ELECTRONIC DESIGN

OCTOBER 1, 1957

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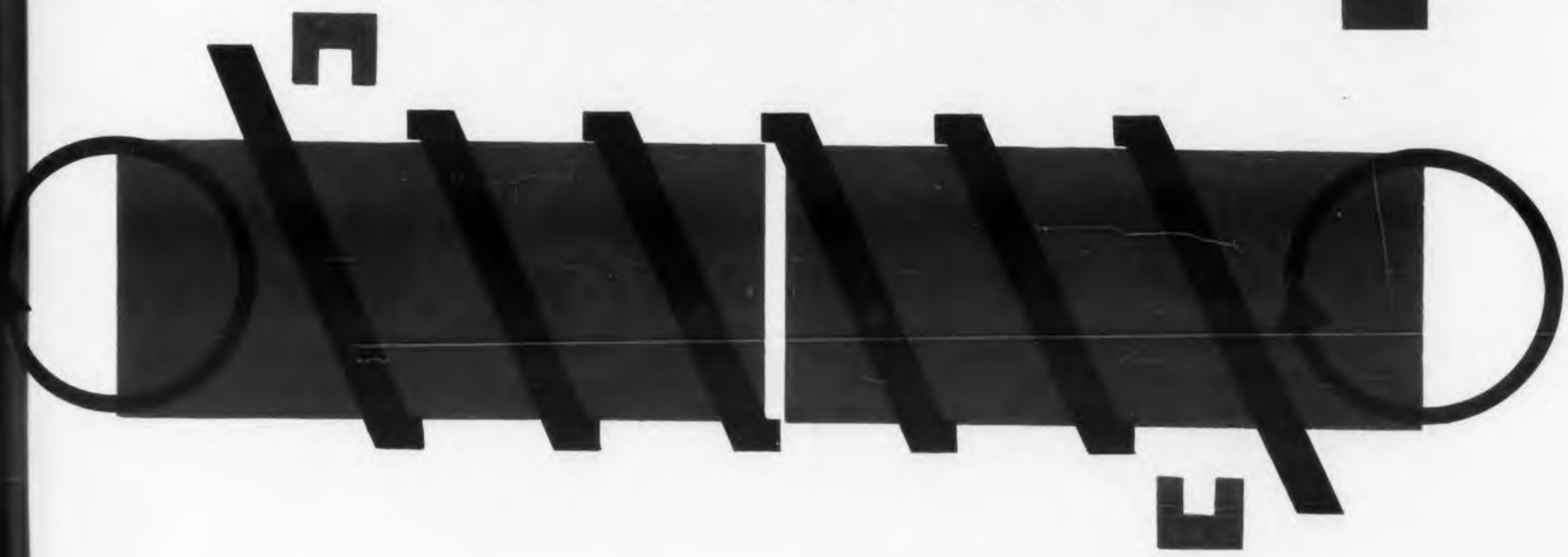

High Speed Indexing Clutch . . . page 34

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ELECTRONIC DESIGN

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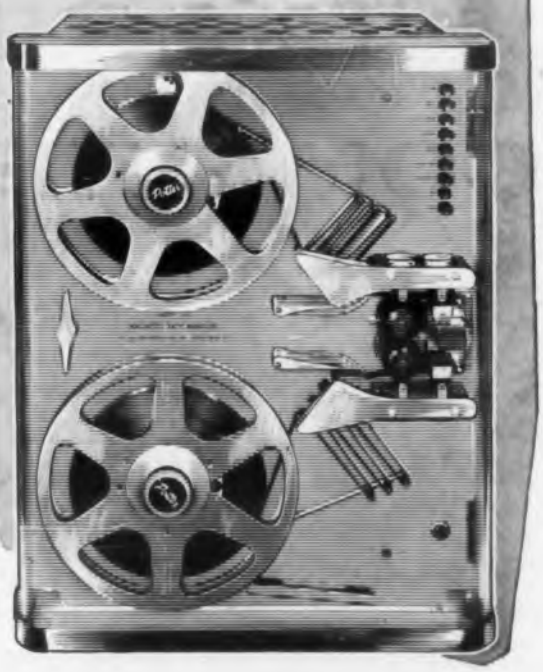
Potter

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)
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Control:	Front panel pushbuttons or remote control contact closure and pulses.
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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.

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POTTER INSTRUMENT COMPANY, INC.
SUNNYSIDE BOULEVARD PLAINVIEW, N. Y.

CIRCLE 2 ON READER-SERVICE CARD FOR MORE INFORMATION

Editorial

Cutbacks, the Handwriting on the Wall

The engineering shortage seemed to vaporize with the recent cancellation of a few military orders and cutbacks in overtime. There actually are engineers around without a job. The more apprehensive ones are even listing themselves with employment agencies. A few short months ago no engineer would consider paying a fee for a job and agencies went hungry for applicants.

Many a young engineer has probably recently experienced an anxiety that heretofore was so remote that it was nonexistent or unreal. Is there a job for me? Since the war, and up until now, engineers have been particularly blessed with regard to job security or employment opportunity. Hundreds of non-engineering people have not had such peace of mind. Most routine white collar workers, not to mention shop personnel, have always been haunted with the fear of being laid off.

For the really bright and adaptable man, these specters of harder times are pretty dim. Employers are still glib about the demand for *good* engineers. Assuming all engineers are bright, adaptability is a clue to future job contentment. Discounting personality factors (which, of course, can't be in the over-all picture), broad experience is what makes a man adaptable to necessary change.

In general, we can say, those who know that their particular experience, skill, or knowledge can be easily duplicated by others, perhaps by those more youthful and aggressive, are the most vulnerable. In electronics, the young man in a hurry who has gone from coast to coast and one higher paying job to the next with a maximum tenure of less than ten months is in the most untenable spot. He can hardly prove that his experience is adequate to complete anything if completely on his own.

On the other hand, a person with only one bit of specialized experience is also in a poor position job security-wise. The market for his specialized knowledge may disappear overnight. If an engineer has been designing one class of transformer which only one manufacturer uses all his life, he may be the top expert in this category. He is valuable at least to one company until someone designs out the need for a transformer.

Although company presidents and stockholders are those that have most at stake in the face of cutbacks, the handwriting is on the wall for engineers. Be ready for new situations. Make sure your interests are diversified enough. Broaden your experience. Demand that your job assignments prepare you for tomorrow.—JAL

Engineering Review

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

Spiral Travelling Wave Antenna

Interest in the travelling wave antenna in recent years, has been for applications in uhf point-to-point communications and fringe area television reception. A familiar example of such an antenna is the array of parallel rods, or Yagi antenna, often used for TV reception.

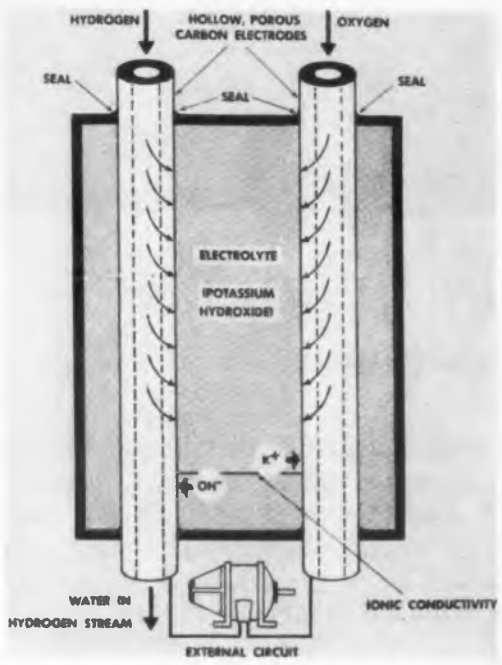
The power gain of the long Yagi antenna is a function of the overall length; doubling the length doubles the gain. There has, however, been a maximum practical length for these antennas in the past, determined by increasing difficulty in exciting the antenna when it becomes very long. This limitation can be removed by twisting the rods of the antenna gradually along the supporting axis, as shown in the photograph. With this technique, much longer antennas with consequently higher gains can be designed.

Experimental work, sponsored by Air Force Cambridge Research Center, in the Engineering Division of Stanford Research Institute, Menlo Park, Calif., has verified the expected behavior of the twisted Yagi antenna. The model shown in the photograph has a total length of 10 ft. and is a small scale replica of the final antenna.

Electricity From Gases Now Practical

The direct conversion of the chemical energy of gases into electricity, long a dream of scientists, and for years a laboratory curiosity, has been accomplished with the development of the first chemical fuel cell capable of economically producing thousands of watts of power. Using hydrogen and oxygen as fuel, the new silent source of power has been developed by scientists at the Research Laboratories of National Carbon Co., New York.

Present designs call for the grouping of a number of specially catalyzed, hollow porous carbon electrodes in a sealed cell containing a solution of potassium hydroxide as the electrolyte. Hydrogen and oxygen enter the cell through the hollow electrodes, and diffuse through porous carbon to the surface, where they come in contact with the electrolyte. At the hydrogen electrode, the electrochemical reaction with the potassium hydroxide



The chemical fuel cell, simplified diagram above, consists of nine hollow, porous carbon electrodes grouped in a round plastic housing. A carbon header on each end conducts the hydrogen and oxygen into the proper electrodes, and electrical connections conduct away the power.

produces water and releases an electron that enters the electrical circuit. The electron flows through the external circuit, and returns to the cell at the oxygen electrode. In the electrochemical reaction of the oxygen and the electrolyte, the electron is accepted. Ionic conductivity through the electrolyte completes the circuit. A concentric tube design has also been developed, in which one electrode tube nestles within the other, with the electrode in between the two. The tubes are made long enough to give the proper cell volume for the current desired.

The general efficiency of the cell ranges from 65 to 80 per cent when operated at normal pressures and temperatures. At lower currents, a greater percentage of the chemical energy is converted to electrical energy. Research to date indicate that the optimum fuel cell design will be one which will produce approximately one kilowatt of power from a packaged unit one cubic foot in volume. The voltage developed across the electrodes of the cell is about one volt and any voltage can be obtained by connecting many cells in parallel.

A future consideration for the fuel cell is in conjunction with the utilization of solar energy. One of the problems in harnessing the energy of the sun is the storage of power. During sunny periods, the energy of the sun could be used to decompose water into hydrogen and oxygen, for later use in the chemical cell.

Missile Data Display

A final visual check of missile performance immediately prior to firing is possible with a new 21-in. screen display developed by Electronic Control Systems, Inc., an affiliate of the Stromberg-Carlson Division of General Dynamics Corp., 2136 Western wood Blvd., Los Angeles, Calif. The system satisfies the need for a quick look at telemetering operation before making the final launching decision. The unit provides a display of 7 commutated data channels.

Acoustico-Thermal Laboratory

A new acoustico-thermal laboratory, designed to aid engineers in lowering sound levels and examining thermal characteristics of transformers, has been added to existing facilities at General Electric's Medium Transformer Dept., Rome, Ga. It will be used to test both dry-type and liquid-filled transformers with ratings up to 10,000 kva.

For thermal tests, heat can be removed from the 2250-sq-ft test chamber at the rate of 2000 BTU per min without a draft. Accurate testing of transformer sound characteristics down to 40 db is also possible. Heavy masonry construction excludes extraneous external noises to help insure low ambient sound, and serrated acoustical insulation in the form of glass fiber bats prevents internal sound reflection. Doors are pneumatically-sealed. Exhaust fans and a duct system make possible the draftless removal of 2000 BTU per min to prevent gradual ambient temperature rise during thermal tests.

A regulating autotransformer—composed of an induction regulator and an autotransformer—provides precisely-regulated power and insures good wave form and the wide range of volt/amp combinations needed for experimental testing. A springless flatcar on which transformers may remain during tests provides efficient transfer of units from the manufacturing area into the 33-ft-high anechoic test chamber.

Defamed and Over-Vaunted VTVM's

Both vendors and competitors have pointed out minor errors and discrepancies in our VTVM survey–Part 1, ED Aug. 15. Discrepancies have arisen because in some cases sensitivities and not full scale ranges were tabulated.

The second-mentioned General Radio instrument is Model 1803B. Its lowest full scale range on ac and dc is 1.5 v.

Metronix Model 571 lowest full scale range is 1 v for both ac and dc.

Correct information for the DuMont type 405 is as follows: On dc scales, input impedance is 121 megohms not 21. Resistance ranges are 7 in number, not 8. The ac frequency range is 50 cps to 700 mc ±1 db of response curve. The tube complement is completely in error. The accessories provided are: probes (2 ac and 1 dc) kit of probe tips and frequency response curves. Available are, one additional ac probe, retractile tip and high frequency Tee connector. The circuit design features are dual input, off ground operation for difference voltage measurements, amplifier output jack, and regulated power supply.

For those of you who looked for and didn't find a particular model that you were familiar with, remember the list was intended as a representative selection of models offered by a manufacturer.

Engineering Review

Brain With Vocal Cords

A voice data link system has been designed which can convert automatic commands from computing machines into verbal messages. The basic system consists of vocabulary storage, word sequence control, programmed sampler and input control units. Combined with an air defense electronic data processing system such as SAGE, the Link can provide fully automatic guidance control of aircraft using existing communication facilities.

The stored vocabulary contains all of the words necessary to command an aircraft on an intercept mission. The best course and altitude for an intercept is computed; the Link transforms this information into the form of a verbal message which can be transmitted to the aircraft using the standard voice channel transmitter. As a multilingual communicator at international air facilities, stored vocabularies in many languages can be utilized by a controller or tower operator who himself may be limited to his native tongue. The word storage unit consists of a rotating magnetic drum and set of recording-playback heads. A basic message format is set up within the Link system so that control signals are required only for the variable parameters within the formats.

Any number of message formats and message lengths may be obtained by proper programming of the system. The choice of sequential and/or repetitive messages can be controlled by either manual or automatic means. The system was designed by Fairchild Controls Corp., Syosset, N.Y.

Germanium Unaffected by Same-Valence Impurities

Experimental evidence recently obtained at Bell Telephone Labs indicates that impurities with the same number of valence electrons as germanium would act as neither donors nor acceptors if present in germanium. Working with tin and germanium, both of which had been highly purified by Bell's zone refining process (see Sept. 15 issue of ELECTRONIC DESIGN, p. 5), single crystals of ge

◄ CIRCLE 5 ON READER-SERVICE CARD

manium containing tin at concentrations greater than 10^{19} to 10^{20} atoms per cu cm were obtained. These crystals exhibited room-temperature resistivities of 30 to 50 ohm-cm, practically the same as ultrapure germanium. The long lifetimes in these crystals, as high as 100 to 200 μsec, also indicate that tin atoms definitely are not effective hole-electron recombination centers.

Germanium crystals containing several hundredths of an atom per cent tin were grown by the pulling technique from melts containing the appropriate percentage of tin. For a higher tin concentration germanium was dissolved in tin at a given temperature and precipitated or grown on a seed crystal at a lower temperature, which may be several hundred degrees below the melting point of germanium.

Chemical analysis of the crystals grown by the latter method, after dissolving excess tin, showed a solid solubility of tin in germanium as high as one atom per cent. Precise x-ray measurements of the lattice constant showed the tin is in solid solution.

Magnetic Core Memory

A magnetic core memory unit, comprising 16,384 magnetic cores, and claimed to be the largest ever assembled in one piece, is intended for use in a 1000 channel kicksorter for Atomic Energy of Canada Limited. The cores are threaded on fine insulated wires and four wires pass through each core. Two of them pass in straight lines from each side of the array to the other, while two more are threaded in an intricate zig-zag path through the cores.

By selecting an appropriate pair of wires, it is possible to choose any particular core out of the 16,384, and store a specific piece of information in it. The memory was assembled by Computing Devices of Canada Limited, Ottawa, Canada.

Correction: The Insulation Tester manufactured by Peschel Electronics, Inc. of 13 Garden St., New Rochelle, N.Y. has a testing speed of 4000 ft per min. The speed erroneously appeared on page 61 of the July 15 issue at 400 ft per min.

CIRCLE 6 ON READER-SERVICE CARD ➤

Engineering Review

Computer Translates Four Languages

An electronic computer has been programmed to interpret four foreign languages and automatically type out idiomatic English translations. The computer, ElectroData's Datatron, does not merely produce a word-for-word record, but correctly renders the thought or sense behind each foreign phrase. The development came from Peter Toma of the California Institute of Technology who transmitted to the magnetic memory drum four specially-condensed dictionaries of Russian, French, German and Spanish. These had been punched on paper tape in numerical computer language, along with instructions telling Datatron how it should go about translating. The computer, which adds or subtracts at the rate of 30,000 numbers a minute, electronically converts the code into alphabetic characters, and compares various semantic and logical patterns with the pre-stored glossaries. Toma's dictionaries comprise about 500 words each. They can be easily retained on Datatron's high-speed internal memory drum, with a capacity for 40,800 digits.

Single-Crystal Ferrites

Techniques to produce uniform, single-crystal ferrite magnetic units are being developed at the Naval Ordnance Lab., Silver Spring, Md. The investigation is in connection with production of jewel-like crystals to serve as memory units in missile guidance systems or computers and in uhf communications equipment.

The reason for the endeavor is that single-crystal units behave better than poly-crystal units. Most crystalline solids found in nature consist of a large number of crystal units arranged at random. In looking at the total specimen any directionized properties that are characteristic of the unit are obscured. A single crystal, on the other hand, has all its units lined up and oriented in the same direction. Therefore it readily can be analyzed to discover the properties necessary for an understanding of the fundamental nature of its magnetism.

There are a number of methods of growing crystals, the most common of which is by preparing a supersaturated solution at about 100 C. When this solution cools slowly a crystal forms. Copper sulfate and rochelle salts are examples of crystals that can be prepared in this way. Another method makes use of the characteristic of some chemicals to sublime or change from a solid to a gas without going through the liquid state. When the gas is condensed crystals form. The method used most extensively at NOL is the flame fusion process, which despite its relative antiquity remains the most practical method

for producing both ferrous and nonferrous metal oxide crystals. The method, however, is a rapid and non-equilibrium process wherein the technician growing crystals does not control the gases involved in the seeding procedure. The attempt is now being made to find a better source of melting that does not involve flame and resultant oxidization of some of the material. It is believed that melting might be done electrically to avoid the drawbacks in the flame fusion process.

Incidental by-products of the quest for better magnetic crystals have included excellent synthetic sapphires made from aluminum oxide powder. Emeralds, rubies and other fine synthetics likewise can be grown. No attempt has been made at producing carbon products, such as diamonds, since work has been confined to aluminum oxide and the oxides of the transition elements iron, chromium, cobalt, manganese and nickel.

Wobbled Image Prolongs TV Camera Life

A device about the size of a cigar box, which hooks on the outside of a television camera, is expected to double the life of costly picture originating tubes. The device, as yet unnamed by General Electric Company's Technical Products Dept., Syracuse, N.Y., is described as an image-orthicon life extender, and is expected to be a major innovation for TV broadcasters. It prevents burn-in and sticking of images on image orthicon tubes, and therefore makes frequent replacement of these expensive tubes unnecessary. In tests conducted at WSM-TV, the device enabled an I-O tube to be used effectively on one camera for more than 1400 hr. On another camera, an I-O tube previously discarded at 700 hr as totally useless has clocked more than 1200 hr of effective use.

The principle of the device is an electron deflecting system used to move or wobble the TV image inside the I-O tube, and thus avoiding burn-in or sticking. To offset the wobble, a scanning beam inside the tube follows and automatically compensates the wobble, causing the transmitted picture to appear as a normal stationary image on home TV receivers. The complete unit comprises about 50 components, including six capacitors, a synchronous resolver and a drive motor.

The unit is also expected to improve studio camera techniques. Usually, while one camera is transmitting, the other is focused on the scene to follow and is alive but not on the air. Prior to development of the unit, the cameraman on the second camera was required to keep moving his camera to prevent burn-in or stickiness of the scene to be televised. Since this will no longer be necessary, he can spend more time studying camera angles and improving techniques with no danger of burn-in.

Engineering Review

Automatic Component Testing

Experimental electronic components are being tested with the Life Test and Data Recording Rack for electron tubes, transistors, and crystal diodes at Wright Air Development Center, Dayton, Ohio. The machine has 8 specimen racks, each containing 100 sockets into which the components are inserted. Four test points are provided for each socket. Tests lasting as long as 1000 hours can be conducted without further attention by the operator and the results are automatically recorded.

When set on automatic, the control console will give accurate readings on all 800 specimens at the rate of less the 10 sec per specimen. At any time the manual control can be switched on and a reading taken on a particular specimen.

The test racks are housed in twelve cabinets, approximately 7 ft. high, 2 ft. wide, and 18 in. deep. Eight of these are specimen racks. The controls and electric typewriter are on a desk-like control console. Special environmental chambers for heat, vibration, and altitude tests are being installed, to permit complete environmental and age testing of the components without their removal from fixtures.

3-D Color TV

The first closed-circuit three-dimensional color television system has been developed for remote servicing of reactors used in development of a nuclear aircraft propulsion system. The color stereo system was designed by the General Electric General Engineering Lab., Schenectady 5, N.Y. to permit use of color-coded parts in reactor components and to provide the degree of precise depth perception required for their correct positioning.

The observer's viewpoint is effectively transferred to that of a camera equipped with a dual-optical system having perspective similar to that of the two eyes of the observer. However, instead of presenting the pictorial image to two sensitive surfaces, as the human eyes do, the stereo-TV system presents two images to a single sensitive surface, a television tube, on a time-sharing basis. The frequency of the time sharing is at the picture rate of the television system, in this case 90 pictures a second. By alternating 45 pictures a second for each eye, engineers have eliminated any objectionable flicker. A rotating shutter in the color-TV camera alternately transmits the scene as viewed from two points to the camera's tube. The distance between the two points corresponds approximately to twice the distance between a person's eyes.

In the viewing console, light from the television image formed on the cathode-ray tube passes through a drum composed of alternate segments of polarizing filters with axes of polarization at right angles to each other. The drum revolves in synchronism with the television frame rate of the camera and polarizes alternate frames vertically and horizontally. Thus, all left-eye pictures are polarized in one direction and all right-eye pictures are polarized in the other direction. An observer viewing the screen, with his polarized spectacles, sees the left optical path with his left eye and the right optical path with the right. The 45-frame-per-sec rate gives him stereo-vision without an objectionable flicker.

Solar Camera: The energy of solar or light rays sets the lens of this 8 mm electric eye camera. Completely automatic, the camera has an electric eye which sets the lens for correct exposure and continually adjusts to changing light. Developed by Bell and Howell, the unit requires no batteries, motor or spring for the automatic exposure control. The light rays striking the photoelectric cell (through the rectangular honeycomb lens at the bottom of the front plate) generate the electricity, which opens and closes the lens iris. An amber exposure beacon glows as long as there is sufficient light for movie making. It turns black to warn the movie maker that the light is inadequate. A needle pointer indicates the f/stop at which the lens is set when the camera is operated automatically. When the dial below the needle pointer is turned to "manual" the automatic exposure control is de-activated and the lens can be set for under- or over-exposure.

Washington Report

Herbert H. Rosen

New Faces—Old Problems

After 4-1/2 years at the helm, Charles E. Wilson has retired from his post of Secretary of Defense. It has been a stormy period, climaxed by the long anticipated but, paradoxically, unexpected parsimony in defense spending. His successor, Neil McElroy, faces problems, the magnitude of which he has never experienced in his business life. The former Procter & Gamble president will be operating a 4-million man organization with a $38 billion budget. In all his 32 years with P & G, McElroy has never had to face the rivalries, confusion, and conflict characterizing the Department of Defense. He will have to call on all his prowess as a public relations expert to solve merely the personnel problems of his chief advisors.

Starting in August, the Joint Chiefs of Staff had a new chairman, Gen. Nathan Twining. How well the former Air Force Chief can assume the role of impartial arbiter between the three services is the big Washington question. Naturally, it will be difficult for him to bend away from the Air Force in the tight squabbles the Joint Chiefs have been keeping away from the public eye under Admiral Radford.

In the civilian hierarchy, McElroy will be meeting a brand new Assistant Secretary of Defense for Research and Engineering. He is Dr. Paul D. Foote. The 69-year-old Dr. Foote has been working at the Pentagon for the past few months as a consultant. In fact, many of the problems formerly solved by Frank Newbury have been passed on to Dr. Foote. The new assistant secretary is reported to be a specialist in magnetic optics, pyrometry, atomic structure, radiation, and petroleum recovery. He retired from the Gulf Oil Company in 1953 after reaching the position of Executive Vice President and member of the Board of Gulf's R & D company.

For the future, we can look to the old cliche about the new broom sweeping clean—except this time he's brought his own soap.

Radar Basic Design Patent Awarded

The U.S. Patent Office has awarded Patent 2803819—Object Locating System—to Col. William R. Blair (U.S.A. Ret.). The claims contained in it virtually blanket all of the basic ideas inherent in pulse-echo type of radio ranging and detection. The award effectively names Col. Blair the "father of radar." According to the Signal Corps, the patent is

"as important and far-reaching in its military applications as the first U.S. patent issued on the telephone to commercial communications." The interest shown by the Signal Corps is manifested in the fact that its attorneys have been handling the litigation surrounding the award for the past 12 years.

Blair dates his claims back to the late 1920's, when he was working on optical-aural sensing projects for the Signal Corps. Practical work on radio ranging and detecting began in the '30's, while Blair was director of the Signal Corps Laboratories. (He retired in 1938.) His laboratory notes show that besides concept, the Colonel also designed circuits for his sensing system.

The project was allotted little money—less than $10,000 over several years. A laboratory model was finally built that, in its completed form, strongly resembled the World War II version of the SCR 268. Blair and the Signal Corps officially unveiled the development to War Department officers and members of Congress early in 1937. As a result of this disclosure, an additional $75,000 was allotted to continue the work. Before the war was over, it is estimated that about $3 billion was spent on the radar techniques that grew out of Blair's basic designs.

Application for the basic patent was made the day after World War II ended in Europe, on June 7, 1945. Throughout the 12 years of litigation, it was opposed by the Navy Department, IT&T, Sperry, Raythéon, RCA, and others. They brought to the attention of the Patent Office certain areas thought to be infringing on and interfering with their own patents. In all cases of basic concept, the Patent Office ruled in favor of Blair.

One additional quirk in the patent law had to be overcome. The law prescribes that an application for patent must be made within one year after public disclosure. By 1945, radar was well known, at least in broad principle. However, the 81st Congress passed a private bill, which absolved the prior publication covenant for William R. Blair.

However, since the development came about in a Signal Corps laboratory, the Government has been granted a royalty-free license on the patent right. On the other hand, industry is in a much different position. Blair can now extract "reasonable" royalties on all electronic equipment incorporating his basic ideas. This includes almost all of the radar equipment manufactured for civil use. Also, it could mean some applications of radar—cooking, for one—would be affected by this situation.

But Blair may also be facing a series of court actions reminiscent of the trials and tribulations Major Armstrong went through in validating his FM patent rights. Blair's attorney, however, feels confident that any action placed before them can be won over. If this is the case, Blair has some 17 lush years before him.

Meetings

Oct. 7-9 NEC

Sponsored by American Institute of Electrical Engineers, Illinois Institute of Technology, Institute of Radio Engineers, Northwestern University and University of Illinois. Sessions on the following topics are scheduled:

Monday a.m., Oct. 7

(1) Transistor Circuits; (2) Communications; (3) Servomechanism Applications; (4) Audio;

Monday p.m., Oct. 7

(5) Semiconductor Devices; (6) Microwaves I; (7) Circuits; (8) Radio Astronomy (Tutorial Session);

Tuesday a.m., Oct. 8

(9) Transistors and Transistor Applications; (10) Microwaves II; (11) Components I; (12) Servomechanism Theory;

Tuesday p.m., Oct. 8

(13) Solid State (Tutorial Session); (14) Computers; (15) Components II; (16) Radar and Radio Navigation;

Wednesday a.m., Oct. 9

(17) Instrumentation I; (18) Electron Tubes I; (19) Circuit Theory; (20) Magnetic Amplifiers;

Wednesday p.m., Oct. 9

(21) Instrumentation II; (22) Electron Tubes II; (23) Network Synthesis.

Oct. 7-9: 1957 International Systems Meeting

Statler Hotel, Los Angeles, Calif. Sponsored by the Systems and Procedures Association of America. The program will consist of panels, seminars, round table discussions, equipment exhibits, demonstrations, case studies, general sessions, illustrated lectures and study groups. The sessions will cover such subjects as systems survey, analysis, procedures, printed forms, electronic systems, organization analysis, systems and management, records management, work simplification and other techniques. For further information, write to the Systems and Procedures Association of America, 629 S. Hill St., Los Angeles 14, Calif.

Oct. 7-11: Fall General Meeting of the American Institute of Electrical Engineers

Hotel Morrison, Chicago, Ill. The technical program will consist of more than 50 sessions devoted to the lastest advances in electrical engineering and allied arts. Nuclear reactors, telegraph systems, research, ethics, television and aural broadcasting, basic science, safety, computing devices, land transportation, power generation, transmission and distribution, system engineering, computers, mining and metal industry, radio, and the chemical industry are some of the subjects being covered. For details write to the AIEE, 33 W. 39th St., New York, N.Y.

Oct. 8: Isocyanate Symposium

Curtis Hotel, Minneapolis, Minn. Sponsored by the Upper Midwest Section of the SPE. Among the papers to be read are "A Comparison of Properties Between Polyester and Polyether Based Isocyanate Foams" and "High Temperature Urethanes." For details write the Society of Plastics Engineers, Inc., 34 E. Putnam Ave., Suite 116-118, Greenwich, Conn.

Oct. 8-12: 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. 9-11: Fourth National Symposium on Vacuum Technology

Hotel Somerset, Boston, Mass. Sponsored by the Committee on Vacuum Techniques. Approximately 25 pages will be presented covering fundamental advances in vacuum technique, means of producing, measuring and conducting low pressures, and advances in applications of vacuum to processing. For further information, write the Committee on Vacuum Techniques, Box 1282, Boston 9, Mass.

Oct. 14-15: Third Annual Douglas Aircraft Co. Inc. and Bell Helicopter Corp. Integrated Instrument Development Program Conference

Hotel Statler, Los Angeles, Calif. Sponsored by the Army and Navy. For more information send to the News Bureau, Bell Helicopter Corp., P.O. Box 482, Ft. Worth, Tex.

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. 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. 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. 17-19: American Ceramic Society, West Coast Convention (Electrical Symposium)

Sheraton-Palace Hotel, San Francisco, California. Sessions that would be of particular interest to the design engineer are "Electrical Ceramics," "Special Purpose-Ceramics," and "Alumina."

Oct. 18-19: Second Annual Symposium on Digital Computers

O'Henry Hotel, Greensboro, N.C. Sponsored by the Piedmont Sub-Section of the North Carolina-Virginia Section of the IRE. "A Short, Short Course in Digital Computers" is the name given to the conference. Discussion topics will be digital computers, computer mathematics, storage devices and techniques, arithmetic units, input and output devices, column shift units, programmers, computer programming techniques, verifications, and digital computer applications. There will also be exhibits. For more information write M. L. Fox, Western Electric Co., Burlington, N.C.

Oct. 21-22: First National Symposium on Engineering Writing and Speech

Sheraton-McAlpin Hotel, New York, N.Y. Sponsored by the IRE Professional Group on Engineering Writing & Speech.

Monday a.m., Oct. 21

1. Engineering Writing is Different; 2. Tricks of the Trade; 3. When you Write for the Air Force.

Monday p.m., Oct. 21

1. More Senses Make More Sense; 2. Should talk be read from prepared manuscript; 3. Scientific Staging.

Tuesday a.m., Oct. 22

1. Ten Commandments for Good Speaking; 2. Does it Have To be Slides?; 3. Technical Films—Luxury or Necessity.

Tuesday p.m., Oct. 22

1. What Magazine Are You Writing For?

Oct. 24-25: Fourth Annual Computer Applications Symposium

Hotel Sherman, Chicago, Ill. Sponsored by the Armour Research Foundation of Illinois Institute of Technology. Advances in automatic coding and new computers and applications will be stressed. Both management and engineering applications will be considered. More information may be obtained by writing the Secretary, Computer Applications Symposium, Armour Research Foundation, 10 W. 35th St., Chicago 16, Ill.

Oct. 24-25: General Assembly of the Engineers' Council for Professional Development and the Engineers Joint Council

Statler Hotel, New York City. Subjects to be discussed are military service and professional development, the community college and technological education, the place of the engineer in industrial management, and new dimensions in post-graduate education for the young engineer. Further details may be obtained from either the Engineer's Council for Professional Development or the Engineers Joint Council, 29 W. 39th St., New York 18, N.Y.

Oct. 28-30: Fourth Annual Atomic Industry Conference

Plaza and Waldorf-Astoria Hotels and Coliseum, New York City. Sponsored by the Atomic Industrial Forum. For information write to AtomForum, 3 E. 54th St., New York 22, N.Y.

Oct. 28-30: Fourth Annual East Coast Conference on Aeronautical and Navigational Electronics

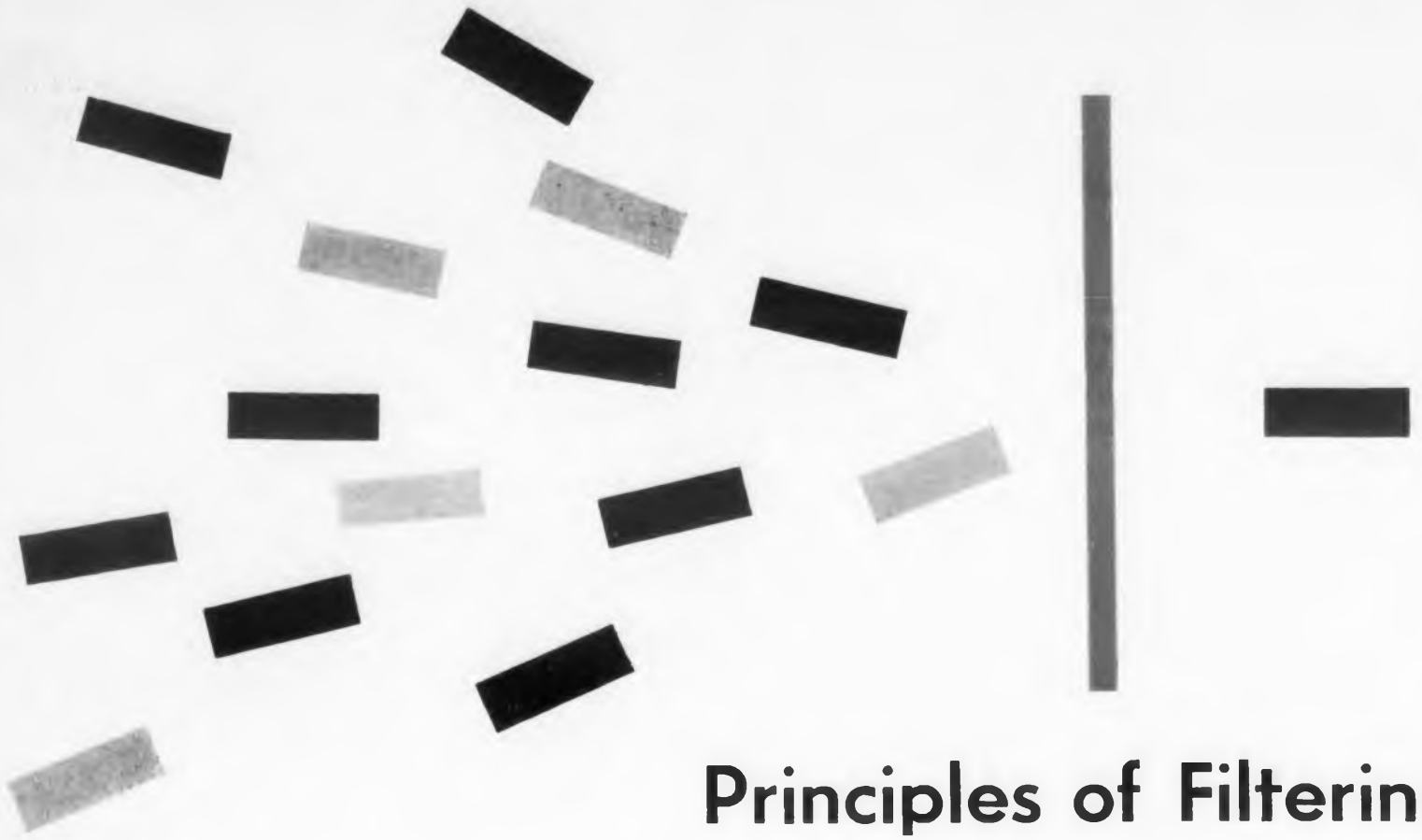
Fifth Regiment Armory and the Lord Baltimore Hotel, Baltimore, Md. Sponsored by the Baltimore Section of the IRE and the Professional Group on Aeronautical and Navigational Electronics. Exhibits will be offered along with the technical sessions. For details write Clayton Knight, 3603 Howard Park Ave., Baltimore, Md.

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.

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.



An approach to the philosophy and tactics of filter design in two parts. The first part presents the criterion and inverse probability method of receiver design and discusses the value of envelope detection. An analysis of matched filtering is made. Part 2 will describe comb filtering, linear integration, correlation (linear filtering), and synchronous detection. A brief discussion of autocorrelation radar will also be included.

The basic operation involved in extracting signals from a background of noise is the utilization of time. This utilization can take several forms, such as integration, correlation, matched filtering, and comb filtering. It will be the purpose of this article to show that these various forms of time utilization are essentially equivalent and that they are all means for increasing signal-to-noise ratio. *However, the end objective of filtering is not, as is often assumed, to increase the signal-to-noise ratio but rather to increase the information rate by reducing the probability of error.*

Principles of Filtering — I

L. S. Schwartz
New York University

WHEN the concept of minimizing the probability of error is applied to digital communication systems or to search radar, it is convenient to minimize the probability of error according to either one of two, equivalent approaches.[1] The first approach is the criterion approach and consists in guessing whether the signal is present or not according to some criterion. In the course of guessing, the operator may make one of two kinds of errors. He may report the signal present when in fact it is not (called a false alarm), or he may may report it as not present when, in fact, it is (called a miss).

The alternative to the criterion approach is to ask: what is the probability that a signal is present if a noise-corrupted wave form in the output of the receiver is assumed? The first approach involves the concept of likelihood directly, and the second the concept of likelihood indirectly, via inverse probability. By "likelihood" is meant the probability that the receiver will respond to signal plus noise rather than to noise alone. The optimum receiver is the one which selects the value of input signal which maximizes the likelihood.[2]

Detection Problem

In the criterion method, the problem of detection is as follows.[3] There are available N voltage samples which are known to have come either from a distribution of signal-plus-noise voltages or from a distribution of noise voltages alone. If the signal-and-noise properties are known, the probability density function of signal and noise and that of noise alone can be specified.

From knowledge of the density functions, it is possible to compute the probability that all the voltage samples came from the distribution of signal plus noise and the probability that they all came from the distribution of noise alone. The ratio of the first probability to the second is the best measure or likelihood that all samples came from the signal-plus-noise distribution. Any monotonic function of this ratio gives an equally good significance test. A constant which the ratio must exceed in order to say that the samples came from the signal-plus-noise distribution is then picked arbitrarily.

This constant determines the false alarm time. If the logarithm of the ratio of the probabilities is taken, it is seen that in the very important case of Gaussian noise at the input to the envelope detector, the measure or likelihood function indicates the following steps: to take the logarithm of the modified Bessel function of order zero of the voltage sample, to add these logarithms for each sample, and to require the sum to exceed a certain value (the logarithm of the constant exceeded by the ratio of probabilities), called the threshold. In other words the optimum receiver has an envelope detector with the law

$$y = \log I_o(av) \qquad (1)$$

where I_o = the modified Bessel function of zero order; v = the amplitude of the noise voltage envelope; a = the signal-to-noise power ratio, prior to detection.

Note that for small values of the argument the logarithm of I_o can be replaced by the square of its argument. For large values of the argument, the logarithm of I_o can be replaced by the argument to the first power. Thus, the $\log I_o$ envelope detector functions as a square law device for weak signals and as a linear device for strong signals. Moreover this detector is followed by an integrator which sums successive voltage samples at the output of the detector. The sum is then applied to a threshold device which, in practice, is some form of trigger circuit that operates on an all-or-none—go no go—principle.

If the receiver is designed according to the foregoing criterion, it will perform so as to maximize the probability of detection for a prescribed maximum acceptable probability of false alarm given by the threshold setting. It will thus be a receiver for minimizing the probability of error.

The procedure followed in the inverse probability method achieves the same results as the criterion method. The former method, developed by Woodward,[2] proceeds from the point of view of "inverse" probability since the problem is to discover the cause x which has produced a given effect y, whereas "direct" probabilities describe the effects produced by a given cause.

To illustrate the significance of these concepts to communications, the example of a given received signal combined with additive Gaussian noise is considered. The reception problem is to operate on the received signal-plus-noise function in such a way as to maximize the probability that the additive mixture of signal and noise originated with some particular message at the sending end. It is found that this probability is indeed maximized if the function

$$q(x) = \int_0^T y\, u_x\, dt \qquad (2)$$

is maximized, where x denotes the message and u_x the signal voltage representing it, y being the received signal. The function $q(x)$ is a measure of the crosscorrelation between y and all the possible wave forms u_x. The most probable message state is the one which yields the largest crosscorrelation. It follows that in the case of Gaussian noise the optimum receiver is a crosscorrelation device.

At first sight the results of the criterion and inverse probability approaches appear to be in disagreement. It is found from the application of the former that the ideal receiver is a *log* I_o detector followed by an integrator, whereas it was just found from the application of the latter that it is a crosscorrelator. Actually, the two results are not in disagreement, since the methods were applied to two different situations. In the application of the criterion approach, an *envelope detector* was considered, but in the application of the inverse probability approach, nothing was said about the kind of detector that was used. If an envelope detector is used, both approaches will work.

The implications of the foregoing results are important. It is seen that if envelope detection is specified, the optimum receiver is a *log* I_o detector followed by an integrator. If not, the optimum receiver is a crosscorrelation device. In view of the fact that envelope detection is used in conventional receivers, the question arises as to whether there are times when it is preferable not to use it. The answer is yes. In envelope detection when the signal is smaller than the noise, the noise suppresses the signal because of the nonlinearity of the process, so that the signal-to-noise ratio at the output of the envelope detector is smaller than at the input. If it is required to operate under high relative noise conditions, it is advisable, therefore, to avoid envelope detection. The alternative to envelope detection is synchronous detection which is described in some detail in Part 2 of this

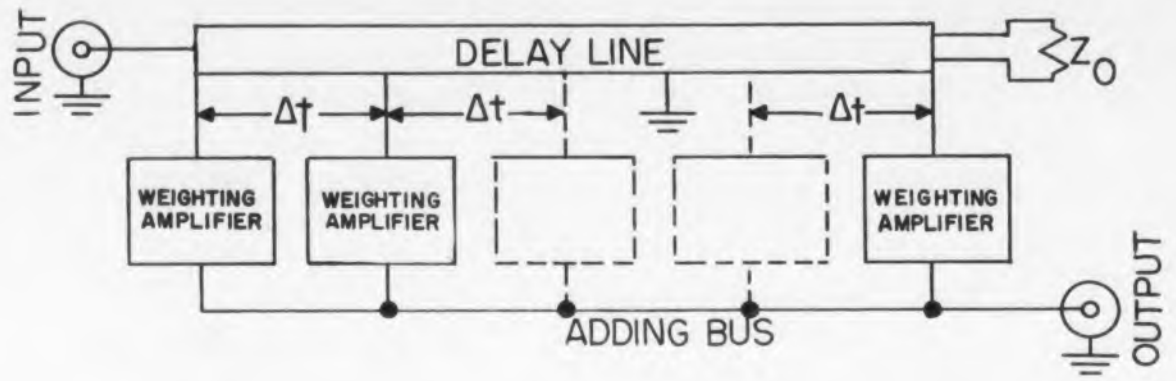


Fig. 1. Block diagram of a matched filter. For a rectangular input pulse, the output is a triangular pulse with a base width twice that of the input pulse width.

series. Synchronous detection will be seen to be a method of removing signal fine structure by cross-correlation. Since crosscorrelation is a linear process, suppression of weak signals by noise does not take place.

Improving Signal-to-Noise Ratio

Implicit in the operation of optimum receivers is the existence of a threshold device at the output of the receiver. A threshold circuit is a necessity because a receiver is, in the last analysis, a decision device. It must decide whether a signal is present or not, and it must make this decision with minimum probability of error. The decision is a yes-no operation which is implemented circuit-wise by means of a threshold device.

The problem of decision then resolves itself into a question of whether the output of the receiver exceeds the threshold or not. If noise alone is present, the threshold should not be exceeded. Since noise alone can have any amplitude with finite probability, it is evident that noise voltages will occasionally exceed the threshold and cause triggering of system output circuits, no matter what the threshold. This event is called a false alarm, and it is desired to have its probability small, a condition which is achieved by raising the threshold an adequate amount.

The threshold cannot be raised indefinitely, however, because then the probability of misses would become unacceptably large. Accordingly, a compromise must be reached which represents an acceptable balance between the false alarm rate and the miss rate. On the other hand, if the signal-to-noise ratio at the input of the threshold were increased, the threshold could be raised for a given miss probability, or lowered for a given false alarm probability, depending on whether the signal or the noise had been increased relative to the other.

In either case, the result is a reduced probability of error, the object of increasing the signal-to-noise ratio. By application of either the criterion or inverse probability approaches, it can be seen that integration or correlation, which are techniques of linear filtering, are optimum means for minimizing probability of error when the noise is Gaussian. Since the probability of error is a function (exponential) of signal-to-noise ratio, it follows that linear filtering techniques are also optimum methods of improving signal-to-noise ratio when the noise is Gaussian. For this reason, it is desirable to compare briefly the various techniques commonly used to improve signal-to-noise ratio and to show the relationship they bear to each other. The first of these is matched filtering.

Matched Filtering

The matched filter, first considered by North[4] and then later and independently by Middleton and Van Vleck,[5] is a filter designed to achieve maximization of the signal-to-noise ratio. The figure of merit p, on which the filter design is based, is defined as the ratio

$$p = \frac{|v(t_o)|^2}{\sigma^2} \qquad (3)$$

where $v(t_o)$ = the value of the output signal at some specified instant $t = t_o$ and σ^2 = the mean-square value of the output noise.

It can be shown that the transfer characteristic of the filter which maximizes p is the complex conjugate of the spectrum function of the input signal. Such a filter has the property that its impulse response is the image of the input signal.

The output of the matched filter for a rectangular pulse input is a triangular pulse the base width of which is twice the width of the input pulse. It is observed that the output of a correlation device for a rectangular pulse input is also a triangular pulse of base width equal to twice the input pulse width. Also, time-aperturing (which is convolution, an integration process) a rectangular pulse with an impulse response function which is the image of the input pulse results in a triangular output. Thus, the matched filter can be looked upon either as a correlation or an integration device. This observation will be supported by a mathematical statement in a later section dealing with correlation.

In determining the improvement accomplished by a matched filter, its performance may be compared with that of a resistance-capacitance (RC) filter the bandwidth of which is appropriate to the signal being used. For a rectangular pulse in Gaussian noise, the maximum value of p is

$$p_{MF} = \frac{V^2\delta}{N_o} \tag{4}$$

where V = the amplitude of the rectangular pulse; δ = the pulse width; N_o = the value of the noise power spectrum.

For an RC filter, the output signal-to-noise power ratio is

$$p_{RC} = \frac{V^2\pi(1-\varepsilon^{-2\pi a})^2}{a\pi N_o} \tag{5}$$

where a is a factor which determines the relation that the frequency cutoff point of the RC filter bears to the inverse of the pulse width. The other quantities have been defined previously. The improvement factor in signal-to-noise power ratio for a matched filter over an RC filter is defined as

$$R = \frac{p_{MF}}{p_{RC}} \quad (6) \quad \text{and} \quad R = \frac{a\pi}{(1-\varepsilon^{-2\pi a})^2} \tag{7}$$

It is observed that the relative improvement of the matched filter over the RC filter increases with a. This means that if the performance of the matched filter is compared with that of an RC filter the cutoff frequency of which is appreciably larger than $1/\delta$, where δ is the pulse width for which the matched filter is designed, the performance will be better than if the comparison is made with an RC filter of smaller relative cutoff frequency. The physical basis of the improvement is that the matched filter has a frequency transfer function which resembles the spectrum of the input signal so that, unlike a nonoptimum filter, it admits only that noise which is coincident with the spectral components of the signal or which lies between them, but not the noise which lies outside of the signal spectrum.

For a reprint of this article, turn to the Reader's Service Card and circle **17.**

References

1. The Theory of Signal Detectability I, II, W. W. Peterson, T. G. Birdsall. Technical Report No. 13, EDG, University of Michigan, Ann Arbor, Mich., June, July 1953.
2. Probability and Information Theory with Applications to Radar (book), P. M. Woodward, McGraw-Hill Book Co., Inc., New York, N.Y., 1953.
3. A Statistical Theory of Target Detection, Mathematical Appendix, J. E. Marcum. Report No. RM-273, Rand Corp., July 1, 1948.
4. Analysis of the Factors which determine Signal-to-Noise Discrimination in Radar, D. O. North. Report PTR-6C, Radio Corp. of America Labs., New York, N.Y., June 1943.
5. A Theoretical Comparison of the Visual, Aural and Meter Reception of Pulsed Signals in the Presence of Noise, J. Van Vleck, D. Middleton. *Journal of Applied Physics*, New York, N.Y., vol. 17, Nov. 1946, pp. 940-71.

Transistor Switchin C

TWO PROPERTIES exhibited by transistors, and not found in vacuum tubes, make them ideal active elements for low power switching circuits. One of the properties is polarity of the elements. In a transistor the collector and base have the same polarity with respect to the emitter, while in a vacuum tube the plate and grid have opposite polarity with respect to the cathode. A transistorized Schmitt Trigger is discussed which makes use of this fact. Another basic difference between the two devices is that the transistor can be made symmetrical, i.e. a transistor which is indifferent to which of two electrodes is chosen to operate as the collector. This property is used to advantage in a discussion of transistorized flip-flop circuits.

Schmitt Trigger

The function of a Schmitt Trigger circuit is the same as that of a simple relay. When the input signal equals or exceeds some threshold value, the output is at one of two levels. When the input signal decreases to some point below the threshold value, the output falls to the other level.

In the quiescent state, *V1* is cut-off and *V2* conducts (Fig. 1a). If a sine wave is applied to the input *V1* conducts. The cathodes rise and the decrease in plate voltage of *V1* is transferred to the grid of *V2*, both effects combining to bring *V2* into cut-off.

In design work, when it is desired that the function of a given vacuum tube circuit be obtained with transistors, a method commonly employed is to design the transistor dual of the vacuum tube circuit where plate becomes collector, grid becomes base, and cathode becomes emitter.[1] Operation of the transistor dual of the Fig. 1a follows the same description with *V1* replaced by *T1* and V2 replaced by *T2*, except that the divider is no longer

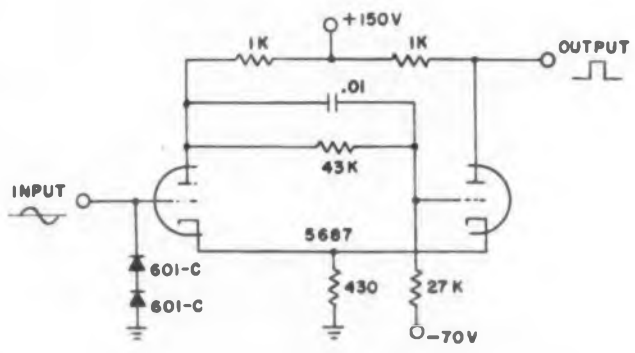


FIG. 1A

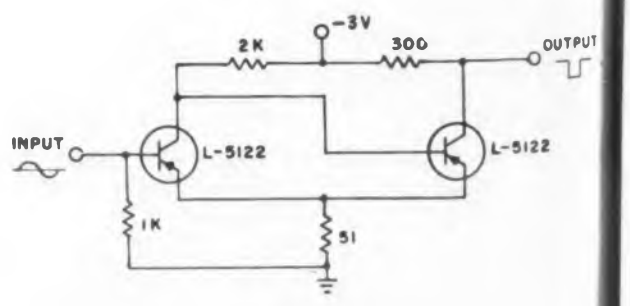


FIG. 1B

Fig. 1. Schmitt Trigger: (a) Transistors do not require the divider used with vacuu tubes (b) Maximum frequency response 5 mc (c) Frequency response 10 cps to 10 m

n Circuits

Mark Smith
Bogue Electric Mfg. Co.

necessary.[2] The divider may be omitted since the collector and the base have the same polarity with respect to the emitter.[3] The transistor circuit requires fewer components and no bias supply. In addition to the fact that the transistor circuit is much simpler to design, it is superior to the vacuum tube circuit on every point of comparison that occurs to the author except magnitude of output voltage.

The circuit of Fig. 1b operates on sine wave frequencies up to about 5 mc with leading and trailing edges ranges from 0.03 to 0.08 μsec depending on the frequency. The swing at the collector of *T2* is 2.6 v.

The circuit of Fig. 1c operates on sine wave frequencies from 10 cps to 10 mc with a negative going edge of at least 0.025 μsec. The high frequency limit was not determined because an appropriate oscillator was not available.

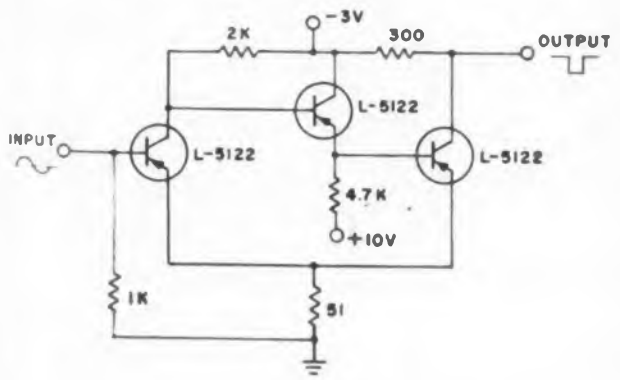


FIG. 1C

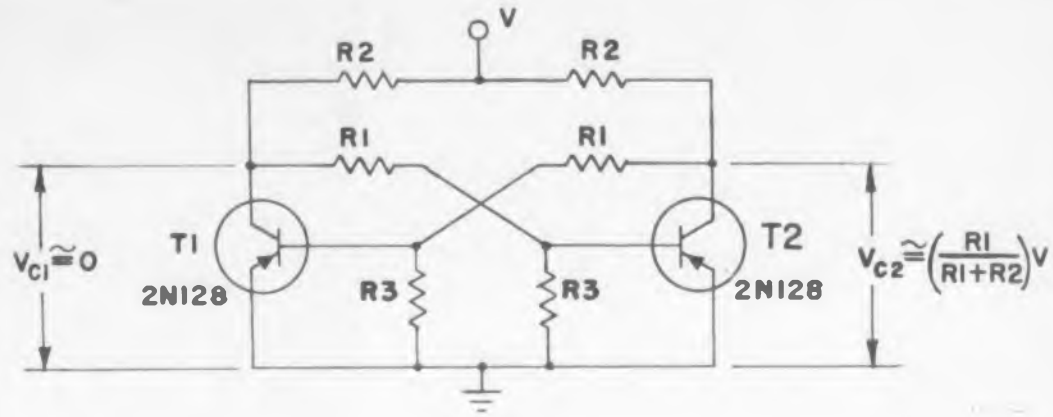


FIG. 2 A

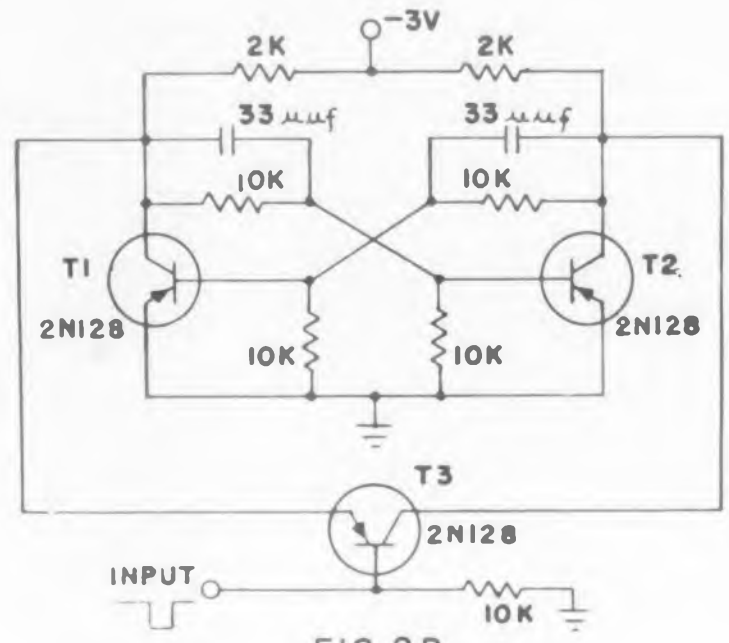


FIG. 2 B

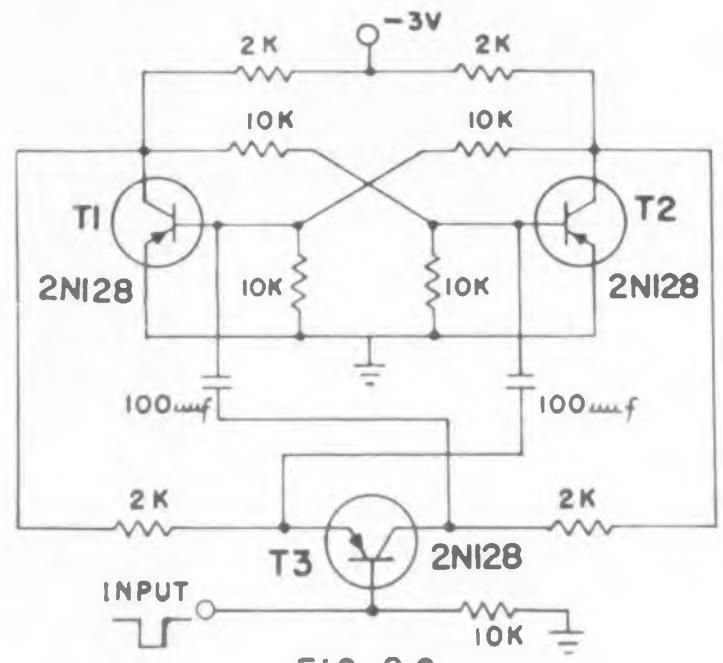


FIG. 2 C

Fig. 2. Eccles Jordan (*Flip-Flop*): (a) Isolation of trigger source is obtained in addition to push-pull action (b) Maximum trigger rate is 10 mc with a positive going edge of .05 μsec and a negative going edge of .12 μsec at the collectors (c) Maximum trigger rate is 3 mc with a collector signal rise and fall time of .05 μsec.

Eccles Jordan Circuit

In the transistor version of the well-known Eccles Jordan flip-flop shown in Fig. 2a, *T1* is conducting and *T2* cut-off. As is generally the case in switching circuits where surface barrier transistors are used, the voltage drop across the conducting transistor is practically zero. In this circuit, the voltage across *T2* approaches *V* since R_1 is large compared to R_2. The difference between V_{C1} and V_{C2} is sufficient to polarize the "emitter" and "collector" of *T3* in Fig. 2b. A negative pulse on the base will therefore cause the transistor to conduct. The pulse is amplified and steered as a positive pulse to the collector of *T2*, and as a negative pulse to the collector of *T1*. In addition to push-pull action, some isolation of the trigger source is obtained. The circuit illustrates a use of transistors which is not possible with vacuum tubes since the latter cannot be made symmetrical.

The circuit of Fig. 2b operated on trigger rates up to 10 mc with a 0.05 μsec positive going edge and a 0.12 μsec negative going edge at the collectors. At the time the data was obtained no symmetrical version of the 2N128 was available. A certain amount of selection was necessary in order to get a *T3* which permitted such high trigger rates.

The circuit of Fig. 2c employs essentially the same method of trigger injection except that the pulses are steered to the bases of *T1* and *T2*. Although maximum trigger rate at which this circuit operates is only 3 mc, both fall and rise time of the collector signals are 0.05 μsec. This is attributed to the fact that the transpose condensers are omitted.

Temperature Stability

In a shifting register containing a number of circuits similar to those of Fig. 2, it was found that with the resistors R_3 grounded, the flip-flop became unstable at 38 C. With the resistors connected to a small positive bias, stability was maintained at higher temperatures. No perceptible changes were observed in a complex waveform produced by these circuits as the temperature was varied from −55 to +75 C with a bias of +0.7 v.

FOOTNOTES

1. Richard Shea, Principles of Transistor Circuits, Ch. 14, John Wiley & Sons, New York, 1955.
2. This symbol is used because it emphasizes the duality. See "Transistor Electronics" Lo, Endres, Zawels, Waldhauer & Cheng, Page 37.
3. For other examples of how this property is employed See A. L. Cavalieri, Jr., What's Inside Transac-1, Electronic Design, July 1, 1956.

The author wishes to acknowledge the assistance of Martin Rabb of the Circuit Research Division of Dumont Laboratories in the preparation of this paper, and the suggestions of Kenneth Hoagland of the Cathode Ray Tube Division.

Frequency Spectra for Pulse Type Waveforms

E. Brenner
College of the City of New York

WHEN aperiodic pulses are impressed on a linear network, Fourier methods can be used provided the continuous rather than the line spectrum analysis is employed. Although the integral relationship which defines such continuous spectra is generally quite complicated, the analysis of a single rectangular pulse yields a wealth of information about the design of pulse type systems.

A single, nonrecurrent pulse cannot be resolved into a Fourier series. Also, when pulses in a sequence have a slow repetition rate compared to the duration of each pulse, the use of Fourier series is not convenient. This is because the problem encountered in response calculations is essentially that of a "repeated transient." The transient associated with one pulse may have "died out" by the time the next pulse occurs. The design of circuits which are to be excited in this manner should, therefore, accommodate a single pulse or a train of pulses which is finite and nonperiodic. Frequency response (i.e. "steady state") methods can be used for this purpose if the continuous spectrum rather than if the Fourier series is used.

Determining the Spectrum

The frequency spectrum for a single pulse can be obtained (and interpreted) by considering a periodic train of pulses, Fig. 1, and allowing the period P to approach infinity while duration, T, remains constant.

The various forms in which a Fourier series can be written are summarized in Table 1. The "complex" forms are chosen here because both amplitude and phase for each harmonic are contained in a single expression. The Fourier series for the periodic train of pulses, Fig. 1, thus has the form

$$v(t) = \sum_{k=-\infty}^{k=+\infty} \mathbf{D}_k \, e^{jk\frac{2\pi}{P}t} \qquad (1)$$

where the complex coefficients, $\mathbf{D}_k$, are given by

$$\mathbf{D}_k = \frac{1}{P} \int_{-P/2}^{+P/2} v(t)\, e^{-jk2\pi t/P}\, dt \qquad (2)$$

so that the periodic pulse train of Fig. 1 is represented by the series

$$v(t) = \sum_{k=-\infty}^{k=+\infty} V_o \frac{T}{P} \cdot \frac{\sin\,(\pi k T/P)}{\pi k T/P}\, e^{j2\pi kt/P} \qquad (3)$$

Note that the "complex" series can always be converted to the "real" trigonometric form by pairing the terms:

$$v(t) = V_o \frac{T}{P} + V_o \frac{\sin\,(\pi T/P)}{\pi}\, e^{j2\pi t/P} + V_o \frac{\sin\,(-\pi T/P)}{-\pi}\, e^{-j2\pi t/P} + \ldots$$

or

$$v(t) = V_o \frac{T}{P} + \frac{2\,V_o}{\pi} \sin\,(\pi T/P) \cos\left(\frac{2\pi t}{P}\right) + \frac{2\,V_o}{2\pi} \sin\,(2\pi T/P) \cos\left(\frac{4\pi}{P}\,t\right) + \ldots \qquad (4)$$

or by the use of the formulas given in Table 1.

To obtain the frequency composition of a single pulse, the amplitudes of the harmonics for the periodic pulse can be shown graphically by a "line" spectrum for several values of P as P becomes successively larger. In Fig. 2 the harmonic components for the periodic train of 1 μsec pulses are shown for three values of P. These spectra are obtained by inserting the proper ratio T/P in Eq. 3 and calculating $\mathbf{D}_k$ for the desired harmonics. As the period increases (i.e. the pulse repetition frequency decreases), the amplitudes of all the harmonics decrease, and the harmonics are crowded closer together.

For a single rectangular pulse, Fig. 3a, the harmonic amplitudes are all infinitesimally large but also infinitesimally close together so that they form a continuous spectral density. The spectral density for the rectangular pulse has the shape given by the envelope of the line spectrum of the periodic pulses (Fig. 2.) The equation, which describes the "harmonic" amplitudes of the single pulse is:

$$\mathbf{F}\,(\omega) = V_o T \frac{\sin\,(\omega T/2)}{\omega T/2} \qquad (5)$$

In Eq. 5 harmonic amplitudes are obtained for a continuous function of frequency so that the single pulse contains all frequencies with different amplitudes. The curve corresponding to Eq. 5 is shown in Fig. 3b for the fundamental and harmonic. No single frequency component however contains finite energy, only a finite "band" of frequencies constitutes a signal.

The relation, Eq. 5, is obtained by Fourier integral "transform" theory. The general formulas for the Fourier integral are given in Table 1. Notice that the "addition" of the "harmonic components" is an integration because the "harmonics" are infinitesimally close together.

To use the continuous spectrum method in design it is only necessary to recognize that the meaning of each frequency component in this spectrum is analogous to that of a harmonic component in the series. Thus, the same impedance function or transfer function which relates the steady state sinusoidal quantities also relates the spectral components of input and output in the continuous spectrum. In Fig. 4a, a freqency response curve of a network is shown. If the single rectangular

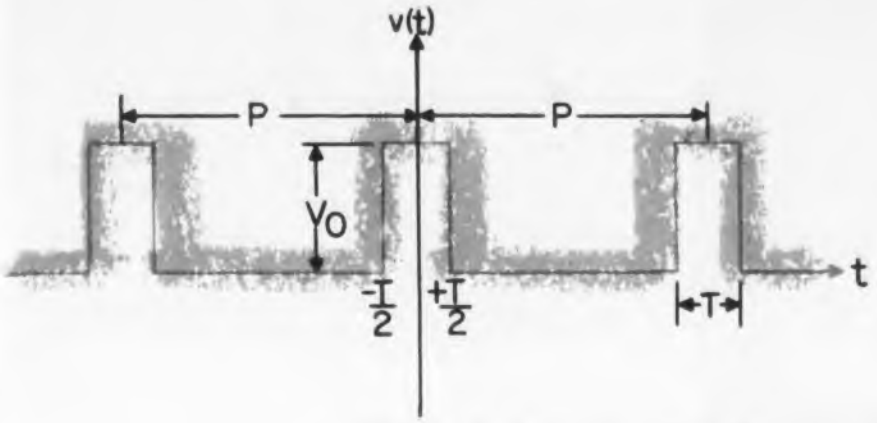
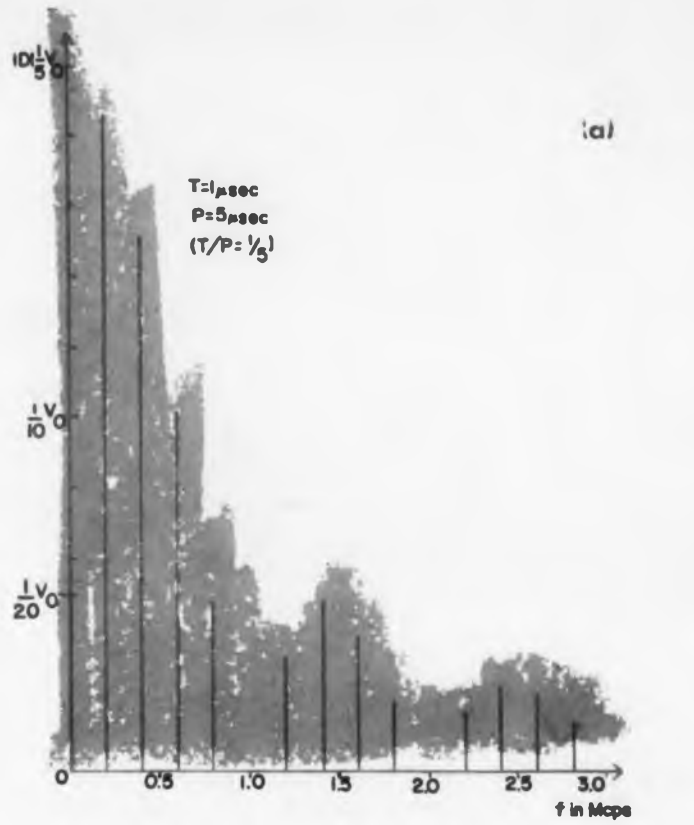


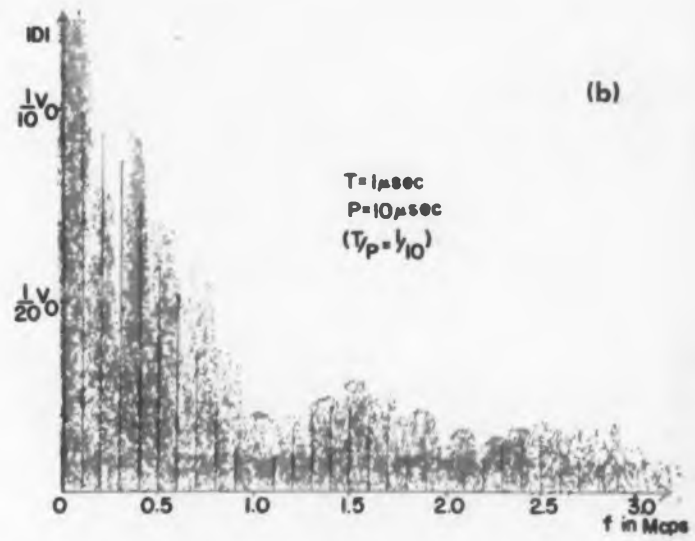
Fig. 1. A periodic train of rectangular pulses.

Table 1 Formulas for Fourier Analysis

(complex quantities shown in **bold face** type)

Fourier Series for Periodic waveforms (period P)	Fourier Integral for Pulse type waveforms ($\omega = 2\pi f$)
Trigonometric form 1	
$v(t) = \frac{A_o}{2} + \sum_{k=1}^{k=\infty} A_k \cos k2\pi t/P + B_k \sin k2\pi t/P$	$v(t) = \int_o^\infty [A(\omega) \cos \omega t + B(\omega) \sin \omega t]\, d\omega$
$A_k = \frac{2}{P} \int_{-P/2}^{+P/2} v(t) \cos (k2\pi t/P) d t$ $k = 1, 2, 3 \ldots$	$A(\omega) = \frac{1}{\pi} \int_{-\infty}^{+\infty} v(t) \cos \omega t\, dt$
$B_k = \frac{2}{P} \int_{-P/2}^{+P/2} v(t) \sin (k2\pi t/P)\, dt$	$B(\omega) = \frac{1}{\pi} \int_{-\infty}^{+\infty} v(t) \sin \omega t\, dt$
Trigonometric form 2	
$[K_1 \cos x + K_2 \sin x = \sqrt{K_1^2 + K_1^2} \cos (x - \tan^{-1} (K_2/K_1)]$	
$v(t) = \frac{A_o}{2} + \sum_{k=1}^{k=\infty} C_k \cos [(2\pi t/P) + \alpha_k]$	$v(t) = \frac{1}{\pi} \int_o^\infty S(\omega) \cos [\omega t + \alpha(\omega)]$
$C_k = \sqrt{A_k^2 + B_k^2}$	$S(\omega) = \pi A^2(\omega) + B^2(\omega)$
$\alpha k = -\tan^{-1} (B_k/A_k)$	$\alpha(\omega) = -\tan^{-1} [B(\omega)/A(\omega)]$
Complex form	
$\cos x = \frac{1}{2}(e^{jx} + e^{-jx}) \quad \sin x = \frac{1}{2j}(e^{jx} - e^{-jx})$	
$v(t) = \sum_{k=-\infty}^{k=\infty} D_k\, e^{j2\pi t/P}\, dt$	$v(t) = \frac{1}{2\pi} \int_{-\infty}^{+\infty} F(\omega)\, e^{j\omega t}\, d\omega$
$D_k = \frac{1}{P} \int_{-P/2}^{+P/2} v(t)\, e^{-j2\pi t/P}\, dt$ $k = 0, \pm 1, \pm 2 \ldots$	$F(\omega) = \int_{-\infty}^{+\infty} v(t)\, e^{-j\omega t}\, dt$
Relationship between the trigonometric and complex forms	
$D_k = \frac{1}{2} [B_k - j A_k]$	$F(\omega) = \pi [A(\omega) - jB(\omega)]$
$D_k = \frac{1}{2} C_k\, e^{j\alpha k} = \frac{1}{2} C_k / \alpha k$	$F(\omega) = S(\omega)/\alpha(\omega)$





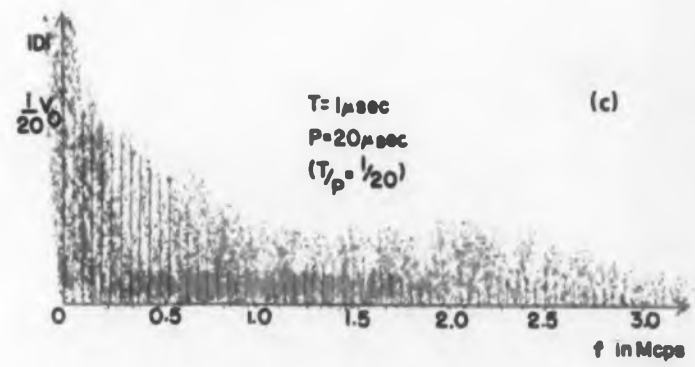
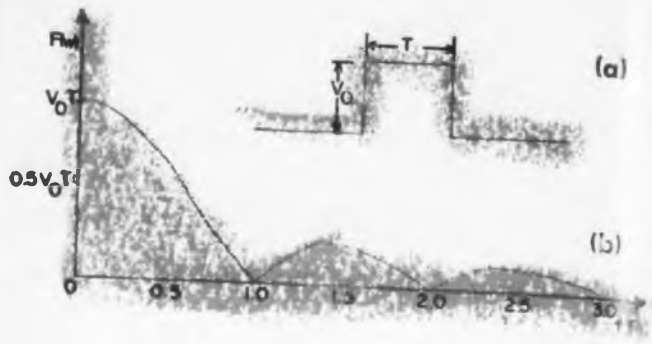


Fig. 2. Magnitudes of the harmonic amplitudes for the periodic pulses of Fig. 1 for various ratios of T/P.



pulse, Fig. 3, is applied to the network, the output has the spectrum shown in Fig. 4b for the case $T = 1/f_c$. This output spectrum has been obtained by (graphical) multiplication of the input spectrum by the frequency response curve.

Conclusions

The general problem of transmission of pulses can be stated as follows: To transmit a pulse with fidelity, the amplifier or transmission network must transmit all the harmonic components of the spectrum which are judged to be significant.

An exact definition of a "significant" harmonic amplitude is not possible. However, one can show that for a low-pass network (dc to cut-off frequency f_c) the rise time of the transmitted pulse is about $0.8/f_c$ and the overshoot is 9 per cent if the cut-off is very sharp, as illustrated in Fig. 5. It is assumed here that the transmission network introduces no phase distortion (i.e., the phase shift in the pass band is linear or negligible).

If the amplifier or network does not pass dc (and the adjoining very low frequencies), rise time is not affected, but the pulse output waveform will suffer "tilt". This effect may be negligible if the pulse duration is sufficiently short (when compared with the low frequency cut-off period).

The use of the integral transform formulas can often be avoided if superposition can be used. Thus, if a pulse can be represented as the sum or difference of waveforms whose spectra are known, the spectrum of the sum of the pulses will be the sum of the individual spectrums. In Fig. 6a a "two pulse group" is shown. This signal can be obtained by the addition of the two pulses shown in Fig. 6b. But each of these pulses has a spectrum which is identical to the curve shown in Fig. 3b. Hence, the spectrum of the two pulse group has the shape shown in Fig. 6b. This curve was obtained by graphical addition of the individual spectral curves.

For a narrow bandwidth (e.g. dc to f_1), the shape of the spectral curve for the two pulse group is almost identical to the curve which represents a single pulse. To transmit such a two pulse group

Fig. 3. A single rectangular pulse and its frequency spectrum. Absolute values are shown so that the spectral amplitudes are positive. The "negative" frequencies which are associated with the complex form of the spectrum are not shown; the curve is symmetrical with respect to the f = 0 axis.

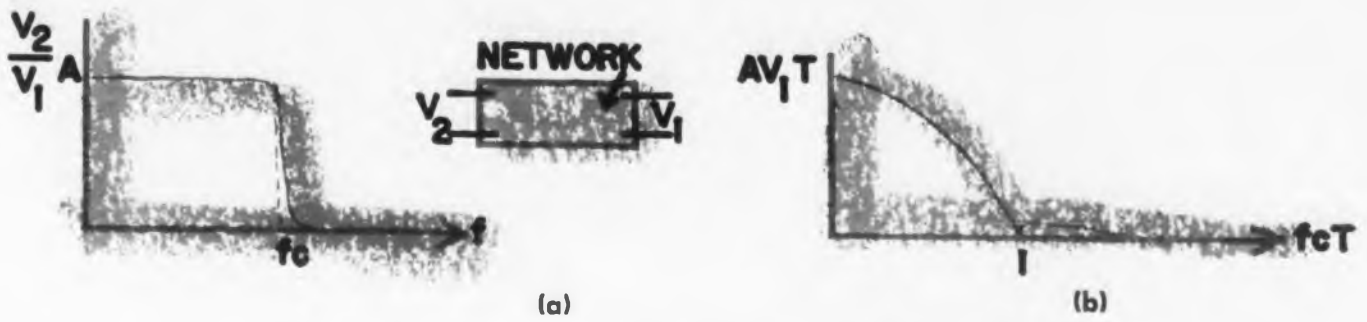


Fig. 4. A low-pass network and the output spectrum for pulse input. In the case shown the frequencies beginning with the second "lobe" of the input spectrum are not transmitted.

Fig. 5. Rise time and overshoots which result when transmitting a rectangular pulse through a low pass structure.

with fidelity, the bandwidth must be sufficiently wide so that the significant features of the spectrum are transmitted; otherwise, the two pulse group will merge into a single pulse and resolution will be lost.

By application of the Fourier Transform formula it can be shown that the harmonic components of an rf pulse, Fig. 7a, have the same relative amplitudes as the single pulse but are centered about the carrier frequency, f_o. This spectrum is shown in Fig. 7b. It is therefore concluded that if a low-pass structure whose band extends from dc to f_c transmits the signal pulse adequately, then a band-pass system whose bandwidth extends from $(f_o - f_c)$ to $(f_o + f_c)$ will transmit an rf pulse whose carrier frequency is f_o satisfactorily. The required bandwidth for the band-pass filter is therefore twice the bandwidth of the "analogous" low-pass filter.

A Short Bibliography

Reference material dealing with Fourier Analysis can be found in many books dealing with transient analysis. Typical are the following:

Linear Transient Analysis, Vol. I and II, E. Weber. John Wiley and Sons, Inc., New York, N.Y., 1954 and 1956. Volume I contains the derivation of the Fourier transform concept from the series. Vol. II has an extensive chapter dealing with the transmission of signals and the resulting frequency distortion. These two books form a complete reference library since all methods for treating such problems are discussed exhaustively in them.

Network Analysis, M. E. Van Valkenburg. Prentice-Hall, Inc., New York, N.Y., 1955. This modern undergraduate textbook has an excellent introduction to frequency analysis.

Pulse Techniques, Moskowitz, Racker. Prentice-Hall, Inc., New York, N.Y., 1951. An introduction to the calculation of the response of networks by use of the Fourier transform is included in the first two chapters of this short book.

Frequency Analysis, Modulation and Noise, S. Goldman, McGraw-Hill Book Co., Inc., New York, N.Y., 1948. This book has a complete treatment of frequency spectra, their application to transmission of signals, noise spectra and the problems of modulation.

Fourier Integrals for Practical Applications, G. A. Campbell and R. M. Foster, D. Van Nostrand Co., Inc., Princeton, N.J., 1942. An extensive and valuable collection of Fourier Transforms of the type encountered in all types of practical problems. This set of tables is also valuable in applications of the Laplace Transform.

Fig. 6. (a) The addition of two single pulses of different duration both centered about t = 0 results in a "two pulse" group. (b) Construction of the spectrum for the two pulse group. (The "absolute value" spectrum for the resultant is not shown here.)

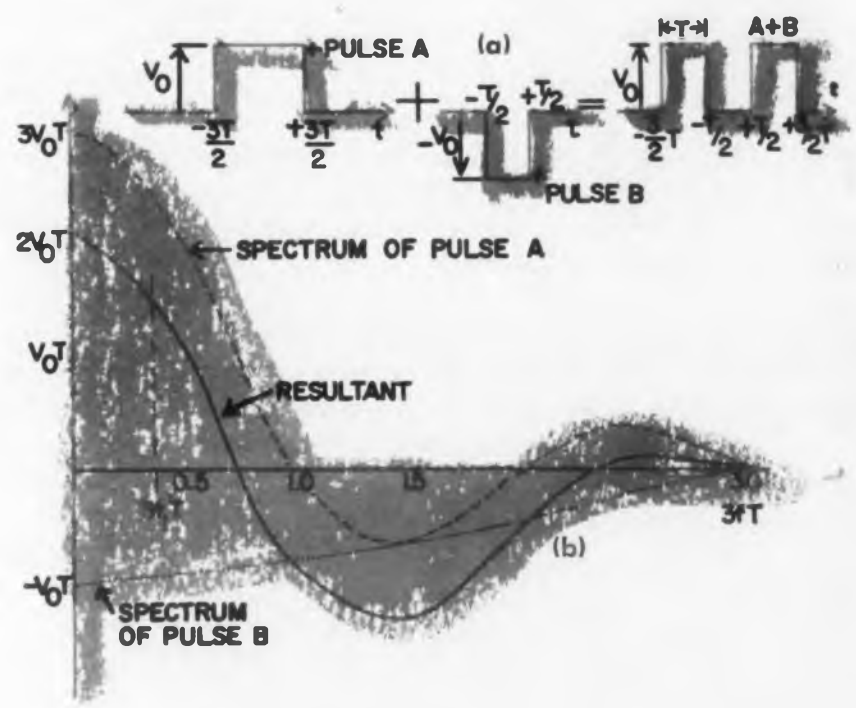


Fig. 7. A single rf pulse and its frequency spectrum.

Solderable Magnet Wire

One way to solve the problem of removing insulation from wires to permit soldering is not to remove the insulation at all. The wire described in this report is coated with an isocyanate resin that will decompose and flow at 650 to 750 F, to provide a flux during soldering. At lower temperatures the coating is a stable insulator. Copper wire coated with this isocyanate resin has the following desirable properties:

- Uniform solderability.
- Relatively low temperature solderability.
- Low losses, good moisture resistance, and
- Good physical, chemical and thermal properties equivalent to conventionally insulated wires.

Ralph Hall
Phelps Dodge Copper Products

ISOCYANATE-COATED wire has started to replace older types of solderable wire. To demonstrate graphically the properties of this solderable wire, a comparison of test results on enamel, nylon, vinyl acetal (Formvar) and Sodereze, the trade name for the coating, are shown in Table 1. Number 18 wire was used in the tests to facilitate the measurement of basic film properties.

One difference exists between Sodereze and nylon or Formvar. The latter two are high molecular weight polymers that are dissolved in suitable solvents, applied to the wire and cured by shrinking and some further polymerization. Sodereze, on the other hand, must be reacted on the wire. The film is produced by the splitting off of phenol groups on the stabilized isocyanate resin and subsequent reaction with other resins to produce the desired properties.

Experience and data have indicated that the Sodereze coating has good electrical properties and has high moisture and chlorinated-solvent resistance. It has long (extrapolated) life, and would be suitable for a 120 deg transformer. Since at extremely high temperatures it starts to decompose, Sodereze is not a wire for short time high temperatures. It could be used as a "fuse" in certain transformers, however, where extreme overloads require shorting and subsequent opening of the windings.

Proposed times and temperature for soldering this wire are given in Table 2. In order that none of the desired properties in Sodereze wire be sacrificed, and to broaden its field of application as well, the temperature of soldering was kept within the 650 to 750 F range. Of interest is the fact that with isocyanate based insulation, the soldering action is progressive. Parts that have been soldered at too low a temperature may be redipped.

The temperature of the soldering pot must be maintained accurately, since wide variation in temperature will influence the rate of soldering. This is important in dip soldering. When a rosin alcohol flux was used on the joint before dipping in the hot solder, more consistent and uniform lower temperature solderability results were obtained. For soldering with irons, high temperature alloy tip irons are recommended to get extremely high temperatures to permit fast flowing of the insulation and quick wetting of the solder. Tip temperatures from 900 to 1000 deg are the most successful, although some soldering is being done at lower temperatures with conventional irons. Minor changes in coil or equipment design for soldering may be necessary. If low temperature plastic parts are used, the point of soldering should be as far away as practical to prevent damage.

Material in this report was originally presented at the 2nd RETMA conference on Reliable Electrical Connections, Sept. 1956. A bound edition of all papers given at this conference may be obtained from Engineering Publishers, Dept. ED, G. P. O. Box 1151, New York 1, N. Y.

Table 2: Proposed Industry Standard For Solderable Magnet Wire

Wire Size AWG	Soldering Time, Seconds	Temperature Deg F	Type of Test
44 to 37 inclusive	4	680	Wound on #20 tinned copper
36 to 30 inclusive	5	680	Tinned copper
29 to 24 inclusive	6	680	Tinned copper
23 to 20 inclusive	8	800	5 to 10 twists in 3/4 in.-cut ends
19 and heavier	8	800	5 to 10 twists in 3/4 in.-cut ends

Wire to be dipped in rosin-alcohol flux

Table 1: Results of Tests on #18 AWG Wire Coated with Various Insulations

Tests on #18 AWG	Heavy Enamel	Heavy Nylon	Heavy Formvar	Heavy Soldereze
I. Physical Properties				
a. Build (increase in diam)	0.003 in.	0.003 in.	0.003 in.	0.003 in.
b. Adherence (snap)	OK	OK	OK	OK
c. Film Flexibility	15 per cent—3 x	30 per cent—1 x	30 per cent—1 x	20 per cent—1 x
d. Abrasion Scrape-NEMA	1-3	15-30	50-125	50-100
e. Unilateral (ITC) .009 in. Needle-Grams to scrape through	800 grams	1000 grams	1100 grams	1200 grams
II. Thermal Properties				
a. Flex Life at 125 C hr to fail 3 x—NEMA	32-50	250-400	400-500	1000-1500
b. Heat Shock—NEMA 1 x 125 C—1 hr	fail	OK	OK	OK
c. Cut Thru—5 lb on cross-over 20 C to 300 C in 30 min	180 C	225 C	210 C	250 C
d. Dielectric Life 175 C	502	260	402 hr	942 hr
AIEE 200 C	164	139	118 hr	70 hr
e. Solderability—Temperature to tin 1 in. lengths in 60/40 solder	will not tin	750 F to 900 F	950 F to 1050 F	750 F
III. Chemical Properties				
a. Solvent Resistance—24 hrs at 25 C Cheesecloth Scuff Test				
Petroleum Naphtha	OK	OK	OK	OK
3 deg Toluene	softens	OK	OK	OK
Ethyl Alcohol	softens	OK	OK	OK
5 per cent Sulphuric Acid	OK	sl. softening	OK	OK
1 per cent KOH	OK	OK	OK	OK
Trichloroethylene	bad softening	OK	softens	OK
Styrene Monomer	bad softening	OK	softens	OK
Butyl Acetate	bad softening	OK	softens	OK
Acetone (1 hr)	bad softening	OK	softens	softens
Toluol Alcohol (Cold)	bad softening	OK	softens	bad softening
15 per cent elongation (Toluene)	bad softening	OK	OK	OK
b. Crazing—Coils dipped in Toluene	no craze	sl. crazing	craze	craze
c. Healing—1 hr 125 C after crazing	——	yes	yes	yes
d. Annealing—1 hr—105 C before dip	——	yes	yes	yes
IV. Electrical Properties				
a. Dielectric Twist-NEMA-volts	8000-9000	7000-8000	8000-9000	8000-9000
b. Insulation Resistance NEMA twists boiled 10 min in water—500 volt DC	10^6 meg	26 meg	21,000 meg	10^6 meg
c. Dissipation Factor 25 C	.010	.065	.015	.0125
Tangent of Loss Angle—800 cps 100 C	.045	off scale	.0125	.020
d. Dielectric Constant 25 C	4.3	6.1	4.2	4.2
800 cps 100 C	4.0	off scale	4.0	4.3
e. Corona Resistance on 33 Heavy with NEMA dielectric twists avg 10 tests in air.				
Volts: 1000	——	——	499 min	946 min
1500	——	——	171 "	353 "
2000	——	——	18.9 "	194 "
2500	——	——	3.72 "	120 "

High Speed Indexing Clutch

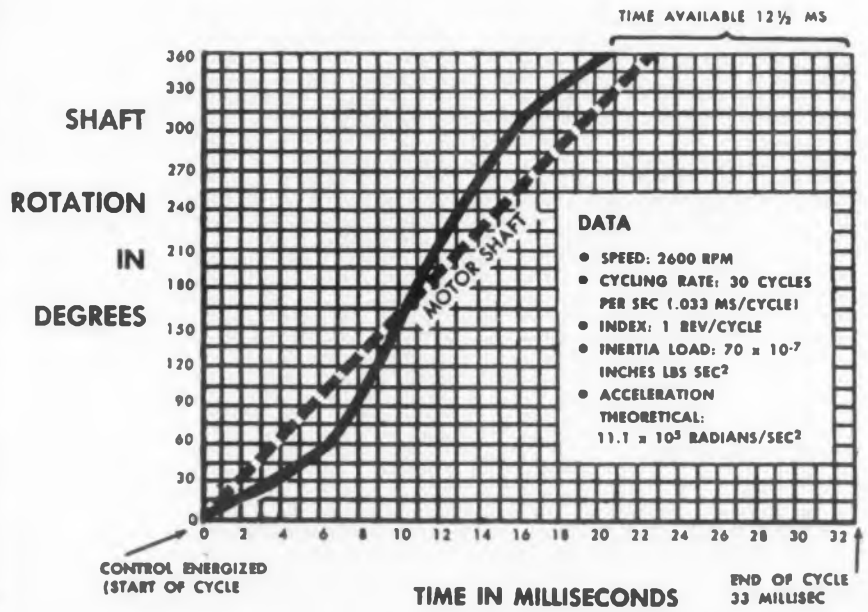
is Mechanical Pulse Amplifier

SMALL triggering forces can engage this indexing clutch in 1 millisecond to transmit 10 in. lb (min) of torque. The small actuating force can be calibrated and is in the order of two to four ounces. The clutch is small and designed with parts having low inertia. High shaft speeds and high speed pulsing are therefore possible. Depending on the index positions, 60 cps is feasible.

Typical applications include remote positioning, and stepping of tape for data processing. As a one revolution device it is useful for computers, control, or, automatic machinery. It is adaptable to servo systems and other numerous clutching, indexing, stepping and pulsing functions. Forces and time delays are carefully specified.

The clutch, manufactured by the Digitronics Corp., Albertson Ave., Albertson, New York, has co-axial input and output shafts; the entire mechanism measures 1 in. in diam and 1-23/32 in. long. The clutch housing has provisions for flange or servo mountings. The rate of index is one revolution or one half revolution, clockwise or counterclockwise shaft rotation. (Less than one half revolution units can be supplied on special order.)

A control or energizing lever, which engages the clutch, is projected outside the cylindrical envelope. Since the transmitted torque of the clutch and the energizing force are known, the amplification ratio of the clutch can be calculated. The amplifica-



Typical performance curve shows how output shaft follows motor shaft to input. The output actually leads the motor shaft in the plot because the spring coupling between the clutch and the motor restored transient energy to the clutch.

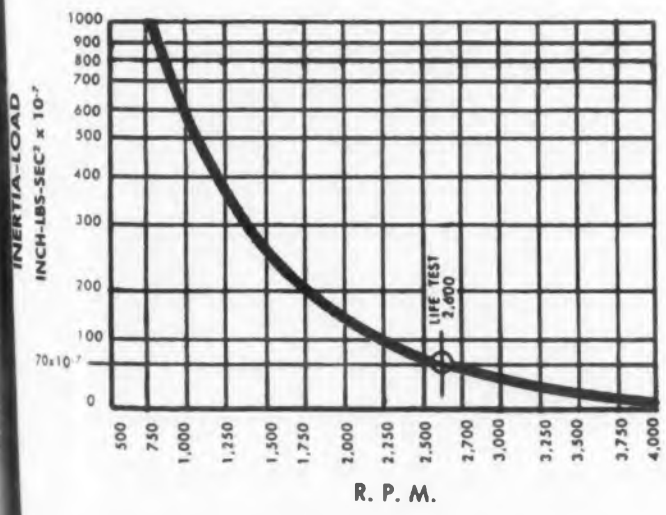
Mechanical clutch (left) and electrical transducer (right) mounted on servo breadboard plate.

tion ratio is the ratio of the transmitted torque to the energizing torque; the ratio of this clutch is 200.

A solenoid type transducer is available for converting electrical pulses to mechanical triggering pulses. The solenoid is linked to the control lever of the clutch. Other actuating or control means can be used depending on the ingenuity of the designer.

The unit uses the wrapping spring principle and is, therefore, well suited for indexing applications. Similar units are being designed for clutching as a function of time, braking, overrunning, and stepping.

For more information on this and similar products, turn to the Reader's Service card and circle **26.**



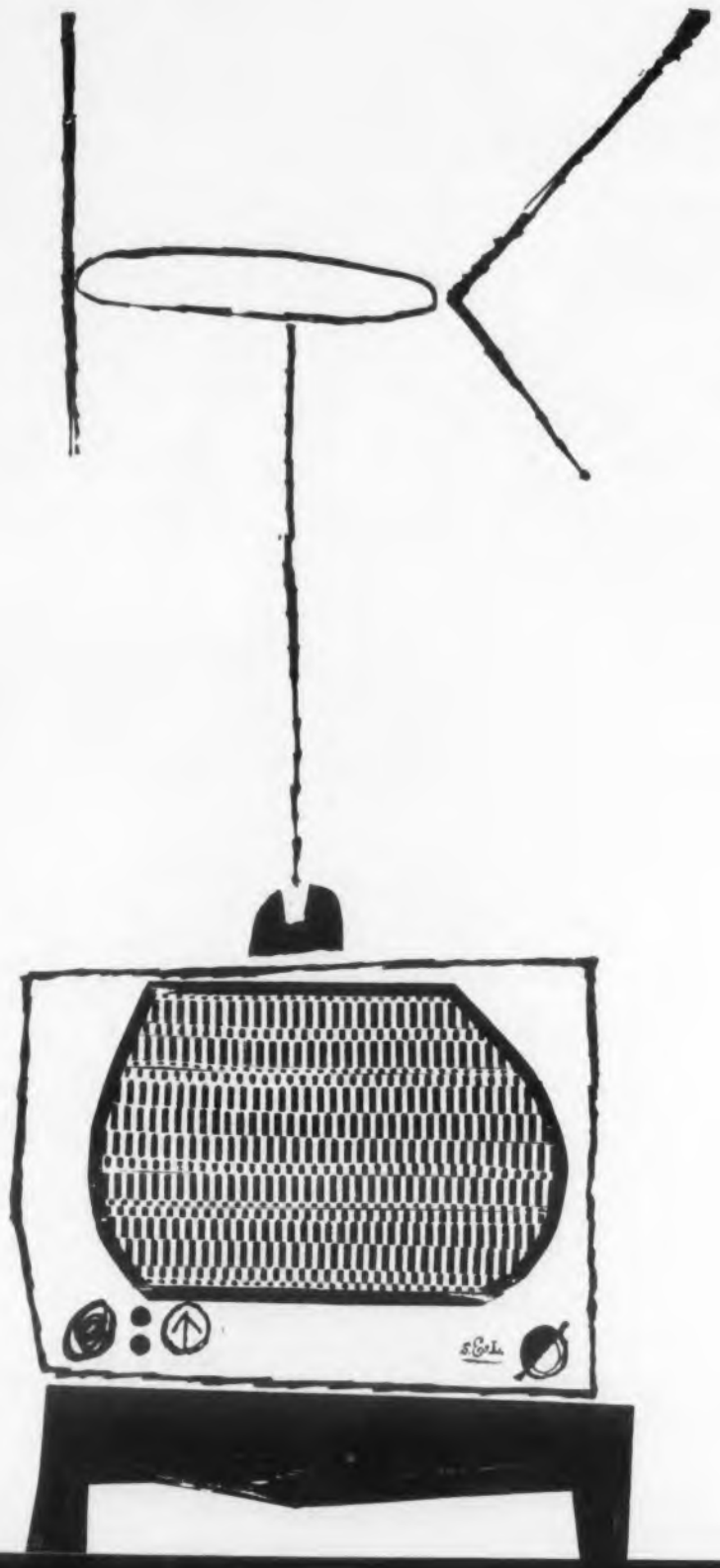
Recommended speed-inertia relationship for optimum design.

Variable Mercury Delay Line Simulates TV Flutter

C. F. Brockelsby
Mullard Research Laboratories
Salfords, Surrey, England

Though it may seem to many of us that most of the efforts of TV manufacturers are directed toward progressive cheapening of TV receivers, there is, in reality, a great deal of attention directed to circuit refinements, at least in the laboratory.

The instrument described here simulates TV multipath effects, such as those due to passing aircraft, and is particularly useful in checking agc systems. It may find application, also, in simulating interference in radar and other pulse equipment. We feel that the novel approach employed in the design of this equipment as well as its application possibilities will be of interest to electronic engineers.



PICTURE flutter on TV receivers, normally due to reflected signals from passing aircraft, may be simulated with this wide band, continuously variable delay line. This flutter and other multipath effects are due to the arrival at the receiving antenna of two signals, one direct from the transmitter, and the other, with a longer path, by reflection from the aircraft.

As the aircraft moves, the path difference, and hence the time delay, between the two signals changes, and so produces a fluctuating interference pattern giving rise to the characteristic flutter. A means of studying these phenomena with a view to developing receiver circuits that are insensitive to such disturbances has been found in variable mercury delay lines, and is currently in use for this purpose in the Mullard Research Laboratories in England. These lines have application, also, as radar signal simulators handling pulses as short as 0.1 μsec, and in work on pulse systems in general.

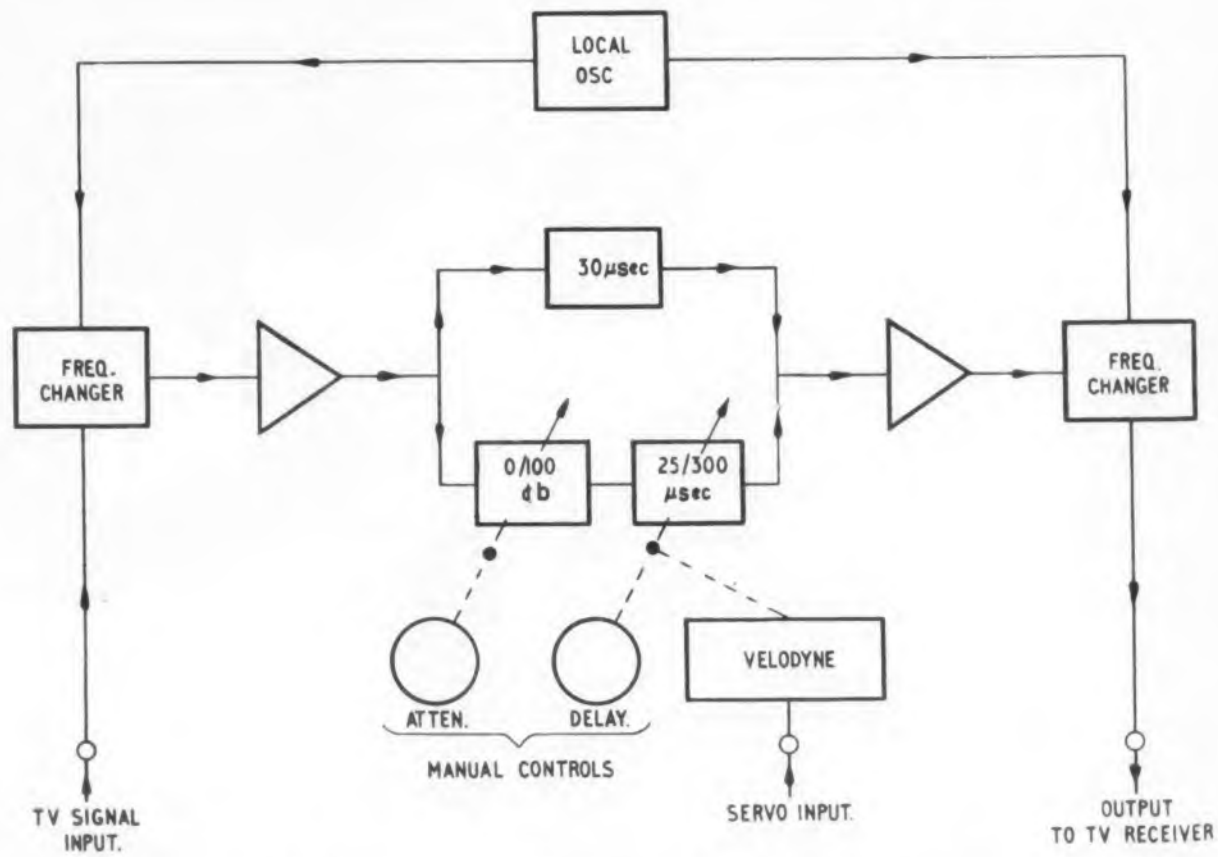


Fig. 1. Block diagram of complete dual path apparatus.

Construction

Basically, the laboratory apparatus is simple (Fig. 1). A test signal, which may be either from a live television transmitter or a local test pattern generator, is frequency changed on a 15 mc carrier and applied to two transmission paths. One of these consists of a short fixed delay line of, say, 30 μsec, and the other includes a continuouly variable delay which can be adjusted from slightly below to well above the fixed delay. The present apparatus uses a delay, variable from 25 to 330 μsec. In series with the variable delay is an attenuator.

The signals from the two paths are combined and frequency changed back to the original carrier which is applied to the receiver under test. By altering the variable delay the effective path difference between the two signals is changed and by altering the attenuator setting the strength of the flutter signal is controlled.

To simulate aircraft in flight it is necessary to vary the delay smoothly and continuously and the construction adopted enables this to be done to better than 0.01 μsec.

The fixed delay line consists simply of a steel tube full of mercury and carrying two quartz crystals, set coaxial and parallel, with a separation of about 45 mm.

The variable delay line presents a slightly more difficult problem. The velocity of ultrasonic waves in mercury is about 1.5 mm per μsec. Smoothness of adjustment to the target figure of 0.01 μsec, therefore, requires a mechanical precision of better than 0.0005 in. (Fig. 2)

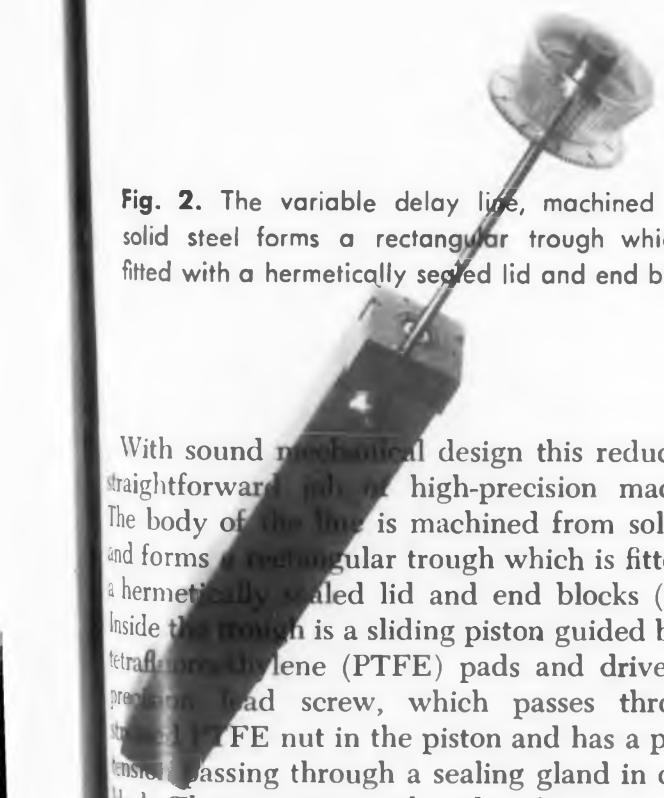


Fig. 2. The variable delay line, machined from solid steel forms a rectangular trough which is fitted with a hermetically sealed lid and end blocks.

With sound mechanical design this reduces to a straightforward job of high-precision machining. The body of the line is machined from solid steel and forms a rectangular trough which is fitted with a hermetically sealed lid and end blocks (Fig. 2). Inside the trough is a sliding piston guided by polytetrafluoroethylene (PTFE) pads and driven by a precision lead screw, which passes through a stationary PTFE nut in the piston and has a plain extension passing through a sealing gland in one end block. The piston is machined to form a corner reflector.

The second end block carries two quartz crystal transducers; the ultra sound radiated from one

travels through the mercury and returns from the corner reflector to the second crystal. The lead screw is cut with the exact pitch required to make one revolution correspond to 10 μsec change of delay, so that a dial and revolution counter give a direct reading scale with an absolute calibration in change of delay.

This calibration, of course, applies precisely at only one temperature. The temperature coefficient of delay is —0.03 per cent per deg C, allowing for the small effect of the expansion of the steel. Fortunately, the delay line is an ideal object for thermostatic control, having a large thermal capacity and high thermal conductivity, so that temperature gradients within it can only be small. A simple enclosure, with a low-power electric heater and thermistor controlled electronic switch, provide temperature control to better than ±0.1 deg C.

In addition to the direct manual drive a magnetic clutch brings in a precision gear drive from a Velodyne. The input to the Velodyne amplifier is a dc voltage to which the motor speed is proportional. It is therefore simple to program the delay against time by supplying the Velodyne control voltage from a potentiometer, geared, for example, to the time scale of a chart recorder.

The complete outfit mounts in a standard 19 in. instrument box which also contains all the necessary power supplies for operation from the ac line. (Fig. 3).

Performance

To transmit a complete television signal without distortion requires a broad frequency band—at least 3 mc and preferably 5 mc—with a good phase response. The behaviour of a mercury delay line in these respects is governed by the characteristics of the quartz crystals. These have been studied theoretically by Mason (1) and others and it can be shown that if the crystal is provided with a backing material of high acoustic impedance, the characteristics are more than adequate for the present

Fig. 3. The assembly mounts in a standard 19 in. chassis containing all necessary power supplies.

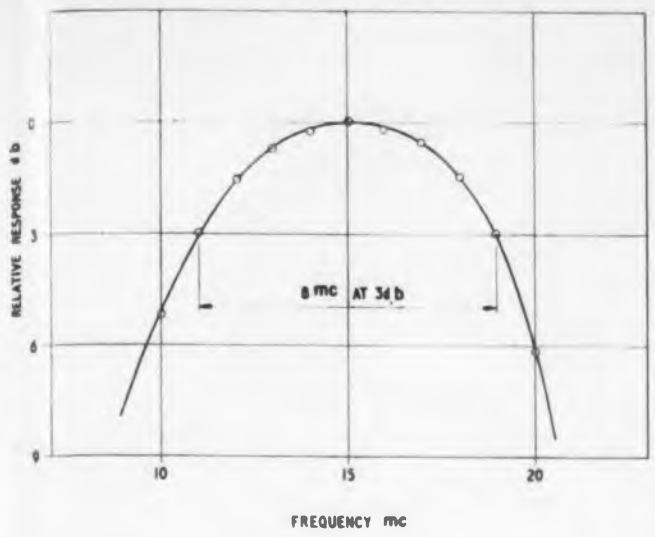


Fig. 4. Frequency response of mercury delay line.

purpose. The frequency response of the complete line is shown in Fig. 4.

It is important not to introduce noise. In this apparatus, provided the signal at the receiving crystal has a level of more than a few microvolts, the noise contributed by the line and its termination is negligible compared with the noise in the receiving amplifier. By working at a received signal level of 3 mv, a signal to noise ratio of 50 db is secured. The insertion loss of the line is around 50 db so that the transmitted crystal needs a drive of only about one volt, which can readily be provided by a small receiving type tube with adequate linearity.

When variable mercury lines were first made experimentally it was expected that difficulties might be found in preserving the received signal—in amplitude, frequency response, or both—while the delay was being varied, since this requires the mercury between the crystals and reflector to be displaced. It has been found possible to overcome these difficulties, and the signal received when the delay is being varied is indistinguishable from that with a stationary delay, except for the inevitable Doppler shift of frequency.

Mercury is poisonous in both vapor and liquid forms. It also amalgamates very readily with almost all metals except steel and nickel. On both these counts it is a dangerous substance to include in electronic apparatus. These mercury lines are therefore hermetically sealed, so that there is no possibility of either vapor of liquid mercury escaping. The very sturdy steel construction assists in the sealing. The hermetic sealing also ensures that no foreign matter can find its way into the system.

Acknowledgements

Acknowledgement is due to the directors of Mullard Ltd. and the manager of the Mullard Research Laboratories for permission to publish this paper.

Reference

1. Mason, W. P., Electromechanical Transducers and Wave Filters, 2nd Ed., D. Van Nostrand, N. Y. (1948).

Power Tetrode Transistor

LOW distortion, high power output and a reduction in complementary circuitry are achieved with this power tetrode transistor, the first available commercially. It is expected to have wide application in the audio amplifier field and in various switching operations.

The H200E tetrode, a germanium pnp alloyed junction transistor, was developed by Minneapolis-Honeywell Regulator Corp., Minneapolis, Minn. Designed to operate from 28 v collector supplies with currents up to 10 a, the device is characterized by two separate leads to the base or control layer. Double base construction permits a high degree of control over the unit through the use of external biasing circuitry.

Low distortion, high efficiency and high power output are obtained without feedback and without input transformer drive, permitting R-C or direct coupling. A direct-coupled Class A amplifier power output stage is illustrated in Fig. 1. Direct coupling is also possible without low d-c resistance in the driving source. The leakage current, particularly in the region near cutoff, flows into the second base contact, bypassing the emitter junction. It is not amplified by the transistor current gain, consequently improving thermal stability.

The tetrode offers more than a fifty per cent increase in frequency response over conventional triode systems. In addition, improvements over triode operation in current drive circuits is possible without the auxiliary battery. Some back bias can be de-

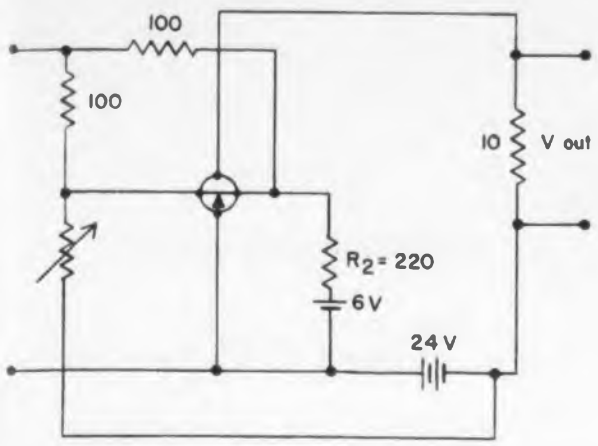


Fig. 1. Class A amplifier. Quiescent collector current is 1.2 a; power gain, 27 db (f = 100 cps); large signal beta, 50; large signal beta cutoff frequency, 12 kc. Total distortion is 0.5 per cent for a 1 w output at f = 100 cps and 2 per cent for a 5 w output. Drain on the auxiliary 6 v biasing battery is about 22 ma.

veloped by using a resistor or, preferably, a silicon diode in the emitter lead. A comparison of triode and tetrode operation of the device in a Class A circuit with a high impedance source is indicated in Fig. 2.

Where operation over a wide temperature is necessary a fixed resistor R_2 may be replaced by a thermistor compensating network. This operating point stability can be accomplished without loss in output power and is of particular value in Class B operation. Junction temperature of the H200E is limited to 95 C with a thermal resistance of 1 C per watt.

For additional information about this power tetrode, fill out the enclosed Reader's Service Card and circle 32.

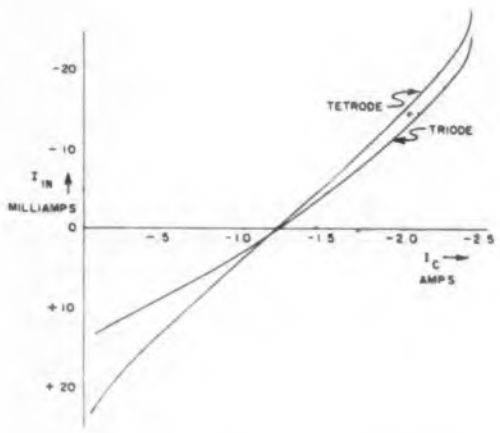
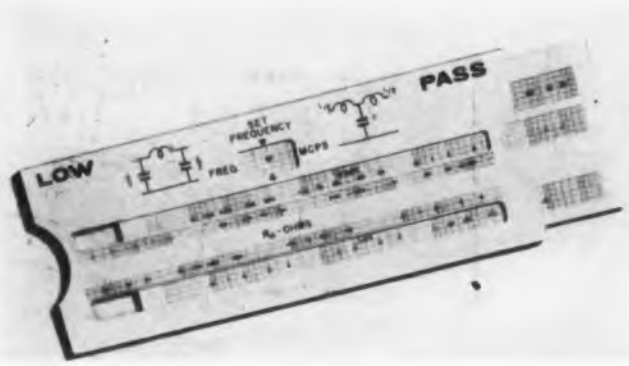


Fig. 2. Triode and tetrode operation in a Class A circuit with a high impedance source.



Do-It-Yourself

Slide Rule for Filter Design

Ralph Davidson
Sperry Gyroscope Co.
Division of Sperry Rand Corp.
Great Neck, N.Y.

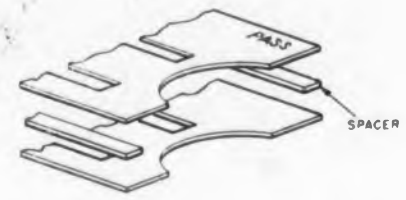


Fig. 1. Cardboard spacers are inserted as above. Spacers should be the same width as the inside slider, to provide the proper amount of friction.

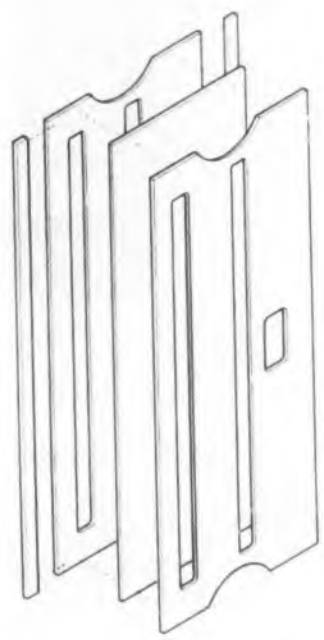


Fig. 2. Exploded view of slide rule. Align arrow markers on both scales; staple along edge through spacers.

◄ CIRCLE 34 ON READER-SERVICE CARD

THIS slide rule was constructed to provide a fast and accurate method for calculating the reactive elements of a low-pass constant K type filter.

This slide rule solves the following formulas:

$C_k = \frac{1}{\pi f_c R_o}, L_k = \frac{R_c}{\pi f_c}$ Low-pass Constant K type

$C_k = \frac{1}{4\pi f_c R_o}, L_k = \frac{R_c}{4\pi f_c}$ High-pass Constant K type

The reactive element configurations are shown on the face of the slide rule. These basic elements can be used to determine the values for M-derived type filters by substituting in the appropriate formulas.

Construction

- Glue all templates to hard cardboard.
- Cut out along marked lines.
- Place spacers as shown in diagram. Remember to align arrow markers on both scales.
- Staple along edge (through spacers).
- Place slider into center section as shown in diagram.

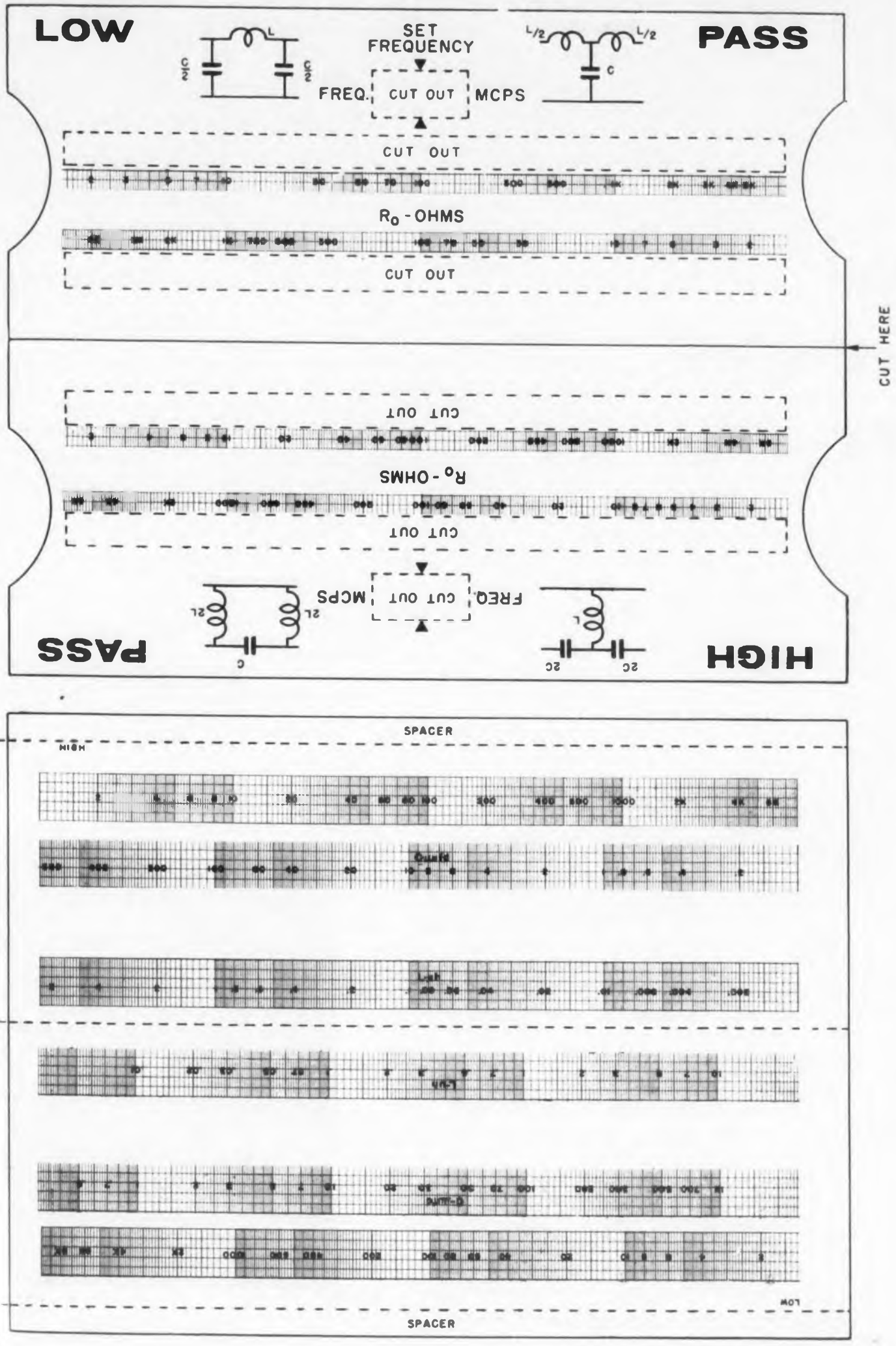
How to Use the Slide Rule

For example, suppose a low pass filter is needed in a 50 ohm system, to reject all frequencies above 150 mc. Set the arrow in the set frequency window to 150 mc. On capacity scale opposite 50 ohms read capacitance (10.8 μμfd). On inductance scale opposite 50 ohms read 0.00265 μh.

References

"Filter Element Nomographs," Pg. 87, *Tele-Tech and Electronic Industries*, February 1954. "Band Pass Filter Nomographs," Pg. 113, *Tele-Tech and Electronic Industries*, June 1954.

CIRCLE 35 ON READER-SERVICE CARD FOR A FREE REPRINT



A Solid Electrolyte Battery

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General Electric Company
Auburn, New York

THIS ARTICLE describes a fundamentally new type of battery employing a solid electrolyte. By virtue of its unique construction and chemistry, it displays very long-life, compactness and ability to withstand environmental extremes. These properties qualify it for applications heretofore not feasible with conventional batteries. Included are tentative specifications of this battery, its construction and chemistry, and typical characteristics of the finished device. A brief survey of its potential applications is also given.

Specifications

The battery is shown in Fig. 1 along with a cut-a-way view illustrating its internal construction. Tentative specifications are given in the table.

It is instructive to compare these specifications with those for a conventional size D flashlight cell. In a volume only 0.026 times as large, this battery produces a potential 63 times as great and has a storage life 10 times as long. These advantages are gained by sacrifices resulting in only 0.000067 as much available charge, and an ability to deliver current reduced by a factor of 10^7. Obviously, this battery is not intended as a replacement for conventional batteries, but instead, will fulfill requirements for which batteries have not heretofore been suitable.

Construction and Chemistry

A typical 94 v battery consists of 127 individual cells which are constructed as shown in Fig. 2. The electrolyte, silver-bromide, is a truly dry solid. The chemical reactions that are believed to take place within one of these cells are shown in Fig. 3. The fundamental action is that of all electrochemical cells, the conduction of ions through an electrolyte. Here, however, this action takes place by the diffusion of positive silver ions through a solid electrolyte. Also the net result of the chemical reaction is the displacement of electrons and the generation of additional electrolyte. In the reaction, the silver is used up and the cupric bromide is converted to cuprous bromide.

The open circuit voltage of such a cell is determined by the partial pressure of the bromide gas within the cathode space. Its ability to deliver current is a function of the cross-sectional area of a

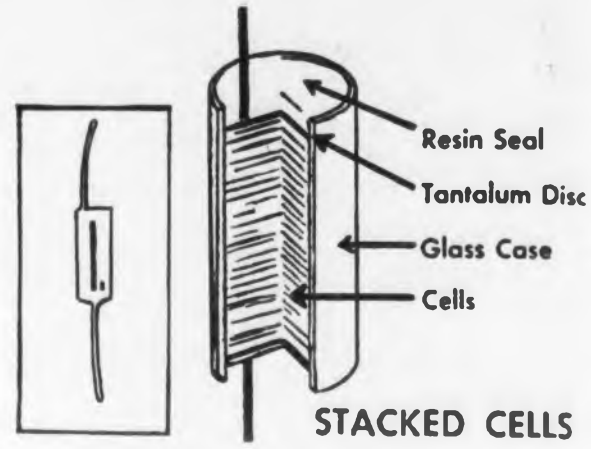

Fig. 1. Photo and cutaway drawing of solid electrolyte battery.

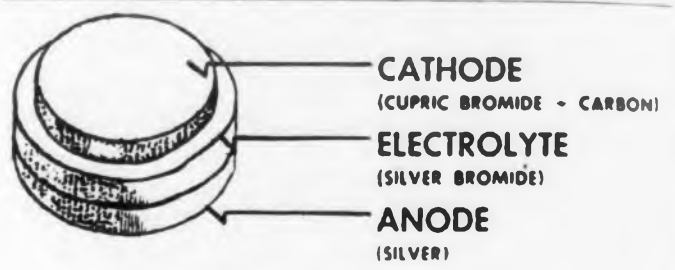

Fig. 2. Basic cell.

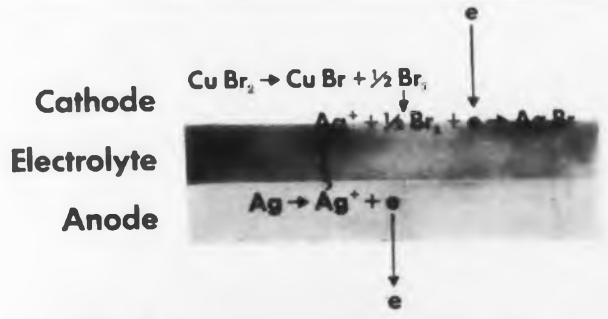

Fig. 3. Chemical reactions within cell.

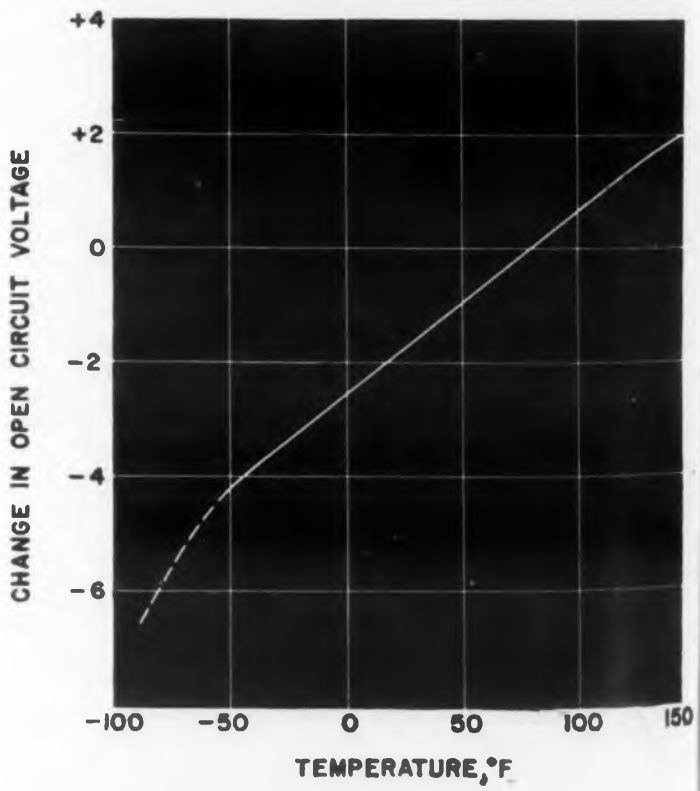

Fig. 4. Voltage-temperature characteristic.

Tentative Specifications of Solid Electrolyte Battery

Physical		Electrical	
Characteristic	Specification	Characteristic	Specification
Length	31/32 ± 1/64 in.	Open Ckt. Potential	94 ± 6 v
Diameter	0.335 ± 0.005 in.	Charge Available	1 coulomb
Leads	1 in., Copper-nickel	Flash Current	4 μamp min (70 F)
Weight	0.15 oz.	Storage Life	20 years (70 F)
Shock & Vibration	Very high		720 hrs. min (165 F)
Temperature	−100 to +170 F		
Humidity	To 50 per cent R. H.		

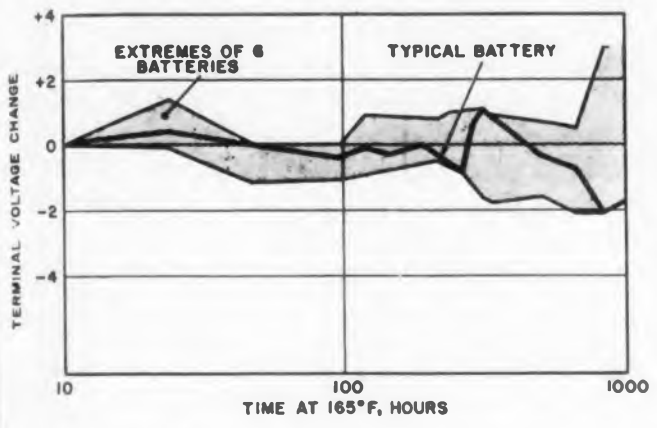

Fig. 5. High temperature stability.

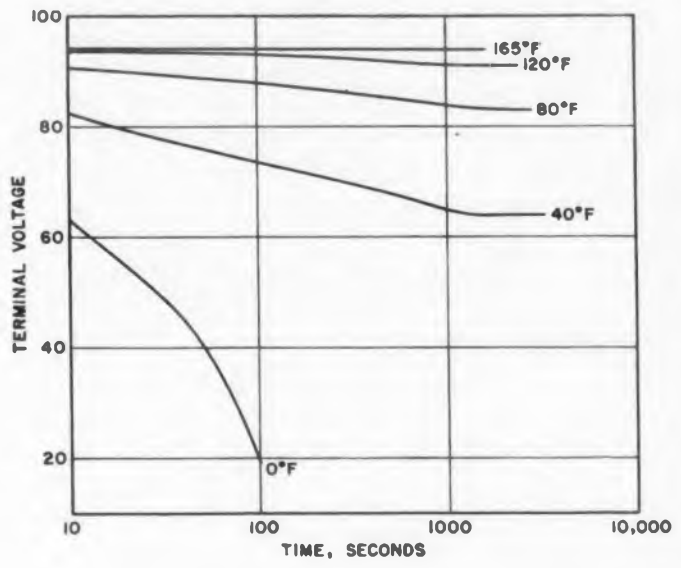

Fig. 6. Constant current characteristics.

cell, the thinness of the electrolyte, and the temperature. The available electric charge is determined by the cross-sectional area and the amounts of cathode and anode materials. It is interesting to note that this type of cell derives its long storage life from the unique properties of the electrolyte. Although the silver bromide demonstrates a usable ionic conductivity, its electronic conductivity is exceedingly poor. Thus, internal discharge, caused by electrons traversing through the electrolyte, is greatly attenuated.

Typical Characteristics

Two important factors were considered in obtaining measurements of the characteristics of this battery. Since the battery was intended for use in a broad range of demanding applications, considerable data have been gathered illustrating its ability to withstand environmental extremes. In addition, the low current capabilities of this battery indicated that many applications would require current levels representing a severe load on the battery. Thus, measurements have been made at conditions which would normally represent extremely heavy currents for such a battery.

Voltage-Temperature Coefficient. The typical effect of temperature on the open circuit voltage is shown in Fig. 4. Note that the relation is approximately linear from −50 to over 100 F. The extreme low temperature readings indicate a sharp roll-off, but this characteristic has not yet been thoroughly evaluated because, at very low temperatures, the current delivery capabilities of the battery become extremely minute, placing severe demands upon the insulation qualities of the instrumentation.

High Temperature Resistance. The ability of the battery to withstand temperatures is displayed in Fig. 5. The shaded area represents the extremes of measurements on six typical batteries while the heavy line shows the variation of one of these batteries. Note that the maximum change does not exceed 3 v over a period of 1000 hr.

Current Characteristics. Illustrated in Fig. 6 is the terminal voltage-time characteristic of a typical battery when subjected to a constant current of 0.1 μamp.

At normal and high temperatures, the terminal

voltage gradually decreases until it stabilizes at a constant level. Since the terminal voltage is a function of the period pressure of bromine gas within the cathode, these curves can be explained by noting that at any constant current and temperature, an equilibrium pressure will be established representing a balance between the removal of bromine by the transport of charge and evolution of bromine by the dissociation of the cupric bromide.

The rapid decay of terminal voltage toward zero at 0 F indicates that, at this temperature, the bromine gas evolution cannot match its rate of removal. Thus, a current of 0.1 μamp cannot be maintained at extremely low temperatures by the electrochemical mechanism. In practice, this current can be maintained at 0 F and lower, but only by the use of an external driving potential high enough to reverse the potential of the cells of the battery. Such an action results in the short circuiting of the electrolyte by the growth of silver dendrites and the temporary destruction of the battery. When the battery is returned to normal conditions, these dendrites often disappear permitting the battery to regain its normal characteristics.

Recovery Characteristics. The normal recovery characteristics of this battery are illustrated in Fig. 7. At each of the four temperatures, the battery has been subjected to a current sufficient to result in a stable drop in terminal voltage of 33 v. This figure indicates that, at high temperatures, most of this drop represents internal resistance effects rather than temporary polarization. Thus, the bulk of the recovery of the battery is accomplished immediately upon removal of the load. At normal and lower temperatures, however, polarization effects predominate and terminal voltage is recovered in a smooth slow curve. Although this figure does not so indicate, full open circuit voltage is eventually recovered on a typical battery.

Load Characteristics. Terminal voltage vs time is shown in Figs. 8 and 9 for several resistor and capacitor loads. These are included to show, in general terms, the types of possible loading that can be used with this battery.

Problems of Application

In applying this battery several precautions should be taken:

External Leakage. If decades of life are required of the battery, care should be taken to avoid the removal of any significant portion of the available charge. This precaution suggests the use of insulating materials having very high volume resistivities (10^{14} ohm-cm or higher). Surface leakage must similarly be reduced by encapsulating, coating or desiccating.

Casting Materials and Methods. Since casting is regarded as an excellent method of supporting and protecting the battery under severe physical and environmental conditions, considerable attention has been given to the problems that are encountered here. Cure time and temperatures are important not only because of possible adverse effects from temperatures above 165 F, but also because of the electrical demands that may be placed on the battery during the curing process.

A low volume resistivity of the uncured components combined with a prolonged high temperature cure cycle can result in the complete exhaustion of the battery. Unmodified epoxy and polyester resins cured below 165 F have been found to be generally satisfactory in this respect. Since these are usually quite rigid, their cure shrinkage and coefficient of expansion should be reduced by heavy loading with inert fillers such as quartz or alumina. If extreme thermal cycling will be encountered, it is desirable to "cushion" the battery with a dip coat of room temperature vulcanizing silicone rubber.

An additional consideration stems from the fact that the battery is not yet hermetically sealed. It is thus important to employ only casting materials resulting in very low volatiles content.

Allied Components. In a typical application, the battery may be connected to such components as resistors, capacitors, wires and switches. Care should be taken to assure that these components protect the battery from undesirable leakage. As an example, capacitors employing Mylar, Teflin, polystyrene or glass dielectric are preferable to paper.

Applications

In general, it is believed that the battery will find application in four broad areas: *1. One-shot devices*, in which the required energy is stored on a capacitor; *2. Intermittent devices* in which the required energy is repeatedly stored on a capacitor; *3. Bias supplies* in which a potential is all that is desired and currents are only leakage current; and *4. Very*

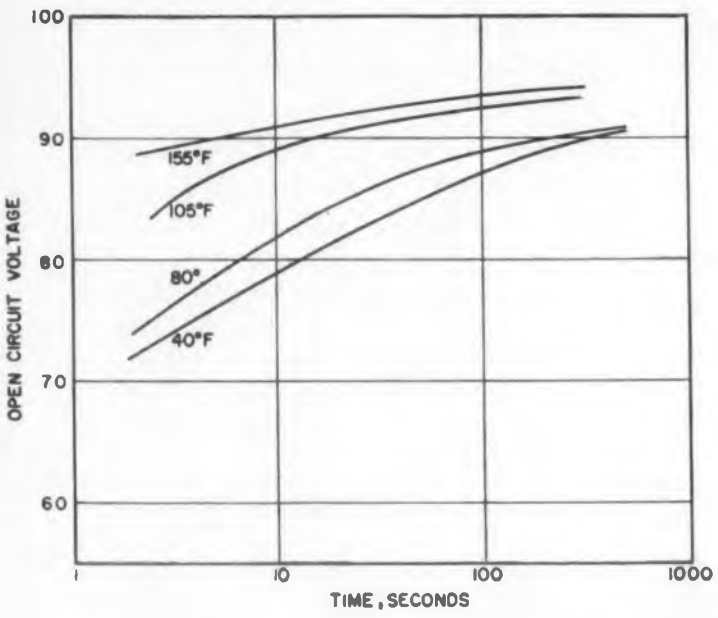

Fig. 7. Recovery characteristic (33 v drop).

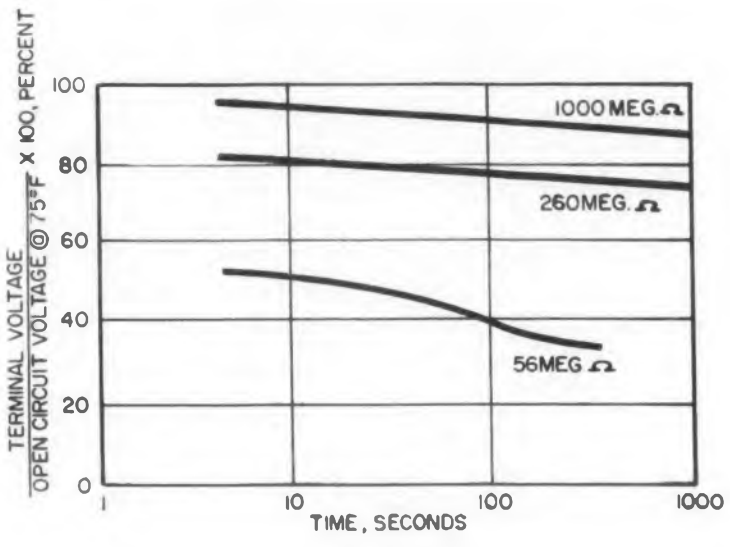

Fig. 8. Resistor load characteristic (75 F).

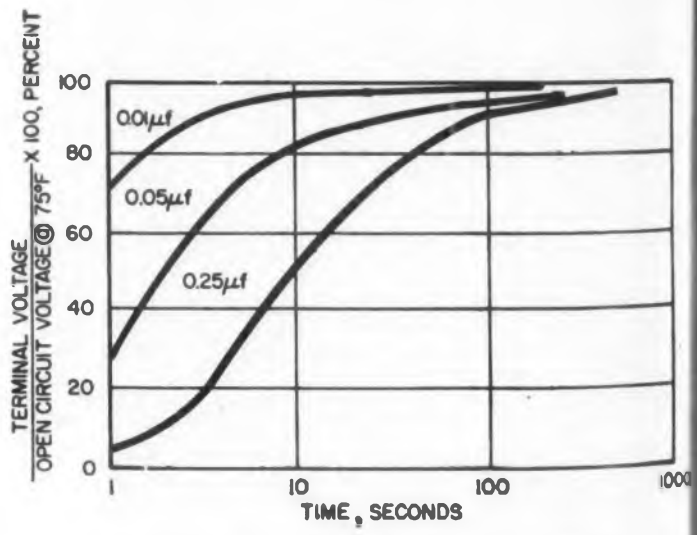

Fig. 9. Capacitor load characteristic (75 F).

low drain supplies wherein long periods of disuse dictate a source having excellent storage life.

Typical of the applications is its possibility of use as a voltage source for the first four or all ten of the dynodes of multiplier phototube. Often, these tubes are used in conjunction with scintillation devices for radiation survey. In such applications, the input is a rapid series of minute, brief pulses of light wherein the average light intensity is very low. Since the current is a direct function of the light intensity, the statements above will apply also to the demands placed upon the power supply. This is, therefore, a good illustration of the very low drain type of device. Since, typically, each dynode requires between 75 and 100 v for proper operation, use of these batteries can reduce the other power supply requirements from an original 1000 v to 600 v or less.

Because such a device is often employed in portable and monitoring equipment, the physical ruggedness, long life and ability to withstand temperature extremes on the part of the battery would be important. Another application that is similar in concept is the use of this battery to power portable ionization devices such as Geiger-Meuller tubes.

The battery is highly attractive in applications where its function is to furnish a deflection potential for cathode ray devices. It should also find use as a power source for numerous transducers such as humidity and temperature sensors. In general, it should find application particularly where long periods of standby service are required and where extreme compactness, light weight and environmental resistance are important.

Future Designs

This battery is but the forerunner of a whole family of batteries, based upon the solid electrolyte concept, that will be realized in the future. Obviously, batteries exhibiting a wide range of characteristics can be made by simply altering the configuration of cells of the present type. As an example, the current and charge capabilities can be greatly enhanced by increasing the cell area. Altering the thickness of the three portions of the cell permits further control of the current and storage life.

With the refinement of basic knowledge, one can expect to see the development of batteries having still greater performance in each important characteristic and to see the solid electrolyte principle employed in many diverse ways.

Based on a paper presented by Mr. Wagner at the 1957 Electronic Components Symposium in Chicago, May 2, 1957. Proceedings of this conference will be published and can be ordered from the sponsoring organizations—RETMA, AIEE, IRE and WESCON.

Background for Designers

Measurement of Capacitor Insulation Resistance

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Sprague Electric Co.
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THE insulation resistance of capacitors is a complex combination of several factors. Among these are semi-ohmic resistance, (anomalous) absorption current, residual charge currents, apparent current readings due to the measuring equipment, and leakage current caused by the capacitor enclosure. In this discussion of insulation resistance, the capacitors are either of the impregnated-paper or plastic-film dielectric types. For purposes of discussion the nomenclature in Fig. 1, the schematic of a basic measuring circuit, will be used. R_c is the primary component of leakage resistance. C_c is the ac capacity. R_m is the equivalent series resistance of the meter. R_a and C_a form an equivalent circuit to account for the absorption current.

For a given capacitor construction some of the important factors which contribute to the leakage current are measuring apparatus, temperature, time, and voltage.

Effect of Measuring Apparatus

The effect caused by the measuring apparatus is perhaps the least understood component of apparent leakage current. In many cases, however, this component may be the principal one. An illustration of its importance is as follows:

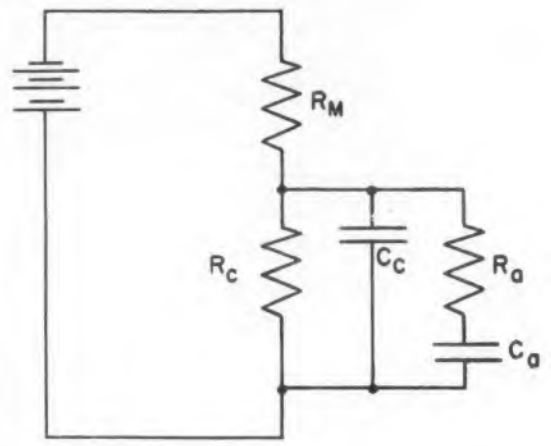

Fig. 1. Basic measuring circuit for capacitor insulation resistance. R_m is the equivalent series resistance of the meter; R_c is the primary component of leakage resistance; C_c is the ac capacity; R_a and C_a form an equivalent circuit to account for absorption current.

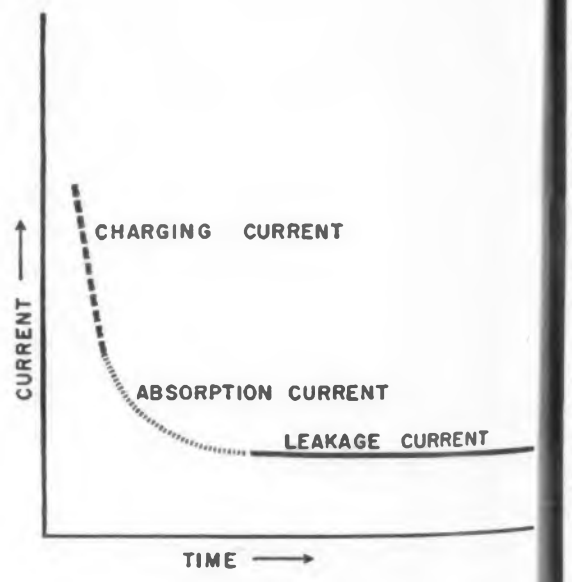

Fig. 2. Idealized curve of leakage current with time.

Assume a value of 10^{10} ohms for R_m, 10^{12} ohms for R_c, and 100 v for the supply. If the capacity of C_c is of the order of 1 μf, the time constant of R_m and C_c is 10,000 sec. It is, therefore, advisable that a quick charge be used. To accomplish this quick charge, R_m is momentarily shorted. This places a charge of 100 v on C_c. The temporary short is now removed from R_m. There is no current flowing through R_m due to the bucking action of the voltage on C_c. Current begins to flow in R_m as the voltage on C_c decays through R_c. The final division of voltage between R_c and R_m will be 100 to 1. Therefore, C_c must decay from 100 v to approximately 99 v before the meter can indicate the true current being drawn by the capacitor. The time for this decay to take place is computed as follows:

$$V/V_0 = \exp(-T/RC);$$

$V = 99$ v; $V_0 = 100$ v; $R = R_c = 10^{12}$ ohms; $C = C_c = 10^{-6}$ f

substituting: $99/100 = \exp(-T/10^6)$; $T = 10^4$ sec.

Therefore, the insulation resistance meter represented by R_m will not read the full leakage current drawn by the capacitor until 10,000 sec have elapsed from the quick charge. As the ratio of R_c to R_m becomes greater, the time lag becomes less. Thus, it can be seen that the above illustration represents a very cumbersome method. Actually, where the values of $R_c \times C_c$ are in excess of 10^5, the ratio of R_c to R_m is all important. If, in the above illustration, R_m is 10^8 ohms, then the division of voltage is 10,000 to 1. Solving for time as above gives:

$$99.99/100 = \exp(-T/10^6); \quad T = 100 \text{ sec}$$

This time is less than the conventional two minute reading, and the measurement of the capacitor leakage current takes only two minutes instead of almost three hours. It is, therefore, usually desirable to have a current or resistance measuring device with a minimum R_m.

Temperature, Time, and Voltage Effects

Time is also a factor of the observed leakage current. Because of the effect of R_a and C_a, these components of dielectric absorption will cause the apparent insulation resistance to increase in a decreasing exponential form. R_c is not a truly ohmic resistance and is somewhat affected by voltage. For some mylar capacitors it is by a factor of 10. That is, the insulation resistance at 50 v dc is ten times that at 500 v dc.

It is well known that temperature has a great effect on the leakage of a capacitor. It also has an effect on R_a and C_a such that at elevated temperatures, the effect of absorption is minimized and the final current due to R_c is reached in a shorter time than at lower temperatures.

Components of Leakage Current

In Fig. 2 is an idealized drawing of the leakage current of a capacitor vs time. The effects due to

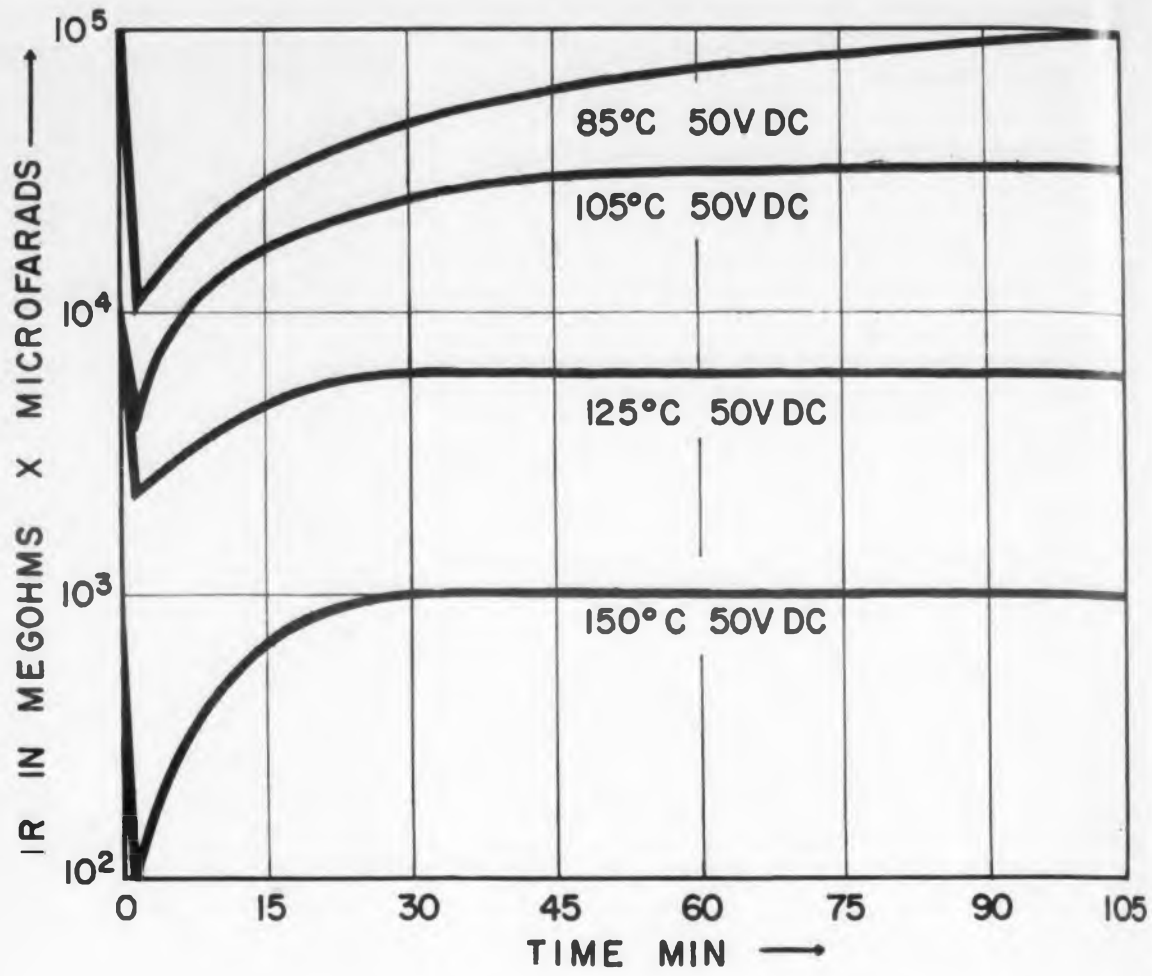

Fig. 3. Leakage current curves for a 1.0 μf mylar capacitor at various temperatures. Note that true leakage current is only measured after considerable time—30 minutes for 150 C.

measuring equipment have been ignored. Initially the current is primarily the charging current of the capacitor. The final steady state current is called the final leakage current due to R_c. There is, however, between these two currents a current that cannot be explained by either mechanism. This current is called the absorption current. The absorption current then is equal to the observed current at time t minus the current due to R_c minus the charging current at time t.

In Fig. 3 is shown a summary of graphs taken on a 1.0 μf mylar capacitor using an SIE Model C-6 insulation resistance meter with a potential of 50 v. A quick charge was used. At all temperatures, the primary component of leakage current for the first 1-1/2 min was due to the equipment. This is the cause of the "null" in readings. From 1-1/2 min until the straight line condition is reached, primarily dielectric absorption current is being measured. Only when the leakage current approaches a straight line is the true leakage current measured. The characteristics of the leakage meter used were such that results are questionable in excess of 10^5 megohms. At 85 C, therefore, even after 105 minutes, the final insulation resistance was not obtained.

From voltage decay tests, there are indications that the insulation resistance of Mylar at 25 C is

well in excess of 10^6 megohms. At 105 C, the final insulation resistance was reached at 45 to 60 min and at 125 and 150 C, it was reached after only 30 min. If two-minute readings were taken on this apparatus, the results would be 5 to 10 times lower than the final value. The actual value reported here for mylar is not to be taken as typical of actual performance, as too small a sample was used. The actual variation from unit to unit even within the same lot of mylar may be considerable.

At higher voltages the final value of insulation resistance is reached in a shorter time. Measurements on this same capacitor at 125 C and 500 v dc showed a final reading at 15 min. This final reading, however, was approximately 7×10^2 megohms instead of 6×10^3 at 50 v dc.

Effects of the Capacitor Case

The shunting effect of the capacitor case sometimes is a factor in the insulation resistance, especially where such dielectrics as teflon or polystyrene are concerned. Protective wrapping and filling or impregnating compounds may decrease the measured insulation resistance as well as external conditions such as dust, moisture, and soldering flux on the glass or ceramic terminals. These factors are widely variable, but they should not be ignored.

Conclusions

The author has no proposal for a simple, quick, effective way to measure insulation resistance. The two-minute reading, which is frequently taken as standard in the capacitor industry, often tells very little. Designers who use capacitors should be aware of this and should take it into account when specifying a desirable insulation resistance. Treat a capacitor not as a simple RC network, but as a complex RC network. Taking into account the effects of absorption is the only effective way of analyzing the behavior of a capacitor when the leakage resistance is a factor in the circuit performance. As more sensitive leakage meters become available (those with smaller R_m, the problem of artificial readings due to the ratio of R_m to R_e will become less important.

Bibliography

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2. "Recognition of Possible Measurement Errors in DC Dielectric Testing in the Field," Curdts and Ross, Transactions Paper No. 55-456, American Institute of Electrical Engineers, 1955.
3. "The Insulation Resistance of Capacitors after Long Time Electrification," Grahame and Schmidt, IRE Transactions on Component Parts, Volume CP4, No. 1, March, 1957.
4. "The Effective Leakage Resistance of Several Types of Capacitors," Tucker and Breskind, IRE Transactions on Component Parts, PG CP-3, April, 1955.
5. "A Critical Resume of Recent Work on Dielectrics," R. Hartshorn, Journal of the Institute of Electrical Engineers, Volume 64, 1926.

New Products

Low Impedance Z Angle Meter

Measures in Polar Form

Type 314-A Z Angle Meter is designed specifically for measuring in polar form. The magnitude of the measured impedance is indicated by balancing a single control for a null meter reading. The phase angle is indicated in similar fashion by a null balance made subsequent to the magnitude balance.

Impedance magnitude ranges from 0.005 to 1000 in six steps; the phase angle ranges are 0 to 90 deg lead or lag. Meter has a frequency range of 30 to 1000 cps. Its accuracy with respect to the impedance magnitude is ± 1 per cent, and with respect to phase angle, ± 1 to ± 2 per cent.

Acton Labs., Dept. ED, Main St., Acton, Mass.

CIRCLE 43 ON READER-SERVICE CARD FOR MORE INFORMATION

Tubular Capacitors

Shape Saves Weight and Space

The rectangular form of these tubular capacitors saves 1/3 the space required by round tube types, and reduces the weight. Units fit closer to the chassis, and can be fixed in place with epoxy adhesive, exposing far more surface to the adhesive than does a round type. Units can be shaped by the manufacturer to fit special configurations. Compression glass-to-metal hermetic sealing is employed. The same capacitance and voltage ranges are provided as in conventional tubulars.

Electron Products Co., Dept. ED, 430 N. Halstead Ave., Pasadena, Calif.

CIRCLE 44 ON READER-SERVICE CARD FOR MORE INFORMATION

Vibrator Replacement

For Two-Way Mobile Radio

A transistorized replacement for vibrators in two-way mobile radio communications equipment has the extra capacity necessary to operate both the transmitter and receiver units. The unit is designed for 12 v systems and is capable of switching over 9 a dc and will operate on both positive and negative sources. The vibrator uses proven solid set components in an exclusive circuit.

Transval Engineering Corp., Dept. ED, 10401 Jefferson Blvd., Culver City, Calif.

CIRCLE 45 ON READER-SERVICE CARD FOR MORE INFORMATION

Digital Storage Drum

Modular Design

This digital magnetic storage drum permits different diameter surfaces to be affixed to a standard hub. The modular design is ideally suited for digital system development groups, process automation systems, buffer storage applications, or for any installation where an inexpensive, versatile memory system would be appreciated. Drum diameter, speed, read/record heads and associated circuitry may be selected by the systems designer to meet his individual requirements.

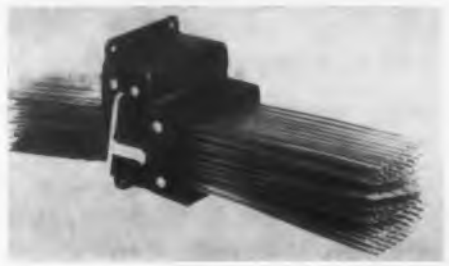
The concept permits engineers to acquire digital storage techniques before investing in a finalized, higher-priced drum.

Monroe Calculating Machine Co., Electronics Div., Dept. ED, Morris Plains, N.J.

CIRCLE 46 ON READER SERVICE CARD FOR MORE INFORMATION

Flexible Printed Cab

Savings in Weight and Size



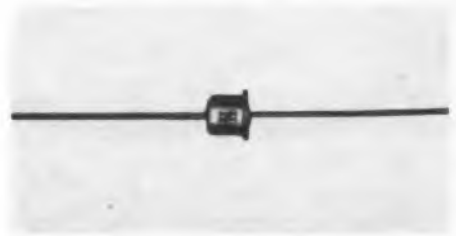
Made of silicone rubber with or without glass reinforcement, this cable can be produced in any length and in various conductor patterns. Weight savings of 4:1 for signal cable and 2:1 for power cable are possible. This type cable is designed for the firm's cable harness system but will be engineered to individual requirements. Also available with the harness system are pressure type connectors for 600 F service. From 10 to 150 contacts with a wide range of ratings are included within a single connector. Continuity checks, to locate a particular conductor, are eliminated because the conductors always remain in a fixed location relative to one another. Terminations are available for the printed cable, conventional cable or printed circuit boards.

Cinch Mfg. Corp., Graphik Circuits Div., Dept. ED, 200 S. Turnbull Canyon Rd., La Puente, Calif.

CIRCLE 47 ON READER-SERVICE CARD FOR MORE INFORMATION

Silicon Rectifiers

Rated 250 Ma at 150 C



These Top Hat Design Rectifiers have current ratings up to 250 ma at 150 C ambient, and peak reverse working voltages up to 500 v. Diffused junction offers long life and high efficiency. They are available in the following RETMA types: IN536, IN537, IN538, IN539, IN540, and IN1095.

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

CIRCLE 48 ON READER-SERVICE CARD FOR MORE INFORMATION

Inductor Assemblies

For Printed Circuits

A wide range of standard variable inductors and coil form assemblies for printed circuit application has been designed for commercial and military applications at audio and rf frequencies. The coils feature mica-filled forms, litz windings, and a built-in torque device for smooth stay-put tuning. Illustrated here is a P 120 variable inductor, one of a standard series covering the 2 to 2000 μh range.

Also available now are the series 700 adjustable coils and the F 700, PF 120 and PF 130 coil form assemblies. The series 700 coils feature high Q at audio and supersonic frequencies. The new coil form assemblies permit winding of coils from 0.5 μh to 2 h, and all forms have four terminals designed for printed circuit use.

North Hills Electric Co., Inc., Dept. ED, 402 Sagamore Ave., Mineola, N.Y.

CIRCLE 49 ON READER-SERVICE CARD FOR MORE INFORMATION

High Voltage Source

Provides 15 Kv

Hyvolt-15 provides a completely adjustable source of high potential (0 to 15 kv) for general purpose use. Its primary purpose is to provide insulation, dielectric and cable test information, and it can be found useful for many other things such as an aid for locating open circuits, etc. It is a reliable source of high voltage for cathode ray, TV tube anodes and nuclear instruments. Two voltage ranges of 0 to 1500 v and 0 to 15,000 v and two current ranges at 0 to 100 μa and 0 to 500 μa are provided. Insulation resistance can be read to approximately 5000 meg. Ac input is 115 v, 60 through 450 cps, single phase. Dc input is 24 to 30 v (to a built-in vibrator supply). The unit weighs 36 lb.

Harvey-Wells Electronics, Inc., Dept. ED, Southbridge, Mass.

CIRCLE 50 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Ultrasonic Cleaning Generator

125 W Average Power

This ultrasonic cleaning generator, Model AP-25-B, was designed for use with standard tank-type or all-welded stainless steel immersible transducers. For cleaning-rinsing or other two-step operations, the generator output can be switched easily between transducers mounted in separate tanks. Rated rf output of the 10 x 16 x 12 in. deep generator is 125 w average power, with peak power on pulses of 500 w. The generator can be used to drive up to three types B (bulkhead-mounted) immersible transducers, or one 125w type E transducer. These are all meant for mounting in the user's present cleaning tanks, or in tanks made to order.

Branson Ultrasonic Corp., Dept. ED, 40 Brown House Rd., Stamford, Conn.

CIRCLE 54 ON READER-SERVICE CARD FOR MORE INFORMATION

Contact Arc Suppressors

Lengthen Equipment Life

These contact protectors were developed to eliminate arcing and erosion across the contacts of relays or switches. Three basic configurations are available: encapsulated diode types, extremely small in size, for application in limited space; fibre tube cartridge types, and hermetically sealed cartridge types for severe environmental conditions.

Types are available for working dc voltages ranging from a minimum of 15 v to a maximum of 154 v, and at maximum coil currents ranging up to 600 ma. Ease of mounting is made possible through pigtail-type construction.

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

CIRCLE 55 ON READER-SERVICE CARD FOR MORE INFORMATION

Transistor Power Supply

Low Ripple and Noise

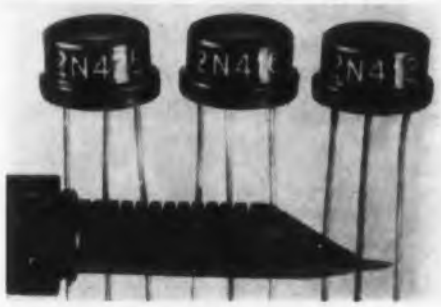
This power source is especially designed for laboratory and development work on low level transistor circuits. Features of the model A-400 include metered output of both voltage and current at extremely low levels with 2 per cent accuracy. Hum and noise output are sufficiently low to permit its use on low level preamplifier, hearing aid, and instrument amplifier circuits. The ripple is less than 500 μv at full output (0.002 per cent) with less than 20 ohms constant internal impedance comparable to a battery. Voltage output ranges of 0-15 v and 0-30 v, continuously variable using auto-former control, and current ranges of 0-15 ma and 0-60 ma allow precise settings.

Perma-Power, Dept. ED, 3100 N. Elston, Chicago 18, Ill.

CIRCLE 57 ON READER-SERVICE CARD FOR MORE INFORMATION

PNP Germanium Transistors

For Computer and Special Purpose RF Use



Of this line of twelve transistors, new in the JETEC-30 standardized package, types 2N425, 2N426, 2N427 and 2N428 are especially for computer use and have alpha frequency cutoff values of 4, 6, 11 and 17 mc respectively. Types 2N416 and 2N417 are for special purpose rf applications and have alpha frequency cutoff values of 10 and 20 mc respectively.

For portable radio receiver circuits there are six new types. 2N413 is designed for local oscillator use. Types 2N414 and 2N415 are converters with 2N414 averaging 26 db and 2N415 averaging 30 db for conversion gain. Types 2N413A, 2N414A and 2N415A are i-f amplifiers with average power gains at 455 kc of 32, 35 and 39 db respectively. Production controls for gain and collector capacity make them ideal for i-f amplifiers with fixed neutralization. All twelve of the transistors come in the JETEC-30 package.

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

CIRCLE 58 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Miniature Connectors

Aluminum Bracket Prevents Damage

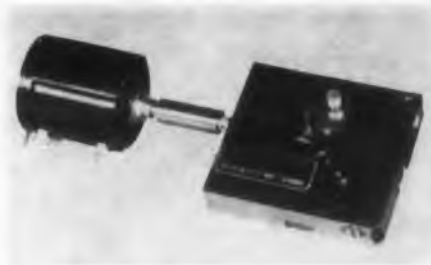
These connectors, though improved, are completely interchangeable with existing military and commercial units of the same type, with the exception of a slight additional width. Screw-locks to facilitate ease of mating and disengagement and to provide a positive vibration-proof lock are mounted directly in the molded insulator. They cannot break loose, rendering the connector useless as often happens with other connectors. The problem is eliminated in the Series WM20 connectors by the incorporation of a die cast aluminum bracket, to which the screw-locks and polarizing guide pins are attached, as an integral part of the connector. This allows inherent body float in the connector, which greatly reduces the chance of damage due to misalignment. The die casting also acts to protect the molding from accidental damage.

Anton Electronic Labs., Inc., Dept. ED, 1226 Flushing Ave., Brooklyn 37, N.Y.

CIRCLE 62 ON READER-SERVICE CARD FOR MORE INFORMATION

Squaring Mechanism

Miniature Computer Device



Shown with a potentiometer attached, this bi-directional mechanical device for squaring and extracting square roots is being manufactured for use in all types of mechanical and electro-mechanical analog computers. Constructed with an aluminum casing, it weighs 10 oz, with a steel casing it weighs 20 oz. The mechanism offers an accuracy and durability which was formerly obtained only in larger devices.

Belock Instrument Corp., Dept. ED, 111-01 14th Ave., College Point, N.Y.

CIRCLE 63 ON READER-SERVICE CARD FOR MORE INFORMATION

Master Scanner Module

Scans 100 Input Channels

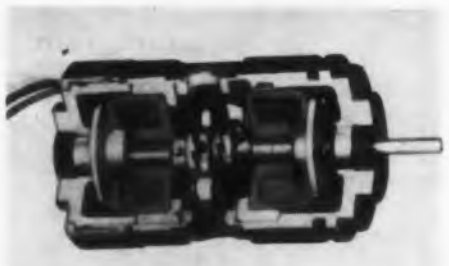
The Master Scanner Module, to be used with the manufacturer's new line of modular instruments for measuring dc, ac-dc ohms and ac-dc ratios permits automatic scanning of 100 input channels. When combined with slave modules of 300 channels each, any number of channels can be selected. Scanning time is 0.1 sec per channel. The number of the channel selected is digitally displayed on a 1 in.-high, edge-lighted display of either 3 or 4 digits, depending upon the model selected. Programming is accomplished manually; however, with the addition of a programming unit, programming can be done with cards or tape. Recycling can be done either automatically or manually.

Electro Instruments, Inc., Dept. ED, 3794 Rosecrans, San Diego, Calif.

CIRCLE 65 ON READER-SERVICE CARD FOR MORE INFORMATION

Positioning Motor

Translates Pulses to Accurate Rotation



This motor is a bi-directional unit translating electrical pulses into uniformly accurate, rotary incremental shaft displacements. They have a wide use as a positioner for guided missiles to adjust heading, fuel flow, altitude, and circuit sampling for telemetering purposes.

The two rotary solenoids contained in each motor produce the incremental motion of the output shaft in either direction. Energizing either of these solenoids produces a combination of linear and rotational motion which moves a ratchet gear axially into engagement with its mating ratchet gear and thus imparts a constant amount of rotation to the output shaft. The detent roller assembly insures constant, reproducible angular shaft rotation increments in either direction and maintains the output-shaft position while the motor is at rest with the power off.

Stepper Motors Corp., Sub. of California Eastern Aviation, Inc., Dept. ED, 7444 W. Wilson Ave., Chicago 31, Ill.

CIRCLE 66 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Transistorized AC Millivoltmeter
2 Meg Input Impedance

The Model 300 millivoltmeter has an input impedance of 2 meg without use of vacuum tubes. Long battery life, twelve ranges covering 0.001 to 300 v, and a frequency response from 8 cps to 800 kc are other features. The unit measures 5 x 7 x 5 in. and has a large 4 in. meter.

Burr-Brown Research Corp., Dept. ED, Box 6444, Tucson, Ariz.

CIRCLE 70 ON READER-SERVICE CARD

Measuring Bridge
Drives High Resistance Instruments

Indicators, recorders, and oscilloscopes available in the 10 mv range work in very well with the B-1 Bridge without the need for further amplification. The bridge measures strain, pressure, load, displacement, acceleration, static to impact speeds, and handles SR-4 strain gages and similar transducers. It drives indicators, recorders, x-y instruments, and oscilloscopes. The unit has low noise pickup and because it operates off the line there is power to drive higher resistance gages fully and thereby get increased sensitivity.

Ellis Associates, Dept. ED, Box 7[illegible], Pelham, N.Y.

CIRCLE 71 ON READER-SERVICE CARD

◀ CIRCLE 69 ON READER-SERVICE CARD

Ceramic Disc Capacitors

Thin for Miniature Circuits

The new copper plating process for manufacturing these ceramic disc capacitors results in increased adhesion and freedom from migration. The process also simplifies production so that noticeable cost savings are achieved. When used for transistorized circuits, the capacitors are made to a thinness of 0.17 max.

Capacities vary in range from 0.01 produced in a 1/4 in. diam body to 0.2 in a 0.72 in. diam body. These values, with a power factor of 3 per cent max at 1 kc, have a working voltage of 30 v dc with a minimum IR of 1000 meg, contingent upon capacity values.

Radio Industries, Inc., Dept. ED, 5225 N. Ravenswood Ave., Chicago 40, Ill.

CIRCLE 73 ON READER-SERVICE CARD

Gold-Bonded Diodes

Combine Silicon and Germanium

This line of subminiature glass diodes incorporating alloys of silicon and germanium is reported to offer a combination of characteristics not possible with silicon or germanium alone. Particularly at elevated temperatures, they are said to combine the higher reverse resistances of germanium diodes with the fast transient response and high forward conductance of silicon diodes. They are particularly suited to high speed computing circuits and other applications where high rectification efficiency at elevated temperatures must be combined with fast recovery time. They are available in standard JETEC type numbers offered in germanium.

Clevite Transistor Products, Dept. ED, 241 Crescent St., Waltham 54, Mass.

CIRCLE 74 ON READER-SERVICE CARD

CIRCLE 75 ON READER-SERVICE CARD ➤

New Products

High Voltage Supply

For Scintillation Counting

This high voltage power supply for use in the field of scintillation counting or ionization chamber work is designed especially for use with the RCA No. 6810 photomultiplier tube. The 10 ma capacity enables it to furnish power simultaneously to several of these tubes for coincidence work. The unit, Model N-413, achieves high voltage with reversible polarity. The high voltage transformer is driven by a power oscillator, stabilized to maintain perfect symmetry, and the output is rectified by means of a bridge rectifier. Polarity is determined by a simple polarity-reversing switch. The voltage amplifier and chassis are at ground potential.

Output voltage ranges from less than 500 to 5000 v dc; regulation of 0.005 per cent is achieved for changes in both line and load; and noise and ripple are held to 50 mv peak to peak at full voltage and load. A standard cell is used for reference. The power supply measures 19 x 8-3/4 x 13-1/2 in.

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

CIRCLE 78 ON READER-SERVICE CARD FOR MORE INFORMATION

Mirror Galvanometer

Highly Sensitive

This mirror galvanometer offering a sensitivity of 2000 mm per μa features a brightly lit, built-in scale, fully legible under normal room illumination. The magnified scale image moves below a stationary index line eliminating the visual effort required by other types of mirror galvanometers. Scale length is equivalent to an optical lever nearly 7 ft long. Both linear and logarithmic scales are available.

Jarrell-Ash Co., Dept. ED, 26 Farwell St., Newtonville 60, Mass.

CIRCLE 79 ON READER-SERVICE CARD FOR MORE INFORMATION

Using Thermistors

Edited by FENWAL ELECTRONICS

Here's more news on thermistors — the tiny, highly temperature-sensitive, semiconductors that are being used in more and more applications in all types of industry.

Let's look at just three ways thermistors are now being used . . . Time Delay, Remote Control and Switching.

A thermistor placed with a variable resistor in series with a battery and a relay (Fig. 1) makes an excellent time delay relay. The high resistance of the thermistor limits the current flow when the switch is closed. The delay time may be increased or decreased by increasing or decreasing the series resistance.

By selecting a thermistor with the same constant as the tube filament it will be in series with, you can keep the current constant during the initial warm-up and prevent an initial current surge.

Bead thermistors are available with attached heaters and mounted in a vacuum bulb. (Fig. 2) The thermistors' resistance is reduced when power is applied to the heater. When placed in the input of a vacuum tube amplifier these thermistors make smooth, noiseless remote gain controls, because there are no moving parts or controls in the grid circuit.

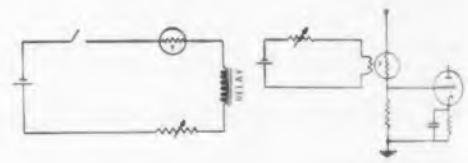


FIG. 1 FIG. 2

When several low voltage light bulbs are connected in series with a suitable thermistor connected in parallel with each unit, (Fig. 3) very little current will pass through the thermistors. Thermistors are not appreciably heated by the small voltage drop across the bulb. If one bulb burns out, the other bulbs remain lighted — the thermistor continues to carry the load of the extinguished bulb. When the bulb is replaced it takes the current from the thermistor. The thermistor then cools off and returns to its idle condition of high resistance and low current.

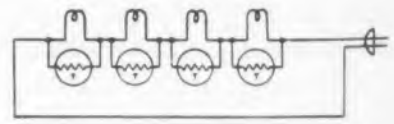


FIG. 3

Engineers: these and other thermistor applications are discussed in 12-page catalog EMC-1. Write for your copy to FENWAL ELECTRONICS, INC., 311 Mellen St., Framingham, Massachusetts.

Fenwal Electronics

Makers of Precision Thermistors

CIRCLE 111 ON READER-SERVICE CARD

Miniature Indicating Switch

Gives Strong Indication

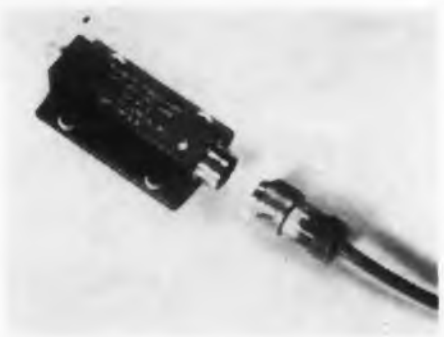
Designed primarily for pulsing remote controlled relays and indicating their operations, the Pan-i-Lite Switch has a maximum diam of 5/8 in. The push-button bulb-lens assembly is an integral unit designed for quick replacement from the front of the panel. Indication can be can be seen at 180 deg and at unusual distances. Bulb-lens assemblies are unusually rugged so can be carried in pocket, tool kit, or mounted conveniently in panel as spares. A versatile electrical layout allows the switch to be wired either as a momentary contact push-button style indicating switch or as a press-to-test indicating light.

Alden Products Co., Dept. ED, 117 N. Main St., Brockton, Mass.

CIRCLE 81 ON READER-SERVICE CARD FOR MORE INFORMATION

Cathode Follower Probes

High Temperature, Shock Mounted



Known as models F-460 and F-460HT, these probes are primarily designed to couple high impedance piezoelectric accelerometers into recorders of telemetering equipment in airborne applications. Weighing 2 oz, the cathode follower probes are designed for continuous operation at temperatures ranging from −65 to +160 F in the case of the F-460, and −65 to +350 F for the F-460HT. No temperature compensation and no external cooling are necessary.

In both cases, complete electronic and vibration testing of all tubes used assures excellent antimicrophonic characteristics. Each tube module is mounted in a silicone compound for shock and vibration isolation and for high temperature operation. Either unit may be supplied with circuit grounds isolated from case ground to prevent ground loops.

Gulton Industries, Inc., Dept. ED, 212 Durham Ave., Metuchen, N.J.

CIRCLE 82 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Time Delay Relay

For High Temperature and Vibration

These miniature time delay relays combine the features of sub-miniature size, light weight, environmental resistance, maximum reliability, and timing accuracy. Applications include aircraft and missile instruments and controls, navigation systems, automation circuits, computers. Through the use of transistors and RC time-constant circuits, all moving parts except relay contacts have been avoided.

Standard models are available with time delay periods from 0.01 to 60 sec delay occurring between application of current and pull-in or relay contacts. Timing accuracy is ±10 per cent of nominal thru a temperature range of −55 to +125 C.

Tempo Instrument Inc., Dept. ED, 240 Old Country Rd., Hicksville, N.Y.

CIRCLE 85 ON READER-SERVICE CARD

Commutator Brushes

Resist Silicone Vapors

These brushes, designated E-26 and E-32, were developed for use on such silicone-insulated equipment as seaboard motors and generators, industrial equipment operating under explosive conditions and semi-enclosed mill-type motors. Earlier brushes used on such equipment have been rapidly consumed by silicone vapors eroding or abrading the brush material. Both brushes are formulated to offset this problem. The E-26 is a high-contact drop grade electro-graphitic brush of rugged construction and long life. The E-32 is a very high contact drop electro-graphitic brush, developed for equipment presenting particularly severe commutating problems.

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

CIRCLE 86 ON READER-SERVICE CARD

CIRCLE 88 ON READER-SERVICE CARD ➤

No. 3 of a Series

Sales and Cooperative Engineering

The Home Office team. These people represent you at headquarters. Call on them for help of any kind.

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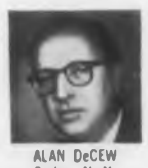
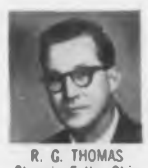
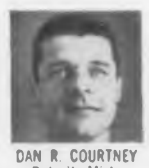


ALAN DeCEW
Sodus, N. Y.



R. G. THOMAS
Chagrin Falls, Ohio



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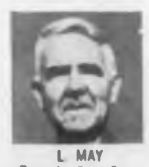


L. MAY
Toronto, Ont. Can.

These men are typical of the more than 70 G-V sales representatives.

Thermal Conductivity Tester

Easy to Use

The K-Factor Tester is a simple apparatus using the bag technique for heat conductivity measurements. Consisting of a portable hot plate unit, a cold bath and a relay rack, the unit meets ASTM requirements, is quick and convenient to use and low in cost. The hot plate unit is a seven layer sandwich of plates held together by spring-loaded bolts. The unit and electrical connections are enclosed in a bag of thin plastic. Measurement can be made with the apparatus in from two to six hours depending upon the specimens. Readings can be taken either from the recorder on the relay rack or from a potentiometer.

Tatnall Measuring Systems Co., Dept. ED, Phoenixville, Pa.

CIRCLE 89 ON READER-SERVICE CARD

Resistor Capacitor Networks

High Accuracy for Summing Amplifiers

Resistor capacitor networks with better than 0.01 per cent accuracy have been designed for use with summing amplifiers operating in the range of dc through 3000 cps. These units are for use in analog computers which can be no more accurate than the accuracy of the resistor capacitor networks employed. Featured in the design are stabilized wire wound resistors that are electrostatically and electromagnetically shielded, and whose residual reactive components are closely controlled. Each unit has a coaxial connector at its output and individual pins resulting in a plug-in network. The rectangular shape is standard, but other shapes and dimensions are available.

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

CIRCLE 90 ON READER-SERVICE CARD

◀ CIRCLE 88 ON READER-SERVICE CARD

Ferrite Core Delay Line

400 μSec Delay, Loss of 3.5 Db

Potted in an epoxy resin to meet MIL specifications, the series P delay lines are available in delays up to 400 μsec with maximum attenuation of 3.5 db. Tapping is readily accessible. A wide variety of rise times and impedances is supplied.

Digitronics Corp., Dept. ED, Albertson Ave., Albertson, L.I., N.Y.

CIRCLE 112 ON READER-SERVICE CARD FOR MORE INFORMATION

Gaussian Noise Generator

Controlled Spectral Density

The Model 301 Noise Generator makes available a random voltage source with a spectral density which is automatically controlled to ±0.1 db from 0 to 35 cps and a Gaussian amplitude distribution with an accuracy of better than 1 per cent. Maximum output voltage is 15 v rms.

The low-frequency noise generator has been used with analog computers to study the effects of random disturbances on fire control systems, guided missile systems and airframe structures.

Electronic Noise Generator Co., Dept. ED, P. O. Box 45344, Los Angeles 45, Calif.

CIRCLE 113 ON READER-SERVICE CARD FOR MORE INFORMATION

Light Beam Projector

For Miniature Photo Cells

Designed for close-proximity use with miniature photo electric cells, this automatic control device can be readily mounted in a single 11/16 in. diam hole. The light source, Model 6375, was designed as a companion component to the recently developed Model 6350 miniature photo electric unit.

Autron Engineering, Inc., Dept. ED, 1251 W. Sixth St., Los Angeles 17, Calif.

CIRCLE 114 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Vamistor Resistor

New Model for 1/2 W, 150 C Service

This model of the Vamistor has a guaranteed change in resistance of less than 1 per cent in 1000 hr load-life test of full 1/2 w at 150 C. Known as the Model 9854, the precision metal film resistor measures 3/4 x 5/16 in. and incorporates the characteristics of stability of other Vamistor models.

Weston Electrical Instrument Corp., Dept. ED, 614 Frelinghuysen Ave., Newark 2, N.J.

CIRCLE 108 ON READER-SERVICE CARD

Radar Test Set

Combines X and C Bands

This set provides all the instrumentation necessary for complete X and C Band checkout of radar and other transmitters in the field, or on the production line. The unit covers frequencies ranging from 5200 to 5900 mc for C Band and from 8500 to 10,000 mc for X Band. For each band, the set contains a spectrum analyzer, power monitor, direct reading frequency meter and signal generator.

Modular-type construction makes it possible to quickly replace any of the sections if necessary. The wavemeter resonant cavity is separately demountable from the rf section for calibration or inspection. Stand-by switches increase the life of all tubes including the klystron, by reducing the filament voltage and removing the plate voltage.

Kearfott Co., Inc., Western Div., Dept. ED, N. Ninedo Ave., Pasadena, Calif.

CIRCLE 109 ON READER-SERVICE CARD

CIRCLE 107 ON READER-SERVICE CARD ➤

New Products

Miniature Twin Triode

Reduced Operating Temperature

This miniature twin-triode with separate cathodes, designated as Type 7062, is designed as an improved plug-in replacement for the older Type 5965 in most computer applications. The tube operates at a reduced heater current of 400 ma as compared with 450 ma for the 5965. A longer glass envelope reduces tube operating temperature and assures more reliable operation.

Amperex Electronic Corp., Special Purpose Tube Div., Dept. ED, 230 Duffy Ave., Hicksville, L.I., N.Y.

CIRCLE 99 ON READER-SERVICE CARD

Record Analyzer and Reader

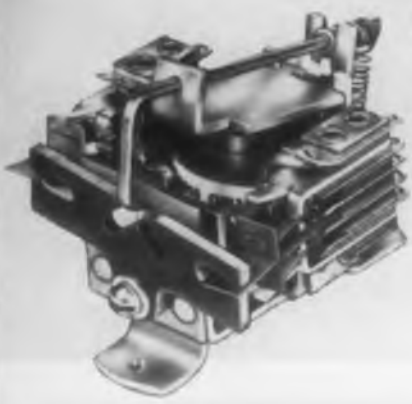
For Limited Points Over Long Record

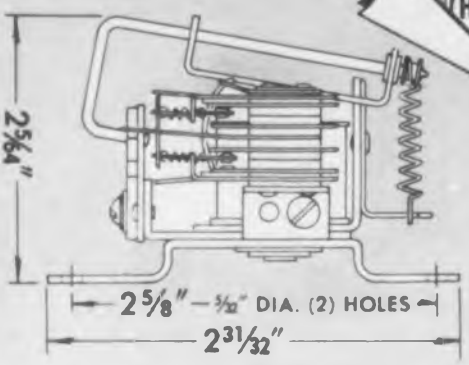
In data reduction situations where a limited number of points are to be read over a long trace record, the Oscarette is useful because of its speed and simplicity. Similarly, where much computing is to be done, the unit is peculiarly applicable as it reads out on a fixed numeric scale. The design permits its use with the Viewpak (oscillograph editor and reader) and also with a translucent screen and projector for film record analysis. This single-axis amplitude-measuring machine, with its motor-assisted cursor drive, has a 9999 count full Y scale and a 15 x 15 in. viewing area. The zero or origin can be set anywhere on the record. The output is to either an IBM Summary Punch or to an electrotyper.

Benson-Lehner Corp., Applications Engineering Dept., Dept. ED, 11930 W. Olympic Blvd., Los Angeles 64, Calif.

CIRCLE 100 ON READER-SERVICE CARD

CIRCLE 102 ON READER-SERVICE CARD ➤





2 1/16" MAXIMUM WIDTH

PC SERIES ENGINEERING DATA

GENERAL: Description: Single coil, impulse latching relay.
Insulating Material: Laminated Phenolic.
Insulation Resistance: 1500 megs. min.
Breakdown Voltage: 500 V. RMS.
Ambient Temperature: —55° C. to +85° C.
Weight: 5 ozs. (open)
Pull-In: DC, 75% } for nominal voltage.
AC, 78% }
Operate: 30 MS.
Terminals: Pierced Solder Lugs
Coil: Two #20 AWG Wires
Contacts: One #20 AWG Wire
Enclosures: "A" Can.

CONTACTS: Arrangements: 4 Form C. max. (4PDT)
Material: ⅛" dia. Silver Cadmium oxide gold flashed.
Load: 5 amp. @ 115 V. AC resistive.
Pressure: 20 grms. min.

COIL: Resistance: .016 to 34,500 max.
Power: DC, 9 watts. } at nominal voltage.
AC, 18.4 Volt Amps. }
Duty: Intermittant.
Insulation: Cellulose acetate wrap; varnish impregnated (open).

MOUNTINGS: Two 5/32" dia. holes on 2⅝" center.

P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC, ELECTRICAL AND REFRIGERATION DISTRIBUTORS

Potter & Brumfield, inc.

PRINCETON, INDIANA
SUBSIDIARY OF AMERICAN MACHINE & FOUNDRY COMPANY
Manufacturing Divisions also in Franklin, Ky. and Laconia, N.H.

Mail the coupon below for further engineering data on P&B's new PC Series relays *plus* new compact catalog of standard type relays. If you need answers to a specific application problem, write in detail.

Potter & Brumfield, Inc., Princeton, Indiana
Attn: T. B. White, Brig. Gen. USMC (Ret.)
Special Projects Engineer

Please send me complete data on the new PC Series relays, plus the new compact catalog of P&B standard relays.

Name_____

Company_____

Address_____

City_____ Zone____ State_____

See our catalog in Sweet's Product Design File

CIRCLE 102 ON READER-SERVICE CARD FOR MORE INFORMATION

Calorimetric Power Meter

Measures from DC to 4000 Mc

These power meters are greatly simplified calorimeters, using an accurate metering pump of the gear type driven by an over powered synchronous motor to keep the fluid flow constant. The instrument is direct-reading, portable, self-cooled and requires only connection to the power line. It does not use any flow meters, thermometers nor any other controls. There is only the on and off switch for the operator to use on the front panel, when a measurement is to be made. A sensitive thermopile and microammeter measure the power dissipated in the rf load. The microammeter is calibrated in watts and is direct reading. The rf load has a low vswr between dc to 4000 mc. This feature makes it possible to calibrate this instrument at 60 cps against an accurate laboratory type wattmeter, and then use it at any frequency up to 4000 mc. Thus an accuracy of 2 per cent can be easily accomplished.

Electro Impulse Lab., Inc., Dept. ED, 208 River St., Red Bank, N.J.

CIRCLE 103 ON READER-SERVICE CARD FOR MORE INFORMATION

Nickel Cadmium Storage Batteries

High Discharge-Charge Rate

Particularly adaptable to missile and aircraft applications, these sintered plate nickel cadmium batteries utilize nylon cell containers. They are capable of operation at temperatures from −60 to +200 F. Cycle life is virtually unlimited. They can be stored for years in any state of charge without damage. Charge retention is excellent. Further advantages include very high discharge rates, rapid charge acceptance and close voltage regulation during discharge. The potassium hydroxide electrolyte does not give off corrosive fumes and there is no gassing on discharge.

Nickel Cadmium Battery Corp., Dept. ED, 64 Pleasant St., Easthampton, Mass.

CIRCLE 104 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Printed Circuit Service

Five-Day Delivery

Five-day delivery of prototype printed circuits is possible with an acid-feed etch system. The new technique provides rapid production of both short-run and volume circuitry on copper-clad dielectric. High speed etching takes place on any copper-clad dielectric material, whether solid plastic, laminate or composition.

Tri-Point Plastics, Inc., Dept. ED, Albertson, N.Y.

CIRCLE 92 ON READER-SERVICE CARD

Pressure Transducer

Measures to 15,000 PSI

Model PT32 excels in situations where large pressures must be measured or recorded with a minimum alteration of the pressure chamber. Overall accuracy, (the maximum deviation from linearity including hysteresis), is within a total of 1 per cent full scale. The pickup operates between −65 to +350 F with temperature effect on sensitivity of 0.005 per cent per F. Minimum output is 3.3 mv per v of excitation.

Dynamic Instrument Co., Dept. ED, 28 Carleton St., Cambridge, Mass.

CIRCLE 93 ON READER-SERVICE CARD

Temperature Test Chamber

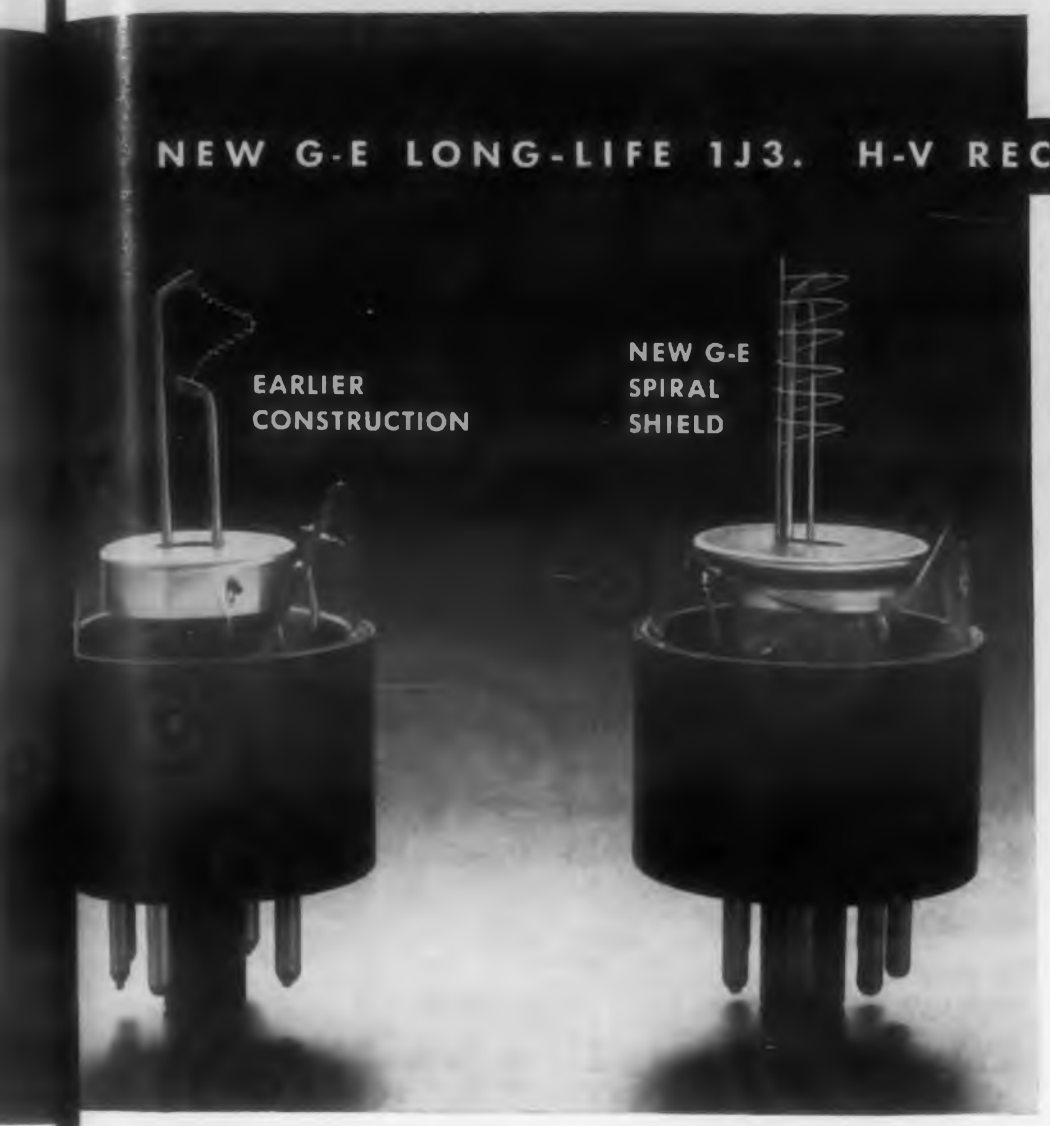
−100 to +1000 F

This chamber makes possible a variance in temperature all in one cabinet of from −100 to +1000 F. Work space measures 2 x 2 x 2 ft. Two recording controllers, one for −100 to +300 F and for +300 to +1000 F, cover the entire range.

International Radiant Corp., Low Temperature Div., Dept. ED, 4 Manhasset Ave., Port Washington, N.Y.

CIRCLE 94 ON READER-SERVICE CARD

CIRCLE 95 ON READER-SERVICE CARD ➤



LEFT: the sharply bowed-out filament on a 1J3 prototype at extreme left, shows how distortion from anode electrostatic pull can easily cause short circuits. In contrast, the tube beside it has G.E.'s new 1J3 spiral-wound shield, surrounding the filament completely, greatly reducing electrostatic pull and minimizing distortion. **ABOVE:** Manager of Manufacturing W. M. Cron scans instrument readings in the course of G-E 100% production testing of 1J3's at higher-than-max operating voltages.

NEW G-E TUBES FOR CRITICAL TV SOCKETS!

Tubes can be used as direct replacements in TV receivers now in production.

Again, by creative tube design—new thinking applied to structure, materials, and methods—General Electric enables TV manufacturers to replace a critical, often short-life tube with one that gives superior service over extended periods.

General Electric's new long-life 1J3 high-voltage rectifier tube—interchangeable with Type 1B3—gives full 360-degree, top-to-bottom shielding against filament distortion from the electrostatic pull of high anode voltages. Electrostatic effect is reduced by more than 2 to 1 over any predecessor tube. This is made possible by a spiral-wound shield surrounding the filament as shown in center, above.

Here is efficient protection against the commonest cause of short circuits and filament breaks in prototypes of the 1J3! Other design features of the new tube promote long-life performance. Moreover, every General Electric 1J3 is factory-tested at 23,000 v d-c, 28,600 v inverse—higher voltages than will be encountered in actual service. *Receiving Tube Department, General Electric Company, Owensboro, Kentucky.*

Your nearest General Electric tube office listed at left will be glad to give you further facts.

Progress Is Our Most Important Product

GENERAL ELECTRIC

162-1C6

Silicon Rectifiers

Rated at 200 and 125 Ma

Sixteen silicon rectifiers characterized by high voltage ratings and excellent efficiency at high temperatures are available. The product line is divided into two groups. Eight miniature silicon rectifiers, designated as the PS100 series, are rated at 200 ma max average forward current; max rms voltage input from 35 to 280 v and temperature rating 150 C. The eight subminiature silicon rectifiers, designated as the PS005 series, are rated at 125 ma, max rms voltage input from 35 to 280 v and 100 C temperature.

Pacific Semiconductors, Inc., Dept. ED, 10451 W. Jefferson Blvd., Culver City, Calif.

CIRCLE 96 ON READER-SERVICE CARD

Precise Color Oscilloscope

Flat to 5 Mc

An oscilloscope, 3151, in kit or wired form, that goes up beyond 9 mc and is flat through 5 mc for color-TV testing, has been announced. The instrument features highly sensitive push-pull vertical and horizontal amplifiers; a 5CP¹ tube with post acceleration; frequency compensated stepping attenuators for both the vertical and horizontal; focus, intensity and astigmatism controls, and output voltage calibration.

Sensitivity is 10 mv per cm, and there are frequency compensated stepping attenuators in the input, and push-pull pentodes in the output. Frequency attenuated stepping attenuators in the input and a cathode follower assure a clean linear horizontal trace. It uses a hard vacuum sweep with sufficient expansion to see color bursts clearly.

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

CIRCLE 97 ON READER-SERVICE CARD

◀ CIRCLE 95 ON READER-SERVICE CARD

MINIATURIZATION IN EVERY PRODUCT LINE

RF CONNECTORS

Subminax® RF connectors to set the highest standards of reliability for miniature components

RG CABLES

Subminax cables—polyethylene or Teflon—mate with Subminax connectors—complete the reliability circuit

RACK & PANEL CONNECTORS

Amazing Micro-Ribbon connectors use flexible "ribbon" contacts, "wedge" principle for quality performance

A-N CONNECTORS

Miniature AN-type 165 series connectors are widely used in military and commercial equipment

MICROPHONE CONNECTORS

New Miniature Microphone Connectors represent AMPHENOL's latest contribution to the art of miniaturization

AMPHENOL Industrial Distributors carry stocks of standard AMPHENOL components in order to provide immediate service

AMPHENOL ELECTRONICS CORPORATION
chicago 50, illinois

AMPHENOL CANADA LIMITED
toronto 9, ontario

New Products

Wire-Wound Resistors

Vacuum Impregnated

This epoxy-encapsulated wire-wound precision resistor is vacuum impregnated and vacuum cast to eliminate hot spots caused by voids in windings. Designated Series EP, the new line utilizes tension-free winding and meets MIL-R-93A and MIL-R-9444. The resistors are heat cycled before encapsulation and post-cured before final inspection, thus resulting in long term stability of resistance under rigid environmental temperature conditions. The series has an operating range from −65 to +125 C and a temperature coefficient of ±0.00002 C.

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

CIRCLE 117 ON READER-SERVICE CARD FOR MORE INFORMATION

High Voltage Supply

0.001 Per Cent Regulation

The high voltage supply has a stability comparable to that of a standard cell through the use of temperature-regulated primary and secondary voltage standards and chopper stabilization of the regulating amplifier. Both the chopper stabilization and temperature regulation are accomplished by means of plug-in units which may be added at any time to the standard HVCST Series. Available in two ranges, 800 to 2500 v and 500 to 1500 v with reversible polarities, these supplies can deliver an output current of 8 ma. The output impedance is less than 1 ohm. Regulation for line voltage changes from 100 to 125 v is better than 0.001 per cent. Long term stability is 0.005 per cent. These supplies are suited for precision spectroscopy and fast coincidence applications where the new fourteen stage multiplier phototubes are used.

Tullamore Electronics Lab., Dept. ED, 6055 S. Ashland Ave., Chicago 36, Ill.

CIRCLE 118 ON READER-SERVICE CARD FOR MORE INFORMATION

◀ CIRCLE 116 ON READER-SERVICE CARD

Component Lead Bending Block

Prevents Damage, Easy to Use

For bending leads on components, during assembly to accurately register with their holes in printed circuit panels, the no. 600 Universal Bending Block eliminates plier damage, wire distortion, and twisted or out-of-line components. All components are accurately centered, and the leads are bent to exactly register with their drilled or punched panel holes. With this tool the entire operation is done in a small fraction of the time required when the leads are bent with pliers. The tool may be quickly adjusted to any component body length from 1/4 to 1-3/4 in. Leads can be bent to within 0.07 in. from end of component and for up to 3 in. hole centers.

By-Buk Co., Dept. ED, 4314 West Pico Blvd, Los Angeles 19, Calif.

CIRCLE 122 ON READER-SERVICE CARD FOR MORE INFORMATION

Precision Power Oscillator

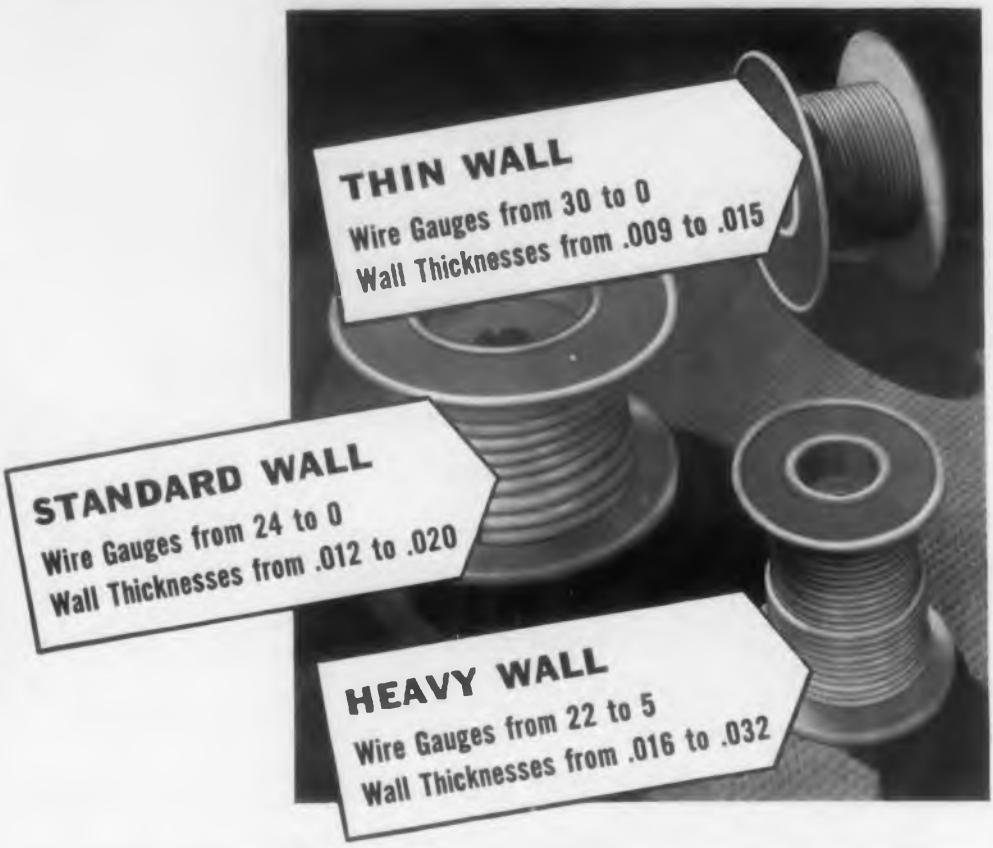
0.02 to 0.5 Per Cent Stability

Precision stability of this audio frequency precision power oscillator is derived from an exclusive high-Q LC tuned circuit and special voltage-sensitive bridge combined in a circuit employing a large amount of negative feedback. A feature of the oscillator is its ability to accommodate line voltage variations. Adjustment to these varying load conditions is almost instantaneous, with no appreciable lag and takes place in a cycle or two. The DK-102 has virtually zero output impedance and is designed especially for applications where tuning fork frequency stability, absolute voltage values, extremely low output impedance, very low distortion and high power capacity are required. General specifications include: frequency stability of ± 0.5 per cent max, under usual ambient conditions; ± 0.02 per cent max, per ± 10 v variation in line voltage, and ± 0.05 per cent max, zero to full load. The unit measures 5-3/4 x 9 x 16-7/8 in.

Electronics International Co., Dept. ED, 145 W. Magnolia Blvd., Burbank, Calif.

CIRCLE 123 ON READER-SERVICE CARD FOR MORE INFORMATION

TEFLON Spaghetti
now in three grades...



to suit your electronic and dimensional needs

Now, it is possible to select the exact grade of Chemelec TEFLON* Spaghetti tubing to serve your specific electronic needs and dimensions—and to realize tremendous *cost savings* by eliminating needless purchase of excess weight of TEFLON.

This sleeving is dimensionally accurate and is made of high grade du Pont tetrafluoroethylene resin, free of impurities, to insure the finest in dielectric service. In all grades and sizes, it is extremely flexible and is a non-woven solid material, molecularly integrated to prevent leaks from cracks, splits or perforations. Available in a full range of colors: natural, red, orange, yellow, green, blue, violet, grey, brown and black.

Have you seen our complete line of Chemelec stand-off and feed-through insulators, connectors and tube sockets?

TREATED SPAGHETTI for Potting

TEFLON spaghetti is also available with specially treated surfaces for maximum adherence of all potting or encapsulating compounds, while maintaining, unchanged, all the fine characteristics of the TEFLON.

Write for Catalog EC-757.

FLUOROCARBON PRODUCTS INC., division of United States Gasket Co., Camden 1, New Jersey.

*du Pont Trademark

Sold through leading electronic parts distributors by Erie Resistor Corp.

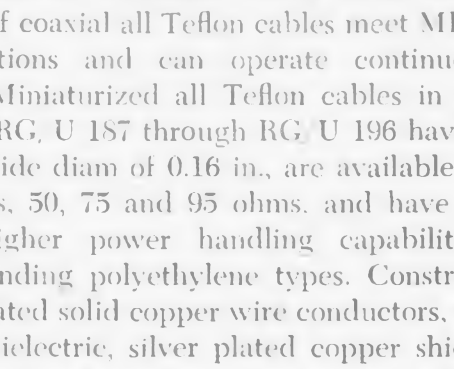
Fluorocarbon Products Inc.

CIRCLE 126 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Coaxial Teflon Cable

Miniaturized



This line of rf coaxial Teflon cables and miniaturized rf coaxial all Teflon cables meet MIL C-17B specifications and can operate continuously at 200 C. Miniaturized all Teflon cables in standard sizes of RG, U 187 through RG, U 196 have a nominal outside diam of 0.16 in., are available in 3 impedances, 50, 75 and 95 ohms, and have substantially higher power handling capabilities than corresponding polyethylene types. Construction is silver plated solid copper wire conductors, extruded Teflon dielectric, silver plated copper shield, with a choice of either sintered tape or extruded Teflon jacketings in 10 standard solid colors for coding purposes.

Times Wire & Cable Co., Inc., Dept. ED, Wallingford, Conn.

CIRCLE 127 ON READER-SERVICE CARD FOR MORE INFORMATION

Diode Recovery Time Tester

High Accuracy in 0.05 μSec Range

This test unit has a degree of accuracy not previously achieved in measuring diode recovery characteristics in the 0.05 to 0.3 μsec range. The unit is an extensive modification of a circuit developed by the National Bureau of Standards, and has been submitted to JETEC for qualification as an industry standard. Including an auxiliary oscilloscope and square wave generator, the unit allows quantitative measurement of the switching transient occurring when a diode is switched from the forward-biased to the reverse-biased state. Forward current and reverse voltage range have been extended to 100 ma and 60 v respectively, where maximums are not used simultaneously.

Pacific Semiconductors, Inc., Dept. ED, 10451 W. Jefferson Blvd., Culver City, Calif.

CIRCLE 128 ON READER-SERVICE CARD FOR MORE INFORMATION

Synchro Index Stand

Suitable for Volume Testing

Designed to rapidly and accurately locate the rotor shaft of a synchro to a desired angular position with respect to the stator, this stand can be used along with other test equipment to determine synchro accuracy, transformation ratio, perpendicularity, and fundamental and rms null voltages. The index stand is dustproof and adapters for holding various size synchros may be readily interchanged without affecting the calibration of the stand. Rapid insertion and removal of the synchro under test is done by a 90 deg rotation of adapter housing.

Kearfott Co., Inc., Dept. ED, 1378 Main Ave., Clifton, N.J.

CIRCLE 132 ON READER-SERVICE CARD FOR MORE INFORMATION

Automatic Tube Analyzer

Fast and Versatile

The basic function of this instrument is to reduce cost through a reduction in manpower requirements in testing vacuum tubes, both from the standpoint of reducing the number of test personnel required as well as permitting the use of less skilled personnel. Another significant factor is the fewer number of test stations required. Tests may be conducted singly or in sequence and may be accomplished automatically, semi-automatically, or manually at the rate of 3000 tests per hr, to ±3 per cent accuracy. The unit provides 17 test positions, which can be set up to perform any combination of 19 basic tests, utilizing the programmer principle consisting of individual, easily inserted patch panels, each unique to a particular tube type.

Rheem Mfg. Co., Electronics Div., Dept. ED, 7777 Industry Ave., Rivera, Calif.

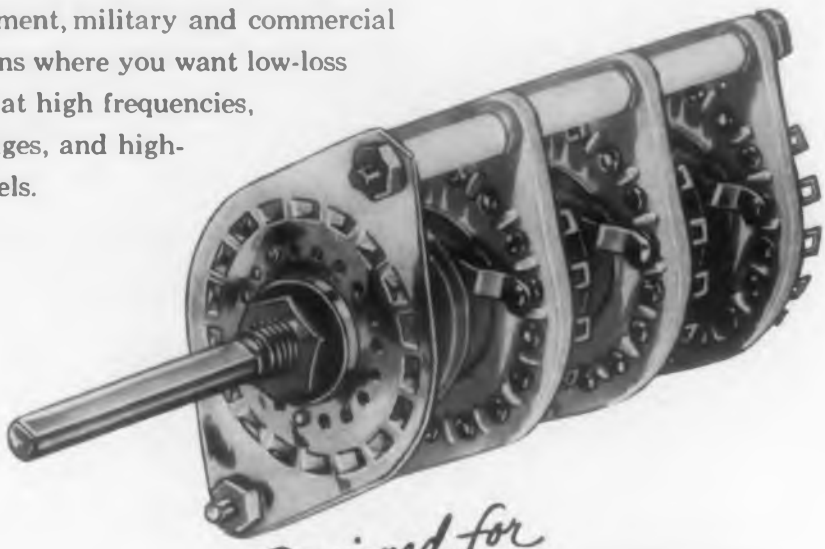
CIRCLE 133 ON READER-SERVICE CARD FOR MORE INFORMATION

Handles a Kilowatt with ease

Centralab Series PA-230 Rotary Power Switch

The most versatile multiple-circuit rotary power switch available

Switching configurations up to 24 positions, shorting or non-shorting. Meets all your requirements for transmitters, industrial test equipment, military and commercial applications where you want low-loss operation at high frequencies, high voltages, and high-power levels.



Designed for **ruggedness, accuracy, long life**

- Sections are Grade L-5 Steatite. Voltage breakdown, 3000 volts R.M.S. between critical parts.
- Ball-bearing index insures positive positioning.
- Square rotor shaft, combined with mating Monel driver, provides rotational accuracy throughout length of switch.
- Coin-silver contacts, for excellent current-carrying characteristics.

New 36-page Switch Catalog.
Write for free copy today.

Customer's problem: Needed 540 contact combination.

Solution: This 30-section Centralab Series PA-230 switch.

Centralab can solve *your* switch problems.

Centralab

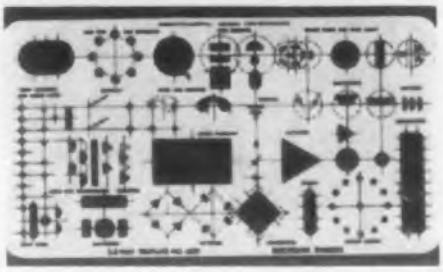
A DIVISION OF GLOBE-UNION INC.
960J—E. Keefe St., Milwaukee 2, Wis.
In Canada:
804 Mt. Pleasant Road, Toronto, Ontario

CIRCLE 136 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Electronic Symbol Template

Includes Wide Variety



Schematic diagrams can be drawn to meet the revised MIL-STD-15A and ASA specification Y32.2 with the No. 6001 electronic symbols template. Symbols that can be drawn with this template include pnp and npn transistors, diodes, tubes, power plugs, pilot lamps, relays, phone jacks, connectors, rotary switches, resistors, capacitors, inductors, transformers, amplifiers and block diagram symbols. The template is fabricated from rigid vinyl plastic that will not burn, warp or discolor and features a special non-slip, low glare surface.

E-Z-Way Templates, Dept. ED, P. O. Box 535, Reseda, Calif.

CIRCLE 137 ON READER-SERVICE CARD FOR MORE INFORMATION

Wave Analyzer

Highly Selective

Model 2170C can be used for microwave channeling, carrier telephone and telemetering measurements of carrier and sub-carrier signals. It employs the heterodyne principle with balanced modulation and highly selective crystal filters for frequency and voltage measurement. The selectivity is based on crystal filters of 100 cps and 3 kc bandwidths. The 100 cycle crystal filter is used on all voltage measurements with the 3 kc crystal filter for single sideband monitoring. Incorporated in this instrument is an internal speaker and headphone output for aural monitoring. The instrument utilizes a direct reading meter calibrated for dbm or rms voltages over the range of from −80 to +32 dbm. Accuracy of ±1 2 dbm is achieved. Frequencies below 1 kc can be measured with care.

Rycom Instruments, Dept. ED, 9351 E. 59th St., Raytown, Mo.

CIRCLE 138 ON READER-SERVICE CARD FOR MORE INFORMATION

EXTENDED SCALE

MEGOHMMETER

Displays six decades of resistance without range switching

HERE is a new standard of resistance measurement for laboratory and production tests—wherever capacitor or insulation leakages above 10 megohms are measured. The Keithley 510 Megohmmeter combines ease of use with great range, speed, stability, and uniform accuracy.

measures 10^7 to 10^{15} ohms

TEST POTENTIALS of 5, 50 and 500 volts are provided: corresponding meter spans are 10^7 to 10^{13}, 10^8 to 10^{14}, and 10^9 to 10^{15} ohms. A novel logarithmic circuit, calibrated by internal resistance standards, eliminates the range switching and scale compression found in conventional ohmmeters. The instrument also offers several times the speed of response and stability of conventional circuits.

OTHER FEATURES include extremely well-regulated test potentials and a guarded, completely shielded input. Volume resistivity and component adapters, as well as triaxial guarded cables, are available as accessories.

COMPLETE DATA are available in Keithley Engineering Notes, Vol. 5 No. 4. A request on your company letterhead will bring your copy promptly.

KEITHLEY INSTRUMENTS, INC.
12415 Euclid Ave., Cleveland 6, Ohio

CIRCLE 141 ON READER-SERVICE CARD

DC Miniature Relay

Close Pull-in and Drop-out Differential

This hermetically sealed dc relay, Model RL-503-ES-H features 5 per cent differential between pull-in and drop-out. It is suited for electronic systems where differential between pull-in and drop-out is critical such as plate circuits, under voltage control relay in military aircraft and electronically regulated power supplies. Other features include: compensation for ambient temperature changes, high repeatability of pull-in and drop-out and excellent resistance to shock and vibration through the use of efficient magnetic circuit and snap switches. The unit meets the environmental requirements of military specifications. The relay measures 2.375 in. long by 1.593 in. wide and weighs 6.9 oz.

Joseph Pollak Corp., Dept. ED, Freeport St., Boston 22, Mass.

CIRCLE 142 ON READER-SERVICE CARD FOR MORE INFORMATION

Miniature Delay Lines

Handle Large Delays

A new technique in delay line fabrication resulting in a high degree of miniaturization and rapid production is made possible by use of Spira-Coil. The coil can be made half the size with twice the inductance of a given printed inductor. This design results in a minimum size at a lowest cost. Lines are potted in epoxy for protection from moisture and fungus and are available with terminals or with pig-tail leads. Delay line shown measures about 2-1/2 in. long. Delays ranging from 0.05 to 20 μsec with tolerances of ±3 per cent or 0.01 μsec, whichever is greater, are available. Operating voltage is conservatively rated at 600 v dc. Insertion loss is negligible. Operating temperature range is from −55 to +125 C.

Com-Tronics, Inc., Dept. ED, 3409 Venice Blvd., Los Angeles 19, Calif.

CIRCLE 143 ON READER-SERVICE CARD FOR MORE INFORMATION

LOOK TO TOBE FOR PROGRESS

electronic RF filters

Medium power, 11 circuit RF filter, designed to operate in the range of −55°C to +100°C.

As specialists in the design and manufacture of RF filters since 1922, TOBE has accumulated a vast wealth of data covering filtering techniques. When it comes to filtering problems, TOBE can solve them.

TOBE Filterettes in both single and multiple circuits, are available in several hundred standard designs to meet any conceivable application. All types are engineered to operate under the most severe environmental conditions.

For further data or engineering aid, write TOBE DEUTSCHMANN Corporation, Norwood, Mass.

Tobe Exclusives:

Miniaturization with maximum quality.

Guaranteed attenuation characteristics under full-load operating conditions.

Current ratings up to 350 amps., AC and DC voltage ratings up to 5000 volts.

Maximum insertion loss at all frequencies from 14 kc to 15,000 mc.

Each type available in a variety of mounting styles.

specify TOBE PRODUCTS

TOBE DEUTSCHMANN • CAPACITOR PIONEERS SINCE 1922

CIRCLE 144 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Printed Circuit Vise

Permits Easy Access

The Model V-4 production vise is designed for holding printed circuit boards, terminal boards, and small chassis assemblies. Jaws lined with a tough cork and synthetic rubber compound assure a positive grip without excessive pressure, completely eliminating cracked circuit boards. The unit can be handled like a conventional metal chassis and assemblies are readily accessible from both sides. Circuit boards up to 7 in. wide and 18 in. or longer are easily inserted in the vise.

Western Electronic Products Co., Dept. ED, 655 Colman St., Altadena, Calif.

CIRCLE 147 ON READER-SERVICE CARD FOR MORE INFORMATION

6PDT Latching Relay

Employs Permanent Magnet

This magnetic latching relay is designed to withstand high shock and vibration while operating on minimal power. Designated KG, the relay employs a permanent magnet to hold the armature securely in either of the contact positions.

Tests show the dual coil relay remains operative during 100 g shock, with the contacts opening for no more than 80 μsec. It also withstands vibrations of 30 g's acceleration from 55 to 2000 cps and excursions of 0.195 in. from 10 to 55 cps with no contact opening. The KG requires 2 w at nominal voltage for 12 msec to effect armature transfer. Contact load capabilities range from dry circuits to 5 a, 28 v dc resistive and to 3 a, 115 v ac resistive. Operating temperature is from −65 to +125 C.

Potter & Brumfield, Inc., Sub. of American Machine & Foundry Co., Dept. ED, Princeton, Ind.

CIRCLE 148 ON READER-SERVICE CARD FOR MORE INFORMATION

Closed-Circuit TV Camera

Self-contained, Weighs 12 Lb

Designated Model PD-500, this TV camera weighs 12 lb and is completely self-contained within the camera housing. A remote control box permitting camera operation from distances up to one mile away is available as an accessory. Remote control kits are provided to allow for remote operation of lens iris, focus and turret.

General Precision Lab., Inc., Dept. ED, 63 Bedford Rd., Pleasantville, N.Y.

CIRCLE 152 ON READER-SERVICE CARD FOR MORE INFORMATION

RF Slip Rings

Available in Special Designs

A new design in rf slip rings is available for aircraft, ordnance and marine purposes. The firm is offering them as separate products designed to customer specifications and is also including them in complete turret slip rings.

Electro Mechanical Products Co., Dept. ED, 32700 Ford Rd., Garden City, Mich.

CIRCLE 153 ON READER-SERVICE CARD FOR MORE INFORMATION

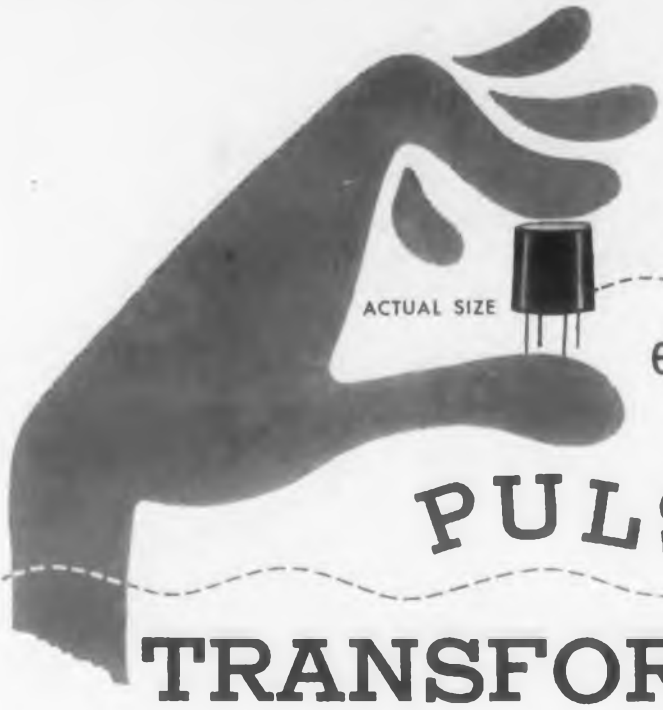
Pressure Scanner

Measures 48 Pressures a Second

Replacing 48 transducers and their zero circuits, Model 48D Scanivalve allows pressure and force data to be taken simultaneously, and precisely reads 48 pressures with only one calibration. Used with x-y plotters, it gives direct pressure profiles. Speeds are available with motor drive from one complete scan a sec of 48 pressures, to one scan per minute.

General Design, Dept. ED, 631 30th St., San Diego 2, Calif.

CIRCLE 154 ON READER-SERVICE CARD FOR MORE INFORMATION

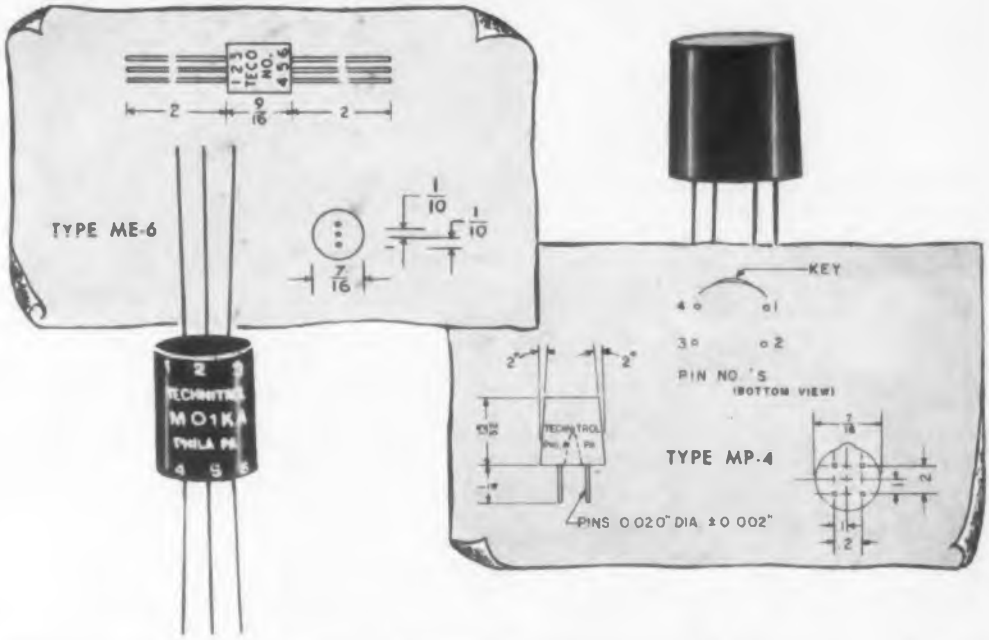


miniature

encapsulated

PULSE TRANSFORMERS

by TECHNITROL



Wound on ferrite cores, the Type M series is available in a variety of windings to cover pulse widths from 2 microseconds down to .05 microsecond, wound inverting or non-inverting.

While the M series is particularly adapted to subminiature and transistor circuits, we design and build pulse transformers to fit specific circuits or to meet definite mechanical or thermal requirements, including MIL-T-27A.

Additionally, Technitrol makes a complete line of lumped and distributed parameter Delay Lines and a variety of electronic test equipment.

For additional information, write today for our bulletin

TECHNITROL
ENGINEERING COMPANY
1952 E. Allegheny Ave., Phila. 34, Pa.

CIRCLE 155 ON READER-SERVICE CARD FOR MORE INFORMATION

Production Products

These production products are intended to acquaint the designer with the latest in manufacturing and processing machines.

Ultrasonic Degreaser

Small-Scale Unit

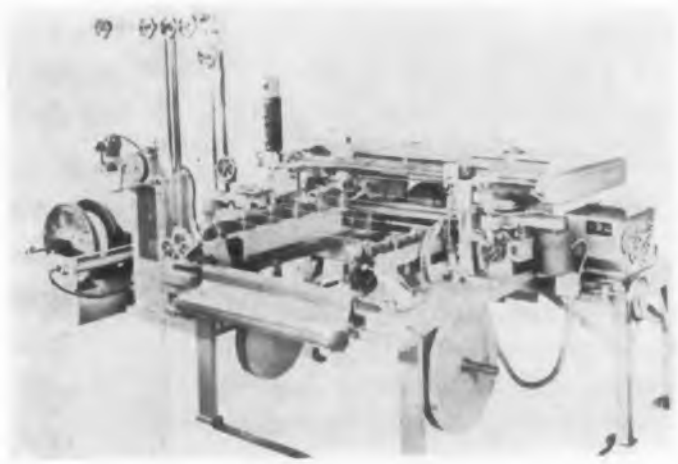
A compact, small-scaled duplicate of large ultrasonic degreasers has been developed by the Ramco Equipment Corp. The DV-18 bench model can be used in engineering and for continuous production work. It thoroughly cleans such typical parts as ball bearings, surgical instruments, watch and instrument parts, tools and dies, hydraulic valves, spinnerettes. The work area is 9 x 9 x 6 in. high with a capacity of 100 lb per min. Overall size is 33 x 15 x 24 in. high, total wt 75 lb. Construction is stainless steel throughout and it features thermostatic control, filter, manual spray, copper cooling coils, stainless heater and solvent recovery system.

Ramco Equipment Corp., Dept. ED, 1373 Lafayette Ave., New York 59, N.Y.

CIRCLE 158 ON READER-SERVICE CARD FOR MORE INFORMATION

Wire Lead Finisher

Automatic Machine



The CS-9-AT automatic machine for finishing wire leads goes a step further by finishing leads and attaching terminals at both ends in one operation. The capacity and versatility of this machine have been developed to answer today's demand for speed and automation. It cuts and processes wire or cable from 5 to 90 in. in length, produces 4000 per hour in up to 45-in. lengths, 2000 pieces per hour in up to 90-in. lengths. It will handle practically any cable, solid or stranded wire from 4 gage down to 26 gage with 1 in. stripping at each end. Special equipment is available for longer stripping if required. An automatic prefeeder assures even lengths of wire leads. A wire reel holder is mounted on the prefeeder which is supplied as standard equipment.

Artos Engineering Co., Dept. ED, 2757 S. 28 St., Milwaukee 46, Wis.

CIRCLE 159 ON READER-SERVICE CARD FOR MORE INFORMATION

Miniature Armature Winder

Winds up to 1-1/2 In. Rotors

A semi-automatic compact machine with a stationary rotor winds 2-pole or multi-slot rotors up to 1-1/2 in. diam and up to 1-1/2 in. stack length using wire sizes 28 to 44. Variable speed control of the Model 46-S-MA permits winding speeds up to 1100 rpm. Bi-directional feature makes possible reversal of winding direction within 15 min when desired. For amateurs requiring instant reversal of winding rotation from pole to pole, Model 46-S-MA-2 is available at extra cost. Machine dimensions are 14-1/2 x 10 x 14-1/2 in. without tension. Net weight is 45 lb. Accurate alignment of winding slots is assured by positive indexing mechanism.

George Stevens Manufacturing Co., Inc., Dept. ED, Pulaski Rd. at Peterson, Chicago 30, Ill.

CIRCLE 160 ON READER-SERVICE CARD FOR MORE INFORMATION

Automatic Taping and De-taping

For Capacitors, Resistors and Diodes

Both taping and de-taping of capacitors, resistors and diodes can be done automatically to supply components on tape-reels for firms using automatic insertion equipment. Components to be taped are fed into the hopper of the taping device and, with the aid of vibration, stacked and oriented in the chute. A pick-off wheel at the bottom removes the components individually and applies them to pressure sensitive tape. A photoelectric device automatically starts and stops the reel in accordance with the level of the components in the hopper.

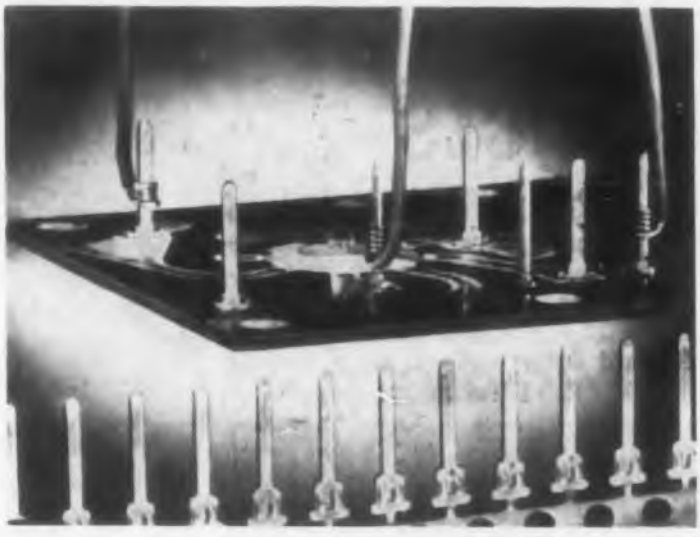
The equipment can also be used as an output device on automatic test equipment by simply placing the input hopper underneath the ejection position of the automatic tester. Components meeting test requirements are automatically taped while rejected units are ejected at another position. Adjustment is provided to accept most axial lead components.

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

CIRCLE 163 ON READER-SERVICE CARD FOR MORE INFORMATION

Wire Wrap Terminals

For Printed Circuit Assembly



Wire wrap terminals are available in loose or chain form. A clinch-type design which holds the individual terminal firmly in the printed circuit board during additional assembly operations and until permanently soldered is featured.

When used in chain form and in conjunction with the manufacturer's lug inserter, the new terminals make possible a fully automatic assembly of 20 wire wrap terminals into printed circuit boards, in any pattern, at rates up to 20 boards per min. For semi-automatic operation, they can be used in chain form for rapid insertion by means of a single terminal inserter.

Malco Tool and Manufacturing Co., Dept. ED, 4025 W. Lake St., Chicago 24, Ill.

CIRCLE 164 ON READER-SERVICE CARD FOR MORE INFORMATION

A New Concept of TIME . . .

. . . this Complete *NEW Line of*

HAYDON*

TIMING MOTORS

Here is a complete line of timing motors that includes the right choice for every APPLICATION . . . entirely re-designed for finer performance. Features include: slower basic rotor speed (450 rpm), controlled lubrication, total enclosure, smaller size, superior accuracy, quieter operation and longer life.

HYSTERESIS . . . *the ideal general-purpose motor.*

INDUCTOR . . . *extra torque (30 ounce inches) for display and other heavy-duty jobs.*

CLUTCH . . . *allows automatic re-setting without external clutches.*

REVERSIBLE . . . *a hysteresis type with 2 coils, each producing opposite rotation.*

DIRECT CURRENT . . . *a permanent magnet type for 6 to 32 volts.*

400 CPS . . . *miniature and heavy-duty models for airborne instrumentation.*

FOR COMPLETE INFORMATION, *write today for new catalog . . . or contact the HAYDON Field Engineer nearest you.*

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HAYDON AT TORRINGTON
HEADQUARTERS FOR TIMING

A SUBSIDIARY OF GENERAL TIME CORPORATION

HAYDON Manufacturing Company, Inc.
2234 ELM STREET, TORRINGTON, CONN.

CIRCLE 165 ON READER-SERVICE CARD FOR MORE INFORMATION

Production Products

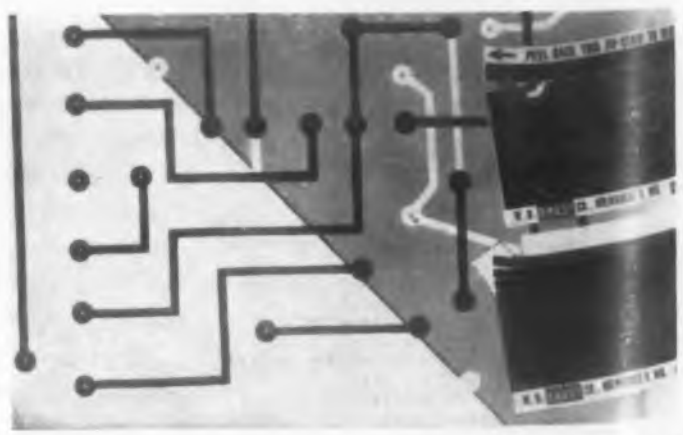
Thermal Conductivity Test Console

An automatic thermal conductivity test console, employing the guarded hot plate principle and conforming to the requirements of ASTM Specification C177-45, has been announced. Hot surface temperatures are automatically maintained in the range of 100 to 1400 F with cold surfaces automatically controlled between 60 and 600 F. Coefficients of thermal conductivity up to 5.0 BTU/ft²-hr F/in. can be determined.

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

CIRCLE 167 ON READER-SERVICE CARD FOR MORE INFORMATION

Printed Circuit Drafting Aid Has Pre-Cut Tapes



Printed circuit layout time is cut with the new "Black 'N' White" drafting aids manufactured by W. H. Brady Co. The new "two-colored," pre-cut,

self-sticking shapes are used for making layouts on clear or translucent film or cloth. Circuitry is laid out on both sides of the sheet.

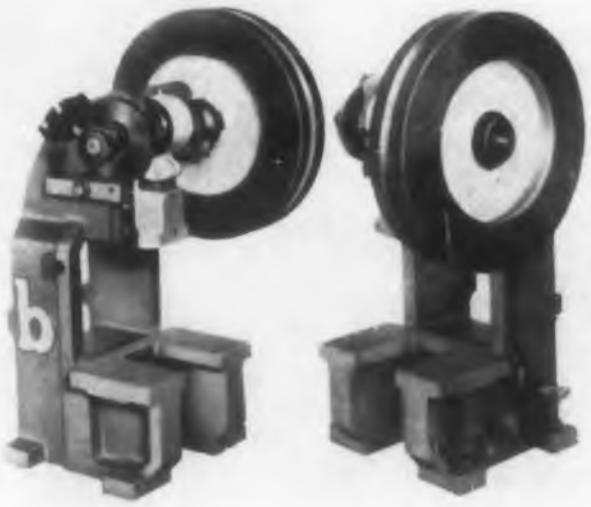
Pre-cut shapes and terminal strips made from Brady B-150X photographic tape have a snow-white adhesive side and a jet-black, non-reflective top side. The new "Black 'N' White" shapes permit a time-saving technique that eliminates setting up the camera twice. Circuits are drawn with "Black 'N' White" shapes on both sides of cloth or film, and the layout placed on a white surface for photographic reproduction. White shapes and strips on the reverse side of the layout do not register. After exposure, the second side of the layout is photographed. "Black 'N' White" shapes permit perfect register of two sides of a printed circuit layout, and assure accurate alignment of connecting strips and terminals on the finished product.

W. H. Brady Co., Dept. ED, 727 W. Glendale Ave., Milwaukee 9, Wis.

CIRCLE 170 ON READER-SERVICE CARD FOR MORE INFORMATION

Two-Ton Press

For Electronic Parts



This special 2-ton fixed bed gap frame press is especially designed for a manufacturer of electronic components. It is equipped with a mechanical clutch which is actuated by an electric solenoid. A single-revolution stop and two cam operated micro switches prevent the electrical system from double tripping. The stopping device consists of a crankshaft-mounted disc notched on its periphery for a spring loaded pall. Ram location at stop position is held to top dead center.

Special ears on the ram are drilled for bolting ram to die set. Tolerances throughout are refined to insure complete interchangeability of all tooling developed for the press. This press operates at 280 to 290 strokes per minute, has a 5-1/8 in. die space (ram up), and a standard stroke of 3/4 in. Other strokes are available. Opening through the back is 4-1/2 in., bed area is 4 x 7-1/8 in.

Benchmaster Mfg. Co., Dept. ED, 1835 West Rosecrans, Gardena, Calif.

CIRCLE 171 ON READER-SERVICE CARD FOR MORE INFORMATION

The LARGEST Selection of the SMALLEST

ELECTROLYTICS

is available from AEROVOX!

...and **only** from **Aerovox** can you choose from the widest selection of case styles and constructions in a complete range of low-voltage values. For small space applications... for transistorized assemblies...**ALL** your requirements for miniature electrolytic capacitors are available from Aerovox.

TYPES TNE & TNED

Preferred type subminiature electrolytics where cost, small size and long operating life are of prime importance in transistor assemblies. These tiny, low-impedance, low power factor units are furnished in film-lined glossy tubes with plastic end seals. Available in standard voltage ratings of 3 to 50 vdc with operating temperature range of —30°C to +65°C. Leads are firmly imbedded in plastic end seal and will not pull out or work loose under the most severe operating conditions. Color coded end-fill and case marking denotes positive terminal.

TYPES SRE, SREN, AND SRED

Improved electrolytics especially suitable for cathode bypass applications, screen circuit filters and transistorized assemblies. Units tightly sealed in tubular aluminum cases available with external wax-impregnated cardboard insulating tube. Exclusive end-seal provides greater creepage distance and assures positive electrical and mechanical contact. Standard dc voltage ratings from 3 to 150 volts. Operating temperatures from 0°C to 85°C.

TYPE XPP

Miniature, hermetically-sealed, **metal-cased** tubular aluminum units designed specifically for maximum life where size and weight must be kept to a minimum. Exceptional shelf-life characteristics. Standard voltage ratings of 1 to 5 vdc and standard temperature range from —20°C to +65°C. Available with axial leads only.

TYPE PWE

Miniature electrolytics encased in dense steatite tubes with special plastic end fill. Offering high capacitance at low voltages, these units are capable of handling full-size loads in industrial applications. Standard voltages from 1 to 50 vdc and standard operating temperatures from —20°C to +50°C.

For detailed technical information write...

AEROVOX CORPORATION

NEW BEDFORD, MASS.

In Canada: AEROVOX CANADA LTD., Hamilton, Ont.

Export: Ad. Auriema, Inc., 89 Broad St., New York, N. Y. • Cable: Auriema, N. Y.

CIRCLE 174 ON READER-SERVICE CARD FOR MORE INFORMATION

New Literature

Battery Boxes 175

A circuit chart and diagram showing hook-ups for many voltage combinations using dry and mercury miniature cells is included in 4-page brochure now available. Austin Craft Co., 431 S. Victory Blvd., Burbank, Calif.

Hi-Temp Insulation Folder 176

"See What's Super-New" is the title of a colorfully illustrated folder now available. The folder contains a representative group of products. American Super-Temperature Wires, Inc., Winooski, Vt.

Radio Catalog 177

Now available is a 196-page catalog on radio parts. It contains extensive listings of electronic parts and equipment for service, industrial, public address, and ham use. Northwest Radio and Electronic Supply Co., Minneapolis, Minn.

Power Reactor Systems 178

Bulletin 1384 presents a detailed picture and word description of various systems using water, gas, sodium and liquid-fuel as coolants. It reviews reactor systems which produce commercially useful electricity from nuclear energy. General Electric Co., Apparatus Sales Div., Schenectady 3, N.Y.

Potentiometers 179

Specifications and features of precision pick-off and sector potentiometers are presented in Bulletin No. 415, complete with photographs and outline drawings. Designed for aircraft and missile control systems, these units have a life in excess of 1,000,000 cycles and resolutions as fine as 0.006 in. The 2-page bulletin states they will operate in damping fluids and in temperatures above 150 C. Norden-Ketay Corp., Commerce Rd., Stamford, Conn.

Protective Closures 184

4-page catalog on caps and plugs supplies complete specifications for rubber and plastic closures. These units, illustrated in the catalog, protect, seal or mask threaded parts, pipe ends or tubing. Seven styles of stock sizes are covered. Shurclose Seal Co., 3000 E. Grand Blvd., Detroit 2, Mich.

Heavy-Duty Footswitch Line 185

Special features of the Hercules, a heavy-duty footswitch line, are discussed in a comprehensive 6-page bulletin recently issued. Grouped in four classes, all in single, two or three stage, are specifications on each of the Hercules' forty models: general purpose heavy duty, water-tight enclosure NEMA Type 4, explosion-proof Class I Group D NEMA Type 7 (for hazardous locations), and high dc rated switches.

Although designed primarily for use as pilot devices in connection with control circuits of contactors or starters, Hercules switches, as explained in the bulletin, may be used for direct control of small motors, riveting machines, welders, solenoids, relays, sound systems, and other electrical devices. Linemaster Switch Corp., 428 Woodstock Terrace, Woodstock, Conn.

Heat Exchange Packages 186

"Heat Exchange System Design for Airborne Electronic Equipment" is a 10-page paper concerning present and future cooling systems for electronic devices. Illustrated with photos and graphs, this discussion of heat exchange packages includes heat transfer systems such as cold plates, gas-air heat exchangers, air-liquid heat exchangers and associated transfer devices, mechanical refrigeration, and expendable refrigeration. Also presented are design analysis, performance characteristics, packaging techniques, and practical aspects of these system's components. United Aircraft Products, Inc., Box 1035, Dayton, Ohio.

Crimping Tools 187

An illustrated sheet of information on the uses and performances of two new multi-purpose crimping tools has been published. These units are applicable for crimping standard and insulated solderless terminals and connectors; stripping insulation from wires and cutting wires and insulation. Data on tool identification and wire gage capacities are included in the text. Electrix Terminals & Connectors, Inc., 990 E. 67th St., Cleveland 3, Ohio.

Measurement Standards

NEW MODEL 1051 C-R-A-M UNIT

Calibrator - Receiver - Amplifier - Mixer

The Model 1051 combines four functions. As a 10 kc to 500 mc frequency standard, it delivers sub-harmonics of a 10 mc oscillator to ±0.0005% accuracy. Discrete sine wave frequencies of 10, 50, 100, 200 kc and 1, 2, 10 mc available from rear terminals. Its 5 mc WWV receiver has a sensitivity of 5 microvolts. The amplifier and mixer sections provide a gain of several hundred times and a comparison of external signals up to 1000 mc or a comparison of external with internal signals. Price $760.

MODEL 531

MODEL 541A

MODEL 459

Crystal Impedance Meters

Four units now available to measure resonance and anti-resonance resistance of quartz crystals, including those covered by Spec. MIL-C-3098B. Capacitance, inductance and performance index (PI) of the crystal can be determined.

Model 531 (TS-683/TSM) covers range of 10-140 mcs, employing 13 calibrating resistors and an anti-resonance adapter for 10-150 ohm crystals. Price $590.

Model 541A (TS-710/TSM) for 10-1100 kc range crystals having resistances from 200 ohms to 0.5 megohms. Power dissipated in the crystal is meaured. Built-in VTVM and ohmmeter provided. Price $860.

Model 459 (TS-330/TSM) covers 1-15 mc frequency range for crystals having resonance resistances from 0 to 9900 ohms. Price $695.

Model 1207 (AN/TSM-15) covers frequency range of 75-200 mcs for 10-125 ohm crystals. Crystal voltage at series resonance is measured and power calculated. Built-in ohmmeter.

All models were developed under Signal Corps technical requirements for the national crystal testing standardization program.

Performance of all models is rigidly guaranteed. Prices are net f.o.b. Boonton, N.J. and subject to change without notice.

SEND FOR TECH. DATA

For additional information, including application data, write or phone DE 4-3100. Demonstrations available by local representatives.

RFL **Radio Frequency LABORATORIES, INC.**
Boonton, New Jersey, U.S.A.

CIRCLE 189 ON READER-SERVICE CARD FOR MORE INFORMATION

New Literature

Endurance Rated Counters 196

Heavy duty electric, stroke and revolution counters; electric counter actuators; small electric and stroke counters; coil winding counters; and automatic batch counters are included in condensed catalog now available. General Controls Co., Products Instruments Div., 706-34 W. Jackson Blvd., Chicago 6, Ill.

Environmental Testing Lab 197

High speed service, accuracy, and complete facilities are the keynotes of a 4-page brochure describing laboratory environmental test conditions. Illustrated with photos showing the equipment used to perform such tests as vibration, high and low temperature, humidity, altitude, salt spray, and acceleration, this brochure contains facts on the wide scope of testing to military, ASTM, and industrial specifications. Associated Testing Labs., Inc., 414 Clinton Rd., Caldwell, N.J.

Film Capacitor Data 198

Three new engineering bulletins covering standard types of plastic film dielectric capacitors have recently been issued. Each of the bulletins describe the various applications applicable to types "E", "F" and "G" capacitors. Sprague Electric Co., N. Adams, Mass.

Frequency Standard Broadcasts 199

Calibration of rf and af signals with standard frequency transmissions is described in "Using Standard Time and Frequency Broadcasts." The 4-page bulletin details a number of methods for utilizing the standard transmissions from stations WWV and WWVH, National Bureau of Standards. Diagrams aid in the discussion of such topics as upward extension of standard frequencies, audio frequency comparisons, and the use of 1000 cycle time pulses. Covering the program schedules of WWV and WWVH, the bulletin also includes short discussions on code symbol notices of propagation disturbances and the conditions necessary for obtaining various levels of signal accuracy. Specific Products, 21051 Costanso, Woodland Hills, Calif.

Transistor Servo Amplifier 200

The 60 and 400 cps TRAMPS are presented in a 4-page brochure, "Transistor Servo Amplifier." Diagram-illustrated, it covers the performance characteristics and applications of production models. Miniaturized units capable of providing up to 9 w controlled power at a weight factor of less than 1 oz per w are described in detail. An application questionnaire is included to assist in the selection of the TRAMP and control system companions which were designed to meet military specifications. M. Ten Bosch, Inc., Pleasantville, N.Y.

Panel Meters 201

Round and square panel meters that meet applicable sections at JAN-1-6 and MIL-M-6B are described in a 16-page catalog now available. Illustrated with diagrams and photos, it contains dimensional details and performance specifications for D'Arsonval-type ammeters, millivoltmeters, voltmeters as well as ac rectifier-type microammeters, milliammeters, and voltmeters. Data on custom meters are also included. Waters Mfg., Inc., Boston Post Rd., Wayland, Mass.

All Transistor Amplifier 202

An all transistor amplifier, designed for use in analog computation and amplification for low level dc signals such as strain gage transducers or thermocouple output, is presented in Bulletin 3003. Containing complete diagrams, block diagrams and photos, the 4-page bulletin cites typical applications and operation specifications of this high gain, broad band, chopper stabilied, precision amplifier. Beckman Instruments, Inc., 325 Muller Ave., Anaheim, Calif.

Current Drivers 203

Designed for the testing of magnetic cores such as bobbin, square loop, and tape wound, two new current drivers, Types 3003 and 3004, are now fully described in a 4-page brochure. Type 3003 produces a negative current pulse, Type 3004 a positive curent pulse. All specifications including rise time, duration, and amplitude of the rectangular output current pulse are listed in this illustrated brochure. Burroughs Corp., Electronic Instruments Div., 1209 Vine St., Philadelphia 7, Pa.

Ballistic Film Analyzers 204

Descriptive information and photographs on ballistic film analyzers are supplied in a 4-page technical bulletin, No. CR-191. These analyzers are used to measure precisely linear distances or angles on photographic film or plates. They convert the measurements into digital form for readout into a lamp bank and punched cards or paper tape, electric typewriter, Flexowriter and other devices. Included in the bulletin are specifications and a block diagram showing the choice of accessory and input-output equipment, with provisions for handling 16, 35 or 70 mm and 5-1/2 in. film. Coleman Engineering Co., Inc., 6040 W. Jefferson Blvd., Los Angeles 16, Calif.

Supersonic Power Steering 205

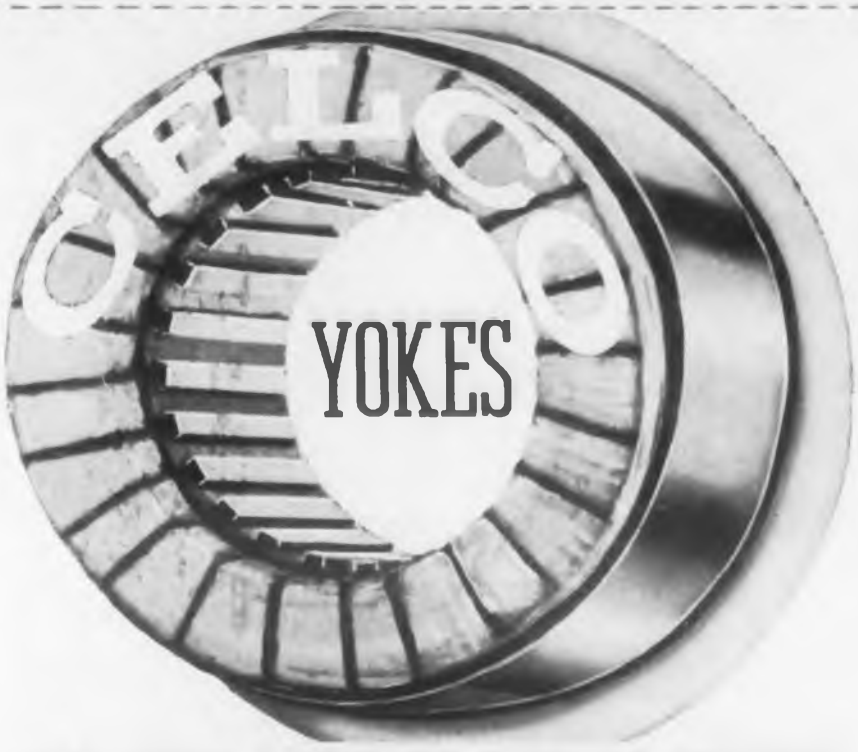
Application, technical and reference data is contained in 8-page technical magazine now available. Entitled "Supersonic Power Steering," it discusses the requirements of an elevator trim system for supersonic aircraft, and shows how the trim servo system is integrated into the delta wing, Convair F-102. G. M. Giannini & Co., Inc., 918 E. Green St., Pasadena 1, Calif.

Thermistor 206

Chapter 1 of "Meet the VECO thermistor" is devoted to fundamentals in the use of thermistors starting with a basic dc circuit. Also discussed is the meaning of temperature coefficient, and how it can be used to advantage. The article is written in easy-to-understand language, and raises the curtain on many heretofore unknown facts. Victory Engineering Corp., Springfield Rd., Union, N.J.

Digital and Analog Instruments 207

Seventeen new devices are described in Catalog C704. Eight pages in size and illustrated, it contains specifications and applications for digital and analog instrumentation. Included in this discussion are preset EPUT meters with variable time base for direct digital readout without conversion and a series of portable EPUT meters. The catalog also covers expanded scale volt and frequency meters, transformation ratio meters, resistance bridges, nuclear scalers, recorders, readouts, and the EASE 1100 analog computer with digital input and output. Beckman Instruments, Berkeley Div., 2200 Wright Ave., Richmond 3, Calif.



FOR HIGH ACCURACY DISPLAY SYSTEMS

We specialize in the design and manufacture of precision deflection Yokes for military and commercial applications. Phone or write for immediate engineering evaluation of your critical display problems — Phone DAvis 7-1123. MAHWAH, N. J.

Celco *Constantine Engineering Laboratories Co.*
MAHWAH, NEW JERSEY

CIRCLE 209 ON READER-SERVICE CARD FOR MORE INFORMATION

PACKS the POWER for 100-WATT SIGNALS...

Since the earliest days of mobile radio . . . some thirty years ago . . . the name of **CARTER** has maintained its prominence in the manufacture of rotary power supplies.

Today, modern 100 watt police radio communication equipment, is produced by ALL major set manufacturers, and obtain power from **CARTER** Duovolt Genemotors . . . the kind most recommended by experts where dependability counts first.

CARTER 6/12v. DuoVolt Genemotors operate equally well on 6 or 12 volt input. They combine the efficiency, economy, and capacity to insure top performance in the best and most powerful mobile radios ever available to the nation's police.

ROTARY **Carter** POWER
(TRADE MARK)

CARTER MOTOR CO.
2764 W. George St., Chicago 18

Please send complete information on **CARTER** Rotary Power Supplies.

Name_____

Address_____

City_____ Zone____ State_____

CIRCLE 210 ON READER-SERVICE CARD FOR MORE INFORMATION

New Literature

Teflon 215

Twenty-page illustrated engineering handbook on Teflon (Tetrafluoroethylene) has been released. It covers advanced usage in practical applications as a cushioning and insulating material for supporting clamps.

The handbook contains information on Teflon including chemical, thermal, electrical and ageing properties as well as methods of handling it. Included is a comprehensive tabulated chart covering 28 tests of various physical properties of Teflon. It also illustrates seven models of Teflon Cushioned support clamps, which are available in 18 standard types. TA Mfg. Corp., 4607 Alger St., Los Angeles 39, Calif.

Shielding Enclosures 216

In a six-page brochure, photographs, charts and graphs illustrate the features and characteristics of enclosures for suppressing radio frequency interference. The catalog gives typical enclosure sizes and performance data and discusses available shielding materials. It also lists typical applications and available accessories. Shielding, Inc., Box 59, Riverton, N.J.

Accelerometers 217

Illustrations, specifications and special design features for a variety of accelerometers are presented in a recent catalog. An instrument application guide for flight- and fire-control system engineers and a detailed performance breakdown for each instrument is given. The catalog also contains information on such optional configurations as dual-output instruments, switch-contact instruments, digital-output instruments, special damping features, and very-low and very-high g-range accelerometers. Technical data, illustrations and possible applications of a new ac output instrument are given. Genisco, Inc., 2233 Federal Ave., Los Angeles 64, Calif.

Electronic Control Assemblies 218

Electronic control assemblies and complex electronic gear that can be produced in large scale is described in this two-color, 22 page brochure now available.

It contains photographs and illustrations of typical projects, and gives the specifications and applications available. Cook Electric Co., 2700 N. Southport Ave., Chicago 14, Ill.

Carbon Film Resistors 219

Low cost, precision carbon film resistors are described in Form 307-1056 now available. The illustrated sheet indicates that construction features a layer of pure carbon particles deposited on a ceramic rod. Silver plated end caps are expansion fitted over silver contact bands for good electrical and positive contact. Tinned copper leads are securely riveted to caps. They conform to Mil-R-10509B, are available in five types ranging from ¼ to 2 w sizes, and are used in test equipment, meters and hi-frequency circuits. Continental Carbon, Div. Wirt Co., 5221 Greene St., Philadelphia 44, Pa.

Heavy Duty Relays 220

An eight-page illustrated booklet gives complete information about a line of interchangeable multiple pole and fixed multiple pole heavy duty relays. Diagrams, dimensional drawings and photographs are used for illustration. Described in detail is the finger-tip convertibility from normally-open to normally-closed poles of the relay. Arrow-Hart & Hegeman Electric Co., 103 Hawthorn St., Hartford 6, Conn.

Ultrasonic Gage 221

Information on the Vidigage, an ultrasonic resonance instrument for fast, nondestructive testing, is available in a technical bulletin of 8 pages. Designated V-200, the illustrated booklet gives complete data on the instrument's time-saving advantages in measuring the thickness of metal, glass, and plastic from one side, and in finding corrosion, laminar discontinuities, and others flaws. The brochure covers the unit's construction, operation, applications and specifications. Accessory equipment is also described. Branson Instruments, Inc., 37 Brown House Rd., Stamford, Conn.

Miniature Electrical Connectors 222

A 24-page three-color catalog describes a full line of miniature electrical connectors. The booklet is illustrated with drawings of each connector and docking charts that show contacts and alternate insert positions. The line consists of miniature hermetic, quick disconnect, push-pull, rack and panel, and edgelite panel connectors. A section of the catalog is devoted to construction and operational features, and charts supply significant dimensions and weights. Mating combinations, special numbering and mounting dimensions are also given. The publication follows a quick-reference data sheet format. Catalog sheets may be added as new connectors and modifications are introduced. The Deutsch Co., 7000 Avelon Blvd., Los Angeles 3, Calif.

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

Automatic Digit Pulser

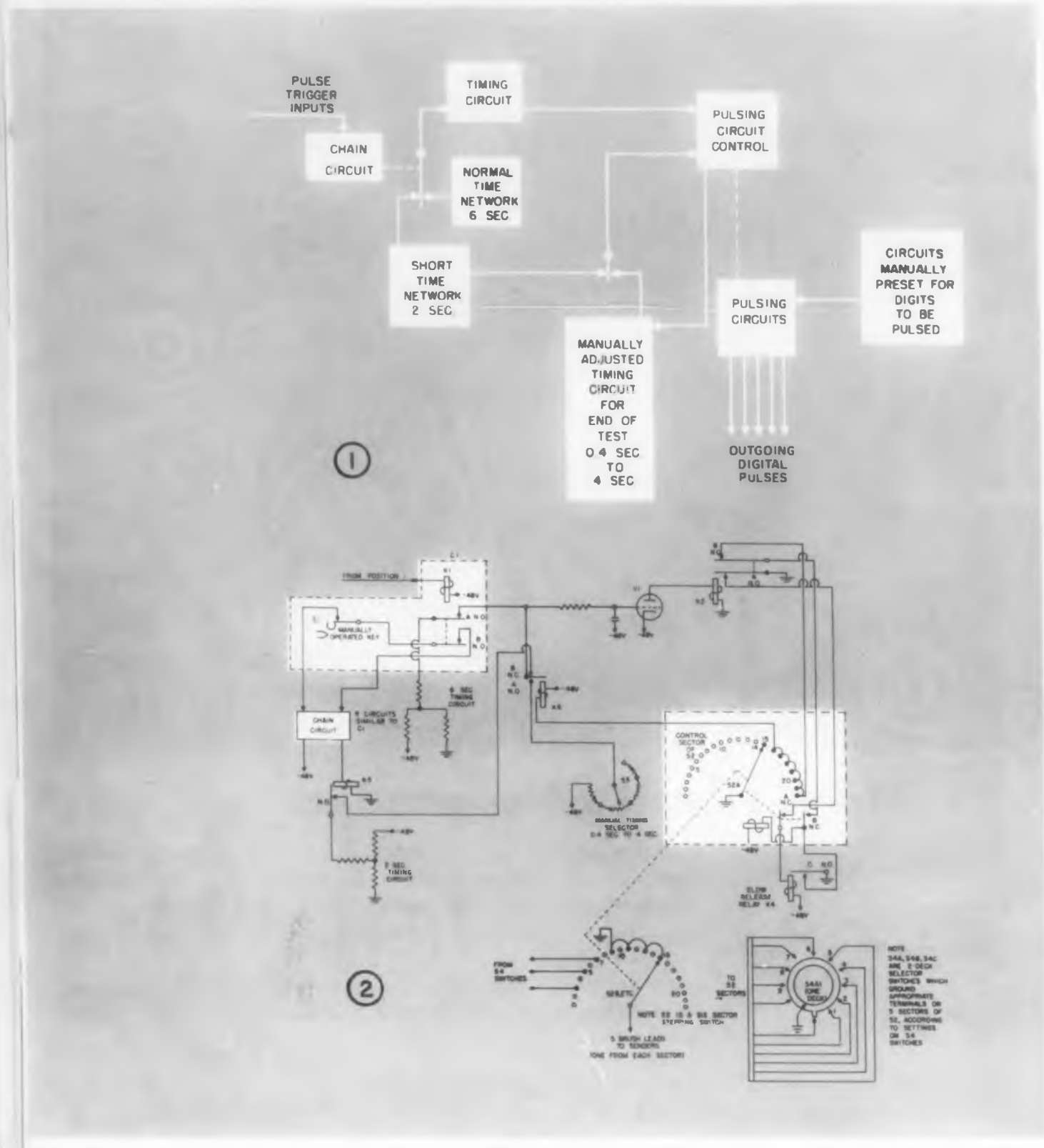


Fig. 1. Block diagram.

Fig. 2. Simplified schematic of the unit.

DESCRIBED here is a versatile automatic digit pulser, suitable for many automatic testing applications, where digital pulsing is used. Although the unit was designed for the checking of centralized Automatic Message Accounting circuits of telephone plant installations, its timing and control circuits are adaptable to many other uses.

The functional parts of the pulser are shown in Fig. 1. A simplified schematic of the unit is shown in Fig. 2. The trigger inputs close each part of the chain circuit involved and start the timing circuit, which consists of a vacuum tube. The purpose of the manual keys (S1) is to enable a tester to close those portions of the chain which will not be used in a test.

If all triggering pulses have closed the chain circuit before six seconds have elapsed, then relay K5 will change the timing circuit from six seconds to an additional two seconds from the time all circuits are seized.

At the conclusion of the six second or shorter timing period, V1 will conduct and the digits are pulsed by the test set through the operation and release of a slow release relay (K4) and a control sector of stepping selector switch S2, each operating through the normal contacts of the other. This operation and release continues until several digits have been pulsed through the settings of manually set selector switches (S4). When the vacuum tube (V1) conducts, K3 closes the normally open contacts A which energize relay K4 through normally closed contacts A on S2. K4 then closes contacts C which in turn operate S2. S2 opens contacts A which in turn deenergizes slow release relay K4. When contacts C of K4 open, contacts B of S2 close and the cycle is repeated. The selector (S2) is equipped with six sectors. Each sector goes through 22 positions or steps, only 15 of which are used for pulsing. One sector is used for control purposes and stops the pulsing, while the other five sectors are used for transmitting ground pulses to appropriate indicating equipment, determined by settings on S4. Each sector has five transmitting leads, and on each of the stepping selector (S2), a combination of 2 out of the 5 transmitting leads are grounded through settings on S4 which will be recognized by the indicating equipment as a number from 0 to 9.

In the case of the present test set, the first three digits (office code) may be manually varied by means of S4, which consists of three two-deck selector switches. The last four digits (numericals) pulsed are zeros since the office code is the main item of information to be passed to appropriate equipment for test purposes and the numericals are used merely to enable the office equipment to complete its functions.

After the seven digits have been pulsed, there is again a time delay which may be varied between 0.4 and 4 seconds. This variable timing interval allows the office equipment to complete its functions before permitting the test set to release and again be in a position to trigger pulses. The short interval is used where only a single code is being pulsed into the test set. Under this condition, the equipment requires a shorter period of recovery time and enables the tester to work more rapidly.

However, the pulsing and coding may be varied to suit particular needs. Inasmuch as only 15 of the 22 positions in the stepping selector switch are used, some of these positions are available for additional work.

H. P. Merrick, Test Design Engineer, Western Electric Co., Inc., New York, N. Y.

Report Briefs

Permanent-Magnet Generators

Recent improvements in the permanent-magnet generator have brought advantages which, if exploited, will place it in competition with the conventional wound-field machine, NRL researchers anticipate. The elimination in the ac generator of exciter, commutator, slip rings, brushes, and field winding makes the permanent-magnet machine especially attractive for mobile applications where size, weight, and environmental requirements are severe. This report presents a simple theory of the generator. It may be used for the prediction of machine performance and as the basis for optimum design of a generator for a specified application. The theory is based on an equivalent magnet circuit and uses the conventional synchronous machine constants. Steady-state and transient operation are analyzed, and the demagnetizing effect of a short-circuit transient is evaluated. *PB 121862, Permanent-Magnet Generators, D. J. Hanrahan and D. S. Toffolo. Naval Research Lab., OTS, U.S. Dept. of Commerce, Washington 25, D.C., Mar. 1957, 18 pp, $0.50.*

Secondary Electron Current

A 2 Mev electrostatic accelerator with a 0.06 usec pulsed electron source was found to produce radiation afterpulses occurring as late as 150 usec after cessation of the source pulse. The rate of afterpulsing was roughly proportional to the pressure in the acceleration and drift tube for pressures up to 5×10^{-5} mm of mercury and rose more steeply at higher pressures. The decay curve of the delayed radiation was independent of the target material and the type of detector used to study it. The energy spectrum was continuous, with an average energy less than that of the bremsstrahlung pulse. The cause of the effect has been determined to be ionization in the drift tube by the primary electron beam. The mechanism for formation of the afterpulses and the instrumentation for their study are discussed. *Secondary Electron Current from a Pulsed Electron Accelerator, A. E. Evans, Jr., D. V. Breitenbecher, D. W. Cady, and L. L. Antes, Wright Air Development Center, Aeronautical Research Lab., Dayton, Ohio, PB 121757, Sept. 1956, 20 pp, $.50. Order from OTS, U.S. Dept. of Commerce, Washington 25, D.C.*

Sn O-Zn Battery Study

Preliminary work toward the improvement of the silver oxide-zinc alkaline battery through a possible increase in cell capacities of zinc alloy electrodes is described. The aim of the Navy project was to determine whether elements which alloy with zinc and change its crystalline structure and other physical properties will increase or decrease the capacity of the silver oxide-zinc alkaline cell. Although the investigation was not completed, and the data is recommended only as a basis for further study, it was reported that most alloying elements decrease cell capacity, particularly if they are present in appreciable amounts. Mercury, however, improved capacity, and a few other elements such as cobalt and calcium indicated promise. The grain structure of electrodes made of zinc and its alloys was shown to have a large effect on cell capacity. *PB 121744, The Silver Oxide-Zinc Alkaline Primary Cell: Part 4, Anodic Characteristics of Zinc Alloys, C. M. Shepard, Naval Research Lab., OTS, U.S. Dept. of Commerce, Washington 25, D.C., Feb. 1957, 25 pp, $0.75.*

Electron Scattering

The higher-order radiative corrections are examined in the infrared region, and Schwinger's conjective regarding the functional dependence of these corrections on the energy resolution is proved. *Higher-order Radiative Corrections To Electron Scattering, D. R. Yennie and H. Suura, Stanford University, PB 12491, Nov. 1956, 15 p, Microfilm $2.40, Photocopy $3.30. Order from Library of Congress, Washington 25, D. C.*

Image Intensifier

Development of an image intensifier is described which makes use of cascaded fine mesh screens coated with an efficiency secondary emitter, cesiumantimony, to achieve mulitplication of weak photoelectron images from a cesiumantimony photocathode. An axial magnetic field is used together with approximate potentials and spacings of the screens to keep the electron image in focus. Forty-five image tubes were produced under this contract, and the methods of production together with the results of tests and experiments on these tubes are described. Recommendations for the course to be followed in the further development of the screen-type intensifier to overcome the drawbacks of the present design are discussed. *PB 124263 Magnetically Focused Secondary Emission Screen Type Image Intensifier, F. F. Rieke, Chicago University, Chicago Midway Labs, Chicago, Ill., Library of Congress, Washington 25, D.C. Aug 1956, 43 pp. Microfilm $3.30, photostat $7.80.*

Report Briefs

Radiometer Calibration at 4.3 Mm

With the advent of the 4.3 mm wavelength radiometer, it became necessary to develop precision instruments for calibrating the radiometer. The major components consist of a hot load, discharge tube, waveguide switch, and precision attenuator. These instruments have performed well in laboratory applications and in routine use. It is believed that they represent a step forward in precision instrumentation at millimeter wavelengths. *Precision Instruments for Calibrating Radiometers at 4.3 Millimeters Wavelength, Arthur I. Reynard, U.S. Naval Research Lab., PB 121947, May 1957, 15 pp, $.50. Order from OTS, Washington 25, D.C.*

AF Multicolor Storage Tubes

Shadow-mask multicolor storage tubes for radar and other applications with low frame rates have been constructed for the Air Force. Design of the tubes was directed towards providing long-persistence displays of high brightness. Such color displays reduce flicker and tend to provide a steady picture. They also permit additional information to be superimposed on the radar display. The multicolor storage tube was built by modifying a direct-viewing storage tube. It showed good color purity in a 6 in. diam circle. The tube has 75 total color dots per in. resolution, 8 ft-L brightness, and about 1 min persistence. *PB 121815, Long-Persistence Three-color Indicator Cathode-Ray Electron Tube, C. D. Beintema, L. L. Vant-Hull, and S. T. Smith. The Hughes Aircraft Co. for Wright Air Development Center, OTS, U.S. Dept. of Commerce, Washington 25, D.C., May, 1956, 29 pp, $0.75.*

Phosphor Research

The results of the project to develop a cathode-ray phosphor having a long persistent exponential decay characteristic with a time constant of the order of 0.5 sec to 2.5 sec or a phosphor having a concave downward decay characteristic with a similar decay time are reported. The effort was directed toward the development of a long persistence exponential decay phosphor. The decay and emission characteristics of phosphors using a strontium, barium, or calcium silicate matrix and rare earth elements as activators are reported. A phosphor having the desired decay properties was *not* found. *Long Persistent Exponential Decay Phosphors, James F. Elliott, General Electric, PB 121527, 57 p, Feb. 1956, $1.50. Order from OTS, Washington 25, D. C.*

Heater-Cathode Leakage

The purpose of the present experimental program is three-fold: *1.* to obtain a phenomenological description of heater-cathode leakage under typical life test conditions of military tube types, *2.* to determine the nature and relative importance of mechanisms responsible for heater-cathode leakage and to investigate the physical and chemical parameters governing the important heater-cathode leakage mechanisms, *3.* to utilize the experimental findings through specific recommendations concerning the use of improved materials, the use of improved processing and aging, and the use of operating conditions to minimize the detrimental effects of heater-cathode leakage. *Heater-Cathode Leakage Investigations, Paul E. Carroll, Julius Cohen, Paul Cutler and J. V. Florio, Sylvania Electric Products Inc., PB 124715, Aug. 1956, 31 p, Microfilm $3., Photocopy $6.30. Order from Library of Congress, Washington 25, D. C.*

Info Theory Logs

In this report, four-place logarithms to the base 2 are presented in table form for the three-digit numbers between 1.00 and 9.99. The table can be used to obtain the logarithmic values of all three-digit numbers between 0.00000100 and 9,990,000. The logarithms-base-2 are tabled in a form convenient to use, since all values are placed on two facing pages. *Four-Place Logarithms to the Base 2 of Three-Digit Numbers, Earl A. Alluisi and Ilse B. Webb, Ohio State Univ., Lab. of Aviation Psychology, and Ohio State Univ. Research Foundation, Columbus, Ohio, PB 121966, Dec. 1956, 8 pp, $.50. Order from OTS, Washington 25, D.C.*

NEL Reliability Design

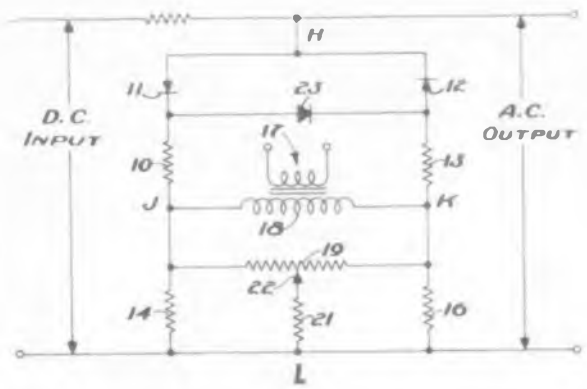
This handbook is intended as a source of information on ways of achieving greater simplicity, economy and reliability in electronics equipment developed for the Navy, and as a medium through which information on new materials, processes, and techniques, as well as design aids and reliability concepts can be disseminated. It is intended as a method of coordinating preferred circuits, construction techniques, design procedures, and application design data. The basic book will be enlarged and kept up to date by means of loose-leaf insertion sheets. In addition to NEL originated material, it will contain current reliability and standardization data from the Bureau of Ships, other government organizations, and contractors. *NEL Reliability Design Handbook. Revised. U.S. Navy Electronics Lab., San Diego, Calif., PB 121839, Nov. 1955, 282 pp, $3.00. Order from U.S. Dept. of Commerce, Washington 25, D.C.*

Patents

Diverter Conversion Circuit

Patent No. 2,786,149. H. W. Patton. (Assigned to Collins Radio Company)

The conversion circuit illustrated converts a dc signal to an ac signal which is of square form and proportional to the dc signal. The circuit is a bridge type with diodes in two arms of the bridge. These diodes are conventionally germanium or selenium which individually have widely varying forward and backward impedances. In order to secure a balanced bridge of conventional type, these impedances must balance. It requires the testing of a great many diodes before matching sets are found. This is, therefore, an expensive and time-consuming operation. Another difficulty with this type of converter is that because of the lack of exact balance of the impedances in both directions it is difficult or impossible to accurately convert minute dc signals.



The circuit described overcomes these and other difficulties in a simple manner.

In the circuit illustrated the bridge junctions are designated *H*, *J*, *L* and *K* with the circuit elements as shown in the figure. A commutating ac potential is applied across the junctions *JK* through the transformer *17*, *18*. The diodes *11* and *12* are poled in the forward direction for half of the ac wave supplied by the commutating potential and for the other half wave the diodes are poled in the backward direction. A resistor *10* and *13* is in series with each diode in its respective arm of the bridge. The arms *JL* and *KL* of the bridge are formed by resistors *14* and *16*. The potentiometer *19*, *21*, *22* is provided for the purpose of balancing the impedances of the resistors *14* and *16*.

The diode *23* shunts the diodes *11* and *12* and is poled to shunt the diodes in its forward direction for that portion of the ac wave which is a backward direction for the two diodes. As a result the backward impedance of the two diodes has essentially no effect on the ac output and any dissimilarity or lack of balance in their backward impedance is of no materiality. The output voltage is determined principally by the impedance of the resistors *10* and *13*.

Other circuits are illustrated and described in the patent which makes refinements to the circuit shown herein. These modified circuits give more precise control of the output of the circuit.

Semi-Conductor Sawtooth Wave Generator

Patent No. 2,797,327. M. C. Kidd. (Assigned to Radio Corporation of America)

The sawtooth wave generator uses a junction transistor with the customary three electrodes. Between the collector and emitter electrodes is a storage capacitor. A first resistor is connected with the collector electrode. A second resistor is connected between the emitter electrode and a point of reference potential. The biasing means for the transistor includes a first source of potential in series with the first resistor and poled to apply a voltage to the collector electrode so that the latter is biased in the reverse direction with respect to the base electrode. A second source of potential in series with the base electrode, is poled to apply a voltage thereto so that the emitter electrode is initially biased in the reverse direction with respect to the base electrode. As a result a negative resistance characteristic is provided over a portion of the operating range of the transistor which results in the storage capacitor being discharged when it has previously been charged. A push-pull sawtooth output wave is then derived from the generator at the output terminals of an output circuit which is connected with the collector and emitter electrodes.

Stat Pulse Doubling Circuit

Pat t No. 2,795,707. J. E. Sunderling. Assign l to Westinghouse Electric Corporation

The doubling circuit includes a saturable core transformer having primary and secondary circuits. An ac voltage is applied to the primary circuit. The secondary circuit includes means for biasing the transformer whereby it will saturate only once during a charging cycle. A load impedance is included in the secondary circuit. Suitable storing means is in series with the load impedance for storing electrical energy during the charging cycle when the transformer is unsaturated. This storing means discharges its stored energy during saturation of the transformer to thereby produce a voltage pulse across the load impedance.

Television Circuits

Patent No. 2,795,728. J. Giuffrida. (Assigned to Columbia Broadcasting System, Inc.)

The circuit described is for a cathode ray tube having an electron beam which scans a surface on the screen. A voltage is derived which varies substantially as a function of the instantaneous position of impingement of the electron beam on the surface. Circuit elements produce a squared voltage, the instantaneous value of which is equal to the square of the instantaneous value of the first voltage. This squared voltage is then applied to the cathode ray tube to vary the focal point of the beam in accordance with the instantaneous magnitude of the squared voltage.

Transistor Oscillator

Patent No. 2,797,328. E. G. Miller, Jr. (Assigned to the United States of America)

The crystal-controlled oscillator uses a pair of transistors each having at least the usual three electrodes. A crystal is provided between the base electrodes for controlling the frequency of the oscillator. Between the collector electrodes, there is an anti-resonant circuit which is tuned to the crystal frequency. A positive and negative bias is supplied to the collector and emitter electrodes respectively. A negative feedback circuit is coupled to the anti-resonant circuit and connected between the emitter electrodes.

Crystal-Controlled Relaxation Oscillator

Patent No. 2,796,522. M. Greenspan and C. E. Tschiegg. (Assigned to the United States of America)

The crystal-controlled relaxation oscillator includes a grid-controlled tube. A direct-coupled low-Q regenerative feedback circuit which includes the stray parameters of the tube is connected between the plate and grid of the tube to form an oscillator circuit therewith. This low-Q circuit has a natural frequency distinct from the relaxation frequency. A timing capacitor is connected to the grid of the tube which applies a rising exponential voltage to the grid. A piezoelectric crystal is coupled to the grid of the tube to form a Pierce oscillator circuit. The crystal has a natural frequency which is harmonically related to the natural frequency of the low-Q circuit. The Pierce oscillator and low-Q oscillator voltages derived from the oscillator circuits are superimposed on the exponential voltage as this exponential voltage nears the conducting value for the tube.

Amplifiers

Patent No. 2,795,752. R. W. Roberts. (Assigned to Westinghouse Electric Corporation)

The saturating-transformer magnetic amplifier is used for supplying energy to a load and includes a magnetic core having a winding inductively coupled therewith. An alternating-current is supplied to the winding during alternate half-cycles through suitable circuit means. The winding, the circuit means, and the magnitude of the alternating-current supply voltage are such as to always effect a substantially complete magnetic saturation of the magnetic core during alternate half-cycles of the alternating-current. During the other alternate half-cycles of the alternating-current, a control signal is developed for resetting the flux level in the magnetic core from saturation flux to a controlled flux reset point. An output circuit produces, over a wide range of variation in the magnitude of the alternating-current, a voltage across the load which is proportional to only the change in flux in the magnetic core that occurs during the alternate half-cycles when the flux level in the magnetic core changes from the controlled flux reset point to saturation flux.

Books

Microwave Measurements

Edward L. Ginzton, McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 36, N.Y., 515 pages, $12.00.

Basic forms of electrical measurements encountered at microwave frequencies have been compiled into an authoritative reference by Prof. Ginzton. Emphasis is on fundamentals, and the topics discussed provide a background for all common microwave measurements, as well as for more specialized applications. Particular fields such as the measurement of dielectric constants, antennas, and transmitter and receiver characteristics are omitted.

Elements of the electromagnetic theory needed to describe the behavior of electromagnetic waves in bounded regions are presented briefly to justify the generalized impedance concept and the use of generalized transmission line theory. These topics are developed sufficiently to make the application of the impedance concept, transmission line theory, and the equivalent circuit approach plausible and logical. The discussion of the numerous laboratory instruments is limited to the extent necessary to enable the reader to use them without risking difficulties because of an incomplete understanding of their functions. The book will prove useful for engineers who have more than a routine interest in microwave-measurement problems.

Thermal Stresses

B. J. Gatewood, McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 36, N.Y., 232 pages, $7.50.

Design problem caused by the thermal stresses which occur at elevated temperature will unquestionably become the limiting factor in missile and aircraft performance. This is the position Mr. Gatewood takes and the solution of this problem is the particular concern of his text. The book is for engineers—particularly aeronautical engineers. The material is well organized, with emphasis on fundamental theory.

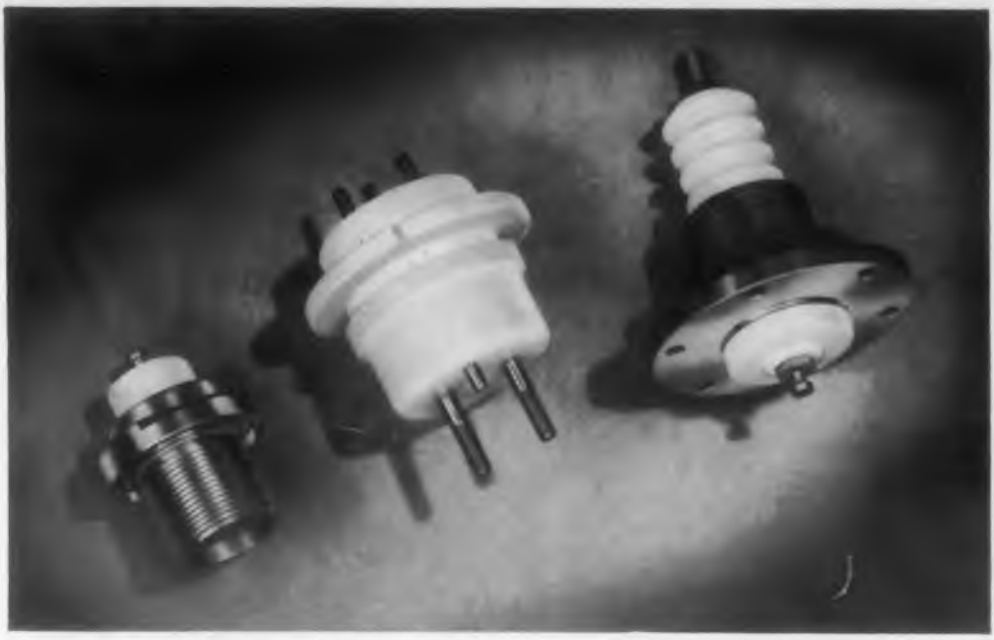
All phases of the analysis and design of structures at elevated temperatures are covered, including temperature distribution, elastic and inelastic thermal stresses, combined applied and thermal stresses, allowable stresses of various materials at elevated temperatures, and the buckling, deflection, stiffness, fatigue, shock, and flutter effects of elevated temperatures. Many of the procedures included are published for the first time. The treatment is applicable to nuclear reactors, rocket motors, steam and gas turbines and their design, as well as guided missiles and aircraft.

Fasteners Handbook

Julius Soled, Reinhold Publishing Corp., 430 Park Ave., N.Y.C., 430 pages, $12.50.

A comprehensive coverage of fasteners with up-to-date answers for fastening problems in all fields has been compiled by Julius Soled. Its pertinent data, illustrations, and full page descriptions supply detailed information on currently available fasteners. It is a handbook in every sense of the word. You can select the type you want from standard and proprietary fasteners of all manufacturers. Specialized types developed since World War II and specific fasteners which increase structural safety and reliability are included for all sizes and types of materials.

Actual uses of fasteners in one industry are related to those of another. Concrete examples of money-saving applications result from the cross reference. The book also points out plus values of many of the less known, but equally valuable, fasteners. All major manufacturers and most smaller ones have contributed material. Industry associations such as the Fasteners Institute and the Screw Bureaus have also supplied information.



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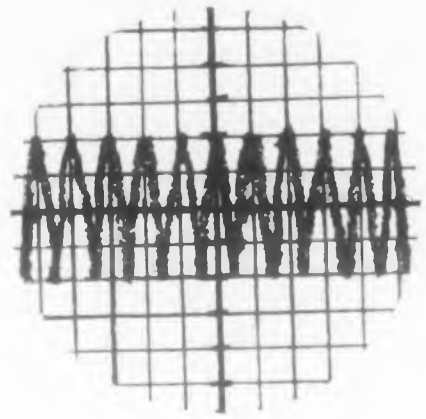
High Frequency Transistor Oscillator



J. George Adashko

THE OPERATING features of transistor oscillators at above-critical frequencies are of considerable interest because the critical frequencies of modern transistors do not exceed several megacycles. In this range, the diffusion character of the motion of the minority carriers from the emitter to the collector exerts a substantial influence on the self-excitation conditions and on the oscillator frequency. The influence of the transistor operating mode on the frequency can be used to produce frequency modulation.

An oscillator of this type was described in Ref. 1, where the frequency dependence of the current gain is given by

$$\alpha = \frac{\alpha_o}{1 + j\frac{\omega}{\omega_{cr}}} \qquad (1)$$

where ω_o is the low-frequency current gain, and ω_{cr} is the critical frequency of the transistor in grounded-base operation. Since α becomes imaginary with increasing frequency, this equation cannot be used to calculate the maximum oscillator frequency attainable.

This article contains an effort to obtain a simple method for the design of nearly-harmonic grounded-base transistor oscillators at above-critical frequencies, to establish the limiting oscillation frequency, and to determine the features resulting from the use of junction transistors in this circuit. The theoretical equations have been experimentally verified.

Analysis of Point-Contact Transistor Operation

Fig. 1 shows the principal diagram of the oscillator, and Fig. 2 shows the equivalent circuit; the capacitance C_c of the collector junction is neglected, as is permissible at frequencies up to 20-30 mc. An attempt to take C_c into account will be made below.

The admittance Y looking into the oscillator, calculated assuming $R \gg r_e + R_b$, $r_e \ll |r_c - r_g|$, and $r_b \ll r_c$ can be given by the equation

$$Y = \frac{1}{r_c} + \frac{1-\alpha}{Z_C} \qquad (2)$$

where

$$Z_C = \frac{1}{j\omega C}; \alpha = \frac{r_m}{r_c}$$

Taking into account the fact that the current gain is complex at frequencies comparable with the critical frequency, we write in general and obtain for Y

$$Y = \frac{1}{r_c} + \omega C\, Im\alpha + j\omega C\,(1 - Re\,\alpha). \qquad (3)$$

It follows from (3) that the circuit of Fig. 2 can be replaced by a parallel circuit consisting of a capacitance

$$C_{eq} = C\,(1 - Re\,\alpha) \qquad (4)$$

and a resistance

$$R_{eq} = \frac{r_c}{1 + \omega C r_c\, Im\,\alpha} \qquad (5)$$

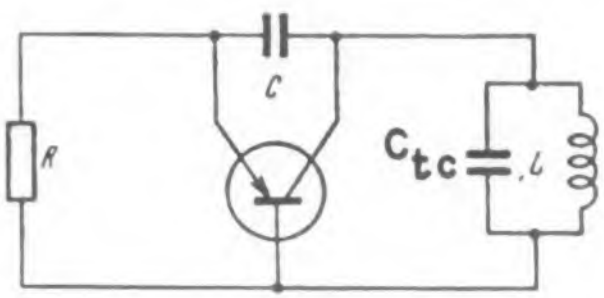


Fig. 1. Basic oscillator circuit.

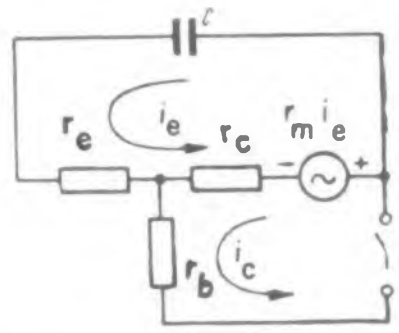


Fig. 2. Equivalent circuit of the oscillator, used to calculate the output admittance, using a point-contact transistor.

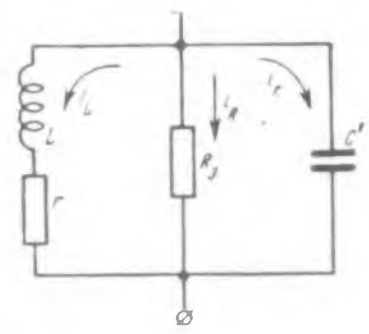


Fig. 3. Simplified equivalent circuit of the oscillator.

If the inequality $|\omega C r_c Im\,\alpha| > 1$ is satisfied and if $Im\,\alpha < 0$, the resistance R_{eq} is negative. Taking C_{tc} and R_{eq} into account, the equivalent circuit is replaced by the one shown in Fig. 3, where r is the resistance of the tank circuit, and $C' = C_{tc} + C_{eq}$.

The differential equation of the system shown in Fig. 3 reduces to

$$\frac{d^2i}{dt^2} + 2\delta\frac{di}{dt} + \omega_0^2 i = 0$$

where

$$2\delta = r/L + 1/C'R_{eq} \qquad (6)$$

$$\omega_0^2 = (r + R_{eq})/R_{eq}LC' \qquad (7)$$

The general form of the self-excitation condition is, according to (6)

$$\frac{r}{L} + \frac{1}{C'R_{eq}} < 1 \qquad (8)$$

and the self-excitation frequency will be given by equation (7) in the linear approximation.

To obtain explicit equations for the self-excitation condition and for the frequency, we must choose a specific analytic approximation for the frequency dependence of α. In addition to the dependence given in (1), there exists another approximation (Ref. 2)

$$\alpha = \alpha_o \operatorname{sech}\sqrt{j\,2.43\,\omega/\omega_{cr}} \qquad (9)$$

obtained by solving the diffusion equation for the minority carriers in the base layer.

The literature contains no indication of the limiting frequency for which (1) or (9) still holds. Our experiments have shown that (1) is accurate to 25% for an overwhelming majority of point-contact transistors up to approximately 3 ω_{cr}, while expression (9) gives adequate results above 3 ω_{cr}.

For convenience let us write the real and imaginary parts of equation (1)

$$Re\,\alpha = \frac{\alpha_o}{1 + \left(\frac{\omega}{\omega_{cr}}\right)^2} \qquad (10)$$

$$Im\,\alpha = -\frac{\alpha_o\left(\frac{\omega}{\omega_{cr}}\right)}{1 + \left(\frac{\omega}{\omega_{cr}}\right)^2} \qquad (11)$$

and of equation (9)

$$Re\,\alpha = \alpha_o\frac{\cosh x \cos x}{\sinh^2 x + \cos^2 x} \qquad (12)$$

$$Im\,\alpha = -\alpha_o\frac{\sinh x \sin x}{\sinh^2 x + \cos^2 x}$$

where $x = \sqrt{1.215\,\frac{\omega}{\omega_{cr}}}$.

Using these relationships, we obtain an explicit

expression for the frequency. Let us note that if the inequality

$$|R_{eq}| \gg r \tag{14}$$

is satisfied, equation (7) simplifies to

$$\omega_g^2 = \frac{1}{LC'} = \frac{1}{L[C_{tc} + C(1 - R_e\alpha)]} \tag{15}$$

Substituting the standard parameters of the transistor and of the circuit into equation (5) and using eq. (13) to determine *Im* α, is it easy to verify that inequality (14) holds quite rigorously for frequencies above the critical frequency ω_{cr}, and that $|R_{eq}|$ increases continuously with increasing frequency. It is possible to compensate for the decrease in the regeneration only by decreasing the resistance r of the tuned circuit. This is why the dependence of *Im* α on the frequency becomes weaker with increasing frequency.

An estimate of the value of *Re* α shows that at frequencies less than approximately 3 ω_{cr} one can no longer assume *Re* α to be much smaller than unity in the expression for C'. In this case the oscillation frequency can be obtained from the following equation, derived with the aid of (10)

$$\omega_g^2 = \frac{1}{2}\left[-\omega_{cr}^2(1-\epsilon) + \omega^2 + \sqrt{\omega_{cr}^2(1-\epsilon) - \omega^2]^2 + 4\,\omega_{cr}^2\omega^2}\right] \tag{16}$$

where

$$\epsilon = \frac{\alpha_o C}{C_{tc} + C} \tag{17}$$

$$\omega^2 = \frac{1}{L(C_{tc} + C)}$$

In the particular case when $C = C_{tc}$ and $\alpha_o = 2$, ϵ is nearly equal to unity and (16) simplifies to

$$\omega_g^2 \approx \bar{\omega}^2\left(1 + \frac{\omega_{cr}^2}{\bar{\omega}^2}\right) \tag{18}$$

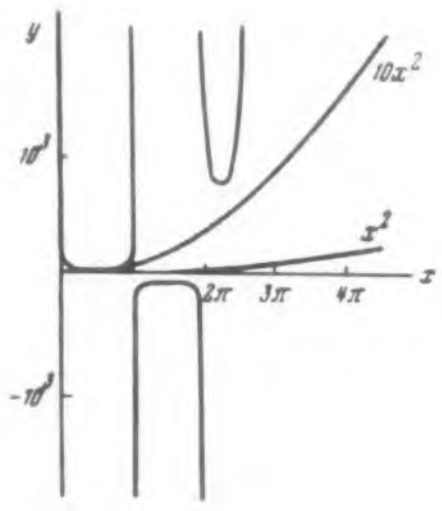


Fig. 4. Graphical solution of equation (20).

A similar simplification is possible also for $\omega_g \geq 3\,\omega_{cr}$. At higher frequencies, in the case of point-contact transistors, the value of α_o of which does not exceed approximately 2, equation (17) can still be used, for the error due to neglecting ω_g does not exceed 25%.

The results have a simple physical explanation. The higher the frequency, the lower and the less regeneration in the system. If one attempts to offset this reduction by increasing the feedback capacitor, the result is a reduction in frequency (eq. 15). The only way to insure self excitation at higher frequency is to increase the Q of the tuned circuit. This is why the oscillation frequency still remains close enough to the resonant frequency of the tank circuit, in spite of the substantial phase shift.

Using eq. (10) and (11) it is easy to derive from inequality (8) a condition for self-excitation, valid for frequencies $\omega < 3\,\omega_{cr}$

$$\alpha_o \geq \frac{1}{\omega_{cr}C}\left(1 + \frac{\omega_{cr}^2}{\omega_g^2}\right)\left(\frac{1}{r_c} + \frac{1}{\rho_{res}}\right) \tag{19}$$

where $\rho_{res} = L/rC'$.

At frequencies $\omega > 3\,\omega_{cr}$, the self excitation condition, derived from (12) and (13), becomes:

$$y(x) \leq Ax^2 \tag{20}$$

where

$$y(x) = \frac{\sinh^2 x + \cos^2 x}{\sinh x \cdot \sin x}$$

$$A = \frac{\alpha_o C r_c \omega_{cr}}{1.215\left(1 + \frac{r_c}{\rho_{res}}\right)} \tag{21}$$

It must be pointed out that both (19) and (20) were derived by neglecting r_e and r_b. These conditions are valid only when the phase shift in the feedback loop is close to 90°. This usually holds for frequencies above critical.

Fig. 4 shows a graphic solution of inequality (20), showing that, theoretically, self excitation is possible if $2n\pi \leq x \leq (2n+1)\pi$, where $n = 0, 1, \ldots$. At frequencies corresponding to $(2n-1)\pi \leq x \leq 2n\pi$, the phase balance conditions are not satisfied, and oscillation is possible only by reversing the feedback polarity.

A simple analysis shows that in practice oscillation is possible only the first region ($n = 0$). Actually, even for $2\pi \leq x \leq 3\pi$ oscillation is possible only for $A > 15$, which can be obtained only with a feedback capacitance of 30-40 μμf, at which the circuit cannot resonate.

The region $0 \leq x \leq \pi$ is shown enlarged in Fig. 5. Self-excitation occurs here at $A = 1$; the theoretical maximum oscillation frequency, corresponding to $A = \infty$, is 8.1 ω_{cr}. In practice, it was verified experimentally that such a generator can operate up to approximately 6 ω_{cr}.

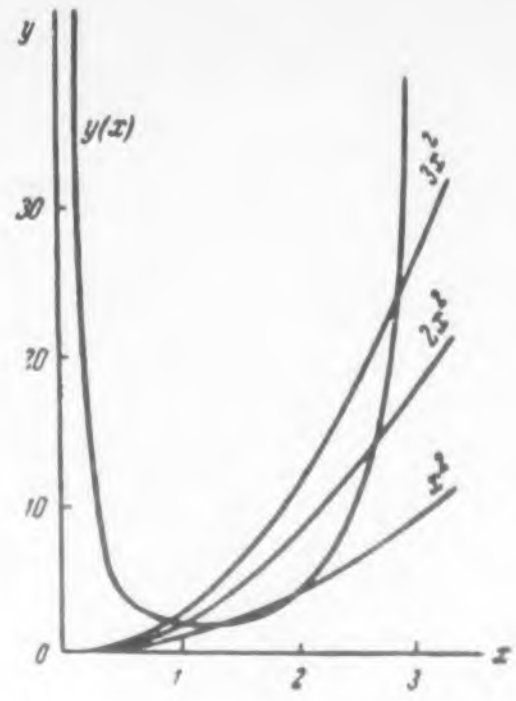


Fig. 5. Region $0 \leq x \leq \pi$ in Fig. 4.

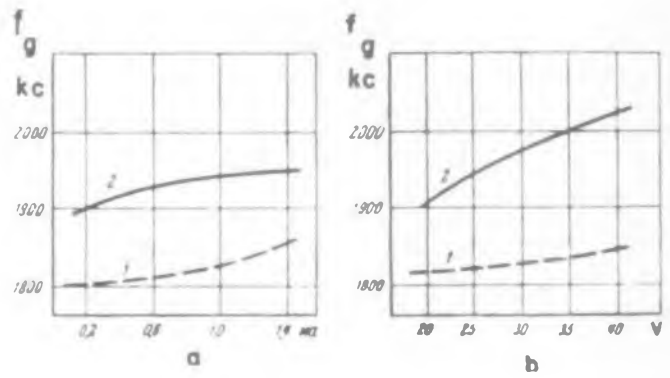


Fig. 6. a—generator frequency ($f_o = \omega_g/2\pi$) vs. emitter current for S1B point-contact transistor; 1—calculated, 2—experimental b—f_g vs. collector voltage for S1B point-contact transistor; 1—calculated, 2—experimental.

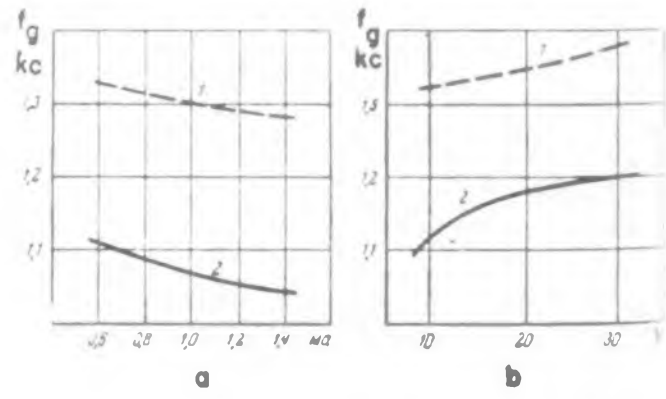


Fig. 7. Same as Fig. 6, but for P1E junction transistor

Extent to which the Theory can be Applied to Junction Transistors.

The results obtained above are valid provided $\ll r_c$, and under the assumption that the capacitance C_c of the collector junction in parallel with r_c is sufficiently low. One can readily check to what extent C_c can be neglected by replacing the parallel network $r_c C_c$ with an equivalent series network $r'_c C'_c$ and compare r'_c with r_b. Evidently, for C_c to be negligible, we must have

$$r'_c = \frac{r_c}{1 + (\omega C_c r_c)^2} \gg r_b$$

In view of the relatively high value of C_c in junction transistors (20 to 70 μμf), it is essential that eq. (22) first be checked before starting the design. If C_c cannot be neglected, it must be added to the capacitance of the tank circuit, and eq. (4) for C_{eq} must be replaced by

$$C_{eq} = C_c + C(1 - Re\,\alpha) \qquad (23)$$

In addition, experiment has shown that eq. (1) for $\alpha(j\omega)$ holds for junction transistors, with an accuracy of 25%, only up to approximately 1.5 ω_{cr}, and eq. (16) and (18) for the oscillation frequencies are valid only over this frequency range. At higher frequencies one can use (17) if (22) is satisfied.

Possibility of Frequency-Modulating the Oscillator.

The equations derived show the generator frequency ω_g to depend on the transistor critical frequency ω_{cr} and on C_c (in the case of the junction transistor). Since these parameters are functions of the operating conditions, it becomes possible to frequency-modulate the generated oscillations.

The solid curves of Figs. 6 and 7 show experimentally-plotted relationships between ω_g and the emitter current or the collector voltage, for a point contact (S1B) and junction (P1E) transistor. The dotted lines correspond to the theoretical values, accurate to 25%.

Measurements have confirmed that it is possible to frequency-modulate the oscillator over a range of 8-10%.

It must be emphasized, in conclusion, that the results obtained here hold only for the particular generator circuit given here. Every oscillator circuit must be analyzed separately.

Reference

1. H. E. Thomas, *Electronics*, Feb. 1954, pg. 130

Abstracted from "Analysis of Nearly Sinusoidal Transistor Oscillator Operating at Above-Critical Frequency," K. S. Rzhevski, L. N. Kaptsov, which appeared in Radiotekhnika i Elektronika No. 5, 19[illegible].

RADIO ENGINEERING AND ELECTRONICS

(Contents of Radiotekhnika i Elektronika No. 2, 1957)

INFORMATION THEORY

On Statistical Methods of Facsimile Transmission, R. R. Vasil'ev, (8 pp, 6 figs.)

The author examines the possibility of increasing the speed of facsimile transmission by increasing the ratio of the entropy of the facsimile image to the capacity of the transmission channel. Analysis of the entropy of two transmission systems, one with flyback of the scanning beam and the other with two-speed scanning, shows that after overcoming many serious technical difficulties the speed of facsimile transmission can be increased by 10-15 times.

Non-Stationary Processes in a Self-Oscillator Driven Hard by Radio Pulses, E. S. Voronin, I. I. Rogatnev (6 pp, 8 figs.)

Report on experiments with a self-excited oscillator close-coupled to a synchronizing pulse source. An attempt is made to determine the optimum synchronization condition, aimed at employing the oscillator for coherent-pulse radar. A block diagram of the test setup (Fig. 1) and some oscillator diagrams (Fig. 2) are accompanied by a detailed analysis of the experimental results.

What the Russians Are Writing

WAVEGUIDES

Gyrotropic Obstacles in Waveguides, V. V. Nikol'ski, (15 pp, 9 figs.)

Expressions are derived for wave propagation in waveguides with gyroscopic obstacles, particularly ferrites magnetized in various directions. The analysis applies to rectangular, coaxial, and cylindrical waveguides with obstacles of various orientations, shapes, and magnetization directions.

Analysis of Certain Types of Corrugated Waveguides, R. G. Mirimanov, G. I. Zhileiko, (12 pp, 2 figs., 1 table).

Basic equations are derived for various corrugated guides, particularly those used for linear accelerators. The equations determine whether E modes with a specified range of phase velocities can be launched in such guides. The irregularities in the longitudinal electric field and the intensity of the defocusing transverse field are evaluated. The authors conclude that standard round waveguide with disks is best for low beam intensities (up to 0.1 a) and high phase velocities. For higher beam intensities either coaxial or rectangular guides with two sets of ridges are recommended. Medium beam intensities and low phase velocities can be handled by the simpler rectangular guide with single ridge.

Design of Symmetrical Round Waveguide Transitions for H_{01} Modes, Iu. N. Kazantsev (7 pp, 7 figs.)

Reflection coefficients are calculated for a few specific types of dielectric inserts and metallic conical transitions between two round waveguides. The investigation yields data on the phase constant of an H_{01} wave in a waveguide with a dielectric insert as functions of the radius and of the dielectric constant of the insert. Certain low-reflection dielectric insert designs are obtained from these data.

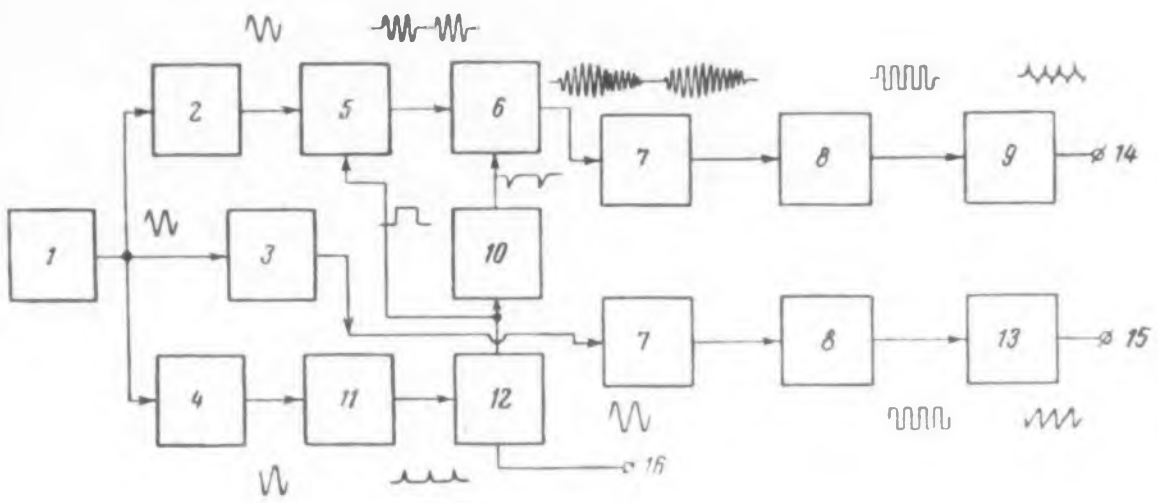


Fig. 1. Block Diagram of Equipment used in Self-Oscillator Experiments. 1—standard signal generator; 2—amplifier with attenuator; 3—phase shifter; 4—amplifier; 5—modulator (paraphase amplifier); 6—self-oscillator under test; 7—cathode follower; 8—square-wave forming channel; 9—differentiating circuit; 10—forming circuit for negative blocking pulses; 11—frequency divider (300:1); 12—multivibrator; 13—sawtooth voltage generator; 14—to oscillograph modulator; 15—to vertical oscillograph amplifier; 16—oscillograph sweep synchronization

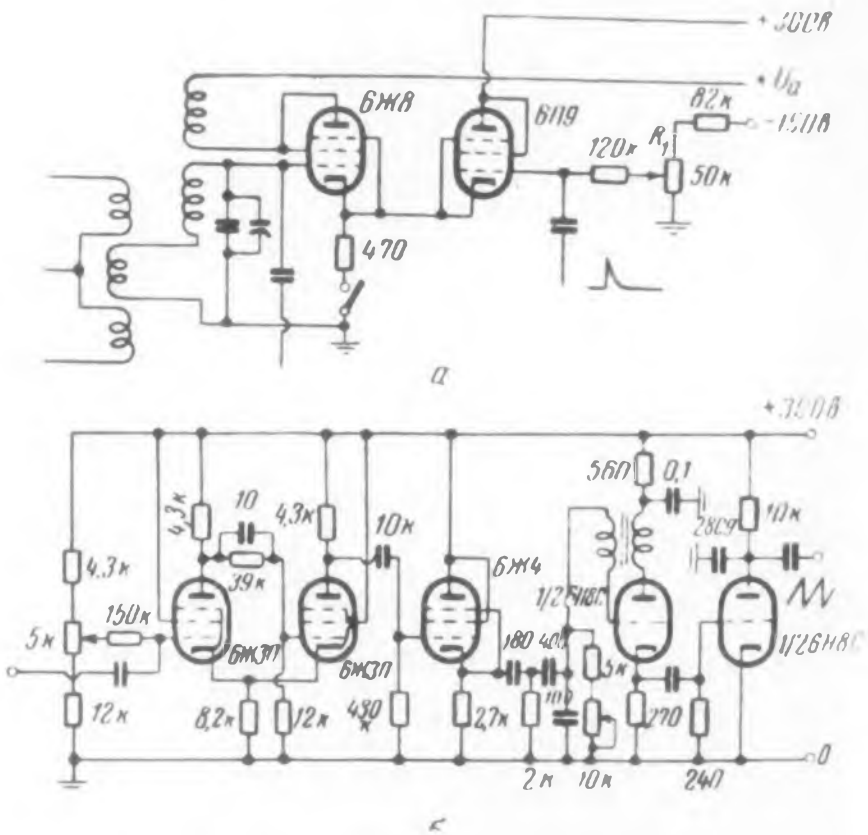


Fig. 2. a—principal diagram of tested self-oscillator; b—sawtooth oscillator.

FIELD THEORY

On the Electric Field of a Charge Spot Produced on the Surface of a Dielectric by an Electron Beam, Part I, V. Ia. Upatov, (11 pp, 6 figs.)

The normal electric field intensity is computed for a spot with uniform distribution and for a spot with a gaussian distribution of the surface charge density. Analysis of the formation of the positive charge spot on the surface of the dielectric under the influence of a stationary electron beam leads to the conclusion that under certain conditions, when the potential in the center of the spot is lower than the collector potential, part of the secondary electrons return to the target. If the collector field is strong, the effect of the spot becomes negligible. This condition is satisfied in most cathode-ray tubes in which the collector is a fine-structure grid, located in the immediate vicinity of the target.

Method for Measuring the Potential Distribution on the Surface of a Dielectric, V. Ia. Upatov, (9 pp, 11 figs.)

A pulse method is devised to measure the potential distribution on the surface of a dielectric. A metal grid is placed under the dielectric which is bombarded with electrons; the potential of the grid is a function of the surface potential of the dielectric. The experimental setup is described in some detail, the errors inherent in the method are discussed, and the results of the experiments are reported. Reference is made to work by Nelson (Journal Appl. Phys., 1938, Vol 2, 539) and Piore and Morton (ibid., 1940, 11, 153).

ELECTRON PHYSICS

Certain Investigations of Cold Electron Emission from Monocrystals of Cadmium Sulfite, R. Rompe, (3 pp, 5 figs.)

Experiments on electron-emission from CdS needles and points are reported. The experimental setup is described and some of the results are tentatively interpreted. The author points out similarities between cold emission and photo-conductivity.

Investigation of Noise Properties of Traveling-Wave Tubes, A. S. Tager, (8 pp, 7 figs.)

Theoretical analysis of noise in traveling wave tubes as a function of fluctuation waves in the electron beam. The noise distribution along a cylindrical beam is evaluated for the case of temperature-limited emission. Experiments show that if the local fluctuations on the cathode and the higher types of space-charge waves in the beam are neglected erroneous estimates are obtained for the effect of cathode space charge on the tube noise. A traveling-wave tube with a movable electron gun is used in the experimental setup, which is described in detail. The experimental results confirm the author's conclusion that the space charge near the cathode

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plays a substantial role in the suppression of shot-effect noise at super high frequencies.

On the Effect of Space Charge on the Interaction Between the Electron Beam and a Traveling Electromagnetic Wave, V. N. Shevchik, V. S. Stal'-makhov, 7 pp, 5 figs.)

The authors calculate the energy of interaction between an electron beam and a traveling electromagnetic wave, derive equations for the velocity modulation and for the transit angle and compute the current bunching and the electron-interaction power. The results are used to determine the starting conditions for a backward-wave oscillator. Comparison with other investigations and with experimental results shows that the theory is applicable to the analysis of several problems in the electronics of backward-wave oscillators.

Cascade Bunching of Electrons as Applied to the Analysis of the Interaction Between an Electron Beam and a Traveling Electromagnetic Wave, V. N. Shevchik, Iu. D. Zharkov, (7 pp, 4 figs.)

Expressions are derived for the bunching current and for the active and reactive components of the electron power. The effect of non-synchronous spatial harmonics on the power is estimated. The results are applied to the analysis of backward-wave tubes, but the authors emphasize the limitations imposed by the approximations used.

Investigation of One Method of Reducing the Bombardment of Field-Emission Cathodes by Ions of the Residual Gases, M. I. Elinson, V. A. Gor'kov, and G. F. Vasil'ev, (15 pp. 21 figs.)

Artificially created field configurations (Fig. 3) in the vicinity of a sharp cathode reduce the number of the positive ions in the residual gases (compare with Fig. 4). The authors estimate the number of bombarding ions, show several versions of protective field configurations, discuss several electrode-manufacturing techniques, and report in detail their experimental investigations. While the method proposed is quite effective, it is also planned to investigate other methods, such as reducing the cathode spattering coefficient.

Concerning the Analytic Treatment of Homogeneous Decelerating Systems, A. I. Shtyrov, (8 pp, 5 figs.)

The propagation of "slow" electromagnetic waves in periodic structures is treated as a combination of total internal reflections. The analysis covers rectangular homogeneous ridges and rectangular ridges filled with dielectrics, which are compared with an isotropic dielectric sheet bounded by an ideally-conducting plane. Energy flow in decelerating systems is also treated.

BIOGRAPHY

Heinrich Hertz (on the 100th Anniversary of his birth), N. N. Malov, (5 pp.)

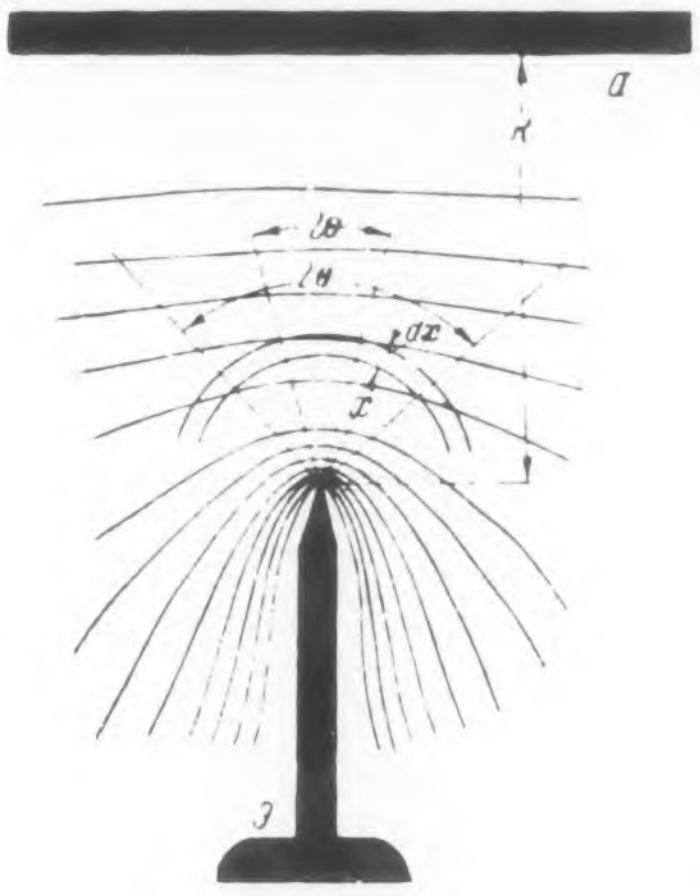


Fig. 3. Electric field modified by insertion of third electrode. $V_3 = O$, $V_a = V_o$.

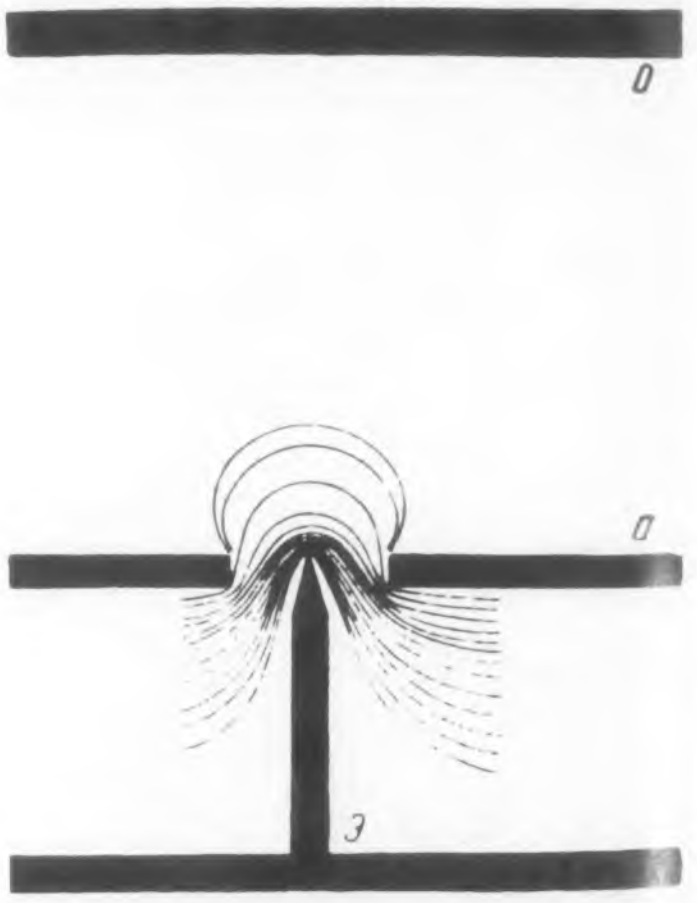
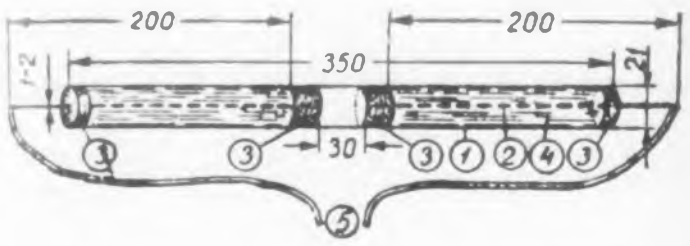


Fig. 4. Conventional system of electrodes used in the investigation of field emission, showing the equipotential electric field lines. 3—metallic point, a—anode.

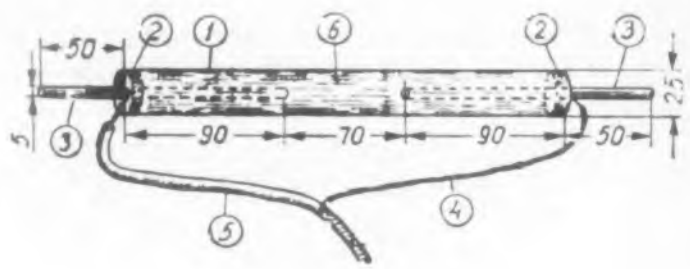
RADIO—No. 6, 1956

Water-Filled Television Antennas

A recent tendency among Russian amateurs (many of whom build their own television sets) is to employ indoor antennas made of glass tubes filled with water or glycerine, examples of which are given in the two accompanying drawings, Figs. 5 and 6. The advantage of such antennas is their small size, the disadvantage—need for a strong signal. Another proposed design (unfortunately without accompanying photographs, consists of two bottles (vodka, no doubt), and copper rods 28-30 cm long and 2-3 mm thick.



Figs. 5 and 6. Examples of water or glycerine filled glass tubes used as TV antennas.



UNESCO BULLETIN FOR LIBRARIES

(Vol. XI, No. 8-9, 1957)

Machines For Retrieving Information In The USSR, B. M. Rakov and V. P. Cerenin (5 pp, 2 figs.)

This article, in English, deals with the library problems of evolving a 'machine language' and working out techniques for information retrieval. The author indicates that the system set up will depend on the type of work for which it is required, the bulk of information, the demands on the service, and the way in which the service is operated.

He discusses the operation of the EIM, an experimental information-retrieving machine produced in 1954 by the Institute of Scientific Information of the Academy of Sciences in the USSR. The EIM uses 80-column punched cards and, despite its simple construction, meets all the stipulated requirements and provides the desired flexibility of operation.

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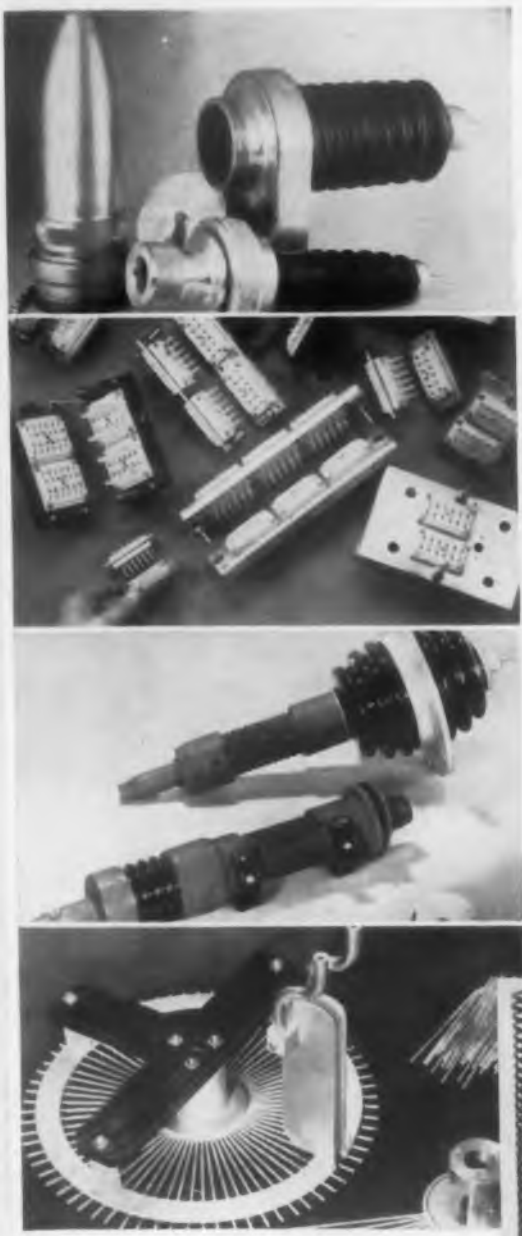

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German Abstract

Quartz Crystal Parameters

E. Brenner

THE use of quartz crystals in the lattice (bridge) connection makes it possible to construct filters which have exceedingly narrow band width. A passband of 20 or 30 cps centered around 100 kcs, for example can be obtained with ease. Such a bridge type filter is shown in Fig. 1. The two quartz crystals used are represented by their equivalent circuits; the $L_3 - C_3 - C_1$ and the $L_2 - C_2 - C_0$ combinations represent crystals. The band width and cutoff frequencies of such a filter depend on the parameters in the equivalent circuits of the crystals, in particular on the series resonant frequencies and on the inductance values. These parameters must be determined with precision; it can be shown that such measurements depend on the precise determination of small difference frequencies.

To measure the series resonant frequency of a crystal, two basic schemes may be used. In the simple scheme the crystal is connected across a precisely calibrated frequency source in series with the resistance. The series resonant frequency is then established by determining the frequency at which the voltage across it is a minimum.

In the alternate scheme the quartz crystal is used as the coupling element in the series resonant oscillator circuit shown in Fig. 2. If the potentiometers P_1 and P_2 are adjusted, the oscillations barely persist. Then the frequency of the oscillations correspond to the series resonant frequency of the crystal. To measure this frequency with precision, it is particularly convenient if a standard frequency source at the nominal frequency of the crystal is available. In that case a Lissajous figure between the unknown and the standard is produced. Since the two frequencies will differ by only a few cps this difference is measured by timing the rotations of the non-stationary pattern on the oscilloscope screen. If the crystal frequency does not correspond to the available standard, heterodyning may be used.

To measure the inductance a calibrated capacitance may be connected in parallel with the crystal. By measuring the resonant frequency of the combination for two values

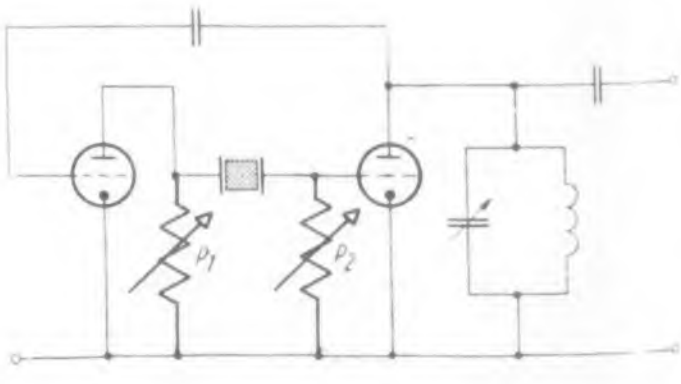

Fig. 2. Oscillator for determines the series resonant frequency.

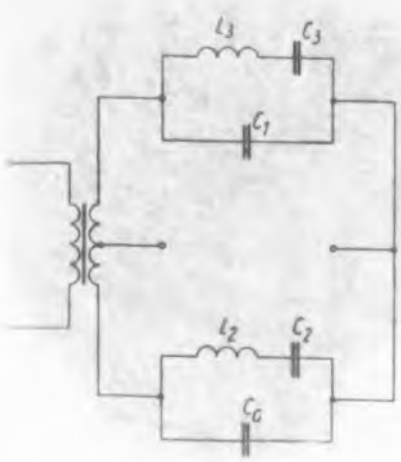

Fig. 1. Schematic of quartz filter.

of this capacitance the inductance of the crystal can be determined. The principle used here is essentially that of a "Q-meter." The precise determination of the difference frequencies which is necessary is carried out with a differential bridge, Fig. 3.

If for $C_x = C_1$ (or C_2) the parallel resonant frequency is f_1 (or f_2) then it can be shown that the inductance is given by the formula:

$$L = \frac{1}{(C_2 - C_1)} \cdot \frac{\Delta_1}{8\pi^2 f_2 (\Delta_0)\ (\Delta_1 + \Delta_0)}$$

where

$$\Delta_1 = f_1 - f_0 \quad ; \quad \Delta_0 = f_2 - f_0$$

and f_0 = series resonant frequency.

The frequency f_2 and the value $C_2 - C_1$ can be determined with the required precision. To determine the difference frequencies the frequency f_2 is mixed with a low frequency f_d (Fig. 3) so that the three frequencies f_2, $f_2 - f_d$, $f_2 + f_d$ are applied to the bridge. Assuming that for none of these frequencies the bridge is balanced, the frequencies f_d and $2f_d$ appear at the plates of the cathode ray tube, the others having been suppressed by the low pass filter. With S_1 closed, f_2 is adjusted so that the middle side band $f_2 - f_d$ is suppressed because of the series resonance of the crystal. The frequency $2f_d$ is eliminated through balancing R_x. This resistance value represents the equivalent resistance of the crystal at series resonance. Opening the switch and varying C_x, $f_2 + f_d$ is suppressed and the frequency $2f_d$ again disappears. Because of the modulation $f_d = \Delta_0 = \Delta_1$ and the inductance is given by

$$L = \frac{1}{(C_2 - C_1)} \cdot \frac{1}{16\pi^2 f_2 f_d}$$

The temperature of the crystal during these measurements must be carefully controlled. The original paper includes alternate measurement schemes and a detailed discussion of the required tolerances for filter design. (*Abstracted from a paper by C. Kurth and R. Mieczynski*, Nachrichtentechnik, *Vol. 1, No. 6, June 1957, pp. 244-249.*)

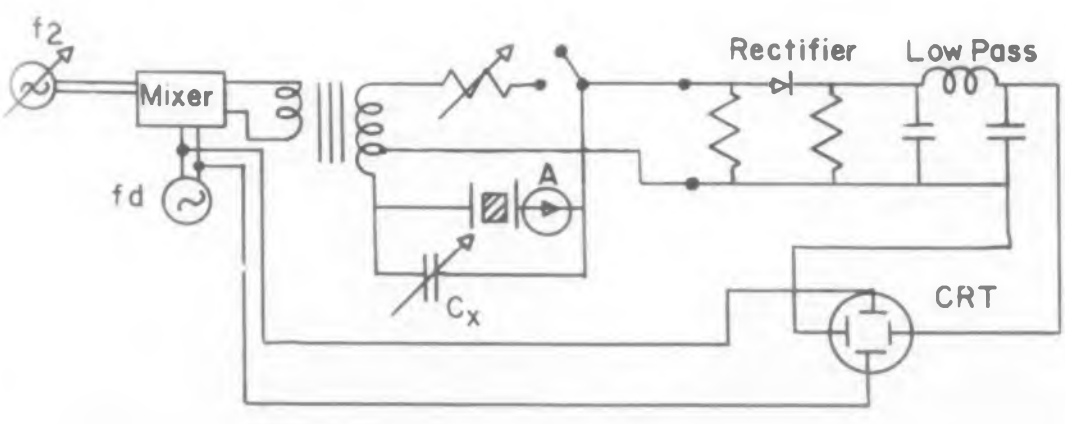

Fig. 3. Circuit for inductance measurement.

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Machine Solution of Higher Order Polynomials

The solution of the algebraic equation

$$f(z) = \sum_{k=0}^{n} a_k z^k = \sum_{0}^{n} a_k r^k \underline{k\phi} = 0 \qquad (1)$$

can be carried out by means of an analog computer. Assuming that the roots are complex (real values are taken as a special case of complex values), the scheme shown in Fig. 1 can represent Eq. (1). If the variable in Eq. (1) is written in polar form we may write:

$$v + \sum_{k=0}^{n} E_m a_k r^k \cos(\omega t + k\phi)$$

The function f(z) is now identified with the voltage v in Fig. 1. The numbers r and ϕ are so chosen that v(t) is zero for all t. The solution of an equation then proceeds as follows. The coefficients a_k are set into the machine and r and ϕ are adjusted until the output voltage vanishes.

The problems in construction of the analog fall into four groups: Raising the voltage to a power, setting of coefficients, phase shifting and summation.

The feedback amplifier circuit shown in Fig. 2 is used to raise the voltage v to any integral power. The linear potentiometers in the circuit are ganged. If the gain V, is unity then $r = \rho$, the potentiometer ratio.

For phase shifting, an electrostatic device, basically a capacitor whose stator is made in four sections, is used. The rotor is specially designed.

The coefficients are set by means of an autotransformer with nine taps, followed by a potentiometer. Summing is accomplished with the usual operational summing amplifiers. An ordinary vacuum tube voltmeter is used as indicator.

An an example, the solution of the fifth order equation is cited. Machine solution was accomplished in 12 minutes although the procedure involves trial and error adjustment. The accuracy of the basic unit is better than 4 per cent. The accuracy of solution can be improved by successively solving equations, in each case shifting the zero point to a previously approximated root. *(Abstracted from an article by G. C. Brack, Elektronische Rundschau, Vol. 11, No. 6, June 1957, pp 183-187.)*

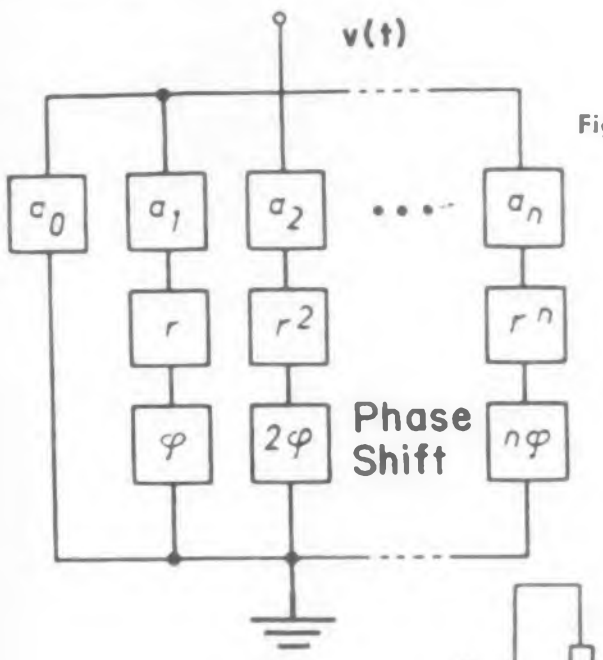
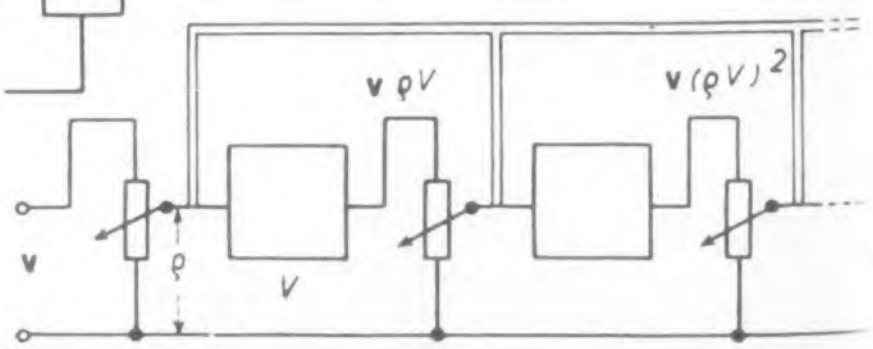


Fig. 1. Analog of the equation.

Fig. 2. (below) Raising voltage amplitude to a power.



Noise in Magnetic Tape

A new, unused magnetic tape, when played back, gives rise to less background noise than a tape which has been used and erased. This is due to the fact that in the unused tape the magnetic domains are of smaller volume than in the reused case because erasing cannot reduce the domains below a certain minimum size.

If it is assumed that the domains are oriented in a random fashion and that each domain, as it passes under the reproducing (reading) head produces a voltage pulse, then the noise voltage density (squared average noise voltage per radian per sec) is shown to be approximately

$$d[V^2]_{av} = \frac{2N_1 m^2 \mu_0 \omega^2 b}{3\pi v}(y_a - y_m)d\omega$$

For integrating over all frequencies the average squared noise voltage power is, approximately:

$$[V^2]_{av} \approx \frac{N_1 m^2 \mu_0 b v^2}{12\pi\, y_m{}^2}$$

where

N_1 is the number of magnetic dipoles per unit volume

m is the magnetic moment of dipole

μ_0 is the absolute permeability

v is the speed of the tape

y_m is the distance from the closest surface of the tape to the reading head

y_a is the distance from the "far" tape surface to the reading head

b is the width of the tape

It can be shown that the maximum noise density occurs at a frequency $f = v/4\pi y_m$ which corresponds to 238 kc for $y_m = 0.5\text{x}10^{-4}$ cm at a speed of 150 cm per sec.

Since the factor N_1m^2 appears in all the equations it is concluded that the greater noise level from a previously used tape results from the reduction of N_1 (number of domains) due to erasing and the corresponding increase in m. Hence N_1m^2 for an erased tape is increased above the value for an unused tape. (*Abstracted from an article by Paul A. Mann*, Archiev Der Elektrischen Uebertragung, *Vol. 11, No. 3, March 1957, pp 97-100*

Abstract

Low Noise Klystron

OWING to the demand for a very low noise klystron in certain applications, investigations into the sources of noise were undertaken. The flexible diaphragms with which most klystrons are equipped were revealed to be the most important source. A non-tunable klystron was developed in which these diaphragms are absent; the tube has a very much lower noise level and can be used in three modes, delivering respectively 5 w, 33 w, and 200 w. The tube can be frequency and amplitude modulated by variation of the collector voltage; amplitude modulation can also be effected by the grid voltage. Variation of the grid voltage also permits—via thermal effects—a certain limited tuning of the tube.

Experiments showed that the noise in a klystron is predominantly due to microphony, to which tubes of this construction are particularly sensitive because of the presence of the two diaphragms. The extremely small vibrations of these diaphragms give rise to slight variations in the tuning frequency of both cavity resonators, resulting in phase variations and hence frequency variations of the output signal. After the spectrum of one of several tubes tested had been recorded, the diaphragms and tuner were cast in plaster of Paris, and the spectrum again recorded. The spectra before and after this treatment are represented as curves *a* and *b* in Fig. 1. The plaster of Paris was then removed and the tube was cast in plastic, after which the spectrum was again recorded. The result is shown as curve *c* in Fig. 1.

Construction

Attempts were made to build a more robust tuner to hold the diaphragms more firmly but the results showed very little improvement. The rms deviation of the tubes so constructed was of the order of 2 kc. As a low noise level was so important that the tunability of the tube could if necessary be sacrificed

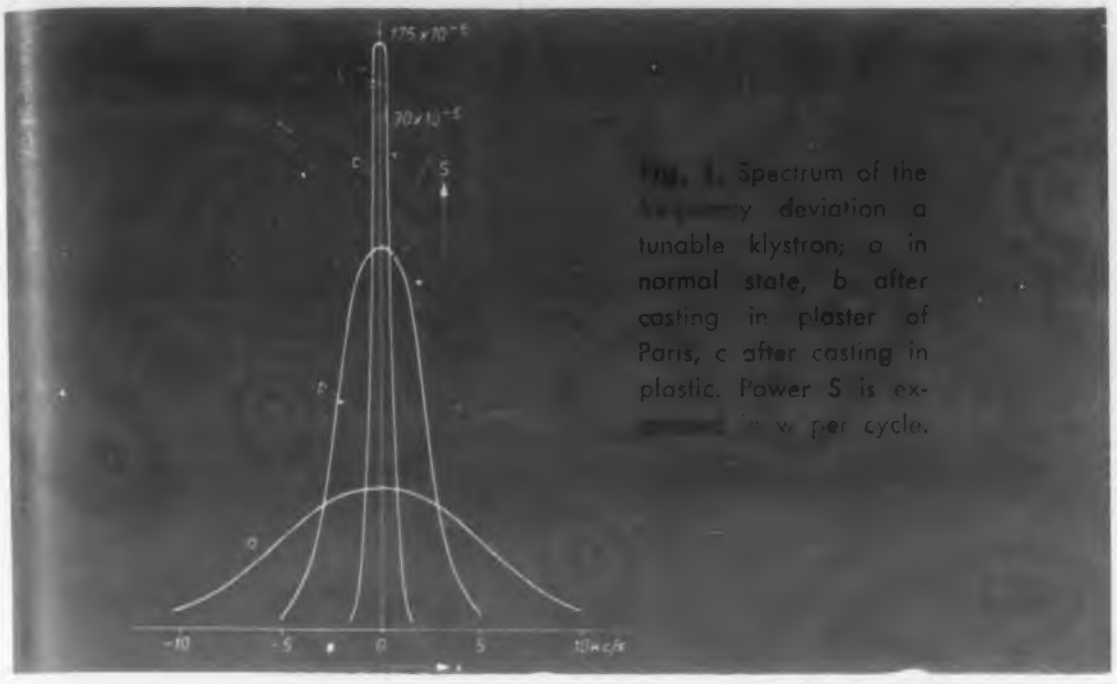
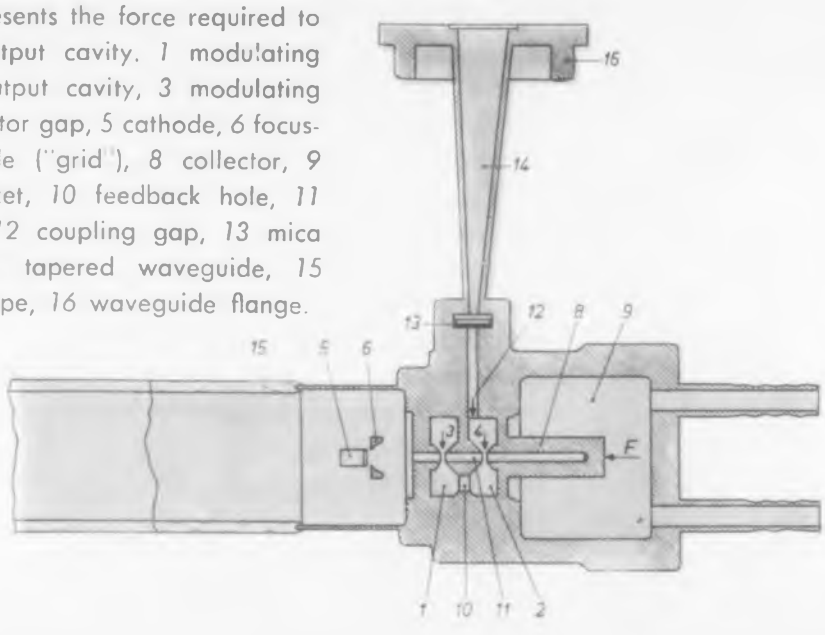


Fig. 1. Spectrum of the frequency deviation a tunable klystron; *a* in normal state, *b* after casting in plaster of Paris, *c* after casting in plastic. Power S is expressed in v_f per cycle.

Fig. 2. Cross-section of a low-noise klystron. *F* represents the force required to tune the output cavity. *1* modulating cavity, *2* output cavity, *3* modulating gap, *4* inductor gap, *5* cathode, *6* focusing electrode ("grid"), *8* collector, *9* cooling jacket, *10* feedback hole, *11* drift tube, *12* coupling gap, *13* mica window, *14* tapered waveguide, *15* glass envelope, *16* waveguide flange.



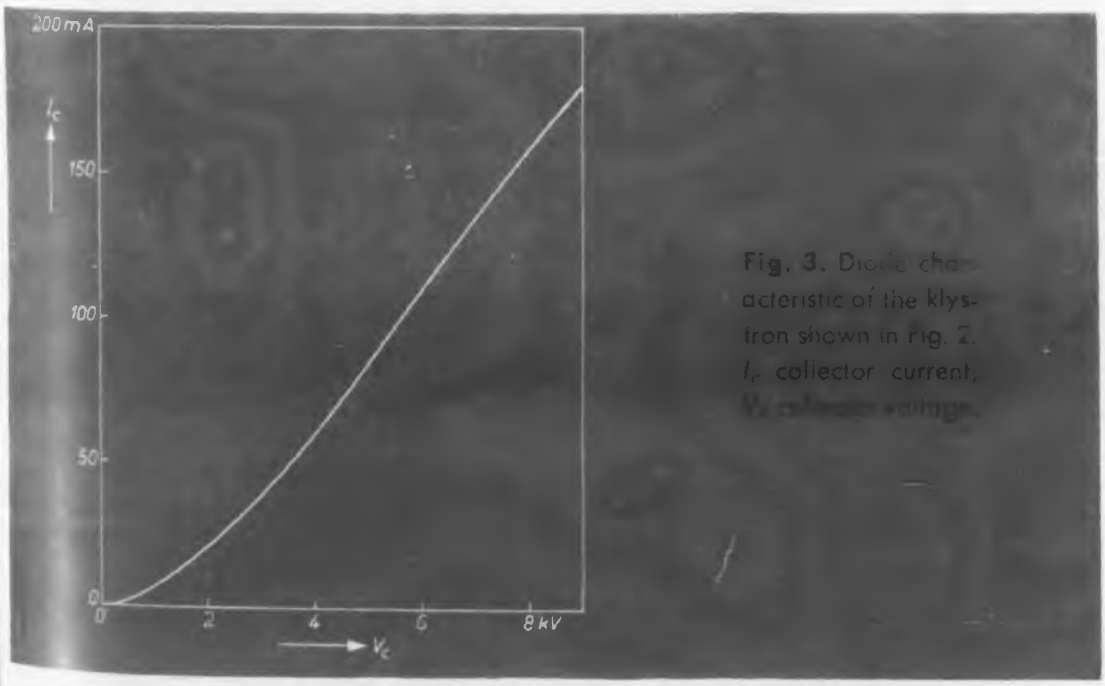


Fig. 3. Diode characteristic of the klystron shown in Fig. 2. I_c collector current, V_c collector voltage.

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Abstract cont.

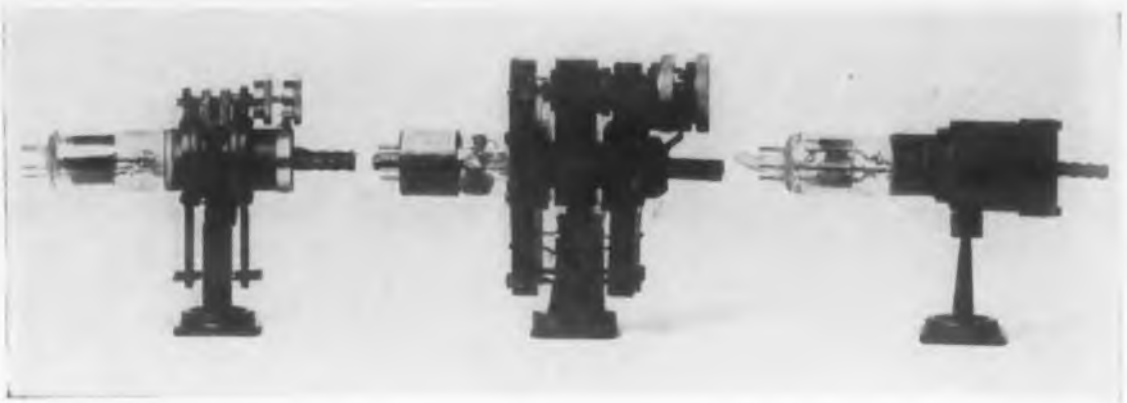

Fig. 4. From left to right: an early type of tunable klystron, a tunable klystron with ruggedized tuning mechanism and a low-noise, non-tunable klystron.

for this purpose, it was furthermore considered to cast the tubes in plastic, after first tuning them to a specified frequency. It would also be possible to make tubes with only one diaphragm—with one of the cavities tuned to a fixed frequency, and finally a tube might be designed with no diaphragms at all. In that case a variable feedback coupling would be necessary to adjust the tube to the conditions for delivering its rated power. An important objection against the latter method lies in the fact that a variable feedback coupling would entail a complicated mechanism, which would very likely also cause microphony and, consequently, noise.

It was therefore finally decided to develop a tube without diaphragms and with a fixed feedback coupling. In spite of the absence of a diaphragm the output cavity can nevertheless be tuned. A simplified cross-section of this tube is shown in Fig. 2. The modulating cavity *1* is permanently tuned to the desired resonant frequency. The output cavity 2 is adjusted, while the tube is oscillating, by applying to the collector a large force, denoted by the arrow *F*. This force is large enough to strain the cavity wall beyond its elastic limit. When this occurs, the cavity can be deformed to the right amount, at which it remains permanently set. As in the tube shown in Fig. 1, the feedback coupling is effected via an opening *10* in the wall between the two cavities.

Characteristics

The cathode of the tube described here may be either an L cathode or an impregnated tungsten type. The life of these cathodes is better than 1000 hours and, compared with tungsten, tungsten-thorium or tantalum cathodes, the heater power they require is low; in the present case it is only 7 w.

The electrode *6* (Fig. 2), with which the electron beam is focused, can be used for amplitude modula-

tion and is therefore generally called the "grid." By varying the "grid" voltage it is also possible to change the frequency between certain limits. At normal operating conditions this electrode has the same potential as the cathode.

The diode characteristic of the tube, i.e. the collector current plotted as a function of a collector voltage, is shown in Fig. 3. As for every diode, this characteristic can be represented by the equation:

$$I_c = AV_c^{3/2}$$

In this tube the constant A (the perveance) is approximately 0.25×10^{-6} $A/V^{3/2}$. The tube is liquid-cooled and the maximum rate of flow required for water cooling is about 1/2 gallon per minute.

Since a klystron can be made to operate with different electron transit times between the modulating and output gaps, the tube under discussion can operate in three different modes, denoted by *A*, *B* and *C*, which correspond respectively to transit times of 2-3/4, 2-1/4 and 1-3/4 periods. The power delivered in these modes is respectively 5, 33 and 200 w. Each klystron is adjusted to operate in only one of these modes and will not perform properly in other modes.

Tunable klystrons do not deliver rated power output over their whole tuning range. The low-noise tube, due to its method of manufacture, gives always its rated power. The frequency where this takes place can (as indeed the most favorable frequency of a tunable klystron) be fixed at any desired frequency with a maximum error of 10 mc.

The absence of a tuner makes the construction of this tube much simpler than that of tunable types. This is illustrated in Fig. 4, in which are shown an older tunable klystron, a tube with ruggedized tuning mechanism and a non-tunable low-noise tube. Because of the remarkable precision with which the new tube can be made for any specified frequency, it is possible to switch over or interchange a series of such tubes for quickly altering a transmitter frequency. This would often be easier than a normal klystron.

The noise of these tubes is so low that it was impossible to measure the power spectrum with the test system used. It appeared that the waveguides in the measuring system were now more microphonic than the klystrons under investigation.

The elimination of the diaphragms and tuner offers some advantages in addition to the substantial reduction of noise. In the first place it lowers the cost of the tube. Further, it allows more accurate alignment of the electrodes, while the absence of diaphragms leads to a somewhat better heat distribution.

Abstracted from A Low-Noise Klystron With High Power Output *by R. A. La Plante and G. A. Espersen, Philips Technical Review, June 1957.*

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Abstract

Research in the mm-wave region has been developing rapidly. Military and commercial interests are finding it desirable to pursue investigations into the nature of frequencies above 30,000 mc. It should be apparent, for example, that aircraft using communication equipment at these frequencies would effectively be preserving radio silence—electromagnetic waves of such frequencies being rapidly attenuated by air. The achievement, however, of carrier waves of millimeter wavelength entails operation with a number of relatively esoteric and awkward devices—maser, crystal harmonic multipliers, and specially designed magnetrons and klystrons. Here is an mm-wave generator that lessens many of the difficulties inherent in producing mm-waves—the O type carcinotron, popularly called the *backward wave oscillator*.

Mm Wave Source

IN THE travelling-wave amplifier or oscillator, a beam of electrons interacts with a guided electromagnetic wave which travels relative to the beam in such a way that the desired amplification or oscillation is achieved. To set up backward waves in which the direction of energy propagation is opposite to that of phase propagation, it is necessary to use a guiding structure which is spatially periodic or repetitive in nature. Slots are machined into a metal waveguide wall, or metal ribbon is wound around a supporting structure, with spacings

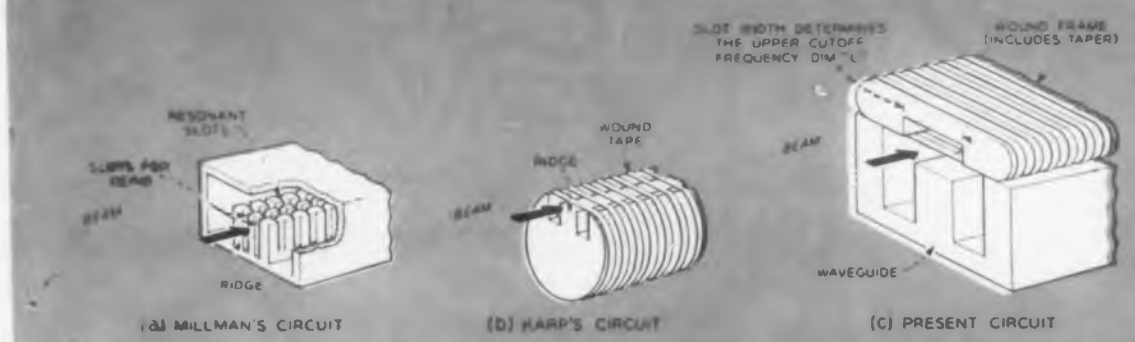


Fig. 1. Evolution of the backward wave oscillator; each type includes a periodic circuit.

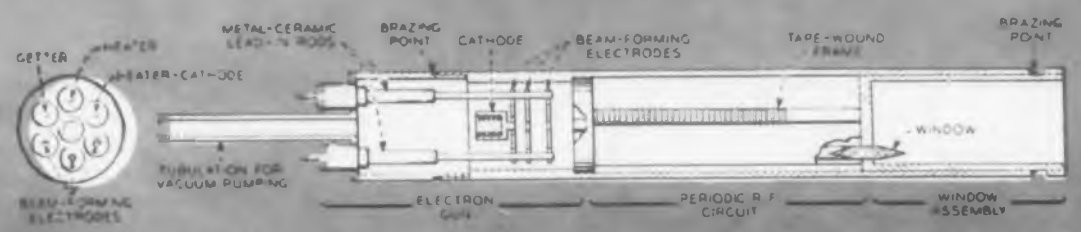


Fig. 2. The new 5 mm bwo;* lead-in rods permit simplified construction.

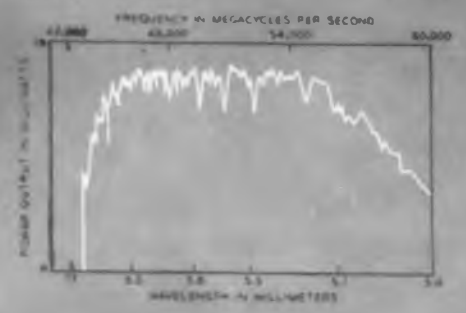


Fig. 4. Power spectrum of the oscillator, showing output in the 42,000 to 60,000 mc region.

Fig. 3. *A*. Component parts of the 5 mm bwo; *B*. A single metal-ceramic lead-in rod; *C*. The tape-wound frame of the rf circuit of the tube; *D*. The completely assembled rf circuit of bwo.

that are periodic in the same sense that the teeth of a comb are periodically spaced along its length.

To maintain the proper phase relationships between the beam and the wave, considerable uniformity of the periodic circuit is required. In the backward-wave oscillator at millimeter wavelengths, the period length may be in the neighborhood of 0.02 in. Since a critical dimension should be within about one per cent of the desired value, the allowable dimensional tolerance will therefore be only about 0.002 in. If the backward-wave type of structure were not used, even smaller dimensions and tolerances would be necessary.

Another requirement is that of holding a large number of electrons in a beam sufficiently close to the periodic circuit—that is, of obtaining a well focused beam of high current density. The bwo described here uses a beam current density about five times that of an ordinary electron tube. To focus and hold the beam near the periodic circuit a strong magnetic field is required.

Prototypes

In spite of these requirements, experimental bwo tubes have been built fairly easily and inexpensively, and their predictability and reproducibility have been good. In the course of many mm-wave investigations they have evolved through various types illustrated in Fig. 1. An amplifier structure used by S. Millman is indicated in Fig. 1a, where it is seen that the periodic circuit is formed by milling tiny resonant slots in a ridge of metal contained in a section of waveguide. A. Karp then conceived the idea of forming the periodic circuit shown in Fig. 1b where, instead of transverse resonant slots as in the Millman circuit, metal tape is wound about the structure to form the top wall of the waveguide. The slotted wall formed by the tape performs the same function as the milled slots of the previous structure. Tape is also used in a third form of this type of periodic circuit, Fig. 1c, which is the one presently used. A parallel electron beam floods the region around the tapes, and as an element of the beam travels down the circuit, little closed feedback loops are established over each period to sustain oscillations in the structure.

Gun Assembly

One of the important improvements in the latter tube is a redesigned electron gun assembly. Conventional tubes usually have an internal insulating and supporting structure on which the various gun electrodes are mounted, but in this tube no such supporting structure is used. Instead, each lead-in is constructed in the form of a mechanically strong rod, insulated from the metal envelope by a ceramic material at the base of the tube. Two of the six lead-in rods are indicated in the left part of the cross-sectional drawing, Fig. 2, and actual rods around the gun electrodes can be seen labeled as "*A*" in Fig. 3a. Each electrode is spot-welded to its supporting rod, which despite its length is rigid enough to hold the electrode accurately in place. A special jig was constructed to determine the centering and axial position of each electrode.

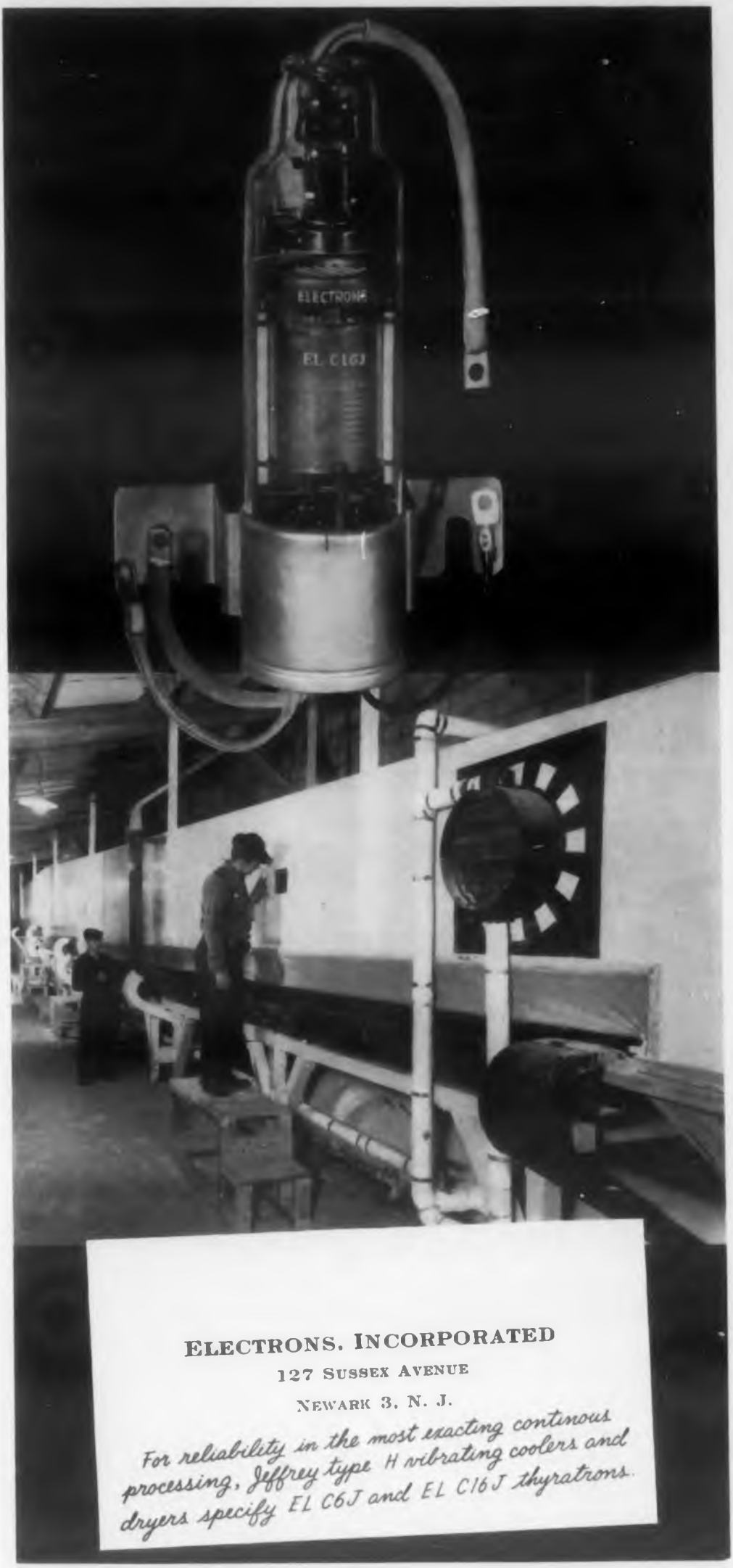
A single metal-ceramic lead-in rod is shown in Fig. 3b. Before it is incorporated into the tube structure, it can be checked for electrical leakage and various flaws. Because only a small mass of ceramic is used, thermal shock characteristics are excellent. Also, it can be used to produce a variety of stem designs. In a completed and evacuated tube, this sub-assembly has been subjected to 6000 volts without showing signs of electrical arc-over to its surroundings.

Voltage Requirements

Although a bwo has been made to operate with a beam voltage as low as 400 v, better performance is obtained by designing for operation at voltages above 1000. The present version of the tube operates between 1000 and 3500 v, and the tuning range is about 35 per cent of midfrequency. A tube constructed to generate 6 mm power (50,000 mc) has an output of about 10 mw, and the power drops to half this value at points about 10 per cent away from the central frequency. As much as 20 mw has been obtained at one frequency, and other tubes have given about 2 mw at wavelengths as short as 3.3 mm.

The power spectrum of a 6 mm bwo is given as Fig. 4. The curve shows the ripples that are characteristic of such tubes. These are caused by non-uniformity of pitch of the periodic circuit, imperfect focusing of the electron beam, and by slight mismatches at various places in the circuit, window and waveguide. Electronic feedback circuits and ferrite devices have been used in order to smooth out such ripples.

Abstracted from A Versatile Source of Millimeter Waves. *C. F. Hempstead and A. R. Strnad, Bell Laboratories Record, July 1957.*



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Standards and Specs

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Repair Parts

MIL-M-17993B(MC), Provisioning Procedures, Technical Data, and Repair Parts List Requirements for U.S. Marine Corps Equipment, 17 December 1956

The detail requirements for the selection of repair parts, and the quantity of repair parts to be delivered concurrently with the equipment are specified. Repair parts include components, assemblies, accessories, and replaceable parts. Also covered in this spec are the requirements for the preparation and submission of a Provisioning List and technical data prepared by the contractors. In addition, this spec covers the requirements for the printing, assembly, and distribution of U.S. Marine Corps Repair Lists and their Addenda.

Capacitance

RETMA RS-191, NEMA 505B, Measurement of Direct Interelectrode Capacitance, June 1957

The measurement of direct interelectrode capacitances of the following tubes is covered in this standard: receiving, cathode ray, gas, phototubes and multipliers, and high power vacuum tubes. Included in this standard are tables of connections of electrodes of tube sections for measuring direct interelectrode capacitances, standards for capacitance sockets, and recommended tube shields for use in measurement of tube capacitances. Copies of this standard are available from the Radio-Electronics-Television Manufacturers Association, 11 West 42nd Street, New York 36, New York, for $1.50 per copy. This standard is a revision of ET-109-A.

Interference Measurement

MIL-I-16910A(Ships), Interference Measurement, Radio, Methods and Limits; 14 Kilocycles to 1000 Megacycles, Amendment 1, 16 May 1957

The requirement that radio interference filters or capacitors be Navy approved types in accordance with spec MIL-F-15733 has been deleted. The new requirement is that interference filters and capacitors employed for the reduction of interference should be products which have been subjected to the required tests and found satisfactory for inclusion in the Qualified Products List of specs MIL-F-18344 for filters and MIL-C-19080 and MIL-C-19624 for capacitors.

Solder

QQ-S-571c, Solders: Lead Alloy, Tin-Lead Alloy, and Tin Alloy; Flux-cored Ribbon and Wire, and Solid Form, 16 May 1957

Six new solders have been added as follows: Sn63, a tin-lead eutectic composition, used for soldering printed circuits where temperature limitations are critical and in applications where an extremely short melting range is required; Sn62, a special-purpose solder, used for soldering silver-coated ceramics; Sn10, a high melting point solder, used in making electrical connections in high-ambient operating-temperature equipments; Sn5 is used for applications similar to Sn10, but having a slightly higher operating range; Pb90, used for general purpose soldering on black steel or tin plate; and Ag1.5, used interchangeably with Ag2.5, but has a better shelf life and does not develop a black surface deposit when stored in humid climates.

Microwave Relay Towers

EIA RS-194, Microwave Relay System Towers, July 1957

This standard describes the requirements for microwave relay system towers. It includes and is supplementary to the latest issue of RETMA Standard TR-116. Definitions of the factors affecting towers are given, such as, twist, deflection, displacement, wind load, guys, foundations, anchors, and protective grounding. Copies of this standard may be obtained from the Electronic Industries Association (formerly RETMA), 11 West 42nd Street, New York 36, N.Y. for 40 cents per copy.

AIEE Standards

The American Institute of Electrical Engineers has announced that the following publications have recently been released:

Number 1D, Guide for the Preparation of Test Procedures for the Thermal Evaluation of Electrical Insulating Materials, June, 1957 (No charge)

Number 1E, Guide for the Preparation of Test Procedures for the thermal Evaluation of Insulation Systems for Electric Equipment, June, 1957 (No charge)

Number 501, Test Code for Direct-Current Machines, July 1957, (60 cents)

Number 66, Guide for Determination of Short-cuit Characteristics of Direct-Current Machinery, July 1957 (No charge)

Number 803, Test Code for Aircraft Equipment Electrical Insulation, July 1957 (No charge)

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Merck & Co., Inc., needs a Sales and Marketing executive with a technical background to organize and direct the Sales and Marketing Department of the Electronic Chemicals Division. This is an outstanding opportunity for an individual interested in building a new department. He will supervise all sales, marketing, and promotional activities.

To qualify for this position, the applicant must have exceptional technical know-how and experience in electronic engineering and physics plus commercial sense and knowledge of markets.

The job will grow in direct proportion to the man's ability. Potential growth is as unlimited as that of the electronic chemicals industry.

Address résumés to: Dept. ED-10

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MERCK & CO., Inc., Rahway, New Jersey

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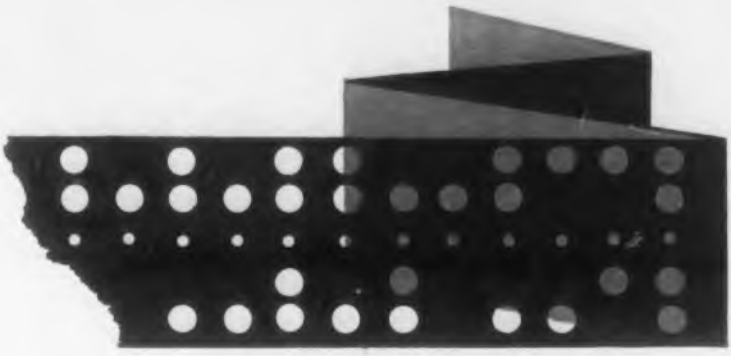

computers

Northrop needs computing analysts, qualified either by experience or education, to work in their ever-expanding Computer Center at Hawthorne, in Southern California. If you are qualified, there is an interesting position as well as a bright future for you at Northrop.

Applied mathematicians and engineers are needed as computing analysts for assignment to Northrop's analogue computing facility, as well as their enlarged digital electronic computer department which provides unparalleled service in the practical solution of complex engineering problems.

Your assignments will be fresh and stimulating, and you will have frequent opportunities to advance in your field. Besides an excellent salary, you will receive company-paid benefits that are unexcelled in the entire aircraft industry. Your colleagues will be the brilliant engineers who developed the USAF-Snark SM-62 intercontinental guided missile and the new USAF-Northrop T-38 supersonic twin-jet trainer. These men are congenial and helpful, and will respect your ability and individuality just as Northrop expects them to do. And you and your family will fully enjoy Southern California's many attractions and its delightful all-year climate.

If you qualify for any phase of computer research, design, or application, we invite you to contact the Manager of Engineering Industrial Relations, Northrop Division, Northrop Aircraft, Inc., ORegon 8-9111, Ext. 1893, or write to: 1041 East Broadway, Dept. 4600N, Hawthorne, Calif.

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The fluid character of these activities provides a keen incentive to JPL engineers and scientists. These men are given wide latitude and unusual individual responsibility—at the same time working as a thoroughly integrated team on all aspects of entire missile systems rather than on certain highly specialized missile components.

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JET PROPULSION LABORATORY

A DIVISION OF CALIFORNIA INSTITUTE OF TECHNOLOGY

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EMPLOYMENT PROSPECTUS

CORNELL AERONAUTICAL LABORATORY

Men needed: Electronics engineers and physicists at all levels of experience. Basic ability and interest in research work are usually more important than experience in any specific field.

Type of work: Principally applied research, with complementary activity in both basic research and development. Present C.A.L. projects include work on computers, communication, radar systems and on guidance, control, and navigation systems for airplanes and missiles. Research is also being done in the areas of intercept tracking and control equipment, search and acquisition radar, subminiturization and heat transfer studies, target discrimination, collision warning devices, weather radars, telemetering, and electronic counter-measures studies.

Description of Organization: C.A.L. is a not-for-profit corporation wholly owned by Cornell University. It is financially self-supporting, and operated for the purpose of advancing and enlarging scientific and engineering knowledge. The value of research completed last year rose to 14 million dollars, an increase of 12% over 1955, and the 6th consecutive annual increase. C.A.L. has 1200 employees.

Desirable features of employment at C.A.L.: VARIETY — the 400 engineers and scientists at C.A.L. are working in 11 technical departments, which last year completed 178 projects, both large and small. INDIVIDUAL RECOGNITION — the high ratio of contracts per engineer, coupled with the Laboratory's practice of using small research teams, allows the recognition of every man's individual contribution. To guarantee this recognition, each man's progress is reviewed every 6 months. SALARY — C.A.L. recognizes its need for above average professionals, and appreciates that such individuals must be compensated accordingly. Annual salary for an Associate Engineer (median of the five non-supervisory categories) can exceed $10,000. INTERNAL RESEARCH — each year the Laboratory sets aside substantial sums for the sole use of staff members in support of their exploration of new scientific areas and the generation of new ideas.

Action to take: If you desire additional information, use the coupon to request "A Decade of Research," a 68 page report on the Laboratory's research programs over the past 10 years. If you are interested in employment at C.A.L., check the box below for additional information. All inquiries will be treated as confidential.

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THE BOMAC BL-803 REFLEX KLYSTRON FOR X-BAND

Improved performance? You can count on it with the new Bomac BL-803 Reflex Klystron for X-band applications. Here's why:

- *New tuning ease* . . . Bomac's positive, self-locking, single-screw tuning* assures accuracy and re-setability under all operating conditions.
- *Added resistance to vibration and shock* . . . proven in many field tests
- *Low microphonics*
- *Electrical uniformity, mechanical stability* . . . assured by rigid test procedures

The new BL-803 is one of a complete line of Bomac Reflex Klystrons, any of which can be tailored to your specific system requirements. Write today for complete information.

**Patent applied for*

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ADVERTISING INDEX
October 1, 1957

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Company

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For Change of Address: Old Company Name

Old Company Address										City										Zone	State
	10	20	30	40	50	60	70	80	90	300	310	320	330	340	350	360	370	380	390		
1	11	21	31	41	51	61	71	81	91	301	311	321	331	341	351	361	371	381	391		
2	12	22	32	42	52	62	72	82	92	302	312	322	332	342	352	362	372	382	392		
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208	218	228	238	248	258	268	278	288	298	508	518	528	538	548	558	568	578	588	598		
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Old Company Address										City										Zone	State
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Available for either servo- or hand-tuned applications, this new family of RCA tunable X-band magnetrons is interchangeable with the 4J50 type magnetron in many systems. All RCA tunable magnetrons are designed for maximum performance throughout warranted life.

If you are working on new designs or modification kits for government end use, investigate RCA's new tunable magnetrons. For additional information on RCA commercial or custom-designed tunable magnetrons, call the RCA Office nearest you:

Typical Characteristics of RCA 200-Kw Tunable Magnetrons

	RCA-6865-A	RCA-7008	Developmental Type*
Tuning Range	8750 to 9600 Mc	8500 to 9600 Mc	8500 to 9600 Mc
Pulse Width	Up to 2.5 μsec at full power	Up to 2.5 μsec at full power	Up to 2.5 μsec at full power
Rate-of-Rise of Voltage Pulse	70 to 180 KV/μsec	70 to 225 KV/μsec	70 to 200 KV/μsec
Stability at Max. Rate-of-Rise of Voltage	less than 0.1%	less than 0.1%	less than 0.1%
Type of Tuner	Hand (with tuner lock)	Gearbox (for servo applications)	Hand (with tuner lock)
Approx. Weight	11.5 lbs.	13 lbs.	11.5 lbs.

*Available with several different tuning mechanisms to meet customer requirements.

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