates a predetermined voltage waveform. This waveform is substantially independent of the amplitude of the noise energy. Circuit components are coupled to the output of the generator which cumulatively stores given portions of the generated wave and produce the squelch biasing voltage.

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Dissipation Factor Range at 1kc:
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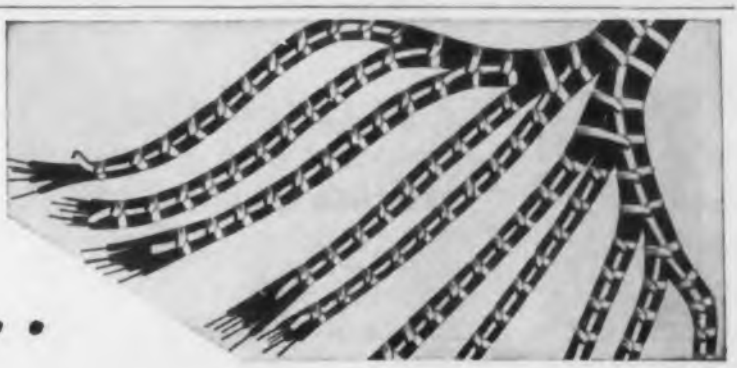

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Books

Magnetic-Amplifier Circuits

William A. Geyger, McGraw-Hill Book Co., 330 West 42nd St., N.Y.C., 394 pages, $7.00.

Guest Reviewer—Joseph P. Harper, Ph.D.

To the uninitiated in the realm of "magamps" it may come as a surprise that there are so many different types of magnetic-amplifier circuits all making use of saturable core reactors. It will be equally surprising that the basic idea of magnetic-amplifiers, wherein relatively small currents are made to control high levels of power without the use of switches, relays, vacuum tubes or transistors, dates back to 1901 when Burgess and Frankenfield applied for an electric circuit regulator patent.

The author, who is associated with the U. S. Naval Ordnance Laboratory, is a recognized authority on magnetic-amplifiers. He has been concerned with them for almost two decades and has made significant contributions in magnetic-amplifier development and applications, particularly in the field of electrical measurements.

Beginning with a short chapter on the historical development of magnetic-amplifier circuits and another on magnetic-amplifier elements, the author proceeds to consider in detail such types as the non-feedback, external feedback, internal feedback, full-wave, half-wave, second har-

monic and self-balancing magnetic-amplifier circuits. The final chapters deal with such topics as the technical properties of magnetic-amplifiers, typical applications and the use of magnetic-amplifier circuits for tracing dynamic hysteresis loops. The treatment of the subject matter is mainly descriptive, is thorough and amply illustrated by circuit diagrams. The use of mathematics is minimized but is adequate to bring out the physical principles involved. Extensive bibliographic material, including references to patents, is given at the end of each chapter.

With their inherent characteristics of long life, compactness, stability and insensitivity to vibrations, magnetic-amplifiers present attractive applications possibilities in this age of instrumentation and automation. Therefore this book will doubtless prove to be an invaluable aid and ready reference for the engineering designer to the principles, development and characteristics of magnetic-amplifiers. It will also familiarize him with the many applications of these amplifiers in the fields of servomechanisms, automatic control devices and electrical measuring instruments.

Dr. Harper is head of the Dept. of Physics, Univ. of Scranton.

High Speed Flight

E. Ower & J. Naylor. Philosophical Library, 15 East 40th St., New York 16, N.Y., 227 pages, $10.00.

Special problems encountered at high-speed and supersonic flight are described in this text. Much of the information discussed has not previously been released for general publication. The fundamentals of flight are first explained and examples given of early attempts to attain supersonic speeds.

An account of how successive difficulties were met and overcome and the inauguration of a new era with the breaking of the sound barrier will prove interesting background material for a person wishing to acquire a speaking knowledge on high-speed flight. Methods of research and experiment in aero-dynamics and the uses of various types of wind-tunnels are clearly described and explained. The subject of rockets and guided missiles is also touched upon. Physiological problems of high-speed flight are reviewed, and some of the future possibilities are assessed. Ower and Naylor keep technicalities to a minimum and present their material in a clear and factual manner.

Standards and Specs

Sherman H. Hubelbank

Requirements for Reliability

The general requirements for the reliability program to be conducted by the contractor for production equipment are established by spec.
MIL-R-25717(USAF), Reliability Program For Electronic Equipment, January 1957

This spec is used as an approach to an adequate reliability program in the production of electronic equipment. To be adequate, however, the detail spec must establish quantitative minimum requirements for reliability, such as mean time to failure for an adequate lot size of equipments. The lot size to be specified by the detail spec will depend upon the quantity of equipment ordered and its rate of production.

It is the responsibility of the contractor to accomplish the degree of reliability required. It shall not be presumed that because an item is committed to production that the prototype model, if any, or the designs therefore, will yield the required reliability if accurately reproduced.

The contractor's latitude in exercising the means to accomplish the reliability required is not limited, except to see that the specified performance and characteristics of the equipment are not changed to obtain the reliability objective. Where a serious situation develops, the contractor is permitted to offer a reasonable compromise proposal to the procuring agency for consideration.

Component parts and materials obtained from sub-contractors and vendors shall receive special attention when specifying and ordering. It is not to be presumed that because a part is JAN or standard that it will automatically possess the required degree of reliability.

Before assembly and fabrication, the contractor shall make absolutely certain that all component parts are rigorously tested under test conditions calculated to expose defective parts or uncontrolled characteristics which could lead to early failure of the equipment.

Since faults due to poor workmanship are just as serious as design or component part failures, the contractor shall insure proper selection and training of personnel to provide the highest quality of work. The contractor shall maintain progressive inspection of the work, in addition to final inspections.

The contractor's production engineering department shall include qualified personnel in reliability design and supervision. The quality control section shall also participate, both at the working level and at the policy level. Quality control criteria shall be subject to approval by the procuring activity.

Education and training courses, scaled to the

particular need, shall be given engineering, quality control, production, test, and purchasing department personnel concerning the nature, scope and importance of reliability.

Since certain types of design deficiencies and defects are not always detected until the first lot of equipment is actually used in service, the contractor should anticipate the possibility that field failure reports or USAF Unsatisfactory Reports may be referred for evaluation and correction of the balance of the production items, and perhaps retrofit of items already shipped. An effective, rapid manner of dealing with such reports shall be established.

The criteria for determining the conformance with quantitative reliability requirements shall be as specified in the detail requirements of the specs for the particular equipment. The adequacy of the contractor's efforts and facilities to comply with the intent of this spec is subject to interpretation and negotiation for the particular procurement situation at the present.

Provision shall be made for individual testing of all subassemblies prior to testing the overall equipment, (subsystem or system). Criteria for acceptability, that is, acceptable limits and tolerances, shall be established by the contractor.

The contractor shall test the required number of equipments, record the failures, analyze causes, and present a summary of the results to the Government inspector. If the failure rate exceeds requirements, the contractor shall propose a course of action.

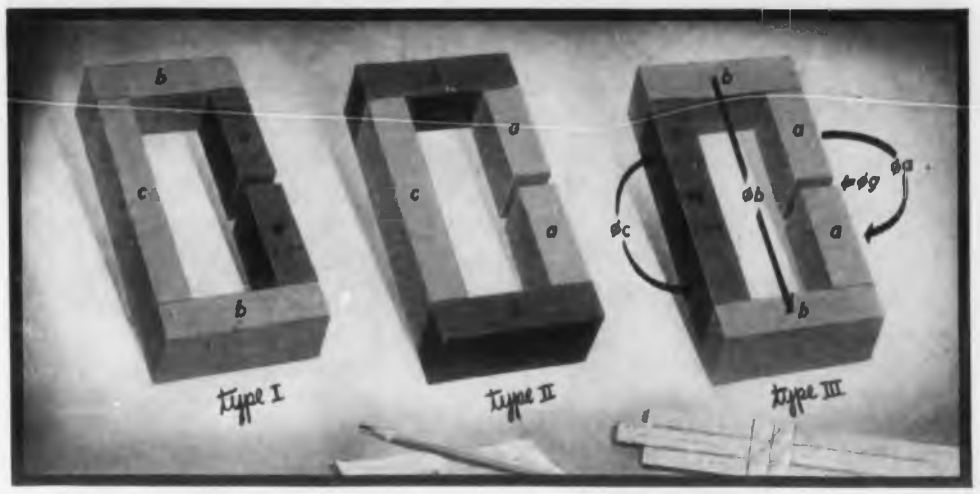
When equipment of the initial test lot is undergoing test, and a failure occurs, the equipment shall be shut off and the cause of failure determined. The cause of failure, (including design), shall be corrected, (part replaced or changed if applicable) and the equipment again placed in operation for the remainder of the test.

The contractor's requirements for both common and specialized facilities and instrumentation to perform reliability testing, in accordance with the requirements of this spec, shall be anticipated and provided for sufficiently in advance. Where such expenditures are associated with the contract cost, prior approval for such expenditures shall be made from the Government procuring activity before any commitments are made. The design, layout, and details of these facilities are the responsibility of the contractor.

Transistor

MIL-T-19112A(SHIPS), TRANSISTOR, TYPE 2N118, AMENDMENT 1, 14 MARCH 1957

This amendment adds outline dimensions of type 2N118 transistor and a curve of collector voltage versus collector current with emitter open circuits. Type 2N118 transistor is a silicon NPN Grown Junction Transistor.



How You Can Save Time Estimating Leakage Factors for Magnetic Circuits

Computing even approximate values for leakage flux in magnetic circuits is a time consuming job. The research department of Indiana Steel recently undertook a series of studies, supported by the U.S. Air Force, to simplify these computations. Dr. R. K. Tenzer reported the results of this work, which reduce the time in computing leakage flux up to 90% by diminishing the number of mathematical operations necessary.

The investigations were done on circuits with permanent magnets; the results were also found applicable to unsaturated electromagnetic circuits when the coil-covered parts were treated as permanent magnet parts.

After checking values obtained by this method with actual measured values for many Type I, II, and III magnetic circuits, deviations were found to be less than ± 10%.

Leakage Flux, Leakage Factor

Because of magnetic leakage, only a part of the total flux through the neutral zone of the permanent magnet is found in the air gap. The difference between these two values is known as leakage flux. Mathematically this is:

$$\phi_L = \phi_t - \phi_g. \tag{1}$$

In practical design, leakage is best considered as a factor stated thus:

$$\sigma = \frac{\phi_t}{\phi_g} = 1 + \frac{\phi_L}{\phi_g}. \tag{2}$$

For simplification, the flux can be assumed to follow three basic, probable paths: ϕ_a between parts a, ϕ_b between parts b, and ϕ_c along part c. The equation above then becomes:

$$\sigma = 1 + \frac{\phi_a + \phi_b + \phi_c}{\phi_g}. \tag{3}$$

With $\phi = mmf \times P$, this formula can be written:

$$\sigma = 1 + \frac{1}{P_g}\left(\frac{mmf_a}{mmf_g}P_a + \frac{mmf_b}{mmf_g}P_b + \frac{mmf_c}{mmf_g}P_c\right). \tag{4}$$

Letting the *mmf* ratios be denoted by K,

$$\sigma = 1 + \frac{1}{P_g}\left(K_aP_a + K_bP_b + K_cP_c\right). \tag{5}$$

This becomes the basic equation for numerical calculations of leakage factors after introducing simple expressions for leakage permeances and mmf ratios.

Simplified Leakage Permeances

The following formulas have been found satisfactory for leakage permeances between soft steel parts:

$$P_a = 1.7 \times U_a \times \frac{a}{a + L_g} \text{ where } U \text{ is} \tag{6}$$

cross-section perimeter;

$$P_b = 1.4 \times b \times \sqrt{\frac{U_b}{c} + .25} \tag{7}$$

where U_b/c is greater than .25 and less than 4. The total length of part b is used.

Since permanent magnets have a neutral zone which does not contribute to leakage, the value of 2/3 of the magnet's total length is used when computing leakage permeances—this is the effective length a' and b' to compute P'; thus the two equations above become:

$$P'_a = 1.7\ U_a \frac{.67a}{.67a + L_g} \tag{6a}$$

and

$$P'_b = 1.4 \times .67b\sqrt{\frac{U_b}{c} + .25} = .67\ P_b. \tag{7a}$$

When part c consists of a permanent magnet (Type III) its permeance can be calculated as:

$$P_c = .5\ U_c. \tag{8}$$

The permeance of the air gap itself is

$$P_g = A_g/L_g. \tag{9}$$

Simplified MMF Ratios

Simplifying the *mmf* ratios is done by neglecting the reluctance in *soft steel parts;* so

$$mmf_a = mmf_b = mmf_g \text{ or } K_a = K_b = 1$$
$$(mmf_c = 0 \text{ so } K_c = 0). \tag{10}$$

Since the *mmf along permanent magnet parts* is not constant, integral values ($\overline{mmf}$) are used. Experiments showed that 2/3 of the mmf_g was the effective *mmf* for leakage flux between permanent magnet parts; thus

$$\overline{mmf_a} = \overline{mmf_b} = \overline{mmf_c} = 2/3\ mmf_a$$

or

$$K_a = K_b = K_c = 2/3. \tag{11}$$

Basic Formulas

By inserting the permeances for soft steel into equation (5), the general formula becomes:

$$\sigma = 1 + \frac{L_g}{A_g}\left(K_a \times 1.7\ U_a \frac{a}{a + L_g} + K_b \times 1.4\ b\sqrt{\frac{U_b}{c} + .25} + K_c \times .5\ U_c\right). \tag{12}$$

This formula contains only constants and dimensions; and by the two following rules this can be modified into the three basic equations for the Type I, Type II, and Type III circuits.

Rules: (1) For leakage flux paths between soft steel parts, use total lengths and constant K of 1. (2) For leakage flux paths between permanent magnet parts, use 2/3 of lengths and K of .67.

The following provide the leakage factors for the three types of circuits:

Type I:

$$\sigma = 1 + \frac{L_g}{A_g} \times .67 \times 1.7\ U_a \frac{.67a}{.67a + L_g}$$

Type II:

$$\sigma = 1 + \frac{L_g}{A_g}\left(1.7\ U_a \frac{a}{a + L_g} + .67 \times .67 \times 1.4b\sqrt{\frac{U_b}{c} + .25}\right)$$

Type III:

$$\sigma = 1 + \frac{L_g}{A_g}\left(1.7\ U_a \frac{a}{a + L_g} + 1.4b\sqrt{\frac{U_b}{c} + .25} + .67 \times .5\ U_c\right)$$

For variations on these basic formulas, write today for the April-June issue of *Applied Magnetics* which also shows examples of the formulas in use.

NEW DESIGN MANUAL READY

Write today for your copy of the newest edition of the Indiana Permanent Magnet Design Manual No. 6. Write to Dept. M-8.

Russian Thermistors

DESCRIPTIONS of the most widely used Russian thermistors are given in this picture caption article.

The letters *MM* and *KM* denote the semiconductor from which the resistance element is made and the numbers *1* and *4* denote arbitrarily the external construction of the thermistor, the former being intended for operation in enclosed dry rooms, and the latter being sealed and capable of operation at higher humidities and even in liquids. The *KMT* types have higher temperature sensitivity. Basic parameters of these types are given in Table 1.

Types *MMT-8* and *MMT-9* are intended for temperature compensation of various elements of electrical circuits, operating over wide temperature ranges. Type *KMT-10* is intended to serve as an electronic temperature sensitive relay, based on the use of a semiconductor in series with a resistor. If a constant voltage is applied to such a series circuit, the current will jump at a certain temperature from a fraction of a milliampere to dozens of milliamperes. If this series resistor is replaced by a relay winding operating at the final value of the current, such a circuit can be used for temperature control and signalling whenever a certain control temperature of the medium is reached. *Abstracted from an article by B. T. Kolomiets, I. T. Sheftel', E. V. Kurlina, and G. I. Pavlova, "Industrial Types of Thermistors and Fields of their Application," from* Radiotekhnika i Elektronika, *No. 8, 1956.*

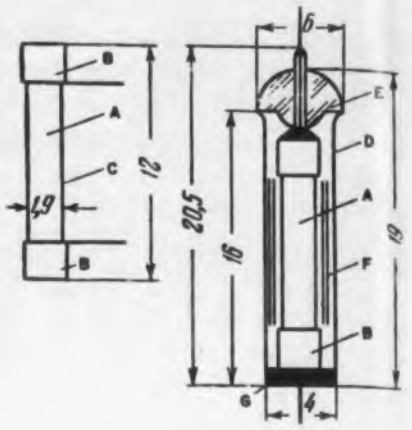


Fig. 1. Construction of thermistors (types MMT-1, KMT-1 on left), MMT-4, KMT-4 on right) a — body of thermistor, b — contact caps, c — layer of enamel, d — protective metallic case, e — glass insulator, f — metal foil, g — layer of tin

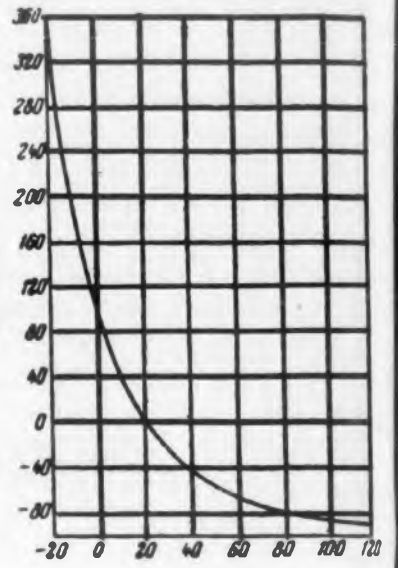


Fig. 2. Per cent change of resistance with temperature from resistance at 20 deg C.

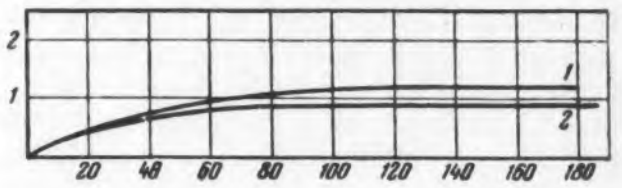


Fig. 3. Character of variation of resistance after heating: (1) KMT-1 at 180 deg C, (2) MMT-1, MMT-4 at 120 deg C. (Ordinate—per cent change in resistance, Abscissa—time in hours)

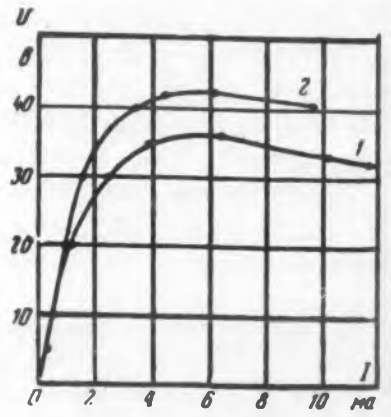


Fig. 4. Current-voltage characteristics of MMT-1 (1) and MMT-4 (2). Ambient—still air at 20 deg C. *R* at 20 deg C = 25,000 ohms.

Table 1—Basic Parameters of Thermistor Types MMT-1, MMT-4, KMT-1, and KMT-4

Name of parameter	Type of Thermistor			
	MMT-1	MMT-4	KMT-1	KMT-4
Range of nominal resistance values, kilohm	1-200		20-1000	
Permissible deviation from nominal value, %	±20		±20	
Temperature coefficient of resistance (at 20°C) percent per degree Centigrade	−2.4 to −3.4		−4.5 to −6.0	
Spread in temperature resistance for batch of similar thermistors, percent per deg. C	±0.2		±0.62	
Constant B ($R = A\ e^{B/T}$)	2060 to 2920		3860 to 5150	
Maximum working temperature, °C	+120		+180	+120
Maximum power, watts	0.4		0.8—0.9	
Dissipation power causing practically no heating in thermistor, watts	0.002—0.005		0.002—0.005	
Time constant in air, seconds	85	115	115	85

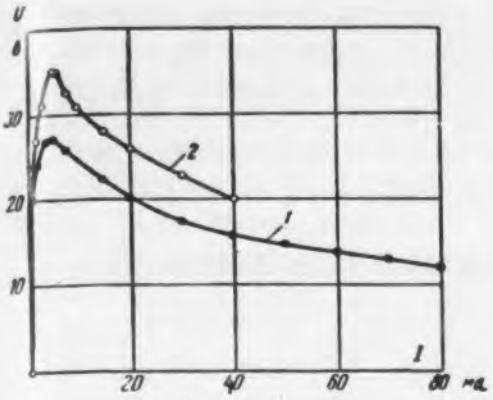


Fig. 5. Current-voltage characteristics of KMT thermistors. $R_{20} = 20{,}000$ ohms.

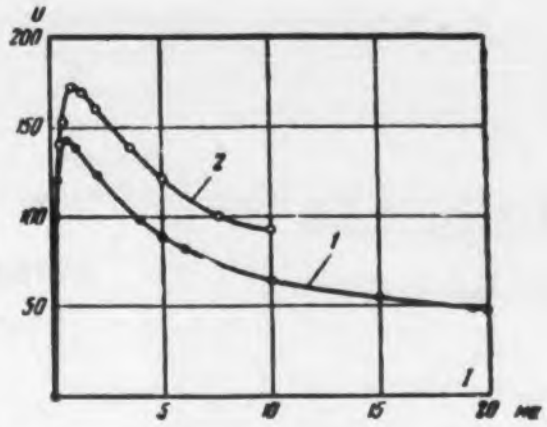


Fig. 6. Current-voltage characteristics of KMT types with $R_{20} = 600$ K.

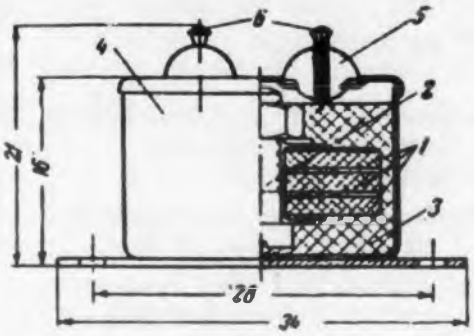


Fig. 7. Construction of MMT-8 thermistor 1—semiconductor discs, 2 — connecting bolt, 3 — compound, 4 — shell, 5—bushing insulator, 6—contact leads

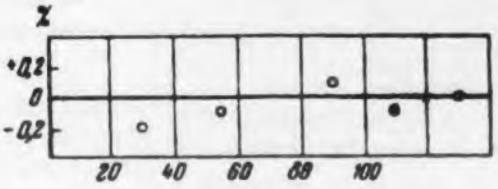


Fig. 8. Stability of MMT-8 thermistors at 70 deg C (Ordinate — per cent change in resistance, Abscissa — time in hours)

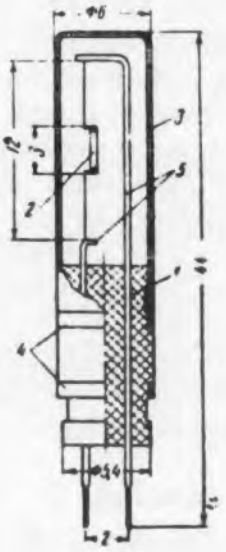


Fig. 9. Construction of KMT-10 thermistor 1—base, 2—thermistor, 3—cap, 4—ring, 5 — terminals

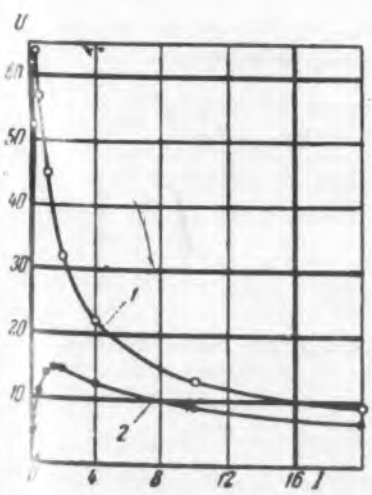


Fig. 10. Current-voltage characteristics for KMT-10 thermistor at 20 deg C (1) and 100 deg C (2). $R_{20} = 830$ K, ambient is still air, current is in ma.

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What the Russians are Writing

J. George Adashko

ELECTRICAL COMMUNICATIONS

(Contents of Elektrosviaz' No. 1, 1957)

BINARY CODING SYSTEM

Parameters of Binary-Coding Systems, V. I. Siforov, (8 pp, 1 fig).

Introduces the concepts of the average probable decoding error and of the optimum average decoding-error probability as applied to binary transmission of communications. Proves that the average probability of the decoding error increases approximately in direct proportion to the duration of the transmission. Introduces also the concepts of the probability of the decoding error per symbol, of the relative probability of the decoding system, of the quality of the coding system, and of the channel utilization coefficient. The physical meaning or all these parameters is explained as applied to binary-coding systems.

POWER CONVERTER

Ideal Power Converter—a New Electric Circuit Element, E. V. Zeliakh, (13 pp, 14 figs, 1 table).

The "ideal power converter" is a four-terminal network having equal input and output impedances for all values of the load. Its matrix equations are

$$\begin{vmatrix} E_1 \\ \\ I_1 \end{vmatrix} = \begin{vmatrix} \frac{1}{K} & 0 \\ \\ 0 & \frac{1}{K} \end{vmatrix} \cdot \begin{vmatrix} E_2 \\ \\ I_2 \end{vmatrix}$$

where K is in general a complex number. Unlike the ideal transformer or the ideal generator, this element is not power-invariant, but serves as either an amplifier or an attenuator, depending on whether K is less or greater than unity.

This element was described by H. A. Haus ("Equivalent Circuit for a Passive Non-Reciprocal Network") in the December 1954 issue of the *Journal of Applied Physics*, but the author claims to have reported on such a circuit at a conference in Leningrad in March 1953.

Discussing various applications of the ideal converter as an equivalent circuit element for non-reciprocal networks, the author illustrates its usefulness in the analysis of a transistor amplifier.

ANTENNA SYSTEMS

Shielding Action and Decoupling in a Periscopic Antenna System. V. D. Kuznetsov, A. V. Sokolov (4 pp, 3 figs).

The degree to which a directional antenna is shielded from "backward" signals determines the suitability of the antenna in many radio-relay lines. The article covers this topic and discusses effective decoupling between the receiving and transmitting portions of the antenna system.

Effect of Antenna Directivity in Long-Range UHF Tropospheric Propagation. V. N. Troitski, (3 pp).

Antennas with exceedingly high gain and high directivity are frequently used for such propagation. This leads to unusual relationships between the signal level and the antenna directivity, and the author derives statistical relationships between these two quantities.

TV STANDARDS

USSR Television Standard, GOST 7845-55, S. V. Novakovski, D. I. Ermakov (11 pp, 7 figs, 4 tables).

This standard, promulgated December 31, 1956, replaces the 1944 one. It calls for 625 lines, 25 frames per second with interlaced scanning, a 4:3 image waveform coefficient, and a maximum video signal bandwidth of 6 mc. The video and audio carrier frequences are separated by 6.5 mc, the audio channel being 0.25 mc wide. FM, with a maximum frequency deviation of ±50 kc, is used for the sound.

The authors discuss the engineering philosophy of the standard and explain why certain parameters had to differ from the optimum values.

NETWORK ANALYSIS

Approximate Method of Calculating the Mutual Relationship between the Frequency and Transient Characteristics of Radio Networks, S. N. Krize, (6 pp, 8 figs).

In spite of the large number of investigations devoted to the mutual relationship between the frequency and transient characteristics of h-f networks, no simple method exists at present for determining the transient characteristics of a system from a specified frequency characteristic, or for the inverse process. The article gives a simple method of calculating the transients from the frequency characteristics, based on an approximation of the Fourier integral; the method is also used for the solution of the inverse problem. Experimental data are given and agree well with the calculations made with the proposed method.

AUTOMATION AND TELEMECHANICS

(Contents of Avtomatika i Telemekhanika No. 1, 1957)

AUTOMATIC CONTROL

The first three articles of this issue are highly-theoretical non-linear treatments of automatic control systems in which a relay element having a symmetrical characteristic controls an amplifier, and the relay is part of the internal feedback loop. The term "sliding modes" pertains to the phase-space representation of the transitions between the backlash zones and the zones in which the relay drives the amplifier, while "relay" stands for various types of contactors. The three articles are:

Approximate Determination of Partially-Sliding Periodic Modes in Control Relay Systems, Iu. V. Dolgolenko, (24 pp, 26 figs).

On the Sliding Mode of Automatic-Regulation Relay Systems, Iu. I. Neimark, (7 pp, 10 figs).

Investigation of the Dynamics of Pulsed Automatic Regulation Relay Systems, V. P. Kazakov, (13 pp, 13 figs, 2 tables).

SYSTEM ANALYSIS

Generalization of the Differential Equations of a Complex Power System and Use of Electronic Digital Computers for Stability Analysis. L. V. Tsukernik (12 pp, 1 fig).

The transient equations of a disturbed complicated power system, with allowances for the automatically-regulated excitation of its parallel synchronous machinery, are expressed in matrix form suitable for computer programming. Sub-programs are prepared for the coefficients of the characteristic equations of the system. A logical program is prepared for determining the stability regions in the plane of the parameters contained in the coefficients of the characteristic equation. The program is suitable for any dynamic system for which the equations of the disturbed state can be obtained.

Determination of Losses due to Throttling in Hydraulic Systems, I. N. Kichin, (6 pp, 5 figs).

Certain Concepts in the Design of External (Minimum-Maximum) Pneumatic Regulators, L. A. Zalmanzon, (5 pp, 5 figs).

ZERO DRIFT

Dependence of the Drift of a Magnetic Null-Sensing Device on Supply-Voltage Fluctuations, A. M. Pshenichnikov, (3 pp, 4 figs).

Discusses circuit modifications that compensate, in certain parts of the magnetization curve, for the

zero drifts due to slight differences in the magnetic properties of the several (usually four) elements of most balanced null-sensing devices.

Other Articles in This Issue

Transient Modes in Relay-Contact Circuits, Ia. I. Mekler, (12 pp, 14 figs, 3 tables).

In circuit algebra one frequently simplifies the electric circuit by adding zero or by multiplying by unity, operations that on the face of it do not change the analytic representation of the circuit, and should not affect its operation. The author points out that this is not true, and suggests ways of avoiding this difficulty.

Concerning One Way of Determining the Desired Logarithmic Frequency Characteristics, P. S. Matveev, (7 pp, 9 figs).

The approximation is based, as usual, on representing the impulse transfer function by a power series, and incorporating into the equations expressions for the physical realizability of the system and for the specified accuracy of the response. A chart is given for the resultant overshoot, and some examples are given.

RADIO ENGINEERING

(Contents of Radiotekhnika No. 1, 1957)

MICROWAVE DESIGN

Design of Complex Cavities, A. I. Zhivotovski, (6 pp, 2 figs, 1 table).

A design procedure for cavities consisting of several segments of uniform coaxial lines, each having a different wave impedance. The gist of the method is readily seen from Figs. 1 and 2.

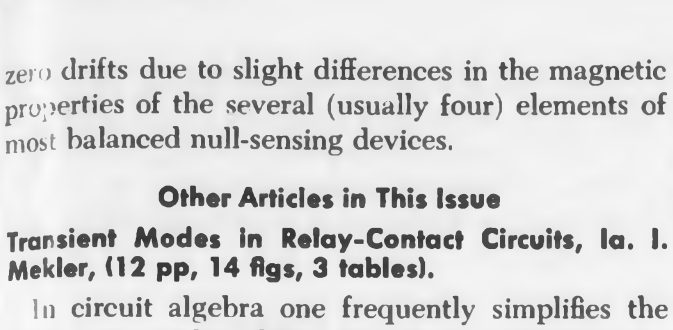


Fig. 1. Several segments of uniform coaxial line

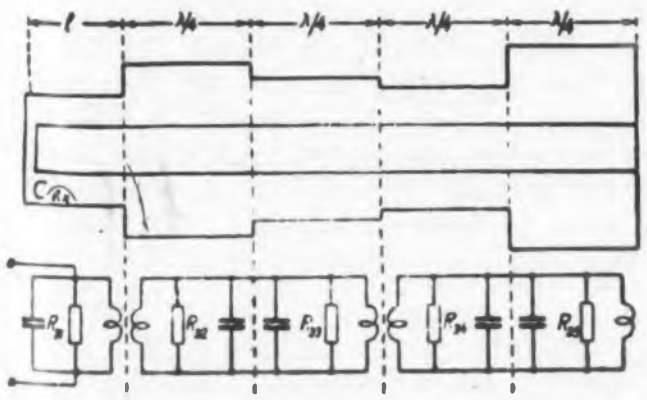


Fig. 2. Several different line sections

Russian Translations

Analysis of an Absorbing Line, V. S. Mel'nikov (3 pp).

In the absorbing line discussed in this article, power absorbed per unit length is constant along the entire line. This differs from the conventional design, in which the attenuation is constant along the line, but the power loss is not.

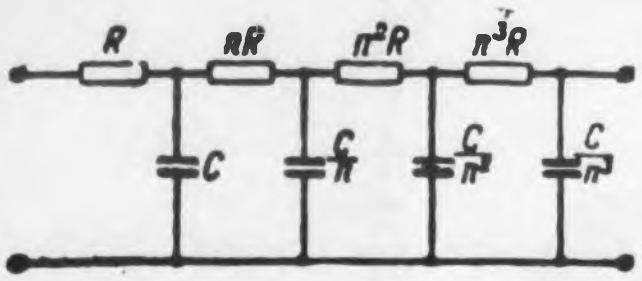


Fig. 3. A shaping filter for Gaussian pulses

GAUSSIAN PULSES

Concerning the Generation of Gaussian Pulses, L. I. Kastal'ski, (3 pp, 3 figs).

A valuable property of the Gaussian pulse $f(t) = A\varepsilon^{-\alpha t^2}$ is that its frequency spectrum is also Gaussian. This result in a low product of the frequency and time deviations, a condition favorable for minimum signal-to-noise ratio. A Gaussian pulse of the same width and duration as a rectangular pulse has a higher signal to noise ratio and a lower bandwidth than a rectangular pulse of the same width and duration. Conversely, for the same s/n ratio, more Gaussian pulses can be accommodated by a multichannel system. In addition, the Gaussian pulse offers better resolution and less interference.

Fig. 3 shows the block diagram of a shaping filter for Gaussian pulses, and Fig. 4 shows a practical circuit, with the tubes compensating for the attenuation in the filter. This particular circuit is designed for input (rectangular) pulses 2 to 7 μs in duration, output (Gaussian) pulses 2.5–8 μs in duration (measured at 67% of peak amplitude), with a 25-kc repetition rate.

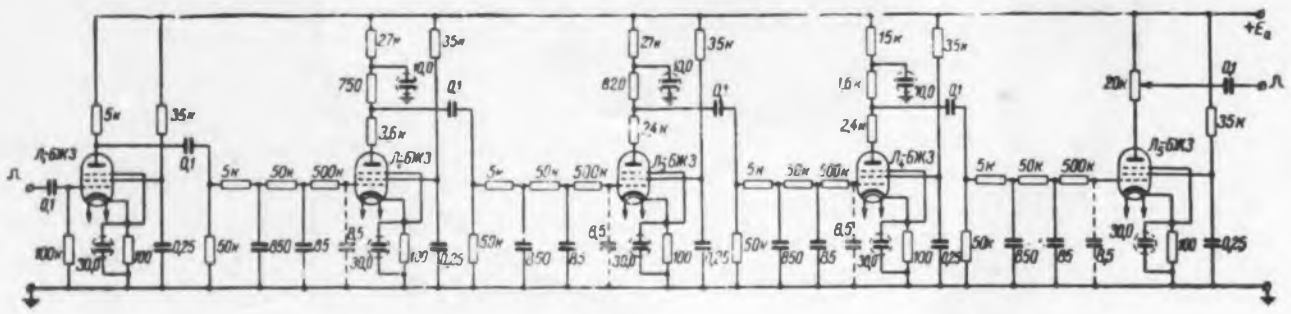


Fig. 4. Practical shaping circuit with tubes compensating for attenuation in the filter

MEASUREMENTS

Instrument for Visual Observation and Measurement of Frequency Characteristics, of the Group-Propagation Time, of the Phase Shift, and of the Modulus of the Transfer Coefficient, I. T. Turbovich, A. V. Knipper, V. G. Solomonov (12 pp, 8 figs).

Description of an instrument for rapid measurement of frequency characteristics, developed in 1953-1955 at the Development Laboratory for Wired Communication of the USSR Academy of Sciences. The article contains an analysis of the block diagram (Fig. 5), a discussion of the measurement errors, and descriptions of several of the stages (limiter, integrator, and input detector). The specifications of the instrument are:

Frequency range	0.2–10 mc
Group-propagation time range	to 10 μs
Accuracy of group time measurement (at an attenuation drop up to 1.5 neper.)	2% ±0.02 μs
Accuracy of transfer coefficient	±0.02 nep. in 0.5 nep. range ±0.05 nep. in 1.5 nep. range
Input impedance	75 ohms
Output impedance	high or 75 ohms

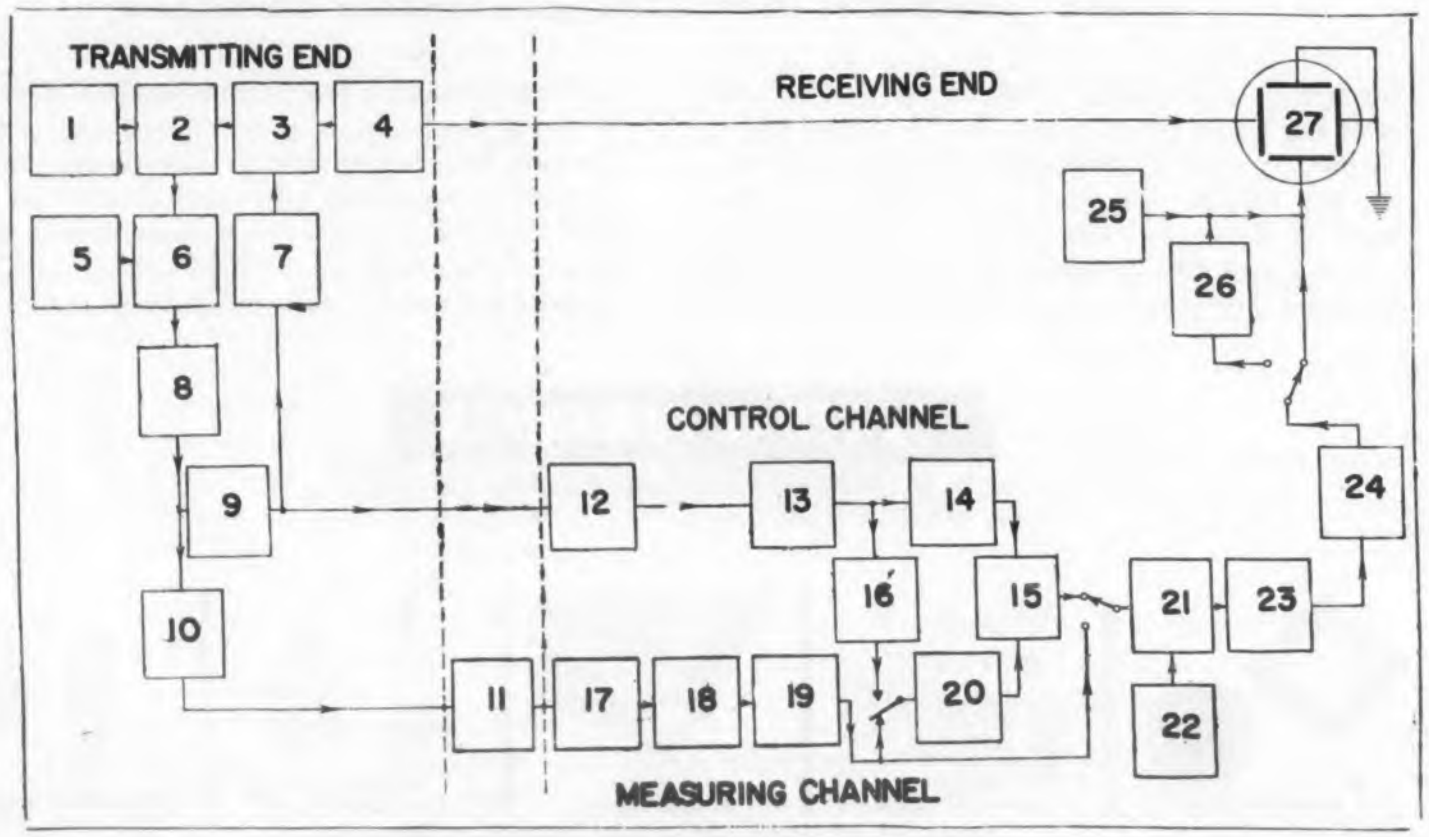


Fig. 5. Block diagram of measuring equipment Key: *1*—crystal oscillator, f=10 kc; *2*—modulator; *3*—FM oscillator, f=40-48 mc; *4*—sawtooth generator, f=1 cps; *5*—oscillator, f=44-54 mc; *6*—mixer; *7*—automatic regulation of modulating amplitude; *8*—broadband amplifier; *9*—detector; *10*—output stage; *11*—tested circuit; *12*—tuned amplifier, f_o=10 kc; *13*—260° phase shifter; *14*—limiter; *15*—phase discriminator; *16*—phase discriminator; *17*—calibration of modulus; *18*—detector; *19*—tuned amplifier, f_o=10 kc; *20*—limiter; *21*—mixer; *22*—oscillator; *23*—amplifier for converted frequency, f=17kc; *24*—detector; *25*—marker; *26*—integrator; *27*—CRT.

TRANSISTOR CIRCUITS

Transients in Pulse Circuits Employing Point-Contact Transistors, O. G. Iagodin, (15 pp, 12 figs).

Discussion of an analytical method based on representing the transistor dynamic properties in terms of an equivalent circuit, and on the linearization of the non-linear characteristics of the transistor. The investigation concerns the transients in a relaxation oscillator and in a trigger circuit, with saturation disregarded.

FREQUENCY FEEDBACK

Frequency Feedback in FM Signal Receivers, L. Ia. Kantor, (5 pp, 3 figs).

Shows the need for retaining the limiter in an fm receiver with frequency feedback. The i-f bandwidth necessary for stability and for specified nonlinear distortion is derived. The concept of optimum frequency feedback is introduced.

DAMPED OSCILLATOR

Self-Excited Oscillator with Highly-Damped Tank Circuit, A. Z. Khaikov, (10 pp, 6 figs).

Shows how the waveform of the self-excited oscillation and the power relationship in the self-excited oscillator vary with the damping of the tank circuit. Derivation of the optimum conditions relative to the power delivered to the load and relative to the overall oscillator efficiency.

Other Articles in This Issue

"Certain Characteristics of Radio Waves Radiated by Cosmic Objects," A. D. Kuz'min (10 pp, 4 tables). (A survey article devoted to radio astronomy, with numerous references to American and British articles.) "Tropospheric Long-Distance Propagation of Ultra-short waves," B. A. Vvedenski, A. G. Arenberg, (9 pp, 8 figs). (First part of a survey article.)

"Distortion of Telegraph Pulses in Tonal-Telegraphy Channels, Caused by Abrupt Changes in the Signal Level," V. N. Amarantov (9 pp, 6 figs). (Shows that much less distortion is produced in fm channels than in am channels.) "Principal Swedish Crossbar Automatic Telephone Stations," A. D. Kharkevich (16 pp, 14 figs, 2 tables).

Books To Be Published Soon

We note with interest the pending publication of the following translations in Russian: N. Wiener, Cybernetics. Wiley; S. Goldman, Information Theory. Prentice-Hall; D. Wright, Semiconductors. Methuen; R. Shea, Transistor Audio Amplifiers. Wiley; M. Kiver, Color Television Fundamentals. McGraw-Hill; Van-der-Ziel, Noise. Prentice-Hall; Jones, Modern Facsimile Apparatus. Murray-Hill Books; Booth and Booth, Automatic Digital Tabulators. Academic Press; Zworykin-Morton, Television. Wiley; Hayashi, Forced Oscillations in Non-Linear Systems. Nippon Printing & Publishing Co.; Storm, Magnetic Amplifiers. Wiley; Lo, Endres Zawels, Waldhauer and Cheng, Transistor Electronics. Prentice-Hall.

Abstract

Here presented are some factors that designers and users of mobile communications equipment might well consider, particularly in view of the excessive demands being placed on the available frequencies in the radio spectrum.

Mr. Curtis B. Plummer of the Federal Communications Commission gave a talk before the Institute of Radio Engineers Annual Convention in New York in March from which these remarks were abstracted.

Conserving the Mobile Communications Spectrum

IN CONSIDERING the factors in spectrum conservation (other than complete reallocation of all services) which have helped and will help to make more efficient use of the present bands of frequencies allocated to the different classes of licensees in the Safety and Special Land Mobile Radio Services, there are certain steps that have been taken and others which may be taken in the near future.

Channel Efficiency

A major factor which has been given the most consideration is the more efficient use of individual frequency channels by the reduction of the bandwidth which is necessary in the over-all system, including both transmitter and receiver, for the intelligible reproduction at the receiver of the desired information. This reduction should be accompanied by a reduction in the occupied bandwidth. These reductions can be, and have been accomplished by:

1. Improving frequency tolerances to reduce occupied bandwidth in both transmitters and receivers. This reduces the guard band necessary which is caused by lack of frequency stability in the transmitters and lack of selectivity in associated receivers. Great strides have been taken in this respect by equipment manufacturers who have taken the initiative in developing and manufacturing on a regular basis transmitters with even tighter tolerances than presently required by the Commission's rules and who have developed and are manufacturing receivers with considerably more selectivity than was available when our present rules became effective in 1949 and 50. The so-called "Split Channel" Report and Order in Docket 11253 has amended the Commission's rules to tighten frequency tolerances of fixed, base and mobile stations over 3 w from 0.01 to 0.002 per cent between 25 and 50 mc, and from 0.005 to 0.0005 per cent between 50 and 1000 mc.

2. Improving transmissions by avoiding spurious emissions caused by overmodulation. The Safety and Special Radio Services Land Mobile rules added a requirement that modulation limiters be on all transmitters "authorized and installed after July 1, 1950" to prevent modulation in excess of 100 per cent on negative peaks when amplitude modulation is used for telephony, and to limit deviation arising from modulation to no more than plus or minus 15 kc from the unmodulated carrier when phase or frequency modulation is used for telephony. The Commission's "Split Channel" Report and Order additionally requires an audio low pass filter to remove distortion products produced by the modulation limiter, to attenuate the audio components above the cut-off frequency, and to attenuate noise components occuring in the audio stages of the transmitter.

3. Stating in the present rules that "the maximum audio frequency required for satisfactory radiotelephone intelligibility . . . is considered to be 3000 cps," and that "the transmission of higher frequencies is unauthorized". This requirement is carried on in the amended rules attached to the Report and Order in the "Split Channel" docket.

4. Requiring in the present rules that the maximum authorized bandwidth in kilocycles to be occupied by the emission shall contain, as stated in Paragraph 58 of the Atlantic City Radio Regulations, 99 per cent of the total radiated power extended to include any discrete frequency on which the power is at least 0.25 per cent of the total radiated power. To show compliance, the rules say,

any emission appearing on any frequency removed from the carrier frequency by at least 50 per cent, but not more than 100 per cent if the maximum presently authorized bandwidth shall be attenuated by not less than 25 db below the unmodulated carrier.

5. Requiring in the present rules certain specified reductions in any spurious or harmonic emission appearing on any frequency removed from the carrier frequency by at least 100 per cent of the maximum authorized bandwidth.

Operational Efficiency

A factor that has been given little consideration in Safety and Special Services Land Mobile use might be termed operational consolidation. It has been very evident to us over a period of years that our compartmentation of radio uses into bands that are related to one industry, including specific uses for that one industry, has created a situation whereby a licensee may necessarily have to have two or more radio systems in different services to accomplish all his radio needs. A rearrangement of all radio services in the direction of allowing a licensee to use radio for his entire business would appear to be beneficial. Likewise, more cooperative base transmitters nad cooperative systems would accomplish this desired objective. Finally, there also appears to be a possibility of achieving certain functional operational consolidation whereby more intelligence might be carried over a land mobile system by utilizing the audio range between 0 and 300 cycles to carry tone for signaling, while at the same time, the audio band between 300 and 3000 cycles could carry voice.

Directional Antennas

A major factor which has not been fully exploited in Spectrum Conservation is the use of directional antennas in those cases where, for example, the emissions of Special Industrial base stations situated just outside Standard Metropolitan areas of 500,000 or more population might cause harmful interference to licensees authorized to operate inside such areas. A requirement in the rules for directional antennas for base stations, where practicable, would permit more systems to operate in a given area on the same or adjacent channel frequencies provided operating areas of mobile units do not overlap too much.

Interference Reduction

A major factor which is just beginning to receive serious attention is the restriction of areas of interference by *1.* reducing radiated power to a level just sufficient to carry on adequate communications; and 2. offsetting carriers. Automatic power control holds promise for congested areas in the Safety and Special Radio Services. At the present time,

licensees can use up to the full power permitted by the rules, but they seldom need it. They might operate a base station with a 20 w transmitter and later, as their business prospers, change to a 500 w transmitter. In congested areas where all frequencies are shared by two or more licensees such power increase might make it difficult for other licensees. It would, therefore, appear that power should be limited to a reasonably low figure even at the cost to the licensee of adding a second base station to cover the area desired, or some means should be developed for the use of automatic power control on base stations, if the need for high power is limited to a small percentage of the communications. Proposals by the Commission in the relatively near future will give opportunity for licensees and prospective licensees to comment on this step in bringing about more efficient use of presently available frequencies. Offsetting carriers also appears to be a method adaptable to the Safety and Special Radio Services, and the Commission proposed in the "Split Channel" Report and Order to offset from the 30 kc channels by 15 kc in the 152-162 mc band, upon request, wherever it appears that the available 30 kc channels already are in use in the area involved and the proposed facilities are sufficiently removed in distance from existing installations to result in a net gain in freedom from interference for the persons involved. Offset assignments by a frequency other than 15 kc will be considered upon the recommendation of a competent engineer who bases his findings on field tests conducted with the knowledge of all licensees concerned and the assignment is to the net advantage of all of the parties.

Geographic Frequency Sharing

Another major factor in spectrum conservation is geographic sharing in and near heavily populated metropolitan areas where there is already a serious frequency shortage in certain services. If the Commission amends its rules to permit assignment in those areas of frequencies allocated to other radio services not operating in the same areas, all needs might be cared for some time to come. This would be a modified "block" system of allocation permitting case by case consideration of applications from the heavily congested areas.

Single Sideband Recommended

Admitting that certain technical difficulties must first be overcome, it appears that the adoption of single side band transmission in place of "spectrum-wasting" frequency modulation presently used almost exclusively on frequencies above 50 mc by the Land Mobile Radio Services would give us the best available "spectrum-stretching" tool. Starting with the 152-162 mc band, it appears that the use of single sideband am modulation would multiply several times the number of frequency channels. Single

sideband has not been proposed by the Commission for frequencies above 50 mc cannot be seriously considered within the next two or three years. At the present time single sideband appears to be impracticable for mobile use above 50 mc, but experimental work in progress will make this possible in the foreseeable future. The principal advantage would be reduced spectrum requirement.

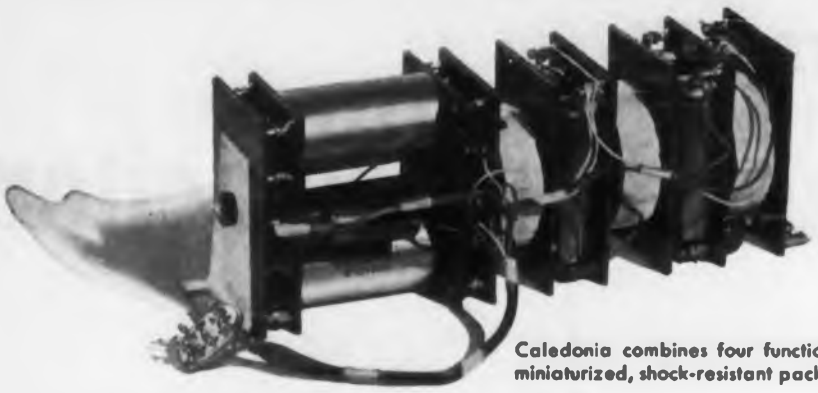
Investment Slows Progress

The Commission maintains close liaison with the manufacturers of land mobile radio equipment and is well aware of the "state of the art". Rules have been proposed and others are under active study to gradually take advantage of improvements in equipment by requiring the narrow bands, the tighter tolerances, and the cleaner signals of the new equipment. The Commission would certainly move faster in this direction if it weren't for the thousands upon thousands of transmitters and receivers having wide band characteristics that still have a few more years of good service left in them. However, recent rules have provided for, and future rules will, propose adequate amortization periods so as to minimize losses due to obsolescence of equipment.

In the meantime, and pending development of vhf and uhf single side band land mobile equipment, many licensees are, and many more will, take advantage of the spectrum-saving improvements already incorporated in conventional fm communications equipment. This equipment has been designed by a forward-looking manufacturing industry for narrow band operation with tolerances that already meet the new rules requirements even though these requirements will not become effective for some time, that is, until the amortization period for the wider band equipment has passed. Licensees now being supplied with modern narrow-band equipment will be among the first to be able to take advantage of the additional channels that will be made available as "channel splitting" rules become effective. Such "voluntary" implementation of spectrum conservation in those areas where the number of narrow band licensees makes it practicable, should prove, by example, to be a strong stimulant to licensees in other areas where changeover to modern equipment is relatively slow.

Manufacturers and FCC Hold Key

Radio engineers have made great progress in condensing more and more information into a given bandwidth, or conversely, in narrowing the bandwidth of emission for a given amount of intelligence. Now it is up to the manufacturers of equipment and the regulatory authority, the FCC, to implement as rapidly as mechanically and economically possible the reduction in the ratio of occupied bandwidth to intelligence bandwidth.



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2. a negative d.c. pulse selector
3. a high level 60 cps band pass filter
4. a 400 cps detector circuit

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CIRCLE 334 ON READER-SERVICE CARD FOR MORE INFORMATION

Abstract

Maid Service for Computermen

THE MAID—Monroe Automatic Internal Diagnosis—system is designed to provide continual automatic detection of errors in complex electronic equipment. Used principally in computers, MAID monitors a system without impairing its operation, warns the operator of impending circuit malfunctions and may be set up to cut the power and light an indicating lamp.

A model system built to check digital computer circuitry is shown in Fig. 1. The circled wave forms represent idealized conditions at various points in the circuit. Variations in the duration, shape, and amplitude of the signals beyond predetermined limits indicate marginal components. MAID dynamically checks the rise time, length, and amplitude of these signals. The points are sequentially connected to a differentiating and amplifying circuit responsive to changes of voltage level. This circuit transforms the rising voltage ramp *A* into a square wave *a*, whose width is a function of slope. Similarly, the slope of ramp *B* is expressed by the width of square wave *b*. If means are provided to measure the widths of *a* and *b*, the slopes of *A* and *B* can be indicated. For circuit convenience, it is preferable to have both waves of the same polarity; a ramp converter changes negative-going signals into positive ones. As a standard for comparison, a square wave of the proper duration is generated either using pulsed delay lines, one-shot multivibrators, or any similar circuits of proven stability. If the waves under test fall within the limits set by the standard wave, no signal is generated and the associated components are considered safe. Component deterioration

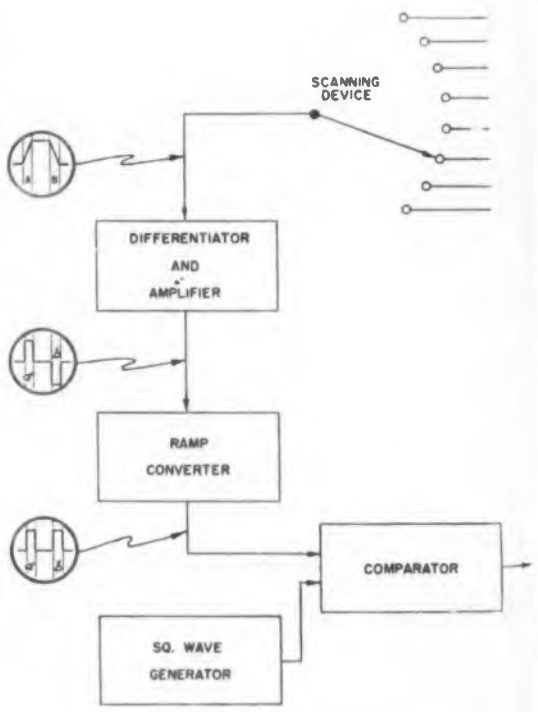

Fig. 1. Block diagram of single unit vacuum tube MAID illustrating operating principle.

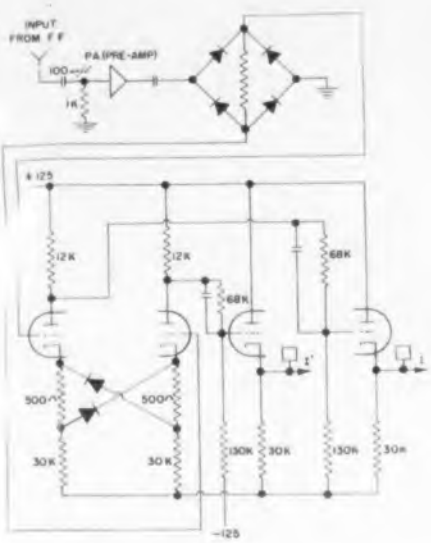

Fig. 2. Ramp converter. This unit converts negative-going portions of the input signal to positive.

acts to lengthen the ramps' slopes, and by properly selecting a standard, the correct degree of marginal safety is insured. In an electronic digital computer an almost natural subdivision is provided by the flip-flop package. For other types of electronic equipment other subdivisions would be made.

The flip-flop outputs are sequentially connected via a scanning device through a differentiating circuit and amplifiers to the ramp converter package shown in Fig. 2. Here, by means of the bridge circuit, negative-going portions of the test wave are converted to positive. Both polarities of this converted wave are available as signal I and I'.

Fig. 3 illustrates the checking circuitry associated with the ramp converter. Here three checks are made simultaneously on the test waves; *1.* to see if the waves are too short; *2.* to see if they are too long and *3.* to see if the voltage levels are correct.

In making the first check, the leading edge of the negative-going *RC* output triggers a one-shot multivibrator. This sends a standard wave to *or* package V_1. If the test wave is too short, a low-level signal is permitted to pass from the V_1 package.

For the second test the P' pulse, which initiates all action in the computer—including the flip-flop—also produces a square wave from the one-shot multivibrator *OSM2*. The trailing edge of this wave is differentiated into a negative-going spike that marks the end of the standard wave. The V_2 package makes a comparison between the test wave I' and the spike and if the spike falls within the test wave, a low output is produced indicating that the test wave is too long. If the spike falls outside the test wave, both inputs are never low at the same time, and a high output is maintained.

The third test uses two Schmidt trigger circuits. One generates a square wave within the allowable tolerance about the upper logical voltage level ($SM+$). Another generates a square wave about the limits of the lower logical voltage level ($SM-$). Only positive waves are presented to *or* package V_3 when the test waves are acceptable. Use is made of the differentiated trailing edge of *OSM2* to time the sensing of the logical voltage levels. If either one is outside the limits set by the Schmidt triggers a low output from *or* package V_3 will indicate this condition. Note that the outputs from all three V packages are combined in an *and* package to yield one signal should any malfunctioning be indicated.

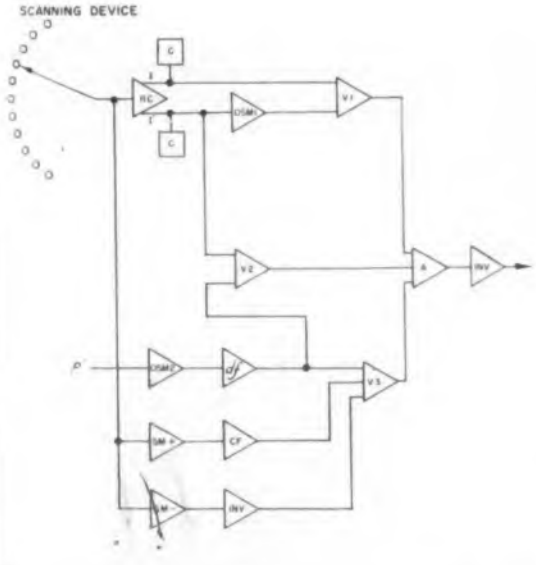

Fig. 3. Marginal check system. *RC* is the ramp converter, SM represents the Schmidt trigger, OSM is a one shot multivibrator, *df* the differentiator. *A* is an *and* gate; *V* an *or* gate, while INV and C represent the inverter and clamp, respectively.

Abstracted from Rapid Fault Elimination in Complex Electronic Systems, *by John F. Scully, a paper presented at the AFCEA meeting, Washington, May 20.*

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Full specifications and application information available on request in Bulletin ED-82

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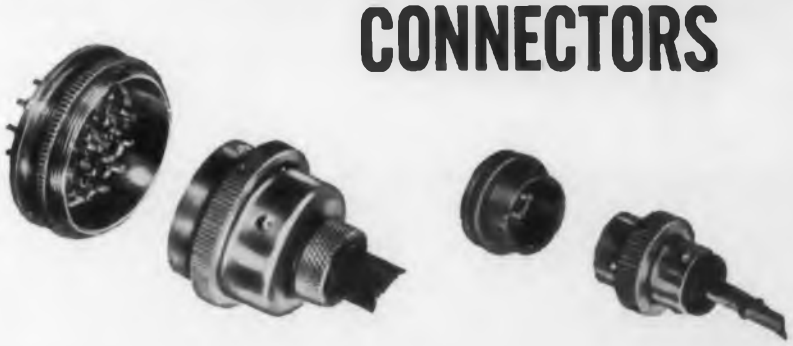

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Abstract

Thermal Relay Applications

FORMERLY a rough, approximate device, the thermal relay now qualifies for functions involving precision and design flexibility. One major application is time delay: thermal relays can be designed to provide delays from about 0.1 sec to 5 min. Another important use of this kind of relay is as voltage or current sensing elements.

■ **Time Delay.** Since thermal relays must ordinarily be allowed time to cool after accomplishing one time delay interval before they are ready to repeat, some means of overcoming this limitation must be found in circuit design. By making use of both the heating and cooling characteristics of *two* relays a thermal time delay which is instantly ready to repeat is possible. In the circuit of Fig. 1 both relays start to heat when the switch is closed. At point *A* the contacts of *TR-1* open, but nothing else happens. Both relays continue to heat and at *B* the contacts of *TR-2* close, pulling in the magnetic relay, which locks in. The relay heaters are broken; the cooling process starts. Since the *TR-1* contacts are still open the output circuit remains open.

As the relays cool, the contacts of the *TR-2* are now out of the circuit. But as *TR-1* returns to its operating level—point *C*—its contacts reclose. The magnetic relay output contact is also closed, as is the load circuit.

On the next duty cycle, both thermal relays effectively have cooled completely and are instantly ready to re-time the cycle. Note that the entire cycle is made up of both the heating and cooling portions and the circuit is recovering its time delay ability during the course of the timing function. The circuit arrangement is such that if there is any interruption during the timing cycle, the circuit will instantly recover at least as much time delay as the cooling period BC. This circuit can also be arranged for a normally closed output.

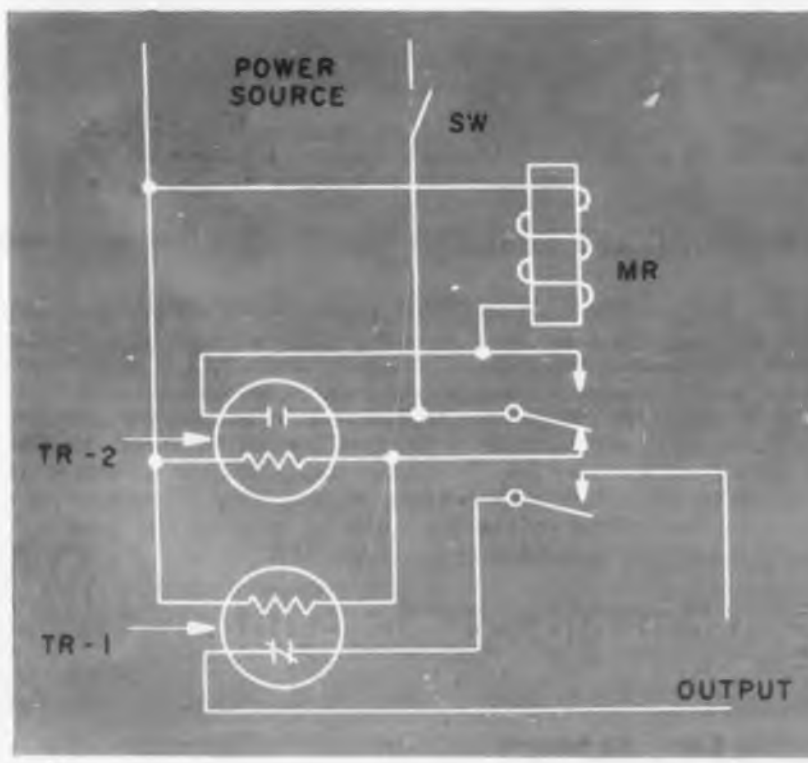
■ **Voltage and Current Sensing.** The thermal relay can integrate rapid fluctuations in voltage. Use of this characteristic is made in the wattage regulation circuit of Fig. 2. The wattage regulator relay and the time delay relay heaters are fed in series through *R*, which in turn is shorted by the normally closed contacts of the wattage regulator.

If the supply voltage varies between any given limits the wattage regulator will open, inserting *R* in series with the heaters, causing them to cool slightly. This action recloses the regulator contacts, shorts *R*, restoring the full heater supply.

As a result the wattage regulator contacts flash on and off. The duty cycle is dependent on the supply voltage; the net effect is that the heater of the time delay relay sees a rapidly fluctuating voltage. The heating effect of the fluctuation is in this way made essentially uniform over the range of supply voltage variation. The timing relay heater integrates this fluctuating voltage so the structure sees an essentially uniform wattage, over the voltage range.

■ **Overload Switching.** In the circuit of Fig. 3 the current through winding *A* normally leaves the contacts unoperated. Upon overload the contacts open, inserting in series the higher-resistance winding *B*. Both windings affect the same thermal element so enough heat is generated to hold the contacts open. In addition the higher resistance of winding *B*—aided by resistor *A* if necessary—limits the load current until the circuit malfunction can be corrected. While this is being done the power source is turned off and the overload relay cools.

By incorporating the proper filter in the heater circuit, this relay can be used in a frequency sensing circuit. Here the thermal relay can protect equipment against unacceptable changes in the frequency of the power supply.



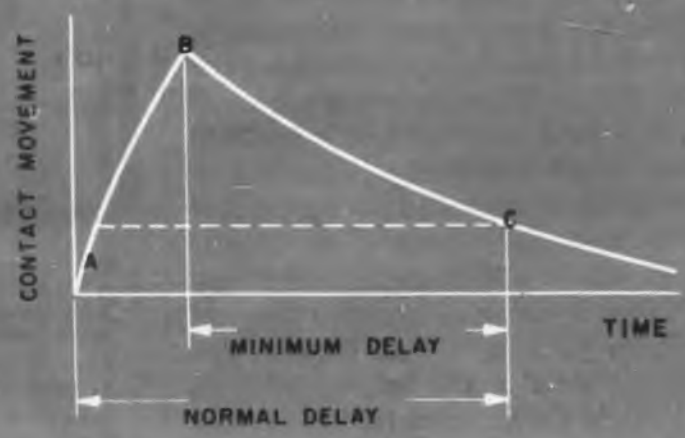


Fig. 1. (Left) Rapid reset time delay circuit. (Above) Heating and cooling cycle of thermistors of the circuit at the left.

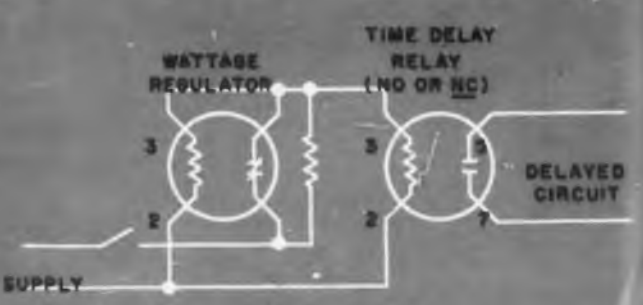


Fig. 2. Circuit for constant time delay on varying voltage.

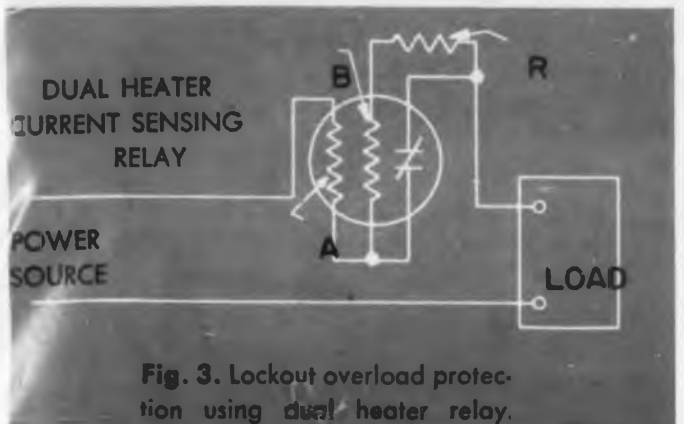


Fig. 3. Lockout overload protection using dual heater relay.

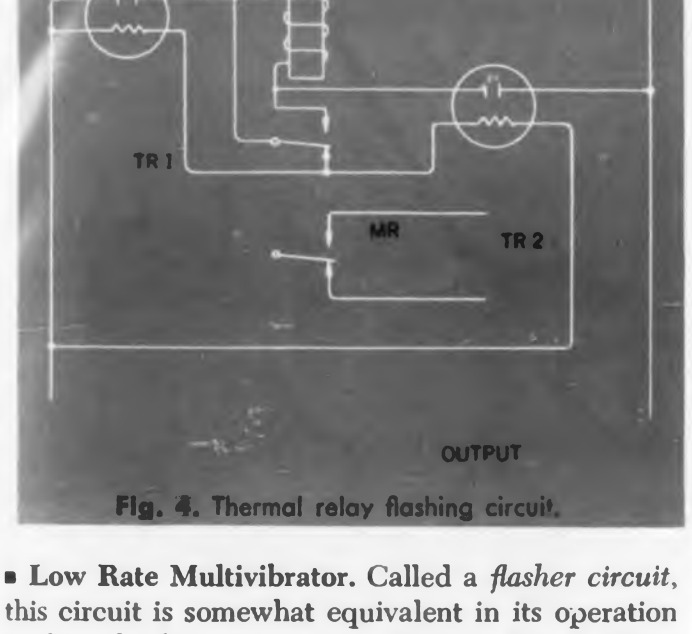


Fig. 4. Thermal relay flashing circuit.

▪ **Low Rate Multivibrator.** Called a *flasher circuit*, this circuit is somewhat equivalent in its operation to that of a free-running mv. Refer to Fig. 4. When the circuit is turned on both thermal relays are energized. *TR-1* closes its contacts first, but nothing happens to the magnetic relay since *TR-2* is still open. Later, the contacts of *TR-2* close, pulling in *MR*. *MR* locks itself in through its front contact and, through its rear contact, de-energizes both relays. The *TR-2* contacts reopen almost immediately, but are shunted by lock-in contacts. Shortly afterward the *TR-1* opens, dropping out the magnetic relay and starting the cycle over again. In this manner one part of the flashing cycle is controlled by the heating time of *TR-2;* the other part by the cooling time of *TR-1*. By judicious choice of these relays a wide variety of flashing rates can be produced.

Reliable Operation

Thermal relays are generally smaller and lighter than other kinds of time delay devices, and are relatively simple in construction. They can be expected to be reasonably trouble-free. Moreover they can be energized interchangeably on dc or ac of any frequency, which means a flexibility of application.

Abstracted from a paper, Some New Developments in Thermal Relays, *J. David Marks, presented at the Fifth National Conference on Electromagnetic Relays, Oklahoma, April 1957.*

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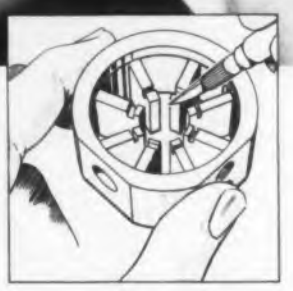

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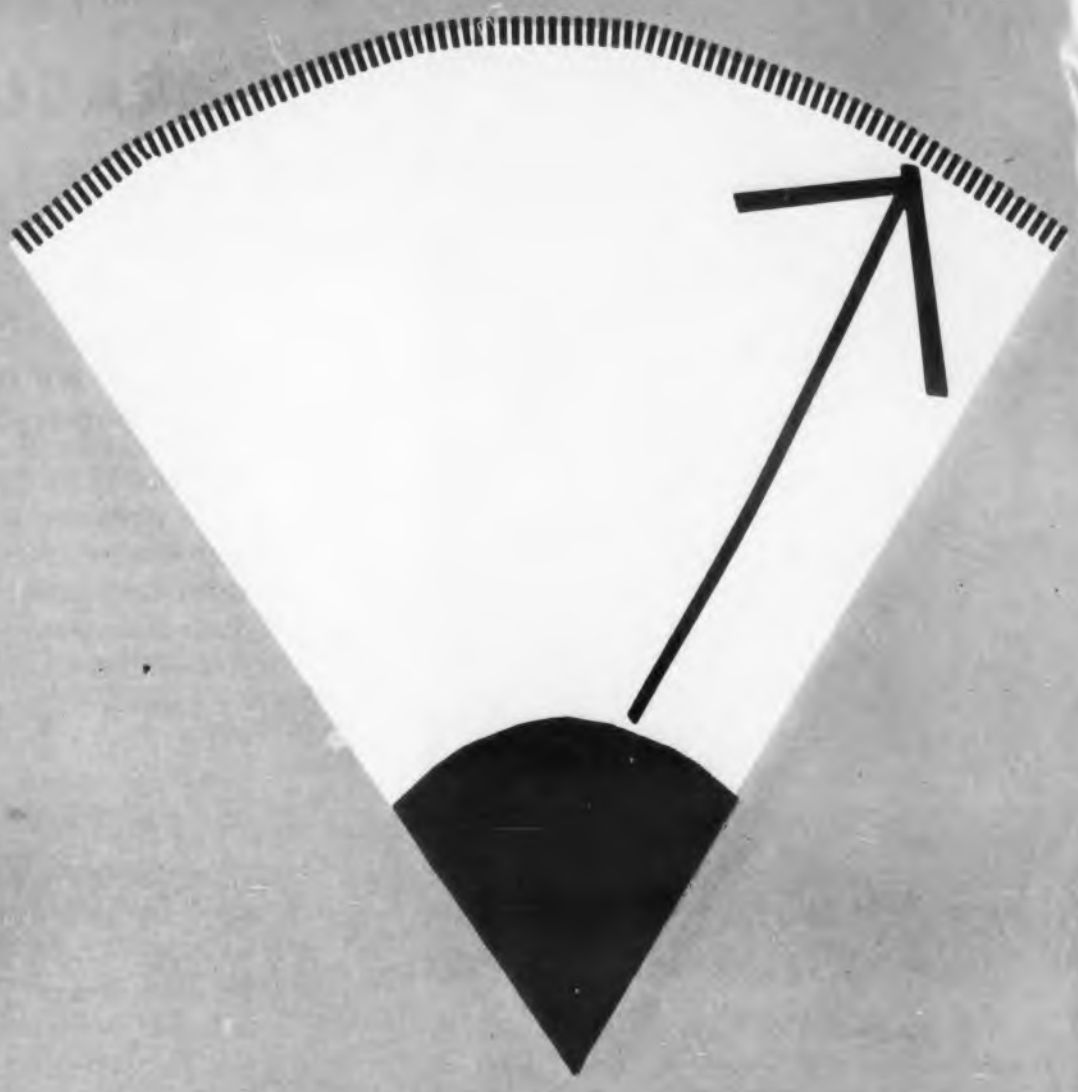
CIRCLE 338 ON READER-SERVICE CARD FOR MORE INFORMATION

Abstract—German



A VHF Vacuum Tube Voltmeter

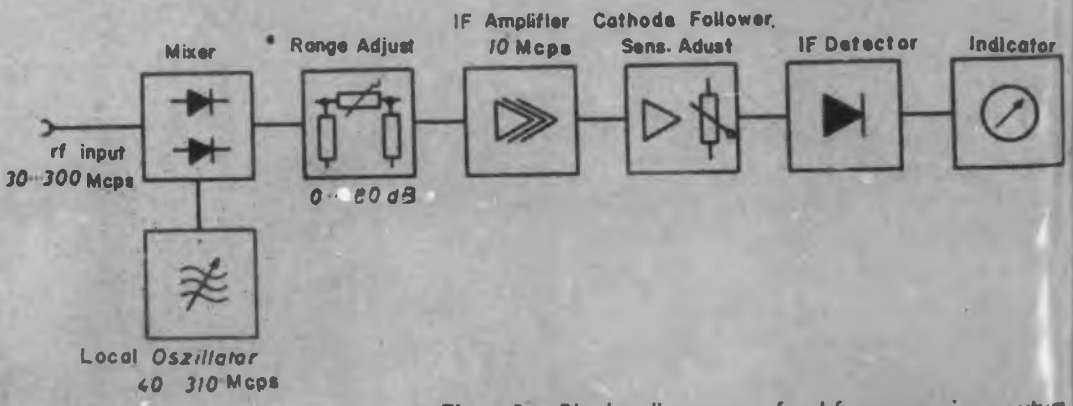


Fig. 1. Block diagram of vhf comparison vtvm.

IN MANY vhf measurements, such as the determination of antenna radiation patterns or echo attenuation, comparative voltage indicators with a range up to 80 db are required. A satisfactory instrument which has a sensitivity range of 3 microvolts to 30 millivolts in the frequency interval from 30 to 300 mcps with a bandwidth of 45 kcps can be constructed according to the scheme indicated in Fig. 1.

The 60 ohm input stage with the coaxial input is shown in Fig. 2. The dimensions were determined experimentally to minimize the mismatch. The standing wave ratio varies with frequency as shown in Fig. 3 and is less than 1.1 for the usable band.

The calibrated attenuator also serves to match the mixer to the if amplifier. The input impedance to this amplifier was reduced to 6000 ohms by resistive loading at the input.

The if amplifier includes four tuned stages. The tank circuit is designed so that the temperature coefficients of the coil which are positive are compensated by the negative coefficients of the ceramic capacitors. The local oscillator is a Colpitts circuit. *(Abstracted from an article by H. Mack*, Electktronische Rundschau, *Vol. 11, No. 4, April 1957, pp 102-105.*

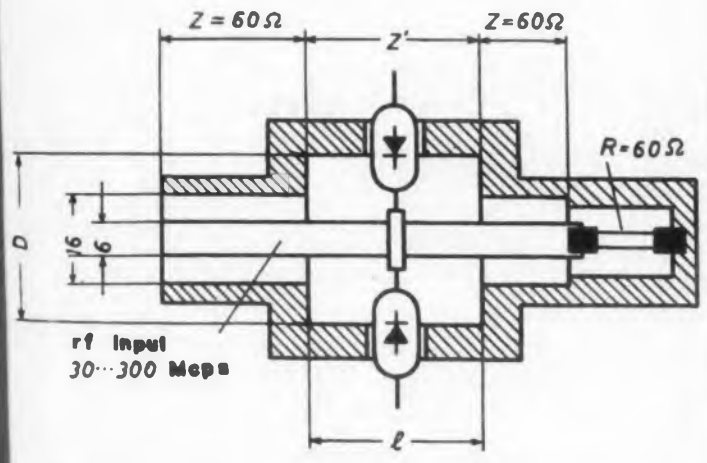


Fig. 2. The rf input section of the vtvm. Optimum matching was established for $D = 30$mm, $l = 30$mm and $Z' = 95$ ohms.

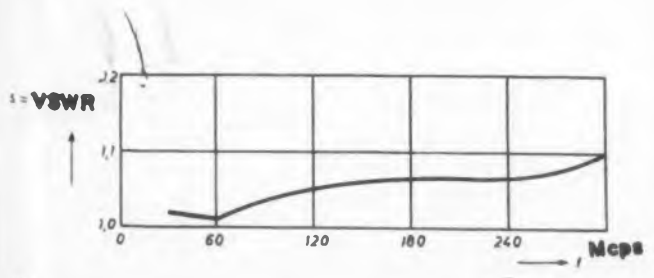


Fig. 3. Standing wave ratio at the rf input section.

ADVERTISING INDEX

August 15, 1957

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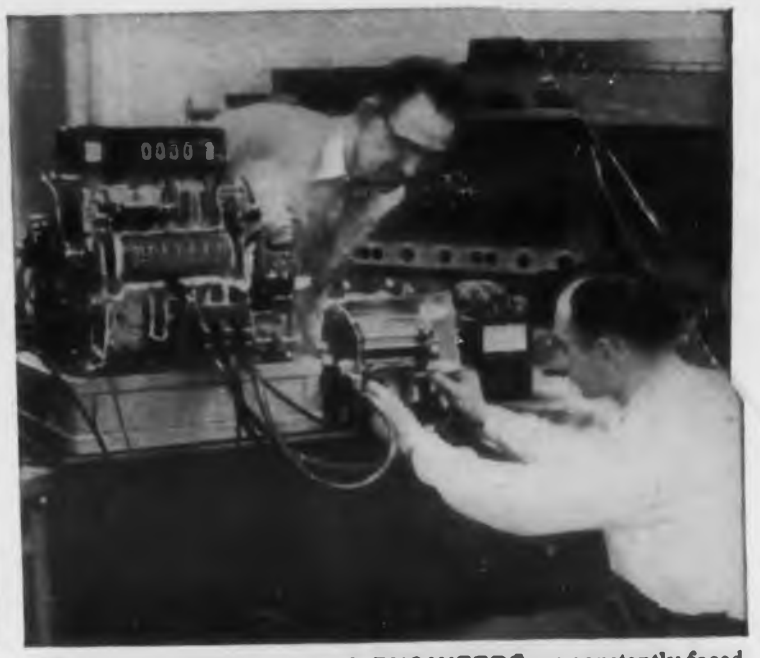

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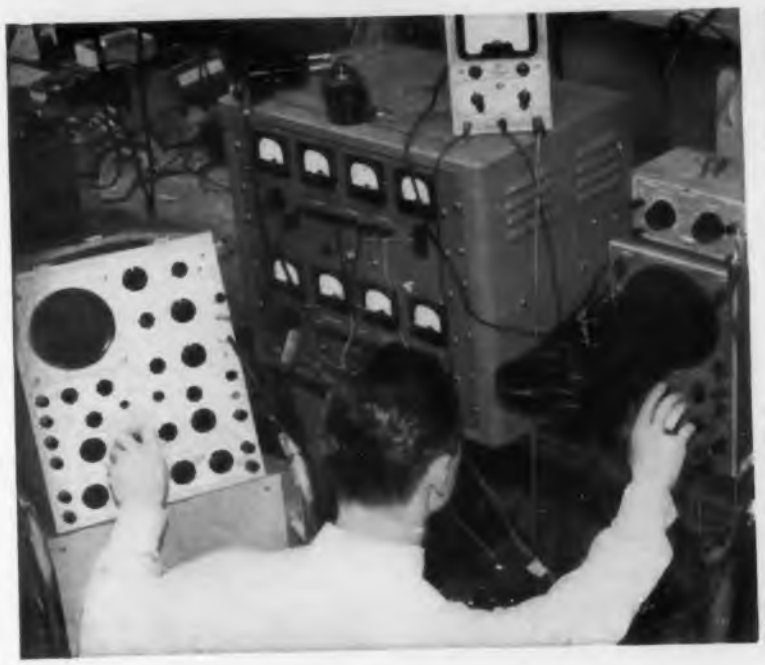

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