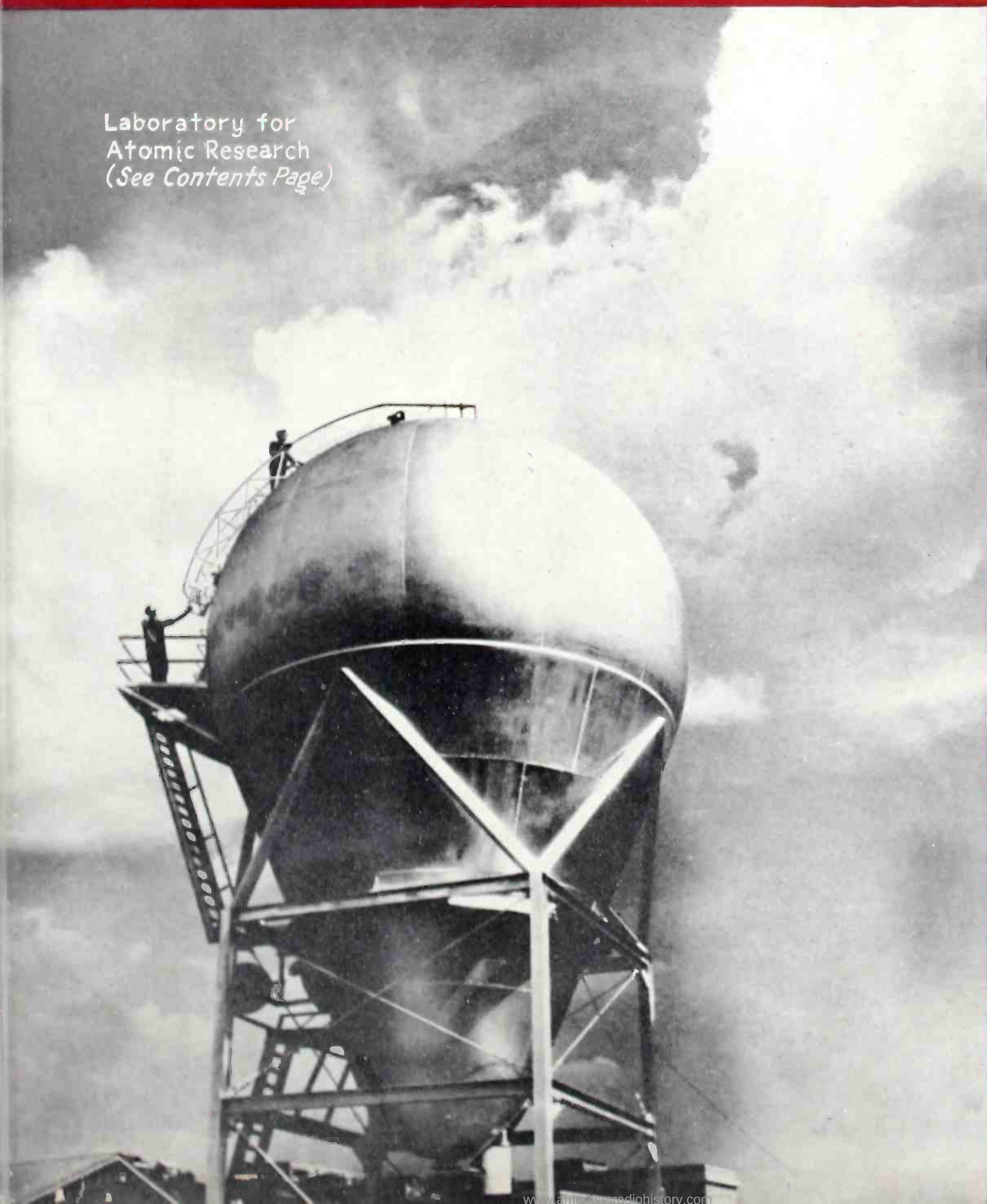
electronics

radio, communication, industrial applications of electron tubes . . . engineering and manufacture



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CONTENTS, NOVEMBER, 1937

DEPARTMENTS

RADIO . . . COMMUNICATION AND INDUSTRIAL APPLICATIONS OF ELECTRON TUBES . . . DESIGN . . . ENGINEERING . . . MANUFACTURE

ELECTRONICS, November, 1937. Vol. 10, No. 11. Published monthly, price 50c a copy. Subscription rates—United States and possessions, Canada, Mexico and Central American countries, $5.00 a year. All other countries, $6.00 a year or 24 shillings. Entered as Second Class matter, August 29, 1936, at Post Office, Albany, N. Y., under the Act of March 3, 1879.

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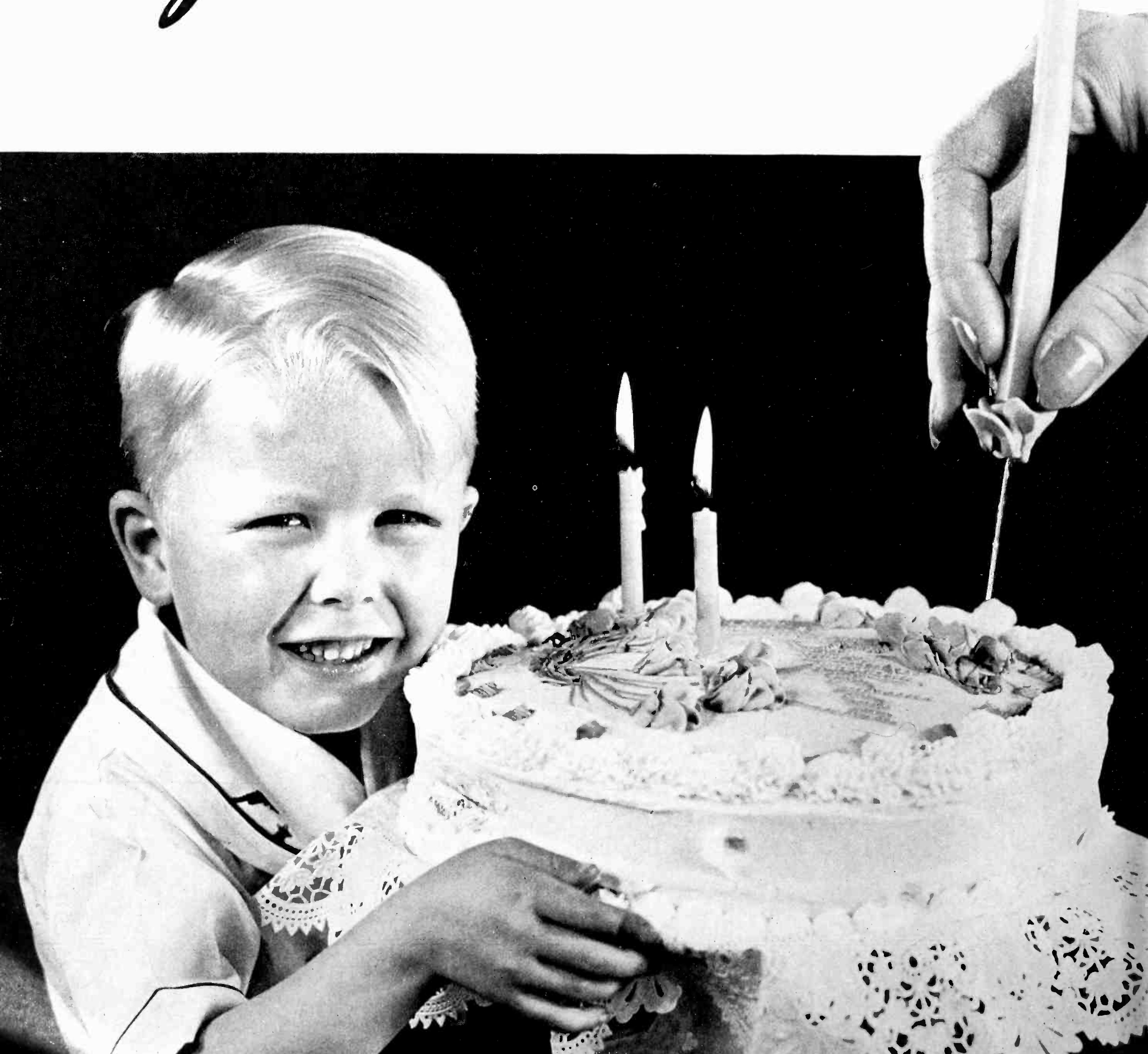
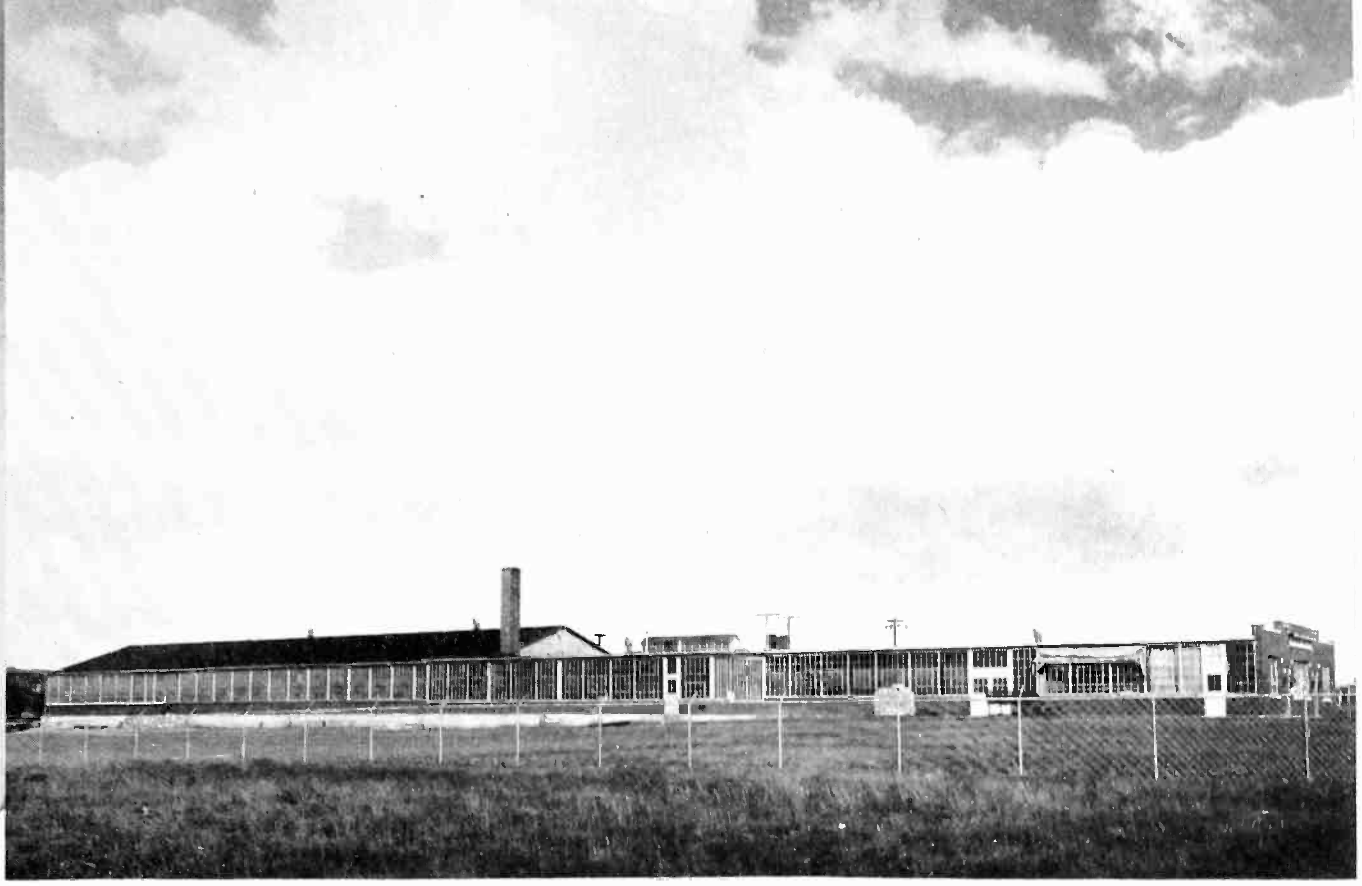
"—and the boy grew older—"





LIGHT up another candle for the festive cake! It's an occasion—our Third Birthday, in fact. And we are, this November, both old enough and young enough to indulge in a bit of pardonable boasting.

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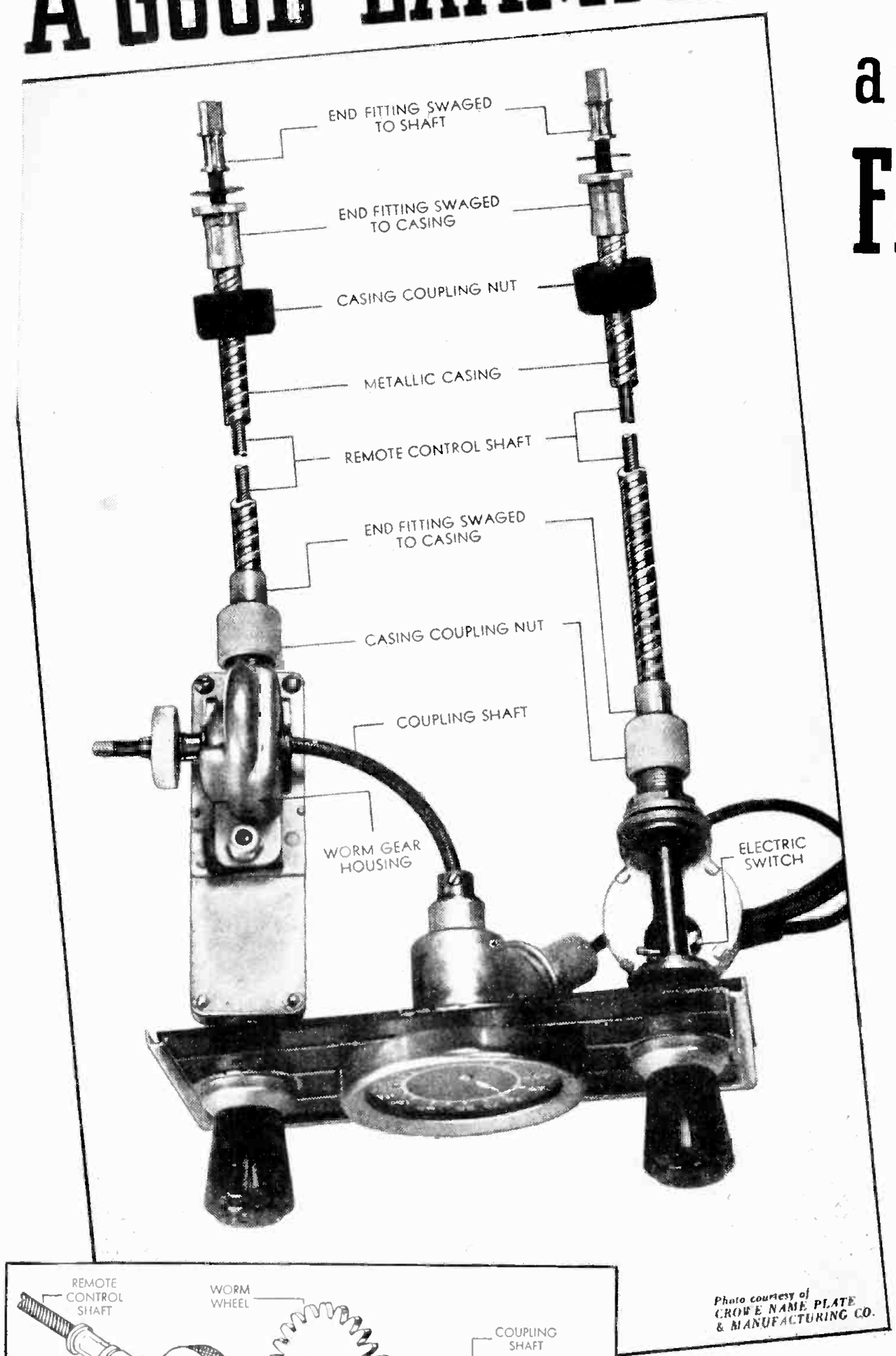
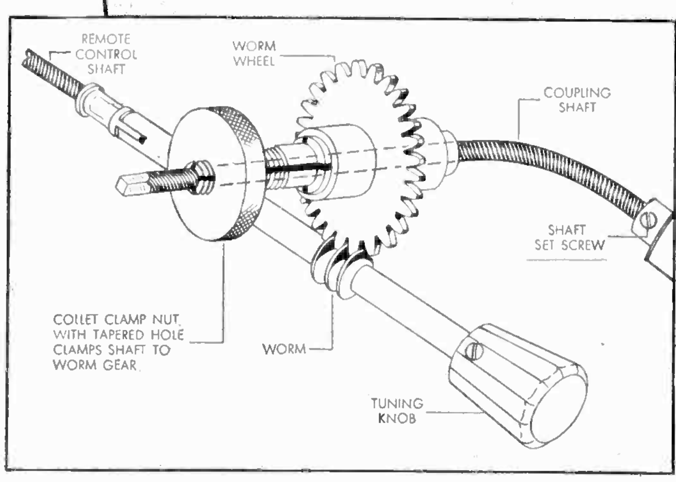


Photo courtesy of CROWE NAME PLATE & MANUFACTURING CO.

Above: Auto Radio remote control head for dash board mounting. The two main shafts carry remote control of tuning and volume to receiver. The short curved shaft "couples" tuning shaft to dial pointer.



Sketch of coupling shaft gearing. Shaft passes thru worm wheel hub and is clamped by split collet on end of hub. This arrangement permits a nice adjustment of shaft length to assure smooth operation.

Of special interest is the use of the short coupling shaft for operating the dial pointer from the tuning shaft. Note also how readily the flexible shaft is combined with gearing.

While the remote control shaft and the coupling shaft in this application are of the same diameter, they differ considerably in physical characteristics. The former, developed specially for remote control, combines these features: Minimum torsional deflection; Equal deflection for either direction of rotation; Low internal friction. The coupling shaft, developed specially for coupling under conditions of very light load and curves of small radius, is characterized by extreme flexibility and internal friction so low as to be negligible.

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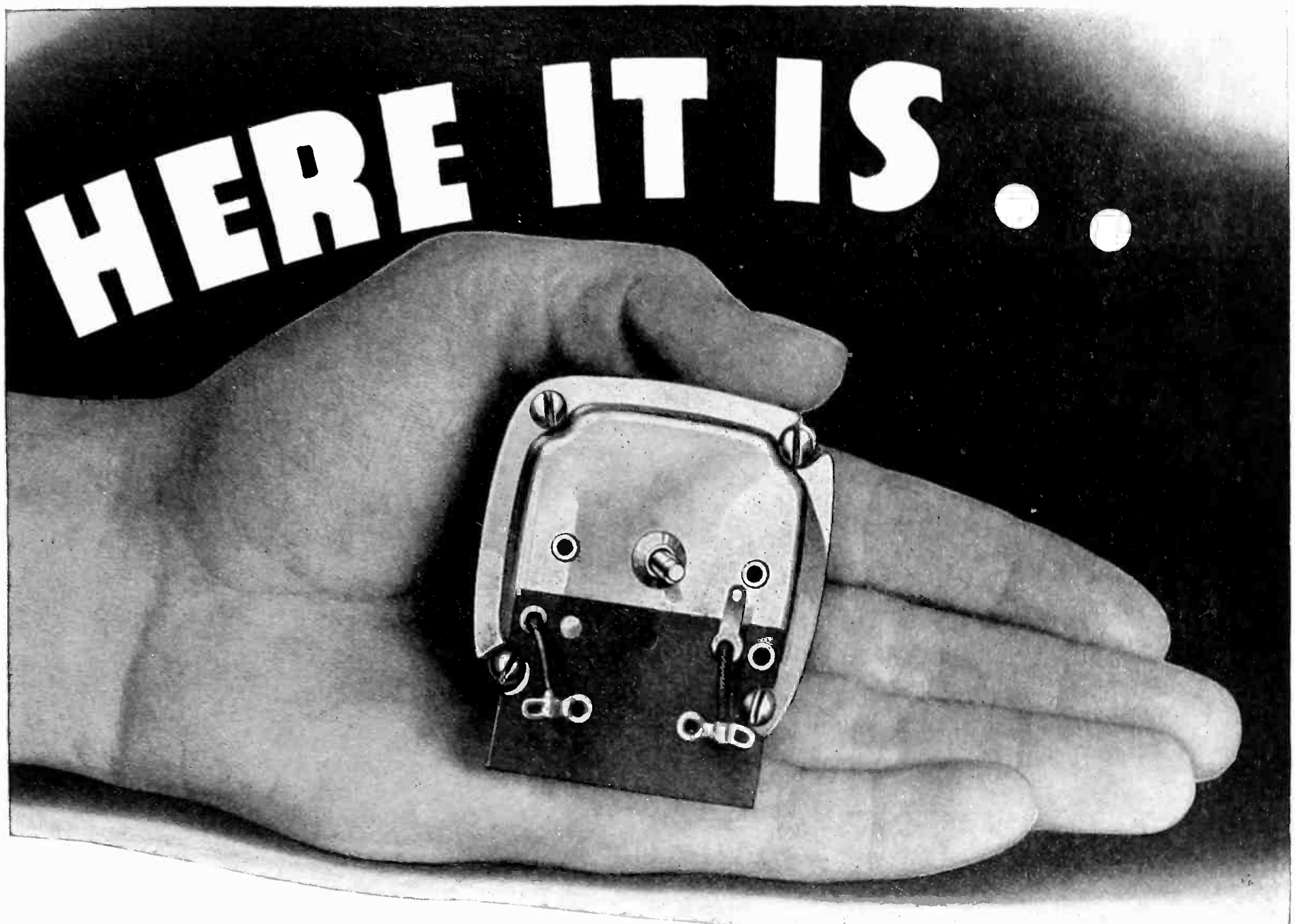

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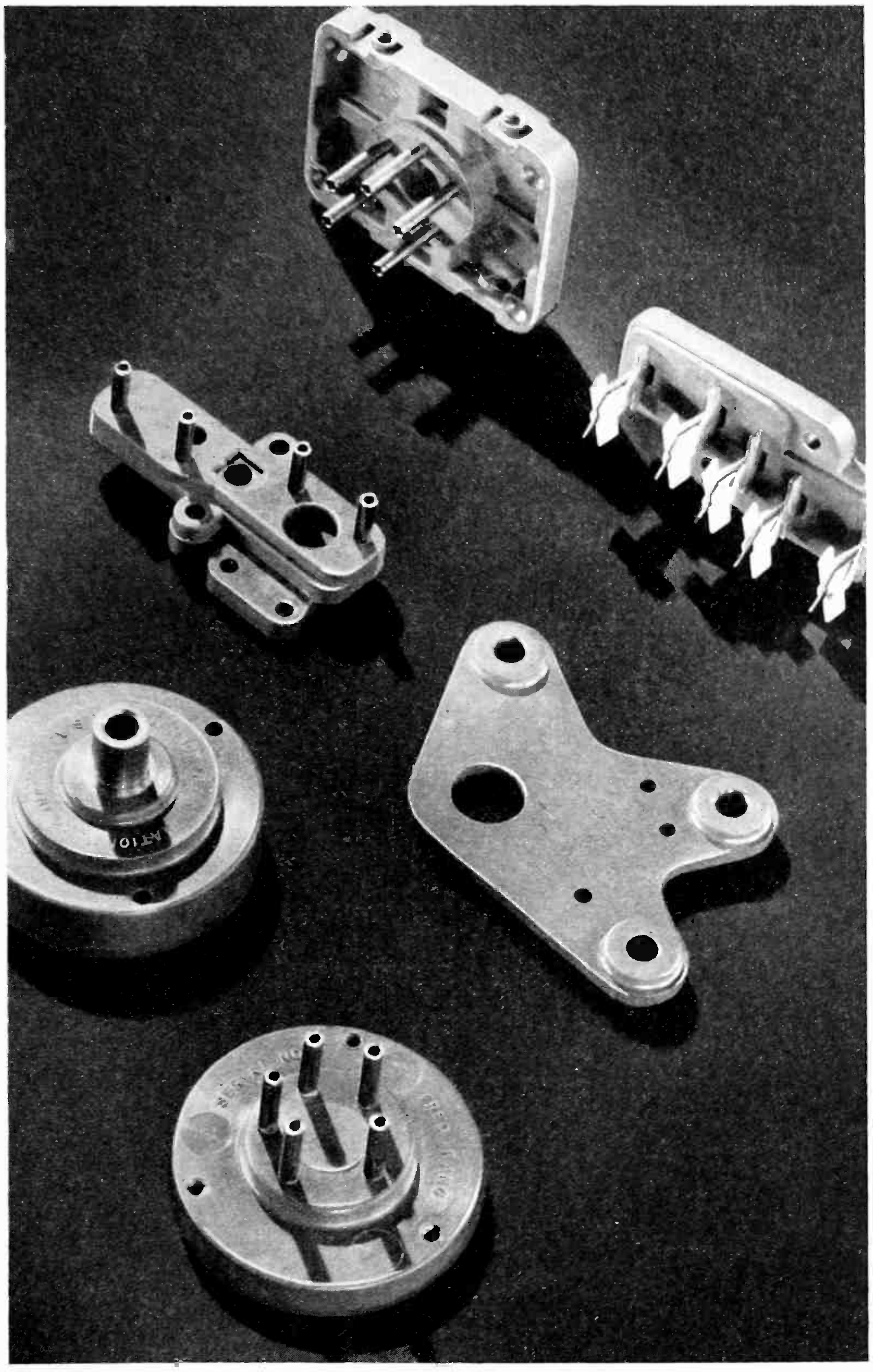

THE rapidly increasing use of special Low Loss Bakelite Molded in electronic devices is due to two important advantages combined in this unusual dielectric. Not only does this material possess an exceptionally low loss factor, but, also, it is readily adaptable to forming into practically any shape.

At 1,000,000 cycles, Low Loss Bakelite Molded possesses a loss-factor of only 14% of the value obtained with General Purpose Bakelite Molded. It may be formed with great accuracy into finished parts, in one molding operation. All grooves, bosses, through-holes, and metal inserts are permanently incorporated during the same molding operation.

The wide adaptability of this dielectric is illustrated by a typical group of Low Loss Bakelite Molded parts employed by the National Company, Inc. Parts pictured are: partition for high-frequency condenser; contact board for automatic coil-plug-in; coil-and-condenser board for same mechanism; and parts for crystal holders.

Other advantageous applications of Low Loss Bakelite Molded are practically unlimited. We invite you to consult us regarding specific applications. Also write for reference booklet 13M, "Bakelite Molded", containing data on numerous types of Bakelite Molded.

(Left) Low Loss Bakelite Molded parts for condensers, receivers and crystal holders produced by National Company, Inc.

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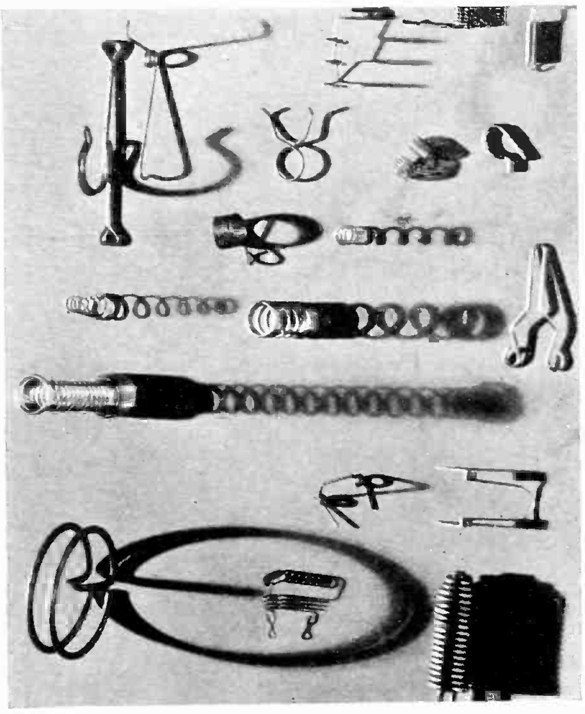

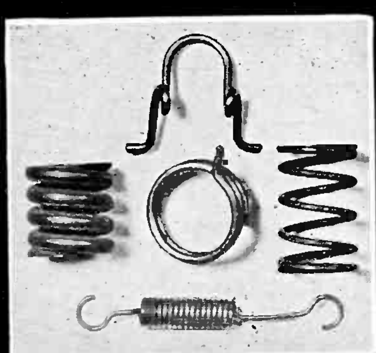

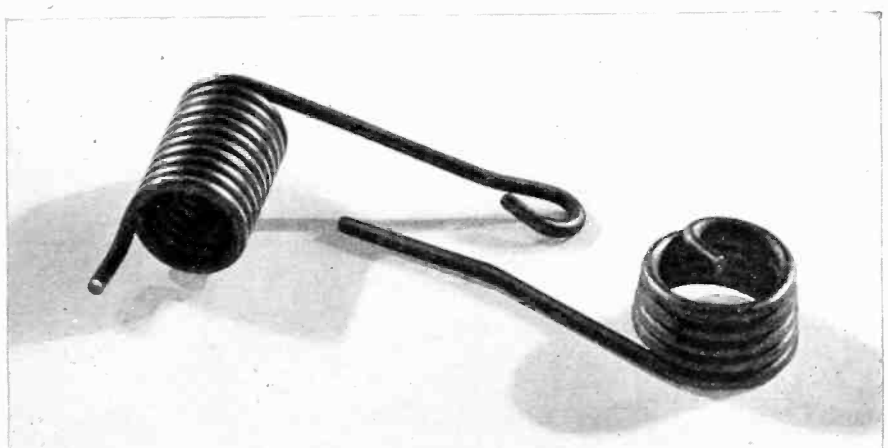

Plenty of Action but No Progress

If you want to picture plenty of action but no progress, page Mr. Squirrel. With his famous cage he offers a parallel that has become threadbare—threadbare because it is so apt. Apt because every attempt to develop a product or improve an operation has its squirrel-in-a-cage moments.

At such moments Mallory first met most of its valued customers. The Mallory business has been built by helping manufacturers reduce the duration of those "'round and 'round" periods.

Mallory accomplishments have touched many fields including the automotive, radio and electrical industries. Mallory developed the electrode material for the new welding technique that made streamline trains possible. Automobile radio became a practical achievement through Mallory-made vibrators. Mallory produced . . .

We interrupt this autobiography here because your interest, as well as ours, is not so much in what Mallory *has* done, but in what Mallory *can* do for you today—and tomorrow.

To give you a quick, concise picture of our facilities we have listed nine groups of problems in the panel. These are the fields in which we have the technical knowledge and experience to help. We hope you will turn to us when such problems confront you.

You can be assured of an active and sincere interest.

The business man's encyclopedia of where to go for help . . . .

Metal Fabricating Problems where resistance welding may be used—See Mallory for resistance welding electrodes and advice.

Contact Problems involving the making and breaking of an electrical circuit—See Mallory for contacts and engineering assistance (Mallory has served the electrical industry for more than twenty years).

Non-Ferrous Alloy Problems where extreme hardness, high conductivity and great tensile strength are necessary--See Mallory for alloys incorporating these characteristics.

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ELECTRONICS

NOVEMBER 1937

KEITH HENNEY *Editor*

Crosstalk

▶ **ALLOCATING MEGACYCLES** . . . In extending its jurisdiction throughout the ultrahigh frequency range as high as 300 megacycles, as it did last month, the FCC has given a new status to a region previously reserved for amateurs and experimental research alone. The allocation of the region to services, on the same basis as in the lower frequency bands, will now proceed with commercial as well as experimental interests in the picture. In their announcement the FCC indicated that seven channels, each six megacycles wide had been reserved for television, from 44 to 108 megacycles, and twelve others from 156 to 300 megacycles. Thus the one-time conflict between industrial and governmental interests has been resolved, and television is assured of adequate space for further experiment and eventual commercialization. Of great importance are the 75 additional broadcast station channels between 41.02 and 43.98 megacycles, which when utilized will create a large market for reliable receivers in this range. Also in the new picture are government services, mobile press services for newsgathering and police radio, the latter to receive 29 new assignments.

▶ **LORD RUTHERFORD** . . . On October 19th the scientific world suffered the loss of one of its most distinguished men, the dean of atomic physics, Lord Rutherford. Lord Rutherford served not only as an original investigator, but as an administrator of scientific research. His early researches into the mysteries of radioactivity led him to the discovery of the nuclear nature of the atom. The influence of this discovery on the subsequent course of theoretical and practical electronics can hardly be estimated. Without it, the theory of the conduction of electricity in gases, and the attendant production of light, both so vital to present electronic practice, would have remained a mass of contradictory evidence. It is not hard to trace the development of the sodium lamp, the most efficient artificial illuminant known, back through Bohr's theory of the production of spectral lines to the atomic nucleus which is its central feature. Perhaps further afield from electronic engineering, but of equal great importance in medicine and pure science is the vast region of discovery which Lord Rutherford opened up in radioactivity, both natural and artificial, and the transmutation of elements. If, as many believe, man may eventually obtain power from nuclear transformations, certainly Lord Rutherford must be given credit for initiating the most significant scientific conquest ever undertaken.

▶ **TELEVISION APPROACHES** . . . Two announcements from RCA affiliates indicate that steps have been taken to bring television one more jump nearer to practical realization. Expanding the scope of its experimental television program, the National Broadcasting Co. inaugurated outdoor pick-ups on October 18 with a mobile television station, according to a statement of Lenox R. Lohr, NBC president. Such portable station will enable NBC engineers to supplement their knowledge of studio technique with experience gained by pick-ups in the field. The portable television station will consist of two specially constructed motor vans, each about the size of a large bus.

Also announced in the middle of October came news from Radiotron of the release of two magnetically deflected kinescopes intended for experimental and amateur television reception. One of these tubes has a 9 inch screen, the other a 5 inch screen. Both have screens of medium persistence and produce an image with a yellow hue.

▶ **DUBILIER** . . . For a quarter of of century, which is the life span of radio, the name of William Dubilier has been associated with fixed condensers, and many have been the receivers and transmitters which have been built with Dubilier units in them. In 1912 a small factory in London began building products which were to spell the doom of the Leyden jar. This was the Dubilier Electric Company. Today that company has grown from one of two rooms to one which covers 8 acres of space.

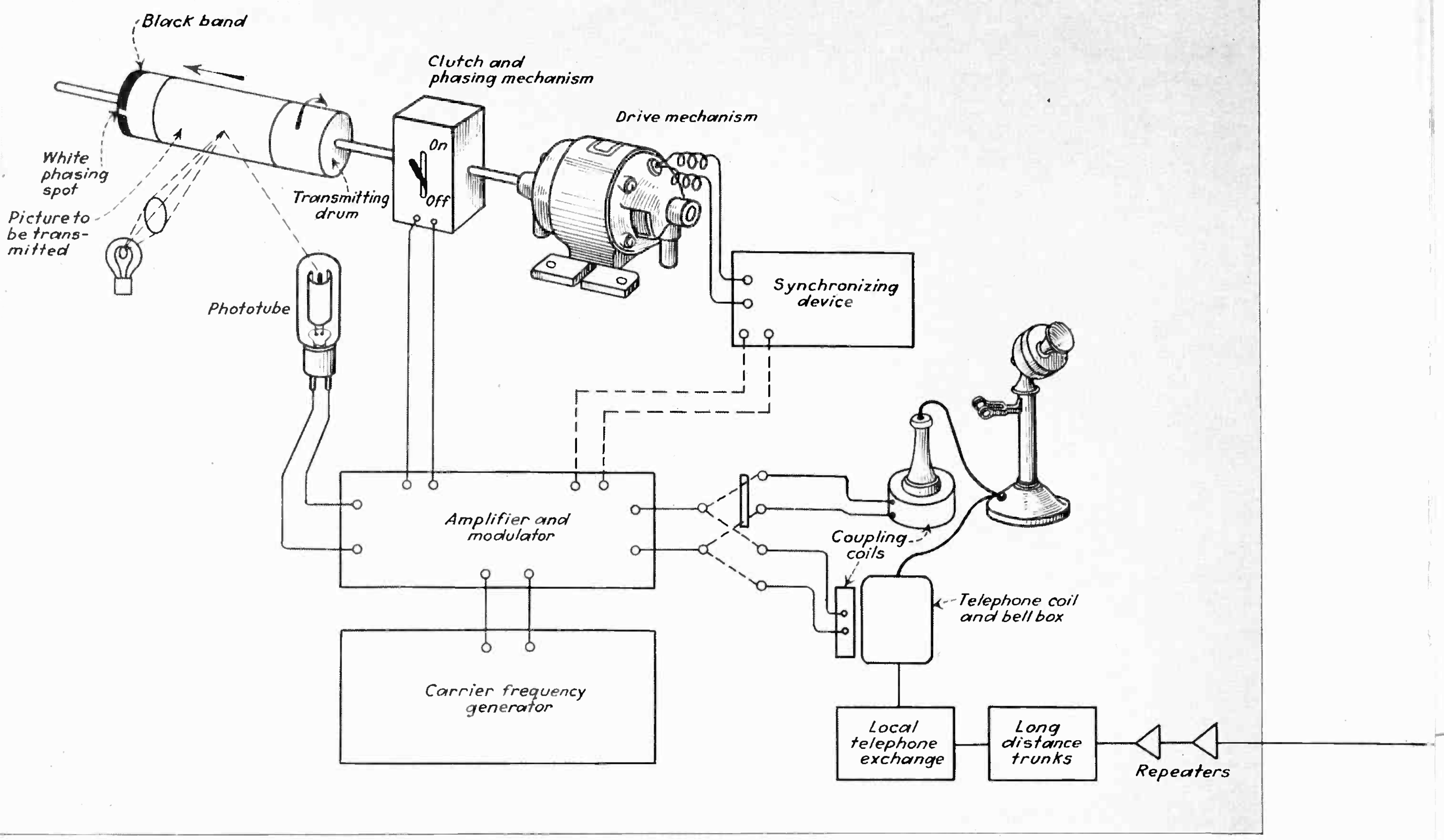
Commemorating the quarter century mark in the existence of the company the English company presented founder William Dubilier with an illuminated scroll which said very complimentary things. The American company is even older, founded in 1910 and, like its English cousin has had a fine growing life.

▶ **EXPANSION** . . . Newspapers have carried the account of how Allen B. DuMont is to move his cathode ray tube plant into a new, and much larger factory. Six years ago the DuMont factory consisted of a few pumps and exhaust positions in the basement of his home, and the growth of his business from that meager beginning is like a Horatio Alger story. Much of the present wide sale of the cathode ray tubes is due to the early missionary work and the continual development and manufacturing of such tubes by Mr. DuMont.

▶ **CONFERENCE** . . . At Ohio State University, February 7 to 19, will occur a broadcast engineering conference intended to interest broadcast station engineers. In addition to members of the university staff, certain outsiders from all branches of the broadcast industry will be on the program and will discuss such subjects as high powered amplifiers, ultra high frequency propagation, antenna design, modulation and distortion measurements, studio acoustics, etc.

Professor W. L. Everitt of the department of electrical engineering is in charge of this project which promises much of interest for broadcast engineers who can arrange to be in Columbus at the time of the meetings.

▶ **MAYBE YOU'VE HEARD THIS ONE** . . . Into the plant of a very large manufacturer of tubes (not in America) marched three members of a far eastern race, armed with cameras, under instruction to shoot everything. They shot in relays, so that no matter how fast they were taken through the place, one of them got the picture. At the end of the tour they felt they had everything. Finally they were taken to the X-ray department where, like the other rooms they had seen, they were given an actual demonstration. X-rays permeated everything including cameras and films. That's the end of the story.



News Pictures by Wire

SINCE about June 1935 extensive commercial application has been made in the newspaper field of the transmission of pictures using telephone lines as the transmission medium. Various news picture systems are now in operation including those of Acme News Pictures, Associated Press, Finch Telecommunications (licensing the Hearst picture system), International News Photo, and the Times Wide World. Portable equipment has been developed for most of these systems so that pictures can be transmitted from any point in the country where there are 110 volt lines and telephone service available. Pictures from remote centers are transmitted by portable equipment to the news bureaus in the larger cities all over the country from which local distribution is made. The flexibility and wide coverage of this general system, coupled with the fact that the transmitted pictures have sufficient detail for the half-tone screens used in newspaper work, have frequently enabled newspapers to illustrate events while they were taking place. It is no longer uncommon to see pictures in the newspapers of a football game hundreds of miles distant before the game is completed.

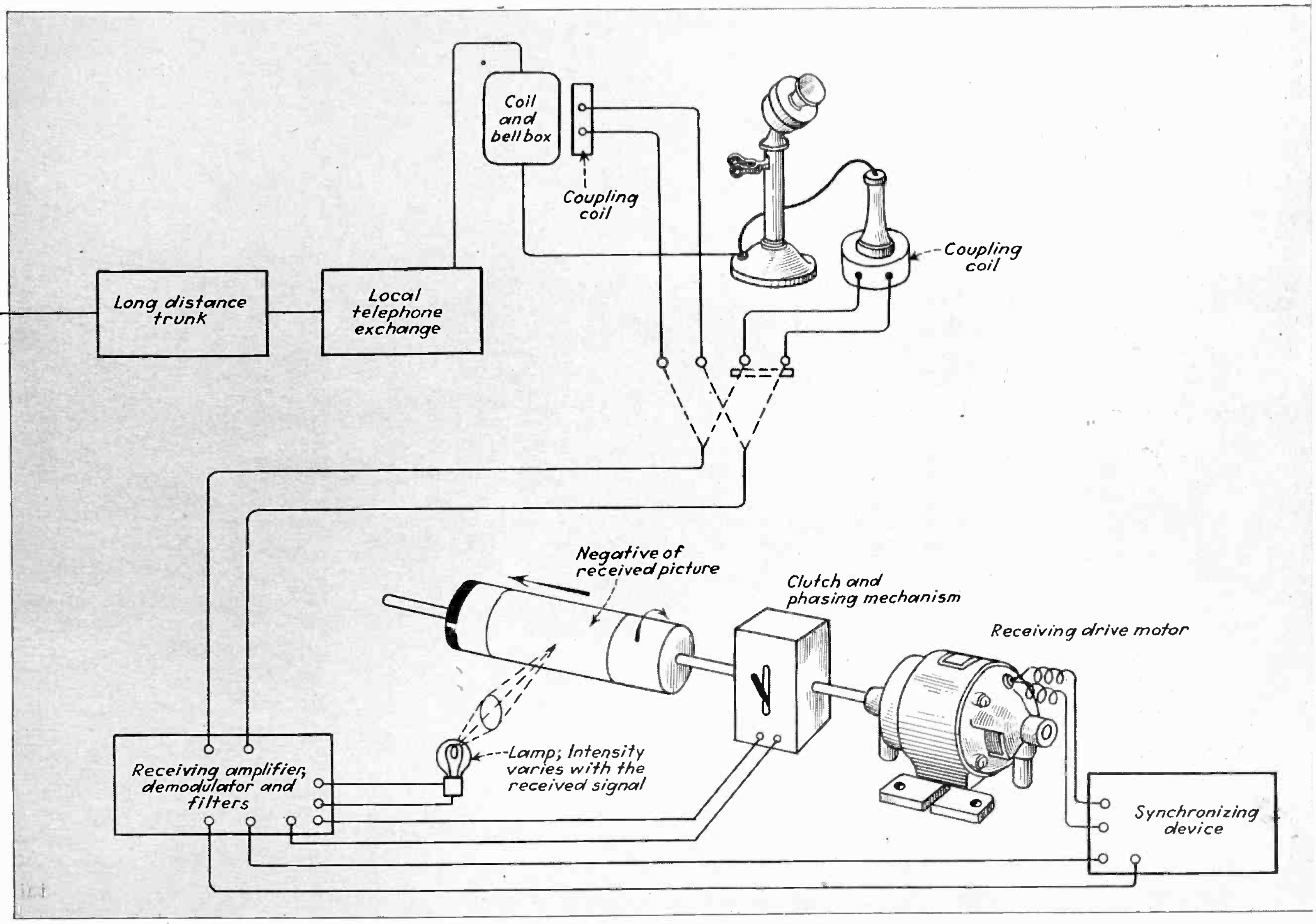
The success of this comparatively new means of communication hinges on the electron tube and the availability of well maintained long distance telephone lines which in turn, are made possible through vacuum tubes.

The elements underlying all of the news telephoto systems in commercial use are shown schematically above. In many cases one particular function may be accomplished in more than one manner; where alternative arrangements are in general use, these are indicated by means of dashed lines.

The complete picture transmitting system consists of (1) a transmitter, (2) the long distance (or local) telephone system and (3) the receiver.

Electrical communication, in general, is carried out by varying the current (or the voltage) of the system. Since the current cannot be varied instantaneously, and since it can only have one value in a given circuit at any one time, all electrical systems convert intelligence into single valued functions variable with respect to time. These variations in turn are converted into time variations of current. In the case of picture transmission, the conversion into elements of the intelligence to be transmitted (the picture) is accomplished by scanning the picture. Scanning breaks down the picture systematically into elementary areas of white, black, and varying shades of gray, one after the other, so that a time varying electrical current may be produced whose variations will correspond with the variations of gray in the picture. Picture scanning is accomplished by picking up reflected light from the various elements of the picture as the relative positions of the picture and the pick-up phototube are varied. In practice, the picture to be transmitted is wrapped around a drum or cylinder in the transmitting equipment. The drum revolves about its own axis when the clutch connecting it with the driving mechanism is engaged, while a lead screw to which the drum

◆ *A complete picture transmission and receiving system is indicated schematically on these two pages. The illustration on the opposite page represents the essential elements and operations in a fixed or portable transmitter. Alternative methods of coupling to the telephone circuit are shown. During picture transmission the telephone microphone is muffled. The receiving portion of the system, shown in schematic form below, produces a film negative from which prints may be made. The receiving drum must, of course, be operated in the dark*



is coupled carries the drum along laterally in a direction parallel to its axis. Because of the rotating and translating motion of the cylinder, any fixed spot on the circumference on the drum will describe a spiral. All points of the picture are scanned in due time.

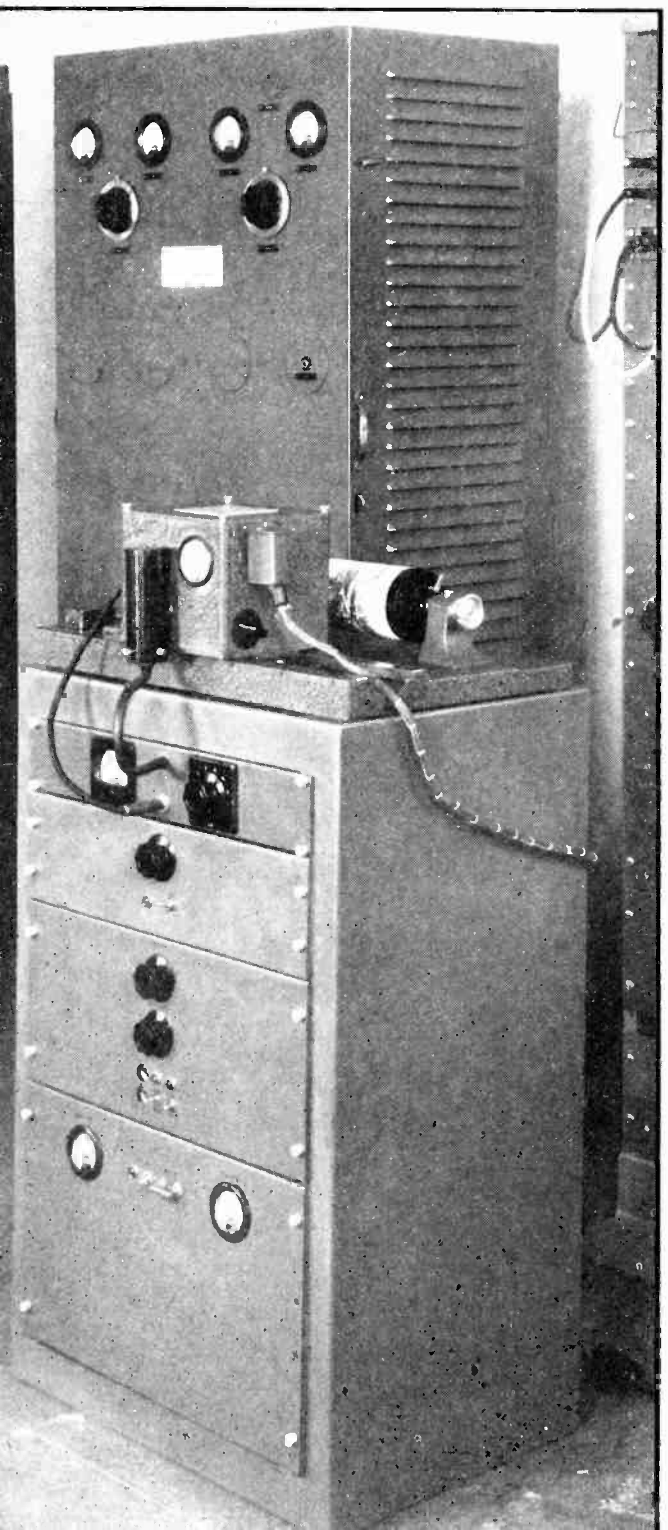
The drum, with the picture, is driven by a motor or similar drive mechanism so arranged that the speed of rotation can be accurately fixed and determined, relatively if not absolutely with respect to that of a similar drum in the receiving end. Connecting the driving motor with the picture drum is a clutch-engaging or phasing mechanism which insures that the received picture be correctly positioned or "phased" with respect to the negative upon which the received picture is to be built so that the center of the transmitted picture falls on the center of the negative in the receiving drum, and not at one of the edges so that the picture appears to be sliced in the middle. The speed of rotation of the driving mechanism is determined by the synchronizing device which consists, essentially, of a source of a.c. of precisely determined and constant frequency. The clutch and synchronizing device for both the receiving and transmitting drums must be so designed and operated that both drums start simultaneously from the same position relative to the picture, and keep precisely in step for the duration of picture transmission.

Synchronizing may be accomplished either by (1) maintaining very precise frequency or time determining systems at both the transmitting and receiving ends of the system, or, (2) by sending from the transmitting end, a signal frequency or series of impulses which may be employed at the receiving end to assure that both drums run in step.

Variations in density of the elementary areas of the print on the transmitting station drum produce varying amounts of reflected light from the illuminated spot as the drum rotates. Light reflected from the scanning spot falls on a phototube where the variations in light intensity produce currents varying in amplitude in accordance with the reflectance of the photographic print. As a general rule the variations due to scanning occur at frequencies of from zero up to several hundred or perhaps a thousand cycles per second, which could not be transmitted over the telephone line without severe distortion and loss of picture detail. To transmit the picture over telephone wires, the frequency is shifted to about 2,000 cycles.

This is accomplished through the use of a generator which combines in the modulator circuit the carrier frequency and the picture frequency coming from the phototube. The modulating process is similar to that employed in carrier telegraphy or telephony, or in radio communication systems. Although the schematic diagram shows a carrier frequency generator feeding the phototube amplifier and modulator, the carrier may be generated by interrupting the light beam before it reaches the phototube.

One of the transmitters of Finch Telecommunications. The drum will hold pictures 11" x 21"



Basically, this is all there is to the transmitting system, although of course many necessary refinements and details have been neglected in presenting this brief sketch of the transmitter operation. The next step is to couple the transmitter to the telephone line, a step which gave some of the early workers in the field, as well as the telephone companies some concern.

Once having at the output of the transmitter amplifier-modulator a signal at audible frequencies it does not seem very difficult to transmit this over a telephone line. Pictures could be transmitted (and some early ones were) by feeding the output of the amplifier-modulator into a headset, loud speaker or other electro-acoustic transducer, and placing this in front of the carbon microphone of the phone. A later and better development was that of electromagnetically coupling the amplifier-modulator to the magnetic circuit of the phone receiver or to the coil box, as shown in the diagram. At the present time both electromagnetic coupling systems are in use; both operate without affixing any attachments to the physical equipment of the telephone companies, and both enable the user to obtain the desired result. Acoustic coupling to the transmitter has been abandoned largely because of microphone noise and the superiority of the magnetic coupling method. When the sound picture equipment is coupled to the telephone circuit it is, of course, essential that the telephone be maintained in a quiet locality or that noise is kept from entering the microphone by placing the hand or a rubber cap over the mouthpiece. Failure to observe this precaution may mean ruining the picture transmittion because speech picked-up by the microphone is transmitted in addition to the picture. From the telephone, the circuit is continued in the usual manner as an ordinary telephone circuit.

The essential elements of the telepicture system as given above are the same for transmission between fixed or portable stations.

The Receiving End

At the receiving end the signal is picked off the telephone line by means of electromagnetic coupling coils, and is fed to the receiving amplifier, demodulator, and filters. The demodulator translates the picture frequency from the side-band frequencies to the original low frequency values it originally had when coming out of the phototube circuit in the transmitting end (0 to about 1 kc.) and the filters are used to separate the various frequency components so that they may be used in whatever manner is necessary or desirable.

The picture frequency components are fed to an optical system in such a way that the light source at the receiving end is made to vary in accordance with the received picture signal. In the schematic diagram, the light-source is shown as being actuated directly from the modulator, and this system is in use. Other systems are also in use in which the light source is maintained constant in its intensity; the intensity of the light striking the negative being varied by means of a light valve, vibrating mirror or similar arrangement.

The varying intensity spot of light is then focused on the negative wrapped around the receiving drum. As the receiving drum rotates the varying intensity of the light source builds up, element by element, a picture or latent image on the negative. At the conclusion of the picture transmission, the negative is developed, fixed, and washed after which positive prints can be made in any desired number.*

Operation of Telepicture System

In operating the system, the photograph to be transmitted is placed on the rotating drum, the transmit-

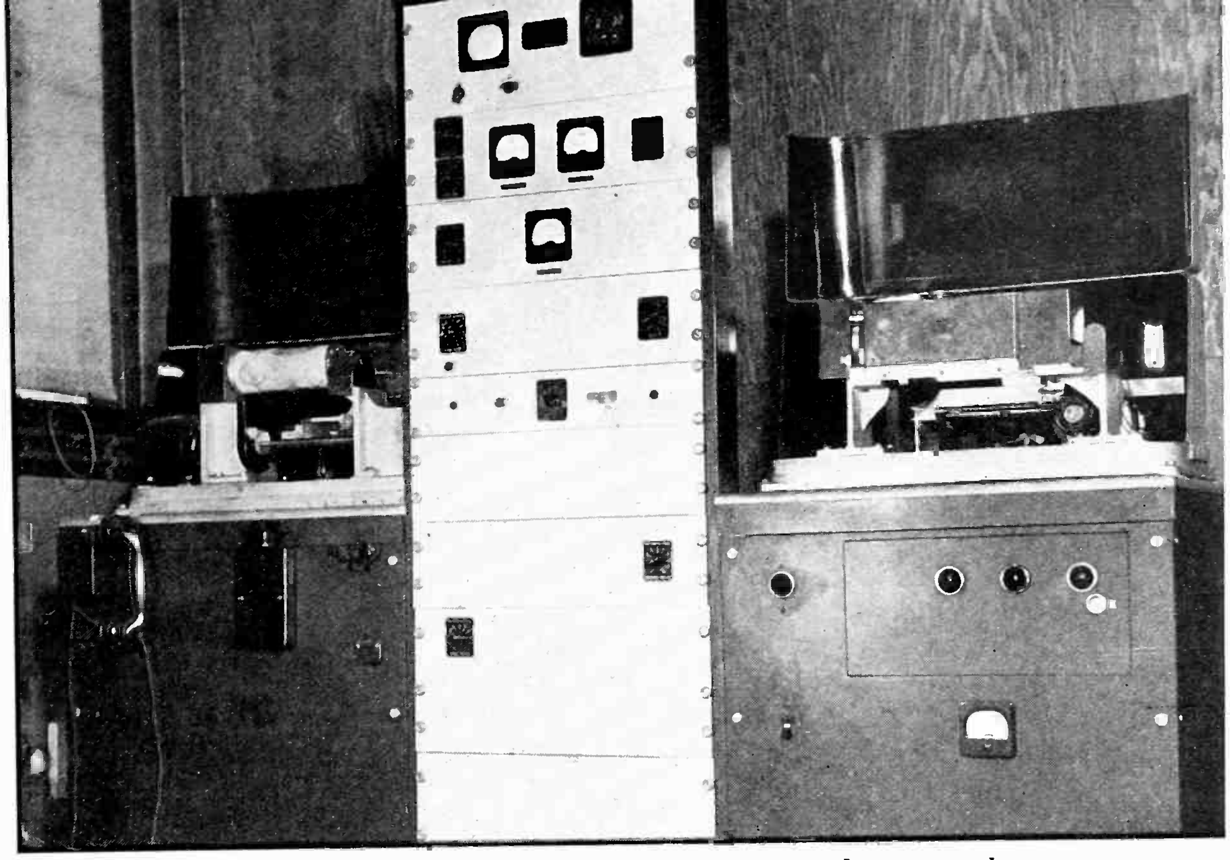
* For additional information on the details of operation of picture transmission systems the reader is referred to:
"Facsimile Transmission" by R. H. Ranger, "Radio Engineering Handbook", 2nd ed.
"Facsimile Transmission and Reception" by Maurice Artzt, "Electrical Engineers' Handbook; Communication and Electronics".

ting set is connected to a source of power, and the synchronizing device is warmed up or put into operation. In several systems tuning forks with temperature compensation are used in the synchronizing device, so that it is desirable that these forks reach equilibrium temperature before transmission is begun.

The picture transmitting operator then places a long distance call to the point at which the picture is to be received, and make whatever arrangements are necessary for the transmission. At fixed receiving points, the receiving equipment is normally maintained in readiness. The receiving drums are stocked with film, the amplifying, demodulating, synchronizing, monitoring, and protective equipment is usually in continuous operation, and the receiving equipment is usually permanently coupled to the telephone line. All of these operations must be carried out before the picture operator is ready to receive the picture.

When both stations are ready for the picture, and when voice conversations are completed, the transmitting picture operator couples the transmitter to the telephone line (as for instance by placing the receiver on top of a coupling coil in the picture transmitter). The transmitting operator then transmits white and black in order to enable the receiving operator to determine the range of transmissions which will be required by the picture, as well as the general level of transmission. This is done by flashing the scanning spot on to a perfectly white picture spot for a few seconds, and following this by flashing the scanning spot on to a black spot. Sometimes these white and black areas are selected from the picture itself; in other cases a strip of paper or painted metal at the end of the drum serves the same purpose.

The white spot at the end of the transmitting drum usually also serves as a phasing mechanism, since the edges of the picture are aligned with this spot. After the transmission levels are adjusted, phasing of the receiving and transmitting drums is usually carried out by setting the transmitting drum into operation with the scanning spot traversing the black band with white spot, shown on page 12. Each time the scanning spot traverses the white spot (i.e., once per revolution) an impulse is transmitted over the line and is manifested by a sudden, sharp increase in intensity of the receiving lamp. In some systems this impulse is made audible through the use of a loud speaker. The receiving operator aligns the receiving drum with the phasing signal in such a manner that the phasing signal is received at that part of the drum where the edges of the negative come together. When this phasing operation is completed, both pieces of terminal equipment are adjusted to transmit the picture proper.



Picture equipment of Acme Newspictures. The transmitting drum is at the left in permanent installations, and the receiving drum at the right. Simplicity is the keynote of the relay rack control panel which contains a cathode ray tube in the upper left corner

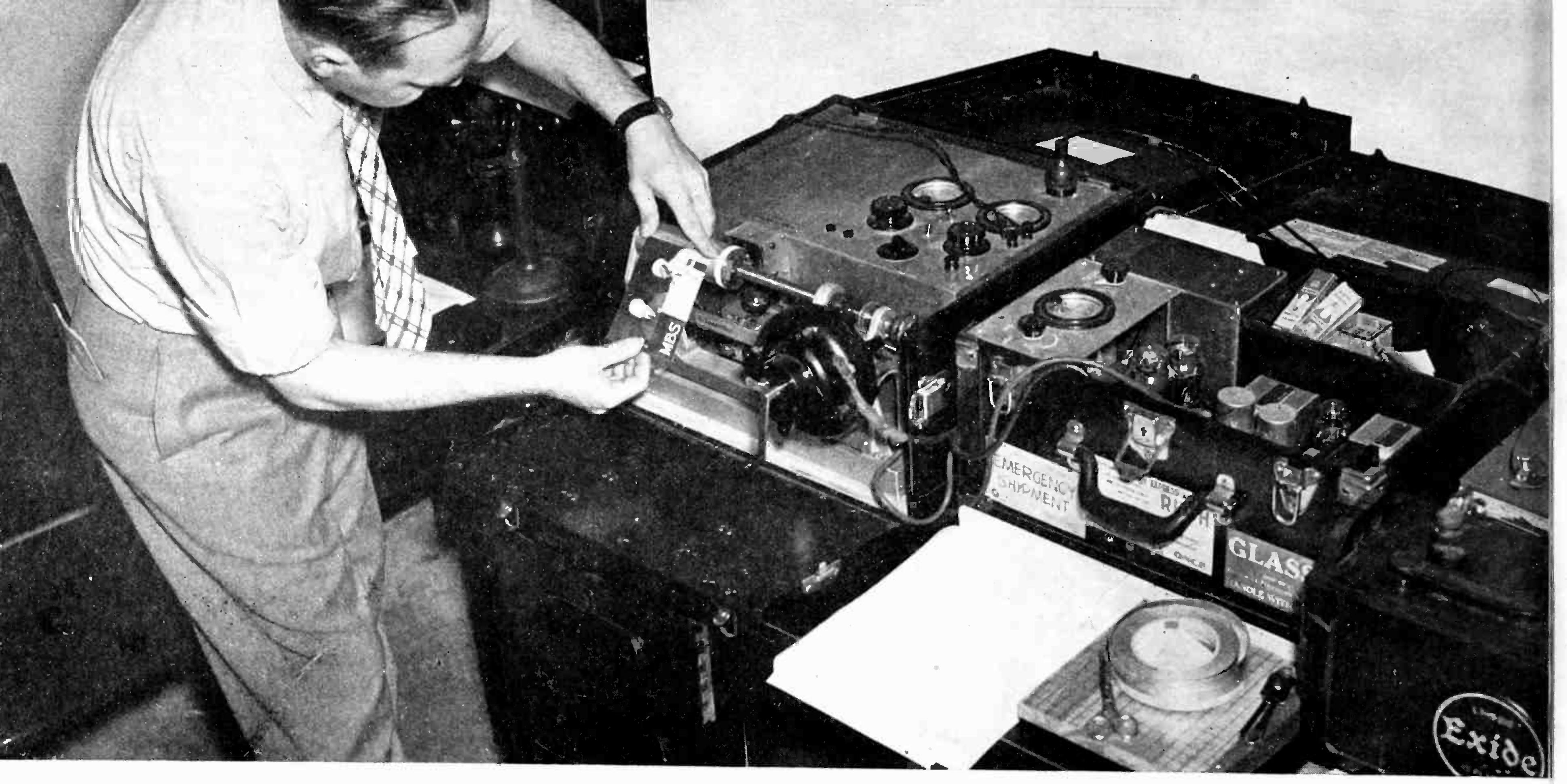
Transmission of the picture usually follows the phasing operation automatically for the scanning spot automatically begins covering the picture as soon as it leaves the phasing band. During the transmission of the picture the telephone microphone must be silenced to prevent acoustic pick-up which would be transmitted over the line with the picture and become evident as streaks or blurs in the picture. There is nothing for the transmitting or receiving operator to do now until the complete picture has been scanned. The length of time required to scan a complete picture depends upon the size of the picture, the detail required, and, to a lesser extent, upon the system in use. As a rough indication, it may be said that an 8" x 10" picture can be completely scanned in about 10 minutes.

In most of the systems the completion of picture transmission is signified by a change in amplitude, pitch, or characteristic signal emanating from a monitoring loud speaker at the receiving station.

The transmitting operator "unmuffles" the phone mouthpiece and sends the caption for the picture (if this was not transmitted as a portion of the picture itself) signs off and packs up his belongings and moves along. The receiving operator removes the negative from the drum to a developing bath, fixes the negative, washes it, and makes as many prints as required.

Such is the general system of operation. Should conditions require, the same picture could usually be transmitted to a number of stations simultaneously by putting all the receiving sets on the same network at the same time. In some instances it is also possible to operate the receiving equipment in such a manner that the received picture is an enlargement of the transmitted picture by the simple expedient of making the diameters of the receiving and transmitting drums, respectively, in the same ratio as the enlargement.

Through the transmission of three color separation prints, it is possible to build up in the receiving drum three color separation negatives, from which, with proper photographic processing and dyeing, a color print can be made at the receiving end. Walter Howey of Inter-



Portable picture transmitting equipment of the Associated Press

national News Photo, and W. G. H. Finch of Finch Telecommunications have transmitted "color prints" in this manner, but there is little demand on the part of newspapers for this type of material.

With this general description of the process as a matter of systems operations, it now remains to say something of the various commercial systems in operation, the extent of available services, and the general features of each system.

Acme Newspictures

At the present time, the Acme-NEA telephoto equipment consists of 9 fixed and 4 portable machines scattered throughout the country. The fixed equipment consists of a center panel of the relay rack type containing the amplifiers, modulators, and adjustments for the receiving and transmitting drums which are located on either side of the main panel. The controls have been simplified and reduced to a minimum, although provision is made for visualizing various wave forms by means of a cathode ray oscilloscope.

The Acme equipment uses a vacuum phototube as the light sensitive element in the transmitting equipment, light from a lamp being focused on the transmitting drum. In the receiving end of the circuit, the latent image is built up by illumination provided by an incandescent lamp, the output of which is varied by a modulator unit.

Synchronization is carried out by transmitting a low frequency synchronizing tone over the line, this synchronizing tone being obtained from a motor-generator set which also provides an 1800 cycle tone for the carrier. A sideband of approximately 450 cycles (including the third harmonic) is transmitted.

Pictures up to 7" x 9" can be carried on the drums. The scanning pitch is 100 lines per inch, with a drum translation of 1 inch per minute. Since the drums are 9 inches in circumference, a 7" x 9" picture can be transmitted in 7 minutes, which represents a scanned area of 9 sq. in. per minute.

The portable equipment is light and truly portable. It consists of two separate units, each in its suitcase container. One of these is the picture drum and scanning unit, the other contains the synchronizing generator, amplifiers, and phone coupling unit. Each unit is slightly larger than a portable typewriter case and operates from the 110 volt a-c line.

Associated Press

The Associated Press news picture system maintains a nation-wide telephone network of high quality lines leased from A. T. and T. All AP subscribers have available to them the entire output of AP pictures, although it is safe to say that no editor uses the 60 to 80 pictures which are transmitted during the average day's work. Another reason why the AP system differs from most of the other systems is because the initial equipment was supplied by the Bell system; and in characteristic Bell system manner, each component part is thoroughly and painstakingly constructed. The equipment is very solidly and substantially built; it is accomplishing excellent work. It is also elaborate and expensive.

Since the AP leases an entire network of high quality lines from the Bell system, it is only natural to find in the New York office, center of AP activities, relay racks filled with Western Electric monitoring, switching, and level indicating equipment, with plenty of plugs, jacks, and keys, so that any station in the network can talk over the circuit to any other station when no pictures are being transmitted.

The standard fixed station equipment has been described in the technical literature.*

The scanning pitch is 100 lines per minute, with a scanning velocity of 20 inches per minute, covering 1

* "A New Telephotograph System" by F. W. Reynolds *Electrical Engineering*, Vol. 55, No. 10, pp. 996–1007, Sept. 1936; *Bell Syst. Tech. Jour.*, Vol. XV, No. 3, pp. 549–574, October 1936.

linear inch of the drum in each minute. Pictures up to 11" x 17" can be transmitted, but the usual practice is to transmit standard 8" x 10" pictures with a 1" caption. Synchronization is by tuning fork controlled oscillators, and phasing of the receiving and transmitting drums is automatic through the use of relay clutch release arrangement. The receiving drums are enclosed in light-tight cases so that daylight operation (except for photographic processing) is possible.

The portable equipment is divided into two separate units. One of these contains the transmitting drum, driving motor, and scanning system while the other holds the fork oscillator, amplifying, modulating, and other essential control equipment. The units operate from 110 volts a.c. or d.c. In addition, a 6 volt storage battery is required to maintain the crater lamp for scanning purposes at the desired temperature.

The portable equipment uses 4" x 5" negatives with a scanning spot 1/200" wide. This 4" x 5" picture is enlarged during transmission so that the received negative is 8" x 10", but has the same detail as if received from a large print.

Complete portable equipment consists of the two picture transmitting units, a portable enlarging outfit, a suitcase of photographic equipment, and a portable typewriter.

Finch Telecommunications

The Finch Telecommunication system maintains 4 fixed stations in New York, Illinois and California. For the purpose for which it is used portable equipment is not required, although present equipment could be used for portable work.

The light spot is produced by a crater lamp and optical system and is picked up by a caesium type phototube. The scanning pitch is 100 lines per inch, and the drum travels laterally 1 inch per minute. Since the drum takes a picture 11" wide the scanning speed is 1½ feet per second, or 11 sq. in. per minute. Pictures up to 11" x 21" may be transmitted.

The carrier is 1800 cycles. Sidebands of 1200 cycles are produced but the upper side-band is suppressed. Synchronizing and phasing are accomplished at every revolution of the receiving and transmitting drums by transmitting a 60 cycle pulse which releases a relay at the receiving station for every turn of the transmitting relay. Ordinarily the receiving drum rotates at a slightly greater speed than that of the transmitting drum, and is stopped every revolution, until the relay disengages the receiving drum and permits it to make another turn. In practice the two drums rotate at speeds sufficiently close together that the receiving drum is not stopped during operation. With a system which phases and synchronizes at each revolution, the maximum displacement of any one line element is a small fraction of a complete revolution.

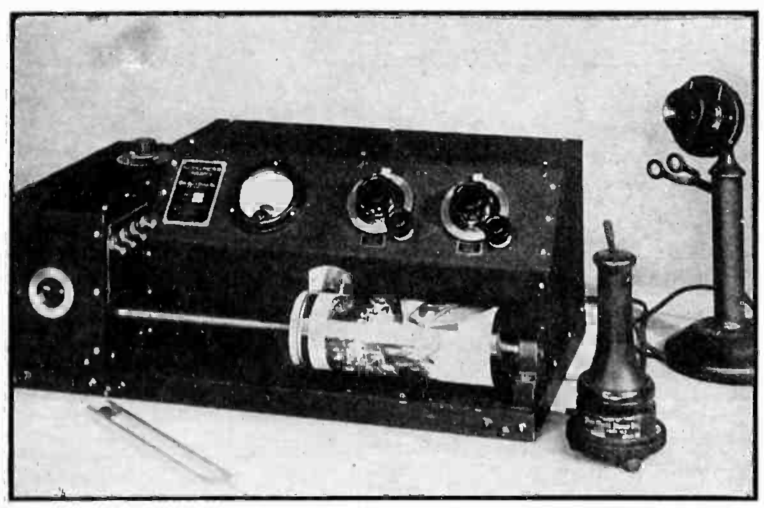
In the receiving equipment, the light source is maintained at constant intensity and is directed on to a small galvanometer mirror which vibrates in accordance with the amplitude of the received signal. Light reflected from the mirror passes through a rectangular aperture before striking the negative, so that as the mirror is deflected, less light passes through the aperture and on to the negative.

International News Photo

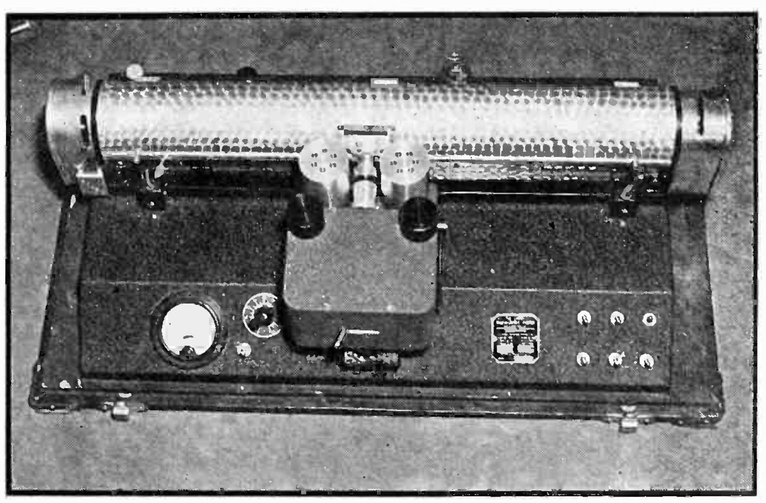
The International News Photo system consists of 15 fixed and 12 portable stations scattered throughout the country, and uses equipment developed by Walter Howey. A feature of this equipment is that the same unit may be used either for receiving or transmitting purposes, as the scanning head is arranged to change from the receiving to the transmitting position by throwing a switch. Thus, one unit suffices for both transmission and reception, and the fixed station units are also used for portable work.

For transmission, the portion of the drum from which the picture element is to be taken is "floodlighted" rather than "spot lighted" as in most other systems. Selection of the desired picture element is made in the beam reflected from the photograph to the phototube. The scanning pitch is 96 lines per inch, and the lateral travel of the drums is 0.864 in. since these rotate at 90 r.p.m. The drums are slightly greater than 8 in. in diameter and will accommodate pictures up to 8" x 10". The area scanned is slightly less than 7 sq. in. per minute.

(Continued on page 82)



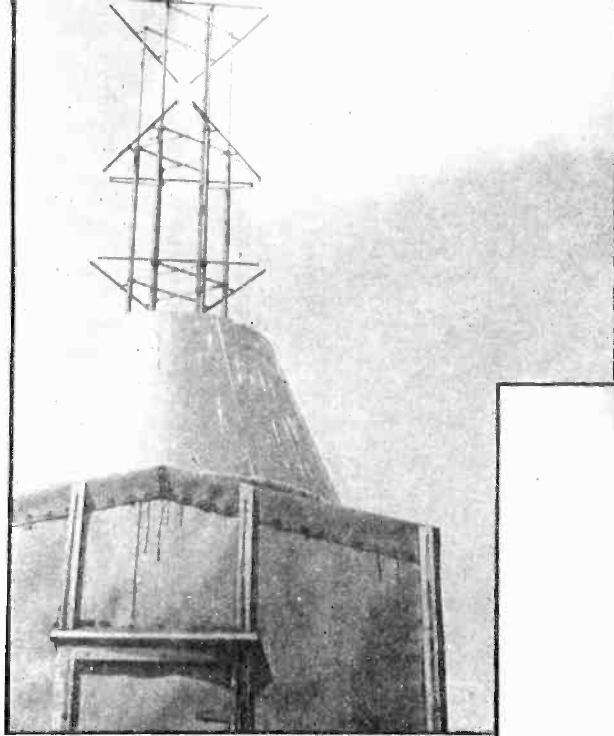
The Times Wide World picture transmitter showing method of coupling to the telephone. The dials on the sloping panel above the cylinders control the adjustments for picture highlights and shadows



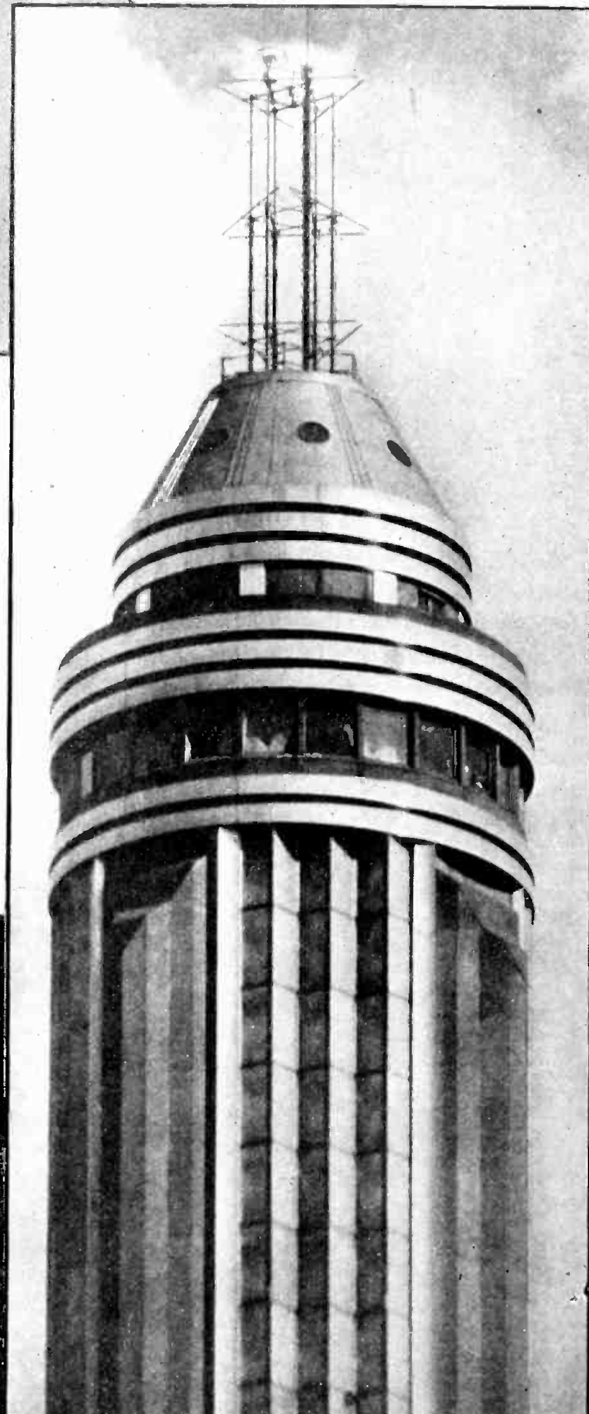
Combined receiver and transmitter of International News Photos. The position of the lever in the foreground determines whether the equipment is to act as a transmitter or as a receiver

"Empire State"

NBC's Television Antenna Enters Its Second Year of Experimental Service

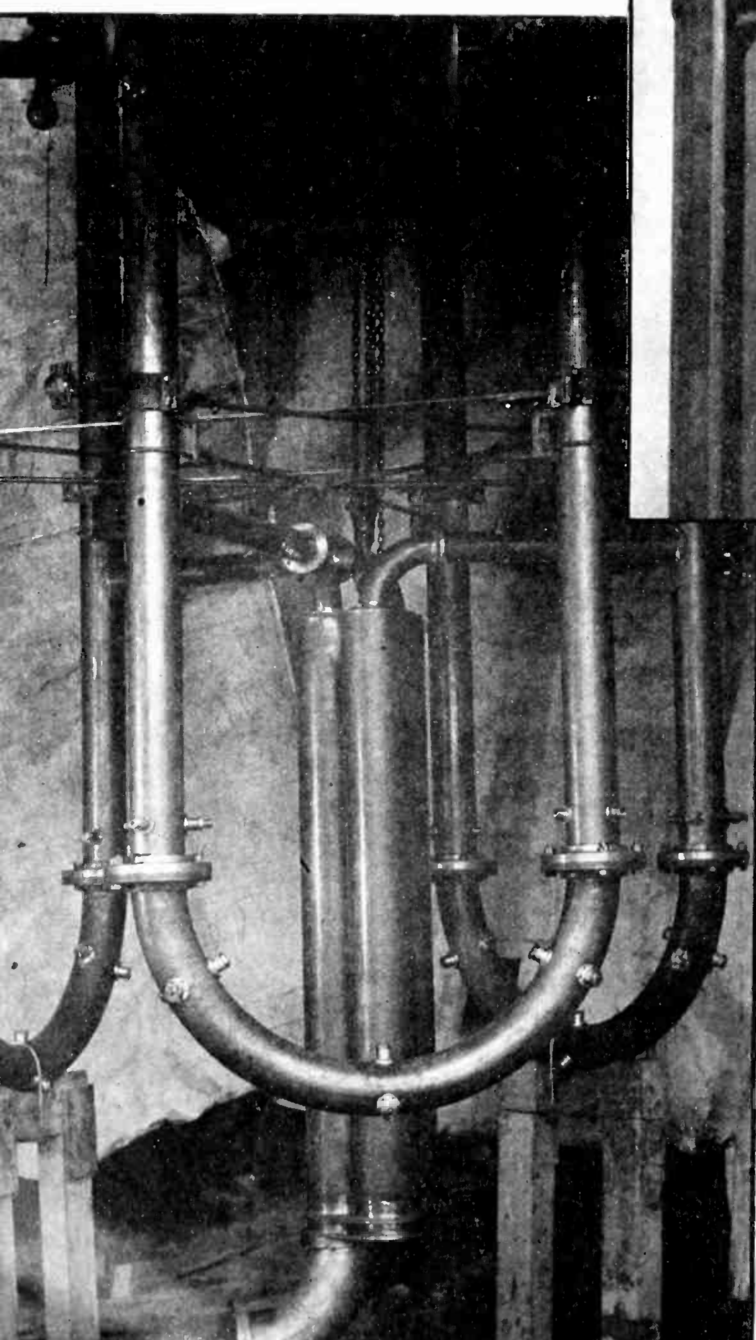


Above, before the Empire State radiator was erected a working model of the antenna was constructed at the RCA Communications Laboratory at Rocky Point. Even the metal top of the tower was copied to study its effect on propagation characteristics

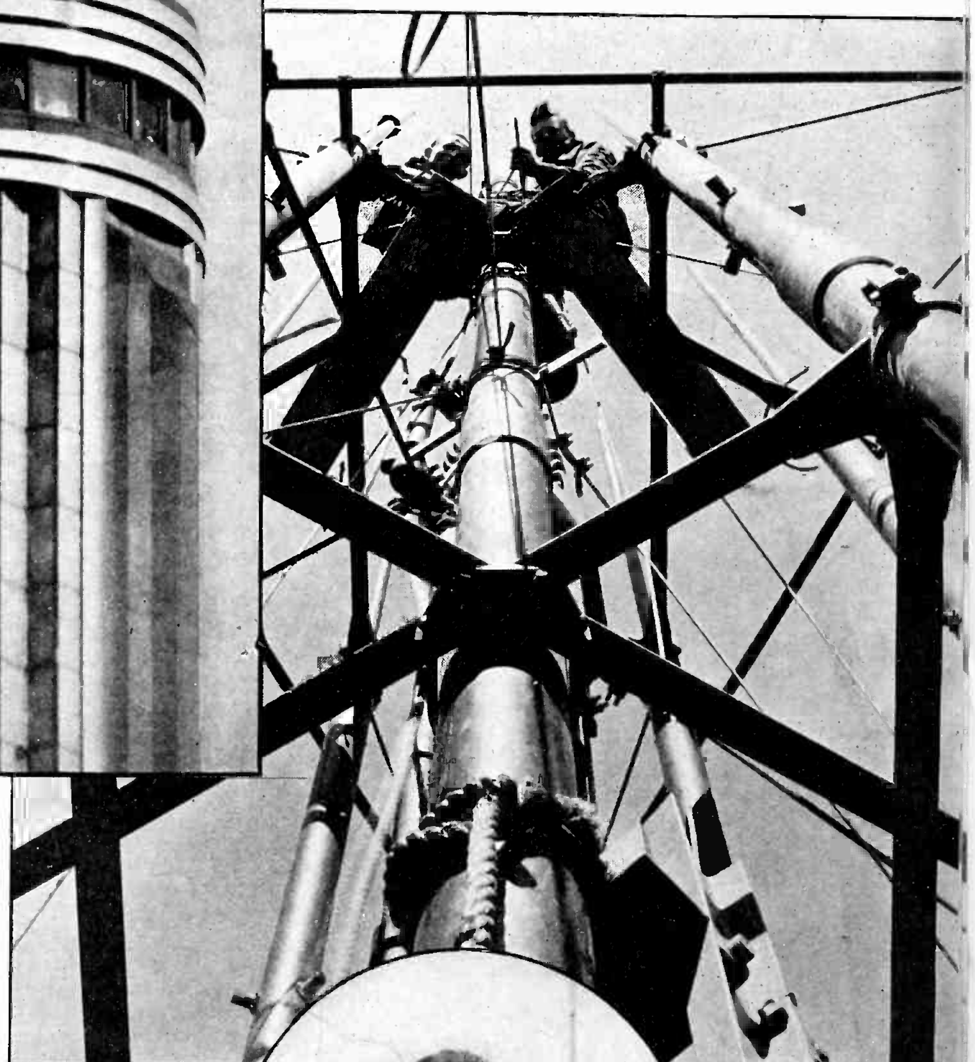


Left, nine horizontal di-poles, arranged in triangles of three, surmount the Empire State Building Tower, 1250 feet above Broadway, New York. Above them is a wind-velocity indicator and a single di-pole for u-h-f high fidelity broadcasting

Below, the resonant coupling filter, used to couple the outputs of the vision and sound transmitters to the single antenna (from which both signals are radiated simultaneously) without allowing energy from one transmitter to enter the other



Below, scene during the construction of the antenna. The supporting rods act as feeders to the di-pole elements (one shown parallel to top of picture)



Right, N. E. Lindenblad, research engineer of RCA Communications, Rocky Point, who was active in the design of the antenna and the construction and testing of the working model

Phonograph Pickup Tracking Error

VS DISTORTION AND RECORD WEAR

By BENJAMIN OLNEY
Stromberg-Carlson Telephone Mfg. Co., Rochester, N. Y.

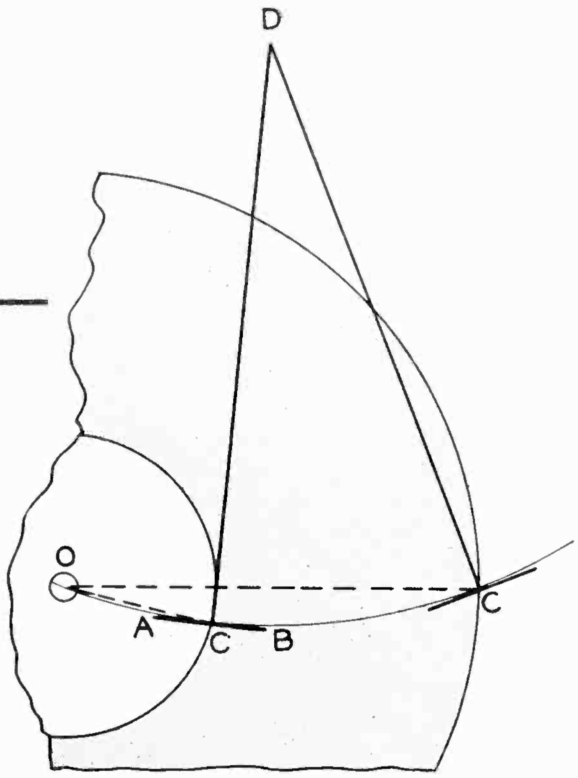


Fig. 1—Tracking conditions in a conventional phonograph

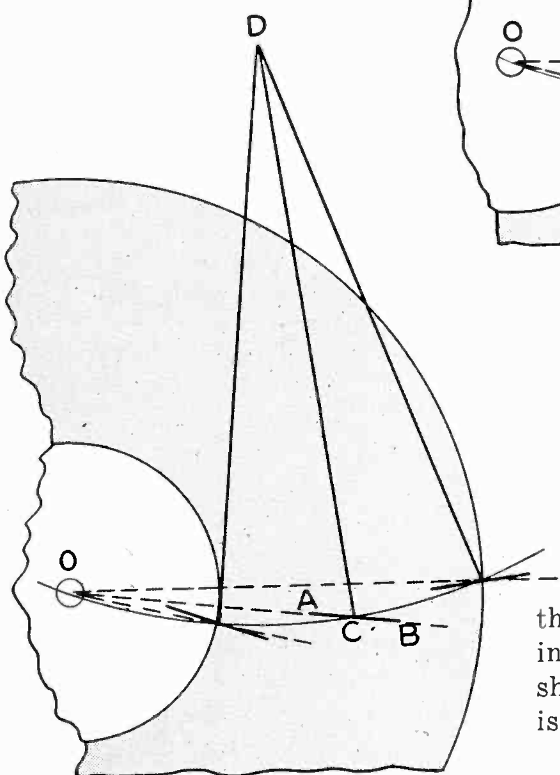


Fig. 2—Illustrating reduction of tracking error by setting pickup at an angle to arm

FOR several years past a feature of phonographs produced abroad has been some special arrangement of the pickup arm for minimizing the so-called tracking error, but it is only lately that such devices have made their appearance in this country. In 1930 the author became interested in this subject through an article published in a British Journal[1] and performed some experiments in an effort to determine if the usual amount of tracking error caused a noticeable increase in distortion or in record wear. The results of the tests were negative and were not published. Lately, however, the notes of the old experiments were resurrected and a further study made of the conditions governing distortion due to tracking error.

In any published articles which have come to the attention of the author it has apparently been assumed that the amount of tracking error usually present in conventional phonographs is harmful, but neither experimental evidence nor extensive analysis has been offered in support of this view. In what follows, the cause and the reduction of tracking error will first be dealt with. This is for the sake of completeness only, as these matters have been fully discussed in recent publications.[2,3] After some reference to practical applications, the 1930 experiments will be described and, finally, an analysis of the effect of tracking error on distortion and record wear will be offered.

In professional recording the cutter stylus generates the sound groove by vibrating along a radius of the rotating wax disc. Therefore, in a theoretically correct reproducing system the pickup must be so guided that the line along which the needle point is free to vibrate likewise coincides at all times with a radius of the record. Expressing the same idea in a different way, we may say that the vertical projection upon the record surface of the axis about which the needle vibrates must always be tangent to the groove at the point of needle contact. This criterion differs from that generally given, which stipulates that the projection of the *needle* upon the record surface shall be tangent to the groove. The distinction between these two criteria should be borne in mind, for it will subsequently be shown that the last mentioned one is lacking in generality.

The diagram of Fig. 1 illustrates the tracking conditions that obtain in a conventional phonograph. DC is the axis of the arm, which swings around its pivot at D. OC are radii of the record. AB is the line of vibration of the needle point and lies at right angles to DC. The arm pivot is so located that the needle point swings through the center of the record. It is obvious that the condition for perfect tracking (AB lying on a radius) is satisfied only in the one (inactive) position where the needle point falls on the center of the record. In any other position of the arm the line AB makes an angle ACO with the radius. This is called the tracking angle or tracking error. Curve A, Fig. 3, shows the tracking error for a 9¾ inch straight arm with the pickup

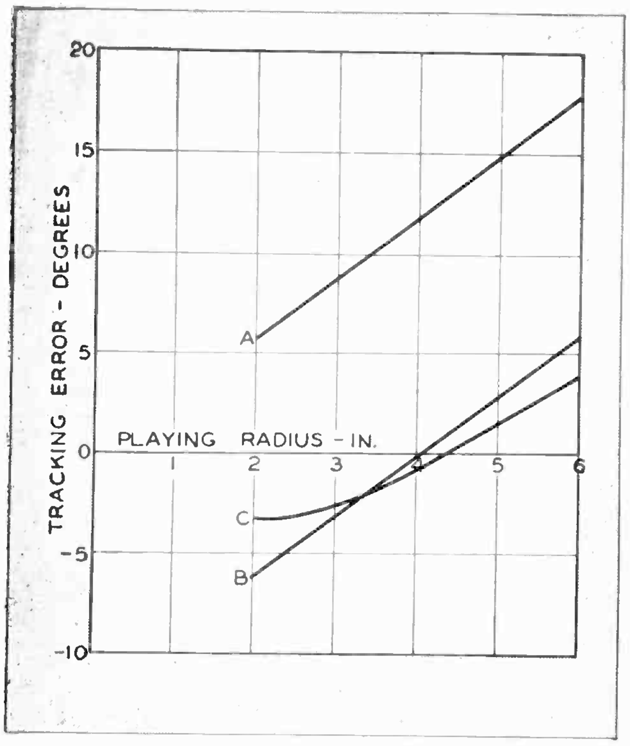


Fig. 3—Tracking error curves for a 9¾ inch arm: A—Conventional arrangement. B—Line of needle vibration set 74 degrees to arm axis, needle swings through center of record. C—Same as B except needle swings ¼ inch past center of records

mounted in the conventional manner and so located that the needle point swings through the record center.

Now, referring to Fig. 2, let us set the needle in the center of the playing portion of the record and so adjust the pickup to the arm that the line of needle vibration AB coincides with a radius of the record. The tracking error is now obviously zero in the center of the playing portion and is reduced to small equal positive and negative values at the start and finish of the recording. Curve B, Fig. 3, shows the tracking characteristic of the same 9¾ inch arm which was the subject of curve A, but with the pickup adjusted as just described. By so locating the arm pivot that the needle point swings beyond rather than through the record center a further reduction in tracking error can be accomplished. It has been considered undesirable to carry this too far, however, because of the development of a force tending to draw the needle against the inner side of the groove[1]. Bird and Chorpening have shown the relations among this overhang distance, the arm length and the angle at which the pickup is offset which result in minimum average tracking error[2]. Curve C, Fig. 3, shows the tracking error when the pickup is so set on a 9¾ inch arm that the line of needle point vibration makes an angle of 74 degrees with the arm axis and the needle swings ¼ inch beyond the record center. This is within about 1½ degrees of the minimum error that may be attained with an arm of this length.

Perfect tracking throughout the record would require the use of rolling carriages or complicated parallel-motion linkages. As shown above, however, a close approach to the ideal case may be had with special arrangements of single, pivoted arms. In Fig. 4 are shown three such arrangements that have been used to place the line of needle point vibration (indicated by the double-headed arrow) at a suitable angle to the effective radius of arm swing.

It is interesting to note in passing that the old acoustic phonographs had their reproducers effectively offset in the manner of Fig. 4-C by virtue of the "goose-neck" construction employed, but the direction of offset was toward rather than away from the record center, thus producing an increased tracking error in all positions of the arm. Also, a widely used professional magnetic pickup is effectively offset to the inside in a like manner.

Another method of improving tracking conditions consists in offsetting radially the needle holder from the axis about which it vibrates and so inclining it that the needle point lies (as in conventional arrangements) in a vertical plane passing through the axis of rotation. The essential features are illustrated in the diagrams of Fig. 5, where A, B and C are top, front and side views, respectively, and where certain dimensions are exaggerated in order more clearly to show the principles involved. It is here that the invalidity of the usual tracking criterion previously referred to can be demonstrated. In A it will be seen that the projection of the needle itself is tangent to the groove as required by the above criterion. The line of needle point vibration, however, still lies at right angles to the axis of rotation of the needle holder, precisely as though the needle were mounted in the usual manner. Consequently, there results a tracking error measured by the angle θ, according to the fundamental concept that the reproducing point must, for perfect tracking, vibrate along a radius of the record the same as did the recording cutter. It seems trivial to point out in justification of the above statements, that the path of the needle point is determined only by the radius x-y as the axis rotates, and that the line x-z-y representing a rigid needle and holder may take any course whatsoever between its given terminii without upsetting this relation.

If it be assumed that record wear resulting from imperfect tracking is caused solely by deviation of the needle projection from tangency to the playing circle and that small departures of the line of needle point vibration from a radius introduce negligible distortion, the above arrangement becomes equivalent in its tracking characteristics to those shown in Fig. 4. It is believed, however, that these distinctions are without particular significance in view of what follows.

Record Wear Experiments of 1930

These experiments were undertaken to investigate the effect of two widely different tracking error conditions on record wear and distortion in reproduction, as indicated by listening tests. Two synchronized turntables were used, one being equipped with a 9¾ inch straight arm mounted in the conventional manner and the other with a bent arm of the same length so mounted that the needle swung ¼ inch past the record center. Their tracking error curves are shown as A and C respectively in Fig. 3. The pickups were of the low impedance, magnetic type chosen to have practically identical electrical and mechanical characteristics. The armature action probably was more flexible than that of the average pickup of that period, the stiffness measured at the needle point being of the order of 5×10^6 dynes per cm. To insure further the impartiality of the test, the pickup heads were transposed after each five playings. Steel needles, changed after each playing, were used as the modern chromium plated needles were not yet available. Quick switching of either pickup to the input of an amplifier of low distortion and adequate power output capacity was provided.

The sound reproducer was an electro-dynamic loudspeaker having an 8 inch diameter corrugated cone with leather suspension, mounted in a large baffle. The pickup and its associated circuits cut off rather sharply at about 4200 cycles, while the loudspeaker was capable of reproducing up to about 5000 cycles. At least two experienced observers listened at each test and others were called in from time to time. For use in these experiments, several new pressings of Victor record 35985, "Zampa Overture", were obtained. This particular record was chosen because, first, the type of music and the instrumentation were well suited for judgments of quality and, second, the recorded amplitudes were very large in the fortissimo passages, rendering the groove walls susceptible to breakdown in the possible presence of unfavorable tracking conditions. Two of these pressings (which will be referred to as the test records) were selected for comparative tests on the two turntables and the others were held for checking purposes. Side A was played throughout the experiment.

Careful listening comparisons made at the start of the experiment did not disclose any difference in the quality of reproduction for the two conditions of tracking. Similar tests were made at first after each 5 playings and toward the conclusion of the experiment, after each 10 to 20 playings. After 68 playings, no difference between the reproduction afforded by the two outfits could be detected, either as regarded quality or surface noise. At this time comparisons also were made between the two records that had been played 68 times and one of the new check records. There was, of course, a pronounced difference in surface noise, but no difference in quality could be detected.

After 90 playings the observers still were unable to detect any difference in surface noise or quality of reproduction between the two test records associated with their given tracking conditions. Furthermore, no difference in quality was observed upon comparing either of the test records with a new check record. Examination of the test records under a microscope disclosed signs of wear at the high amplitude waves but, so far as the observers could judge, the wear was substantially the same for both conditions of tracking.

At 120 playings a loss in quality in the test records was noted when they were compared with a check record. This was heard as roughness in the loud passages. There was little to choose from between the two test records in this respect. Surface noise was very high on both. The test was stopped when the records had been played 185 times each and the quality had become very bad indeed. The needles still would track the grooves, however, showing that complete breakdown of the walls had not yet occurred. The observers were unable, either at the conclusion of the test or at any time during its progress, to detect with certainty any difference between the reproduction afforded by the test records on their respective phonographs. It was concluded, therefore, that the amount of tracking error present with conventional pickup and arm arrangements was not harmful either as regards distortion or record wear, and that further development work tending toward its reduction was unwarranted.

Analysis of Wave Distortion and Wear Conditions

The recent revival of interest in tracking error prompted the present analysis which proposes to show, principally by graphical methods, that the negative results of the 1930 experiments are not discordant with theory. For purposes of illustration, the nature of the wave-form error due to imperfect tracking will first be investigated in two cases where the proportions of the waves lead to large amounts of distortion and, finally, where the proportions are representative of actual recording practice. An analysis of this sort must necessarily be confined to the reproduction of recorded sine waves.

In Fig. 6-A the broken line represents the center line of a record groove, which is a sine wave of length λ and amplitude α drawn to the proportions $\lambda/\alpha = 3$. This is a relation commonly approximated in waves drawn for illustrative purposes. Let us first consider the case

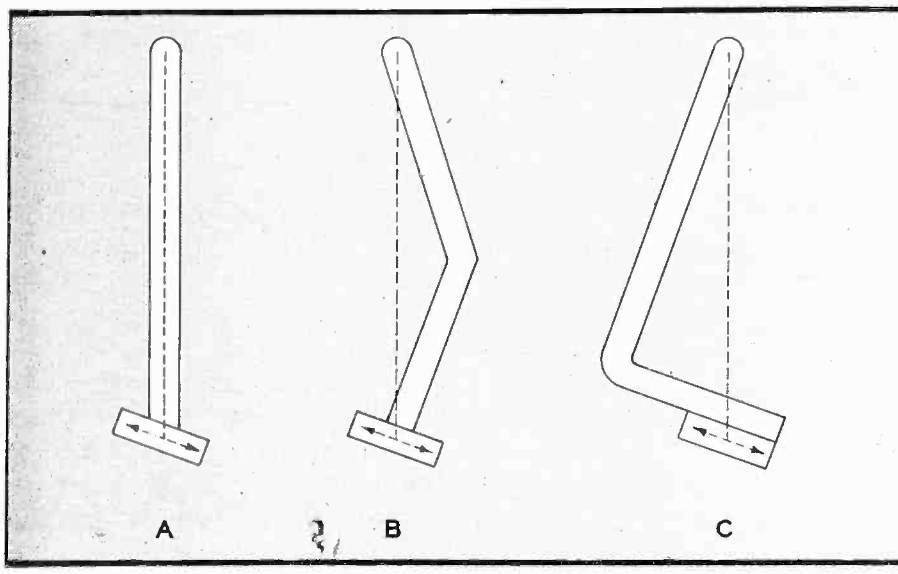


Fig. 4—Three arrangements for reducing tracking error which are employed at the present time. Each results in less error although affected by a slightly different method

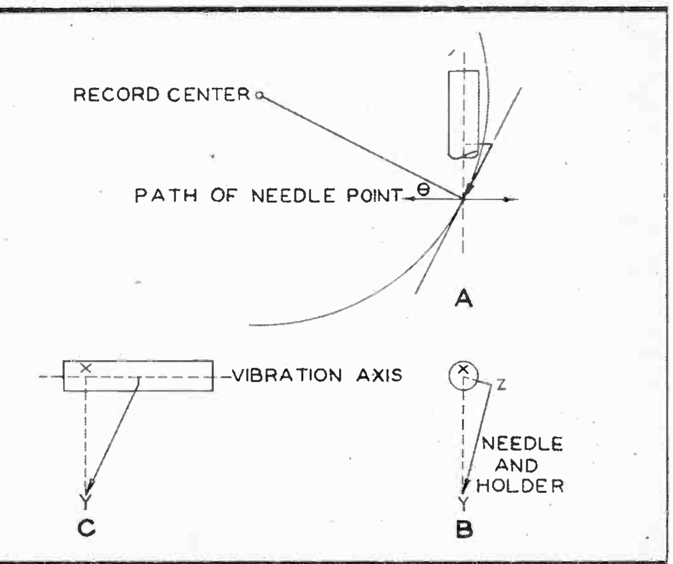


Fig. 5—Condition under which tracking error may occur when projection of needle on record is tangent to playing groove at point of needle contact

where the pickup is set for perfect tracking, the needle point being thereby constrained to vibrate about its undisplaced position at point A along a line perpendicular to the time axis of the wave. Imagine the whole wave having started from a position shifted the distance OA to the right. Then, at the instant depicted in the diagram the needle point, following the groove, will have been driven from A to D. Now let us assume the pickup to be set to produce 15 degrees tracking error, a value around the maximum occurring with average conventional arm and pickup arrangements. The needle point is now forced to vibrate along a line AB, making an angle of 15 degrees with its former path AD at their common intersection with the time axis. With the same travel of the wave as before, namely the distance AO, the needle point will now be driven from A to B. To relate this displacement to the instant of time A, with A as a center and radius AB an arc BE is described intersecting a perpendicular erected at A. C, the point of intersection, is a point in the needle displacement wave to the same time base as the driving wave. Other points are located in a similar manner and the wave represented by the solid line is drawn.

It is evident from an inspection of the derived wave that the conditions stipulated above produce a large amount of distortion. (This distortion and that of the other waves of Fig. 6 will be evaluated later.) It would furthermore appear that, with a given tracking error, the amount of distortion should decrease rapidly with increase in the ratio λ/a because not only does the intercept DB on the original wave then become shorter but the steepness of the wave-front is simultaneously reduced. Both of these factors lead to a smaller departure of the derived wave from the original wave. This is illustrated in Fig. 6-B, where λ/a for the original wave is double that for wave A.

To illustrate clearly the principles involved it has been found desirable in the foregoing to employ exaggeratedly small values of the ratio λ/a. We shall now investigate the recording conditions in order to estimate the smallest value of this ratio that may be expected to occur in common practice. First, let us consider the minimum wave velocity, c. Assuming a turnable speed of 78 r.p.m. and a minimum groove diameter of 4 inches,

$$c = \frac{4\pi \times 78}{60} = 16.3 \text{ in. per sec.}$$

The wave length in inches then will be:

$\lambda = 16.3/f$,

where f is the frequency in cycles per second.

The maximum amplitudes will now be investigated. Sivian, Dunn and White have found[4] that an orchestra delivers its peak power in the 250-500 cycle band. As the highest frequency combined with the greatest amplitude will give the smallest value of λ/a, we shall choose 500 cycles and assume the amplitude to be 0.002 inch, a value commonly given as the maximum permissible in lateral recording. Then,

$$\lambda/a = \frac{16.3}{500 \times 0.002} = 16.3$$

It is of interest also to evaluate this ratio for other frequencies near the extremes of the usual recorded range, say 70 to 5,000 cycles. Most professional recorders whose descriptions have been published have been designed to produce, with constant electrical input, a constant amplitude response below about 200 cycles and a constant velocity response above that frequency. The maximum permissible amplitude (0.002 inch) will therefore be assumed to prevail at 70 cycles. Then,

$$\lambda/a = \frac{16.3}{70 \times 0.002} = 116$$

In the case of 5,000 cycles, if we as-

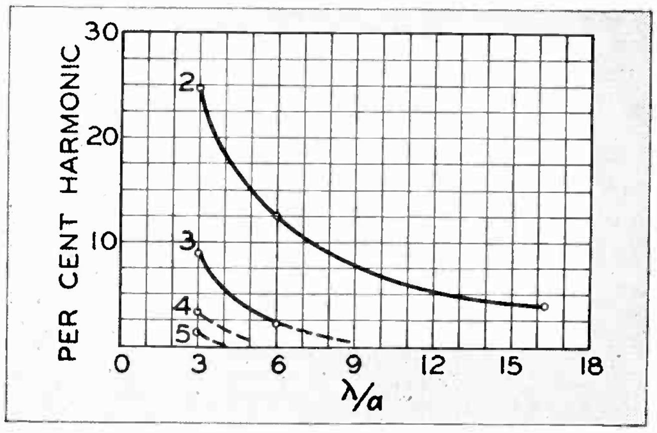


Fig. 7—Showing harmonic production as a function of the proportions of the wave. 15 degrees tracking error assumed

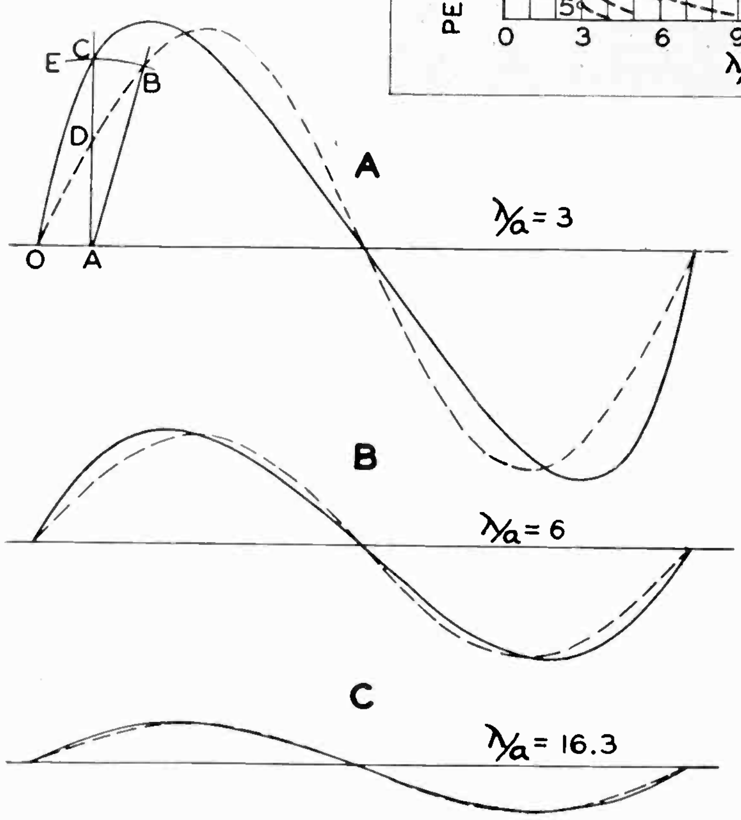


Fig. 6—Distortion caused by 15 degrees tracking error. In A and B the proportions of the waves are exaggerated to illustrate principle. C shows the worst condition liable to occur in practice

sume a 0.002 inch amplitude at 250 cycles and the same sound intensity level at both frequencies, the amplitude at 5,000 cycles will be 0.0001 inch. However, it has been shown[4] that the peak power delivered by an orchestra is about 9 db lower in the 4,000-11,500 cycle band than in the 125-250 cycle band. Applying this correction, the peak amplitude at 5,000 cycles becomes 0.000035 inch and

$$\lambda/\alpha = \frac{16.3}{5000 \times 0.000035} = 93$$

Comparing the values of λ/α calculated in the three cases, that for 500 cycles, namely, 16.3, is found to be the smallest. This value, therefore, should give rise to the greatest possible amount of distortion due to tracking error that could be expected in the reproduction of a sine wave recorded under conditions representing common practice. A sine wave having the above proportions is shown in Fig. 6-C to the same scale as the other waves in the figure. The wave derived on the assumption of 15 degrees tracking error cannot be well shown to this scale, as its departure from the original wave is very small. It is, nevertheless, large enough to produce measurable distortion, as we shall presently show.

To evaluate the distortion, the three derived waves of Fig. 6 were drawn to a wave length of 40 cm. and were analyzed on a Henrici-Coradi harmonic analyzer at the Eastman Kodak Co. Research Laboratories by Mr. V. C. Hall, to whom acknowledgement is hereby gratefully made. The results of the anlysis are given below in Table I. While it is admitted that these data are rather meagre for the illustration of a general law, they are shown plotted in Fig. 7 as a matter of interest.

TABLE I

Harmonic Analysis of Derived Waves of Fig. 6, Showing Distortion Due to 15° Tracking Angle

Wave No.	λ/α	Harmonic Content % 2nd	% 3rd	% 4th	% 5th
6-A	3	24.7	8.9	3.3	1.4
6-B	6	12.6	2.2	0	0
6-C	16.3	4.1	0	0	0

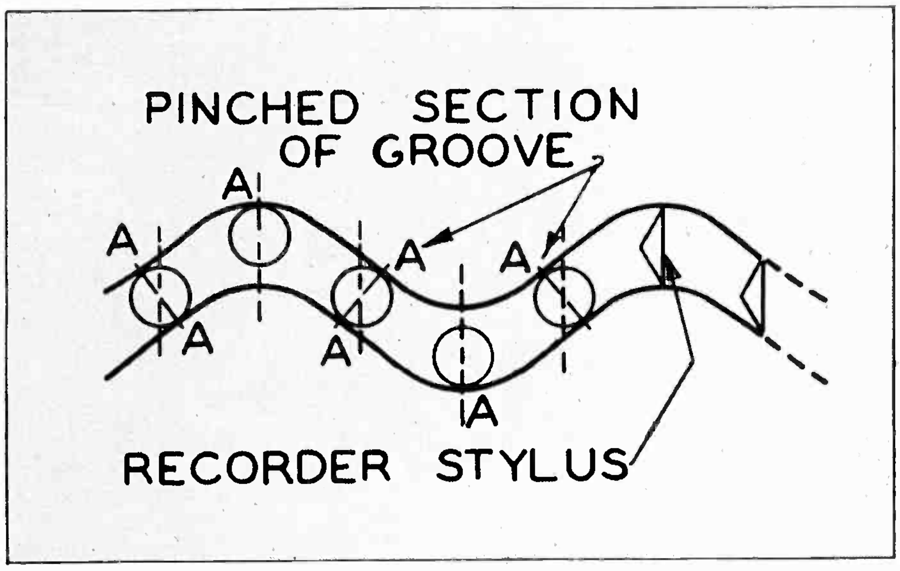


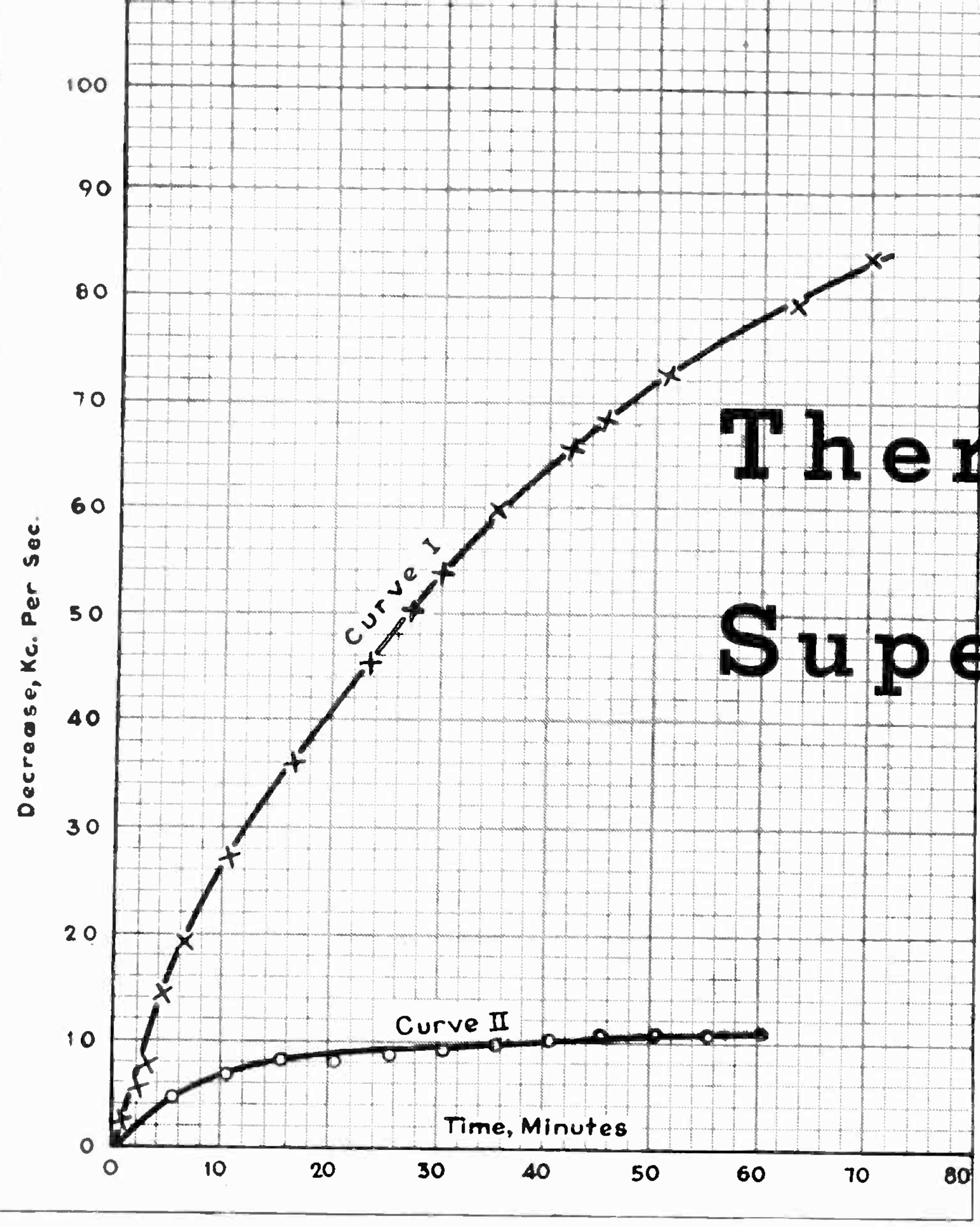
Fig. 8—(After Frederick) Illustrating "pinch" effect and the shift of reproducer stylus bearing point, A

It is believed that the negative results of the 1930 experiments may be justified in view of the analysis just offered together with some additional considerations. Little quantitative information has been published on the effect upon the ear of non-linear distortion of reproduced sounds. Data secured by Massa[5] indicate that at least 12% second harmonic must be present to be detectable on speech by direct comparison in a system having an upper cut-off frequency of 5,000 cycles, and about 6% in an 8,000 cycle system. Although there appear to be no data similar to the above available for music, it would seem reasonable, in view of the results for speech, that the amount of distortion contributed by the worst tracking condition in our 1930 experiments should be undetectable; bearing in mind that, as shown by our analysis, the maximum distortion due to this cause may amount only to 4% second harmonic for a recorded pure tone.

Another reason why possible distortion due to tracking conditions could not be detected in our experiments may be the presence of distortion from other causes connected with recording and reproduction on disc records; notably the so-called "pinch" effect and the shift in needle bearing point, both of which have been described by Frederick[6]. These effects are shown in Figure 8, copied from Frederick's paper. In the first case it is important to note that the recorder stylus, being chisel-shaped, generates a groove of varying width dependent upon the steepness of the wave-front. Assuming the reproducing needle to wear itself to the narrowest dimension of the groove, the point then may skid from side to side in the wider portions of the groove. The other possible cause of distortion, due also to recording with a chisel-shaped cutter and reproducing with a round point, comes into play as the needle rounds a curve and is clearly illustrated in Fig. 8 by the shifting of the point of contact A.

To obtain some idea of the possible magnitude of these effects, a segment of groove having the proportions $\lambda/\alpha = 16.3$ was, together with the reproducer point, drawn to a large scale after the manner of Fig. 8. It was found that the maximum possible departure of the needle path from that originally executed by the recorder stylus was of the same order as the difference between the original and the derived waves of Fig. 6-C. The reader is reminded that the latter wave represents the maximum distortion caused by the usual amount of tracking error alone. In view of the loose assumptions which would have to be made regarding the needle skidding action, it was not attempted to derive and analyze waves illustrating the above effects. It seems reasonable to expect, however, that the distortion due to the "pinch" effect would be comprised of a more extended series of higher order components (some of which might possibly be inharmonic) than would that due to tracking error because of the possibility in the former case of sharp and irregular changes in needle mo-

(Continued on page 81)



Thermal Drift in Superheterodyne Receivers

JOHN M. MILLER

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Fig. 1 — Decrease in oscillator frequency during heating. Curve II — After modification of apparatus

RADIO engineers have realized for a number of years that during the warming-up period after a superheterodyne receiver is put into operation, a large change in tuning occurs with time. The change is most pronounced on the highest frequency range and increases as the high-frequency end of this range is approached. This drift in tuning persists for an hour or more and necessitates frequent readjustments of the tuning control in order to keep a short-wave station in tune. The effect is a source of annoyance when an attempt is made to listen continuously to a program from a short-wave station unless the receiver has been in operation for an hour or more. Complaints from users with regard to this receiver defect are, however, surprisingly few, indicating that either users do not ordinarily listen continuously to such short-wave programs or that they blame the station or fading, rather than the receiver, for the frequent loss of signals.

The direction of the drift in the tuning is toward a higher frequency, that is, the dial setting must be continuously shifted toward the high-frequency end of the range to keep the station in tune. Since the tuning of a superheterodyne is generally determined primarily by the oscillator frequency, it seems obvious that frequency variation of the oscillator is the cause of the drift. Because correction of the drift requires an increase in the oscillator frequency, the drift itself represents a decrease in the oscillator frequency with increasing temperature. That this is the source of the frequency drift is shown by Curve I in Fig. 1. This curve shows the decrease in the oscillator frequency with time in the case of a 1936 model of receiver. The measurement was made near the high-frequency end of the band which includes 15 and 18 megacycles. The drift in kilocycles per second is plotted against elapsed time in minutes after the first measurement of the oscillator frequency, which is taken as soon as possible after the cold receiver is turned on. This curve represents, of course, the most unfavorable condition of operation, the drift at lower frequencies on the same range being much less. In fact, the drift in kilocycles on any range is generally proportional to the cube of the frequency. However, a 10-kc. drift is usually sufficient to tune completely from one station to another so that it is evident that much less drift than that shown by Curve I would still be objectionable. To study and reduce objectionable drift, the condition of the curve is most favorable for measurement purposes.

To Measure Drift

A method of measurement of the oscillator drift is the following. An auxiliary stable oscillator operated from batteries and an auxiliary receiver are employed. The frequency of the auxiliary oscillator can be varied by a vernier condenser which is calibrated in kilocycles per division. The oscillations of both the oscillator under measurement and the auxiliary oscillator are tuned in on the auxiliary receiver and the auxiliary oscillator is adjusted to the same frequency as the oscillator under test using as an indicator the reduction of the beat note to zero frequency. Loose coupling between the two oscillators is required. A drift in frequency of the oscillator under test is then measured by the change in the auxiliary oscillator required to restore the zero beat.

The cause of oscillator drift appears to have been unknown, at least up to a year or two ago. At that time the author, himself in the dark, caused inquiries to be made of two laboratories who had worked on the matter. The replies were negative, the only remedial suggestion being the use of a compensation device. Such a device has been developed by the author; it is believed that at least one radio concern has put such a device on a commercial receiver.

The drift appeared to be due to some abnormal effect. Suppose, for example, a calculation is made of the change in tuning due to temperature rise in the coil and condenser of the oscillatory circuit. The measured rise in temperature of these units in an hour is usually of the order of 10° C. If all parts of the coil and condenser had a normal coefficient of say, 20 parts in a million per degree C, each of these units would increase in value with this same coefficient, and the frequency would decrease with the same coefficient. The frequency drift at 18 mc. would be only 3.6 kc. in one hour. This is negligible and far below the observed values. Changes in voltage applied to the oscillator due to heating of the speaker field and other units of the receiver might also be suspected as the cause of drift but are found experimentally to be entirely too small. Changes in frequency due to heating of the oscillator tube itself can be checked by substituting a cold tube for the hot one in a hot set. Here some drift is observed, but still this is far below the total drift of the receiver. Furthermore, due to the rapid heating of the tube, it is found that this component of the drift quickly reaches a stable value, coming up to about ninety per cent of its final value in the first ten minutes. This is a much less objectionable component of drift than that which persists for an hour or more.

In connection with other work, the author found that condensers employing certain dielectrics showed very high positive temperature coefficients of capacity or of effective dielectric constant. While this finding is probably not new, the effect is apparently not generally known. In different dielectrics, the effect appears to increase with the dielectric losses. Thus low-loss dielectrics show a small temperature coefficient of effective dielectric constant or even a negative coefficient, while the higher-loss dielectrics will show very great positive coefficients. The following table gives observed coefficients of effective dielectric constant in parts in a million per degree C for samples of several materials:

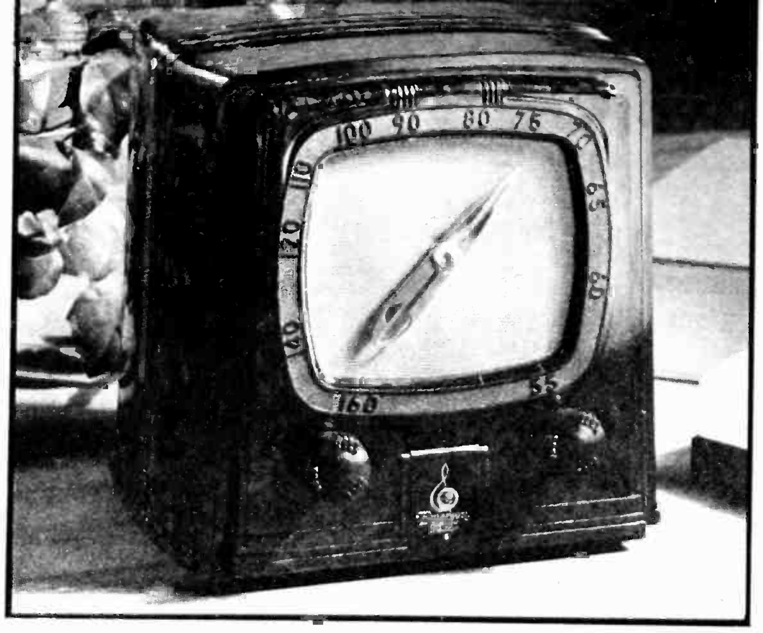
Varnished Cambric	+2100
Synthetic Resin	+1660
Insulation of push back wire	+1500
Rubber covered wire (low grade)	+1100
Enamel Insulation	+ 470
Rubber covered wire (high grade)	+ 200
Hard rubber	+ 200
Ceramic Insulation	+ 100
Victron (white)	— 35

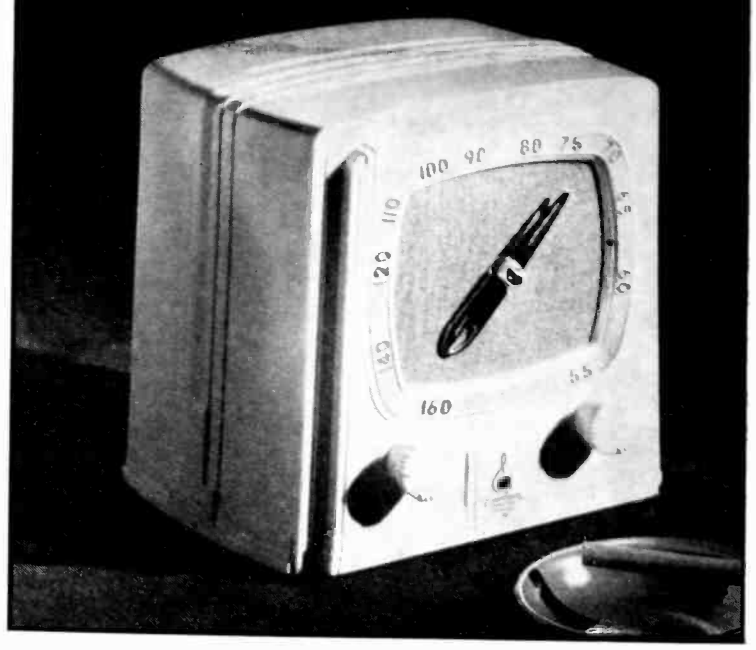
Since the minimum capacity in a receiver is largely comprised of capacities through insulators in the wave change switch, the condenser, coil form, leads, tube socket, and base, and since synthetic resin insulators are widely employed, the possibility is that the temperature variation of these capacities might cause the major drift in the receiver. Likewise, some of these parts warm up slowly to their final temperature. Such a capacity change would change the minimum capacity of the receiver which, on a given range, would bring about a frequency change in kilocycles proportional to the cube of the frequency. A check at several frequencies over the frequency range of the receiver used in obtaining Curve I of Fig. 1 showed that this relationship holds to a fair degree of accuracy. The attempt was then made to reduce the drift in the receiver. For the oscillator section of the variable condenser there was substituted a small variable condenser with ceramic insulation. This was mounted as near as possible to the unused section in order to obtain the same temperature changes. A coil wound on a ceramic form was substituted for the original coil and mounted in the same shield. The wave change switch contacts on the high potential side of the oscillator were eliminated by means of direct connection with stiff leads in air. Ceramic tube sockets were installed and an oscillator tube with ceramic insulation was used. A synthetic resin block which supported the high potential terminals of the grid leak and grid condenser in the oscillator circuit was also removed leaving the junction in free air.

Curve II of Fig. 1 shows the large reduction in oscillator drift which resulted from this elimination of capacity effects produced primarily by the use of synthetic resin. The drift in one hour has been reduced to 15 per cent of the original drift. Still more marked is the reduction in drift after the first ten minutes of operation. In the succeeding fifty minutes the drift is reduced to ten per cent of the original drift. Restoring the receiver to its original condition resulted in the same large drift as originally observed.

In the case of another commercial receiver it was found that at the high-frequency end of the broadcast band there occurred a thermal frequency drift amounting to about 30 kc., which represents a very large change in the minimum capacity. This was found to be due to capacity between a tickler winding and the main oscillator winding. The tickler was wound over the main oscillator coil with several layers of varnished silk between. Replacing the tickler winding by one wound on a separate coil form inside eliminated the drift.

It is realized that the above tests by no means represent a complete practical solution of thermal drift for the commercial receiver manufacturer who must consider cost, mechanical properties and coefficient of expansion of the various insulators. It is hoped, however, that the results insofar as they explain the main cause of frequency drift, may be of value in bringing about its reduction.





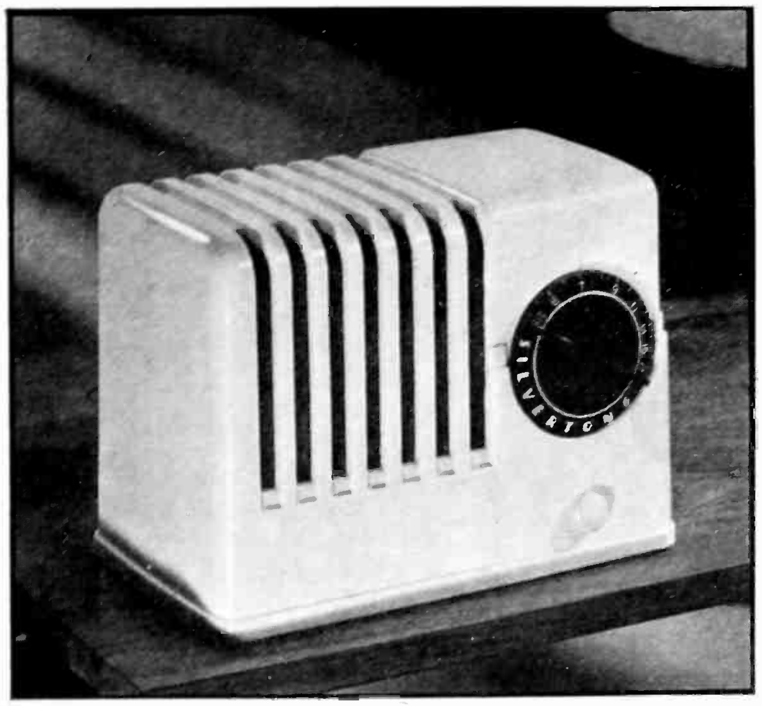
Two views of the Emerson midget receiver with dial surrounding the speaker grille. The dark cabinet is of mottled Durez, while the ivory housing is of Beetleware. These illustrations show the variety which may be obtained through the use of plastics of various colors and compositions

New Plastic Materials

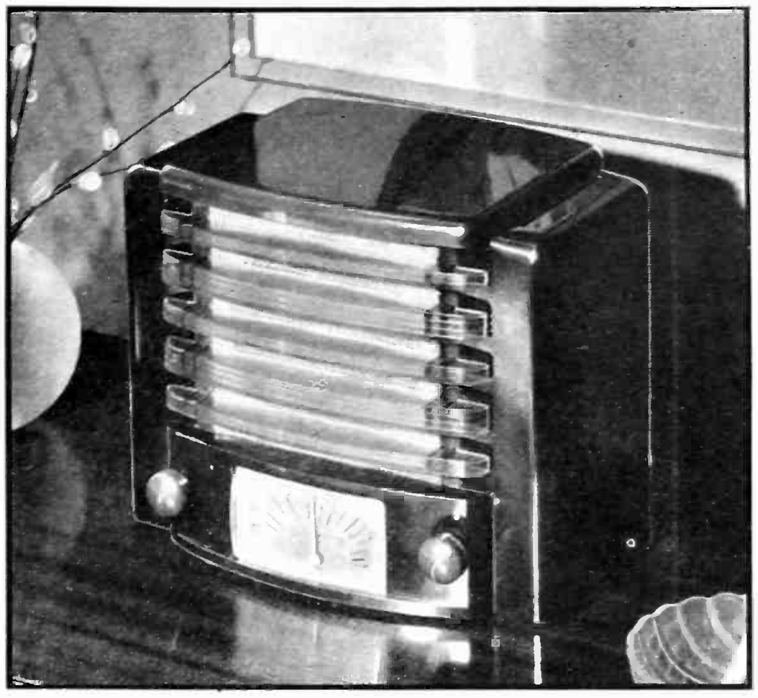
In *Electronics*, March 1936, the writer explained the properties of plastics of various types indicating which types are best suited for the variety of uses encountered. Here the application of plastics in cabinets and external fittings is considered and the materials compared with other types available

Seven English receiver cabinets of varying size and shape, all of which are produced in molded Bakelite

PLASTICS have long since demonstrated their suitability for use in cabinets and parts exposed to view in radio receivers and certain other electronic applications. Their use is extending, but they are still in active competition with wood. This competition promises to continue, especially as there are numerous factors besides the properties of the two materials themselves to be considered in making a choice. Where either type of material meets requirements, relative cost of the complete cabinet is likely to be the chief factor in determining which is chosen, but other factors such as



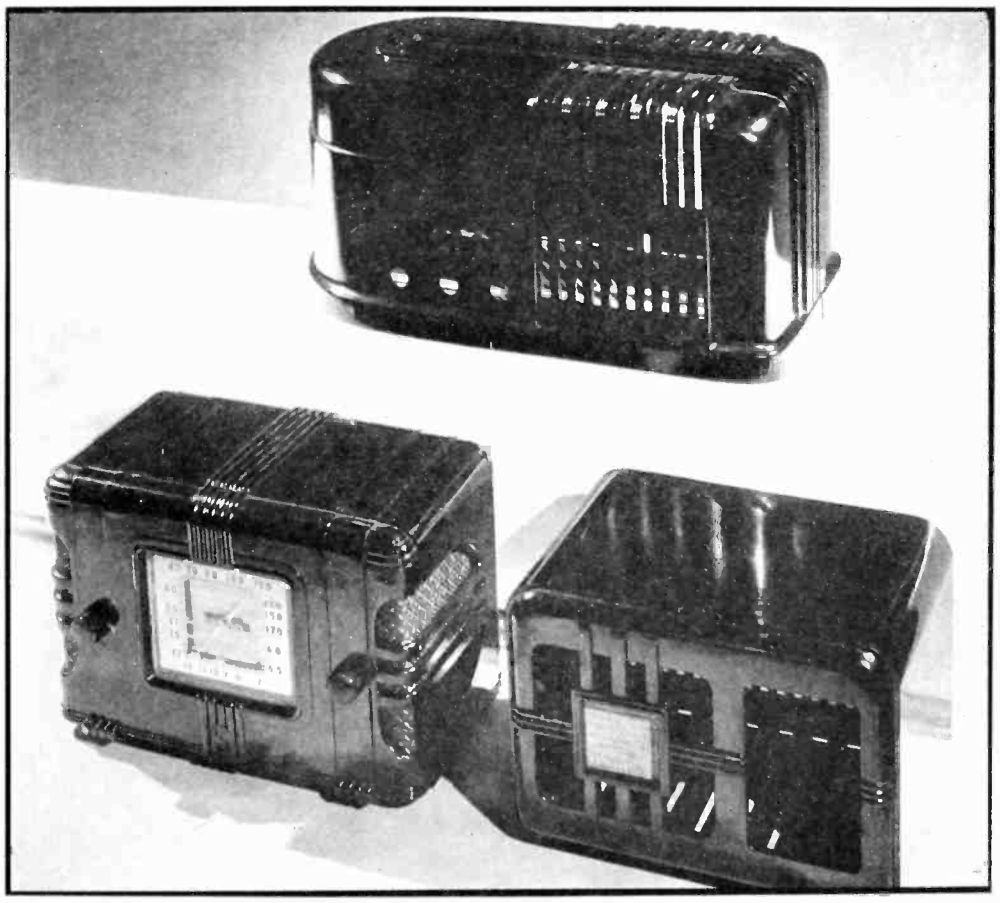
This prize winning Silvertone model is made of ivory Plaskon with an injection molded Tenite dial



International Kadette model having a three piece cabinet, the cover and grille being molded separately from the main section

for Cabinets

By HERBERT CHASE



Two cabinets and a complete Garod receiver with housings of phenolic plastic Durez. Usually housings such as these are molded in a single piece without joints

that of appearance (which is a matter of opinion) enter and often make the choice more difficult. Available production facilities also have to be considered and much may depend on the method used in figuring costs. The success gained with plastic cabinets both in this country and abroad, however, makes it clear that the merits of plastic cases are deserving of study, as, of course, are their limitations.

The use of plastic control knobs is nearly universal and in recent months there has been a sharp swing toward other plastic fittings such as bezels and dials, partly because of improved methods and machines for the injection molding of cellulose acetate. Some of the moldings include a glass lens employed as an insert and becoming in effect one piece with the molding. There are also more makes of plastics available and some of those long used to a limited extent have been improved greatly and come in a wider range of colors. There are, too, some entirely new types of plastic, including one (a methacrylic plastic called "Lucite") which is glass clear besides being capable of injection molding. One company (Catalin Corporation) is offering transparent and translucent thermo-setting phenolic compounds capable of molding, a type of material heretofore not available on a commercial scale.

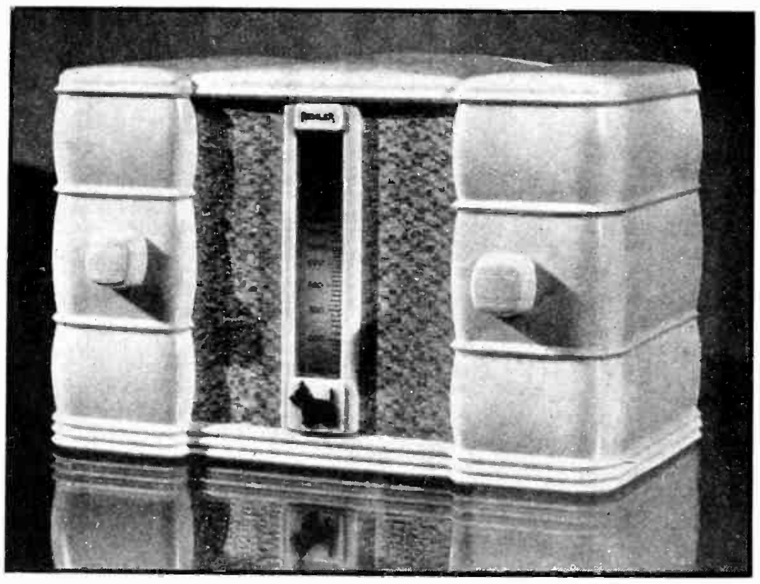
Laminated plastics, once very widely employed as front panels of receiving sets, are used today for this purpose chiefly in commercial applications. They enter also into equipment for broadcasting and for commercial communication units where the quantities produced are small. Many panels, however, are of metal. An important use of laminated plastics in a comparatively new form for home receivers is in the making of dials of translucent material. The latter is now available in white or light tints made from paper impregnated with special phenolic or urea resins and can be printed or the paper employed can be printed before impregnation, giving any dial markings required. Such dial stock is non-flammable, little affected by temperature changes within the temperature range commonly encountered, and retains its shape and dimensions. Its translucency permits of illumination by transmitted light, just as with the older nitrocellulose and cellulose acetate sheet.

To date, the only plastic materials to be employed for complete molded plastic cabinets are the phenolic and urea molding materials. The phenolic type, which includes Bakelite, Durez, Textolite, Resinox and Makalot, among other makes, is employed chiefly in black and dark colors which are opaque and cost somewhat less than half as much per pound, as a rule, as the urea materials, marketed under the names Plaskon and Beetle. The latter, however, are available in white and light tints, either opaque or translucent, and are used chiefly where light colors are desired. Most of the significant properties except color are about the same as for the phenolics. This applies to strength as well as to resistance-to-water, non-staining properties or marking, as by beverage glasses, which if left standing on a wooden cabinet often leave an unsightly mark. This does not occur with plastic cases and, as they require no applied finish, there is nothing to chip, check or deteriorate as in wood cabinets. Somewhat more care is required in molding the light colored ureas, but the process is much the same and the chief difference in cost as between phenolic and urea cabinets is in the material itself.

Although it is possible to produce cabinets in molded phenolics or ureas which substantially duplicate in appearance ordinary wooden cabinets, and vice versa, the molded form can be and often is made in shapes which are not commercially feasible to reproduce in wood. Sections are also thinner in the molded cabinet and for a given outside dimension. This results in more internal space. The molded cabinet can be made without joints and never requires gluing, as does wood. It is thus free from the defects of glue and of ply-wood, which may be quite important in moist climates. At least one maker of receiving sets employs them chiefly for export, as oversea shipments may be hard on wood cabinets. In addition, the plastic case is free from attacks by insects and fungus which may be serious where wood is used in tropical climates. Moreover, the dimensions of the molded cabinet can usually be held and maintained within closer limits than with wood and it is not subject to warping. All these are important considerations favoring the molded cabinet.

On the other hand, it is probably true that the molded cabinet is more fragile than wood if dropped or subjected to shock. Injury is likely to result if any cabinet be dropped, however, and the molded one can be replaced easily if broken. With proper packing and reasonable handling, however, breakage in transit appears not to be a serious factor whatever form of cabinet is used.

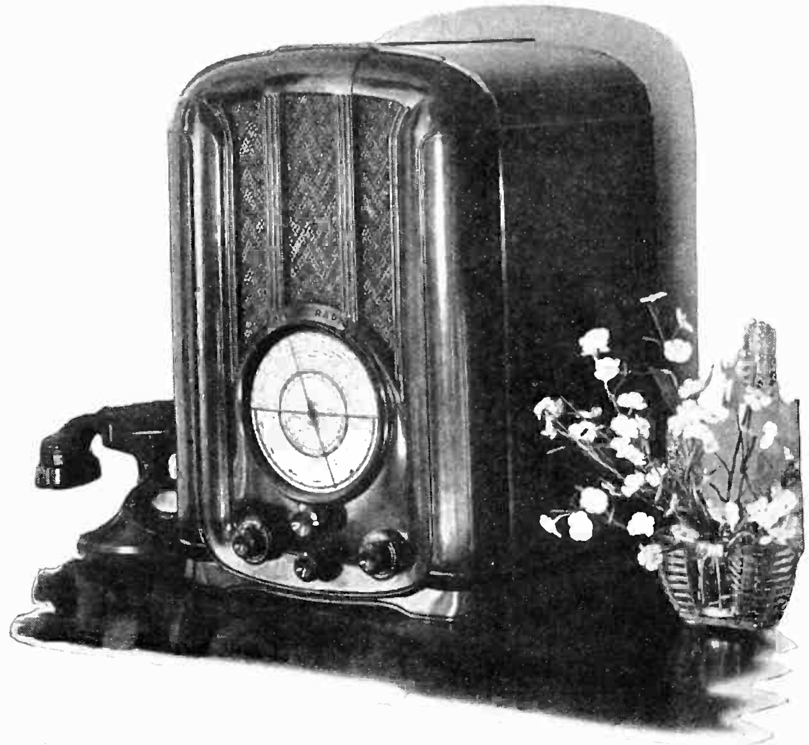
It is sometimes urged pertinently that the molded cabinet is inflexible



Smart Remler cabinet designed for the younger generation and molded in ivory Plaskon. A cabinet of this shape would be expensive to produce in wood, and would be difficult to keep clean

Frames or bezels injection molded from Tenite around glass lenses for RCA-Victor by Erie Resistor Corp. The frame at the top measures slightly more than 6 in. x 13 in. and is said to be the largest injection molding yet produced. It includes both glass and metal inserts

The Motorola fittings at the left are injection molded from the cellulose acetate plastic, Tenite



Pilot all-wave receiver as molded in Bakelite, is one of the largest plastic cabinets yet produced. It is 18¼ in. high, 13½ in. wide, and 10⅜ in. deep, and weighs ten pounds

in the sense that, once molds are made, changes are difficult or impossible, whereas, with wood, almost any change can be made at relatively low cost. Although this is true, it can be made of little or no consequence by proper planning and testing of models. Naturally, the molded case should not be considered at all unless there is reasonable assurance that the particular models to be produced by molding will sell in quantities sufficient to warrant the investment in molds. With proper forethought and study of hand-made models, however, the chance of having to scrap a mold without amortizing its cost over a fair production run is not great.

Although each molding is an exact duplicate in shape and size of each other from the same mold, it does not follow that appearance need be identical, for almost any range of color variations can be employed. In addition, if a two-piece or three-piece cabinet be molded, several combinations of color within the same cabinet are possible. Thus, if the side walls and a part of the front be molded in one piece, a cover for a top opening in a second piece and a grill in a third piece, as has been done in some designs, each of these can be in a different color or even in a different plastic and an unlimited set of combinations can be chosen for production with no mold change. This practice is likely to be followed more in the future, affording differences in eye appeal which, with other variations in chassis and equipment, may yield a wide range of models all from one set of molds.

Precisely this has been done by at least one maker, the cabinet being offered, for example, with a dark phenolic case, a light urea cover and an acetate grille. Another model may come with both case and cover in light urea and the grille in a contrasting shade of acetate. Dial and knob colors may also be altered giving still further variations. There are unlimited and highly attractive possibilities along these lines yet to be realized and quite sure to be capitalized by designers with foresight and imagination. It is probably true that a one-piece molded case costs less than one assembled from two or more parts molded separately, and that the mold cost is greater in the latter case, but the difference need not be very great and the possible variations so attractive as to warrant the extra cost many times over.

Mold cost is often the critical factor in determining whether or not to employ a molded cabinet. This cost varies greatly with such items as the design of the case, its dimensions, the number of cavities needed in the mold to yield the required production rate; the number of molds needed, especially if a "spare" is considered essential or more than one source of supply is required as a matter of insurance that production will be continuous despite possible accidents or strikes, and with other factors. One manufacturer of receivers reports that mold investment runs from about $1,200 for a very small cabinet up to around $4,000 for a table cabinet approximating 8 x 13 in. in frontal dimensions. The cost per molding in the latter instance runs well under one dollar as against about \$1.50 for a wood cabinet of similar dimensions. Whether the price of the molding includes mold amortization and if so over how large a run is not stated, but this maker favors the molded case on a cost basis in table cabinets in which the volume of sales warrants mold investment.

As opposed to this, another large producer using only wood cabinets reports the latter as less expensive and considers the mold cost for a plastic case too great, especially with yearly changes in design and the need for multiple molds required for large production. This conclusion may well be influenced, however, by large investments in plant for turning out wooden cases at moderate cost. Many makers buy all cabinets, whether wood or plastic, from outside sources and logically employ the less expensive type, be it wood or plastic, where satisfaction in performance can be gained with either type. It is recognized, however, that plastic cases may have a distinctive type of sales appeal not duplicated in wood and this is taken into consideration.

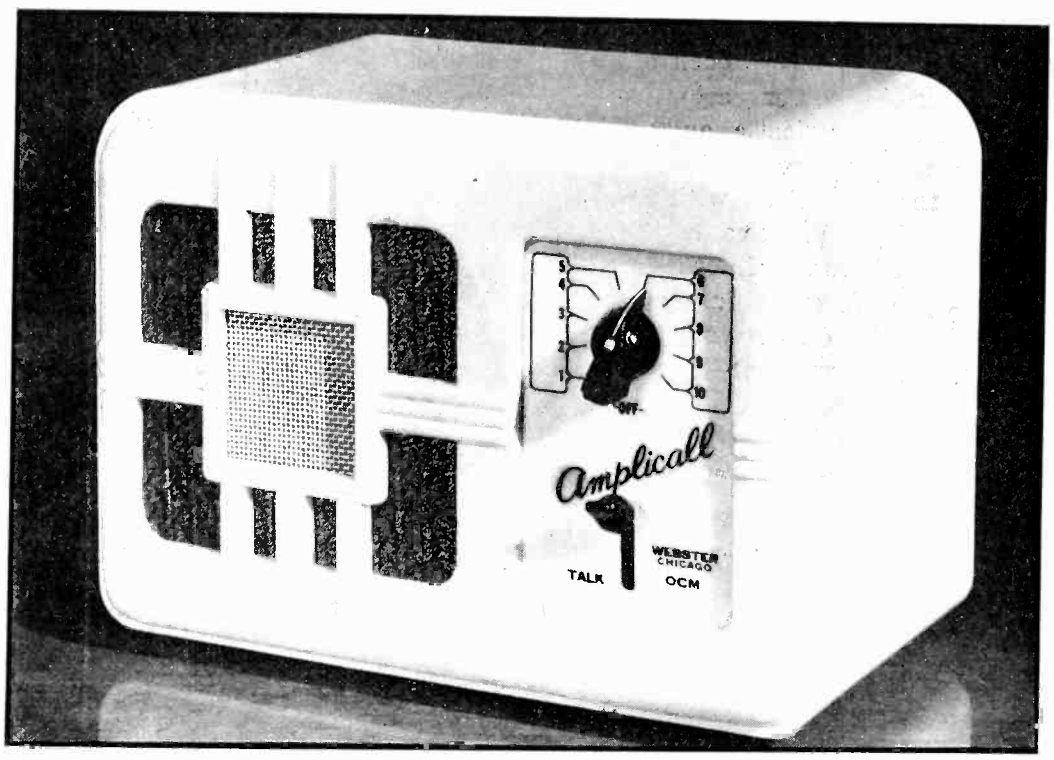
To date, one of the largest if not the largest molded radio cabinet produced measures 18¼ in. high 13½ in. wide and 10⅜ in. deep, and weighs ten pounds. Although it is doubtless possible to mold larger cases, the feasibility of doing so would demand careful study before mold construction would be undertaken. There are possibilities in cases assembled from molded sections to gain large size, but whether they would represent economies as compared to one-piece-cases depends on too many factors to warrant any generalized conclusion.

Available data as to the effect of a molded cabinet on tone quality are of somewhat uncertain character, being in part a matter of judgment or opinion. Plastics are generally credited with being non-resonant, but this is probably true only in a degree. One manufacturer using molded cabinets reports that they result in a higher pitch than with wooden cabinets, but this was remedied by suitable juggling with speaker cones and appears not to be a serious drawback, if so regarded at all.

To generalize in a summary requires many qualifications, but it may be said that experience with molded cabinets appears to be generally favorable. It is sufficiently so, in any event, to have accounted for a wide increase in their use and to warrant further consideration for models promising production in quantities large enough to justify mold investment.

Little need be added, perhaps, as to the desirability of plastics for fitments, whether the cabinet be wood or plastic. Plastic knobs are almost universal, as they are pleasant to the touch, do not wear from handling and can be made decorative or inconspicuous, as desired, besides being low in cost. There is also a growing demand for molded or laminated dials of plastic as well as for bezels. Erie Resistor Corp. has a patented method of molding a bezel or frame of cellulose acetate around a lens of glass to make a handsome and permanent assembly which is also highly pleasing from an appearance standpoint and has already gained considerable use. The injection molding process and newer machines for injection molding pieces of larger size have made this development possible. This form of molding is rapid and is applied also to many small radio parts, the molds being small and moderate in cost. Bezels, dials and escutcheons are molded with raised or debossed figures if desired and can be produced in any color or degree of translucent or transparency or made opaque, as shown in accompanying illustrations. Colors may match or contrast with wood or with other plastics.

Many fitments are molded by compression, as opposed to injection, and they may be of cellulose acetate or of the thermo-setting phenolic or urea plastics, some of the latter being translucent. This applies to grilles as well as to dials, knobs, bezels and the like. Plastics have an advantage over metal parts, such as bezels, as they retain their natural finish indefinitely and do not require plating or any form of applied finish. They do not emit a metallic sound and the molds for forming them may cost less than dies to produce stamped parts. All these factors point toward a wider use of plastics for small fittings regardless of what material may be used in the cabinet itself.



Webster Amplicall with a Beetle molded housing. Plastic cases enter the field of office intercommunication as well as that of radio receivers

Screens for Television Tubes

A review of phosphorescent screens used in television cathode-ray tubes, including their influence on the contrast of reproduced images, abstracts from Chapter XI of the forthcoming book "Electron Optics in Television" to be published this winter by McGraw-Hill

By I. G. MALOFF and D. W. EPSTEIN

RCA Victor Division, Camden, N. J.

ANY emission of light, not directly ascribable to incandescence and therefore occurring at low temperatures is called luminescence. There are a great many forms of luminescence differing one from another in forms of excitation, such as: photo-luminescence, cathodo-luminescence, chemi-luminescence, etc. In cathode ray tubes the only type of luminescence utilized is cathodo-luminescence, i.e., luminescence with electron bombardment as excitation. The luminescence of a substance during the excitation is called fluorescence, while the luminescence of a substance after the excitation has been removed is called phosphorescence.

Phosphors

Solid luminescent materials possessing properties of fluorescence and phosphorescence are commonly called "phosphors". The theory of luminescence of phosphors is very involved and as yet has not been firmly established in all its details[1].

Of the great number of phosphors known, only two groups are commonly used for screens in television tubes. They are silicate phosphors and sulfide phosphors. The predominant metal (but not the only metal) in either of the two groups is zinc. Of silicate phosphors the most widely used is willemite. Chemically, willemite is zinc orthosilicate (Zn_2SiO_4) with small traces of manganese or other metals present. It is very popular with American makers of cathode-ray tubes[2]. Of sulfide phosphors, zinc sulfide (ZnS) is the best known. In Europe zinc sulfide (copper-activated) and zinc-cadmium sulfide[3] have gained far greater popularity than willemite.

Screen Efficiency

Under normal conditions the candlepower of a given luminescent screen per watt of the beam power input (screen efficiency) varies some, but not very much, with the values of current and voltages used in television. For accurate comparisons, however, the curves of screen efficiency vs. beam current and voltage are required.

It can be said that screen efficiency of good luminescent screens of television tubes is of the order of 1 and 2 candlepower per watt when viewed through the glass bulb from the side opposite to the one from which the electron bombardment takes place. When viewed from the gun side the efficiency is higher by at least 50 per cent. A simple calculation then shows that the total light generated by a good screen is between 8 and 16 lumens per watt of beam power. An efficiency of 12 lumens per watt is given for the ordinary 60 watt tungsten lamp.

Willemite

The name "willemite" was given to the natural material by its discoverer, A. Levy, in honor of King Willem I of the Netherlands. Natural willemite is found

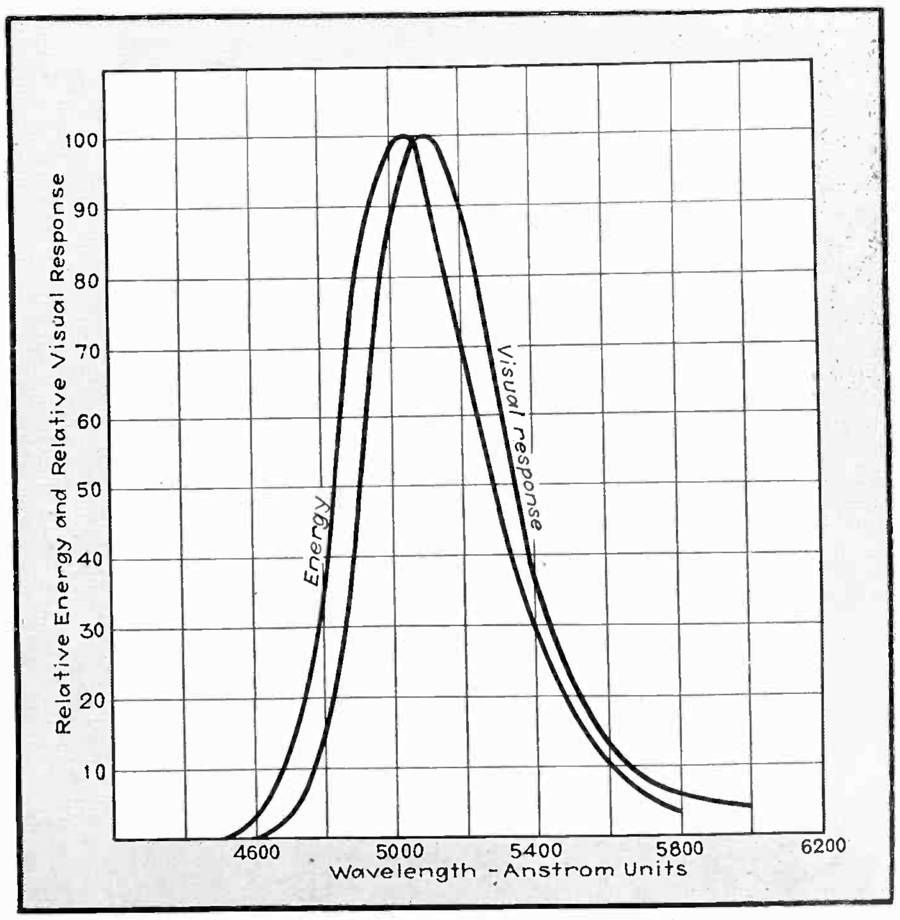


Fig. 1—Energy distribution of light from green willemite, compared with the visual response of the eye

[1] See E. L. Nichols, H. L. Howes and D. T. Wilber, "Cathodo-Luminescence and Luminescence of Incandescent Solids", a publication of Carnegie Inst. of Washington (1928); also R. Tomaschek, "Optik und Elektronik fester und flussiger Stoffe", Die Physik, Vol. 2, #1, p. 33 (1934).

[2] See T. B. Perkins and H. W. Kaufmann, "Luminescent Materials for Cathode Ray Tubes", *Proc. IRE* Vol. 23, p. 1324, November, 1935.

[3] See L. Levy and D. W. West, "Fluorescent Screens for Cathode Ray Tubes for Television and Other Purposes", *Journ. IEE*, Vol. 79, p. 11, July 1936.

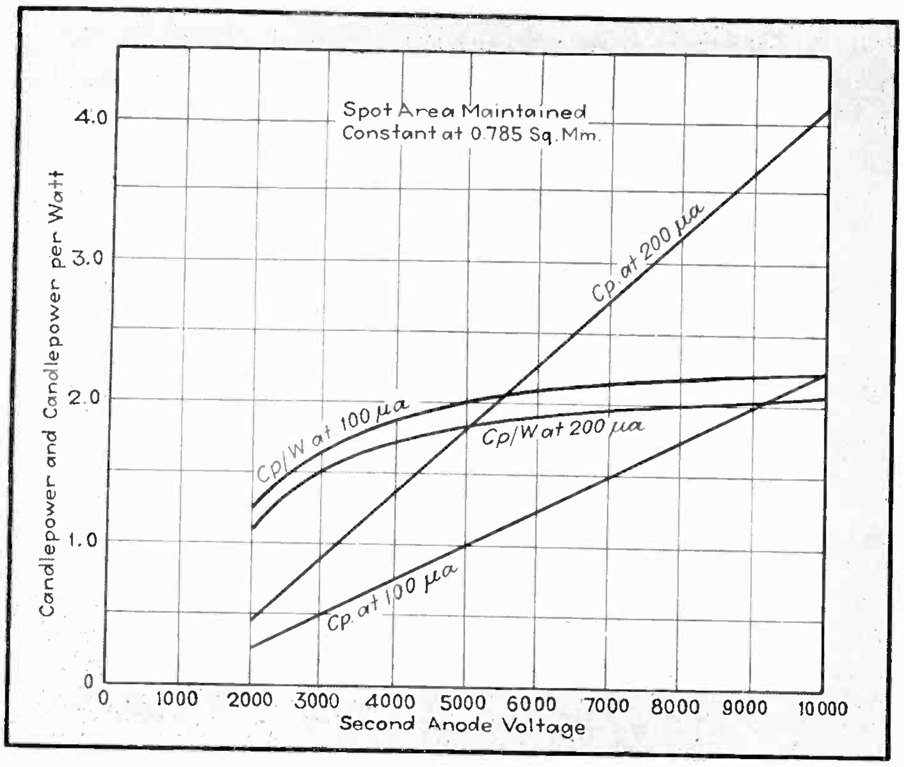


Fig. 2—Luminescent efficiency of willemite as a function of voltage

in the U. S. near Franklin Furnace, N. J., and is suitable for use in television cathode-ray tubes. The variations of the impurities contents, however, render the natural mineral rather undependable. In the first decade of this century W. S. Andrews of the General Electric Company succeeded in producing synthetic willemite with manganese as activator. Most of the modern tubes made in this country use synthetic willemite for luminescent screens. Manganese is still considered as the most suitable activator for it. The colors of fluorescence and of phosphorescence of the best known type of willemite are green and yellow.

Synthetic willemite is prepared by mixing suitable proportions of zinc oxide, silica, activator and flux and fusing it in a furnace into a uniform substance. After cooling the resultant silicate is ground, sieved, and put into a solution, which is applied to the inside surface of the tube. The willemite thus obtained is a glass-like inorganic substance capable of withstanding without decomposing all the temperatures that the tube has to undergo to insure a long life. These temperatures reach as high as 500°C. in vacuum and 550°C. in air, to secure an optimum outgassing and annealing of the glass. The two commonly used methods of application to the walls of a tube are, first, spraying with a suitable binder, and second, settling from a solution and slowly decanting.

The spectral distribution of the light emitted by the green willemite under electron bombardment is shown in Fig. 1. As the curves show, the spectral characteristic of this willemite follows very closely the general shape of the eye visibility curve, although it is somewhat narrower and more sharply cut off in blue and red.

The overall efficiency of a willemite screen varies between one and two and a half candlepower per watt, depending on the following factors: size of willemite particles, thickness of the luminescent screen, second anode voltage, degree of saturation of willemite, type and concentration of activator, etc.

Figure 2 shows the candlepower per watt as a function of beam voltage at two values of current for a typical green willemite screen, manganese activated, sieved through 400 mesh and applied to a pyrex bulb in quantity of 0.7 milligram per square cm. Figure 3 shows the candlepower as function of beam current at a constant value of beam voltage for the same screen.

Zinc Sulfide

Zinc sulfides, while very popular with cathode-ray tube makers in Europe, have only lately reached any noticeable prominence in the U.S.A. The activator in case of zinc sulfides is almost invariably copper and its quantity is so minute that preparation of these sulfides usually begins with purification of a salt of zinc to remove the excess of copper and other heavy metals.

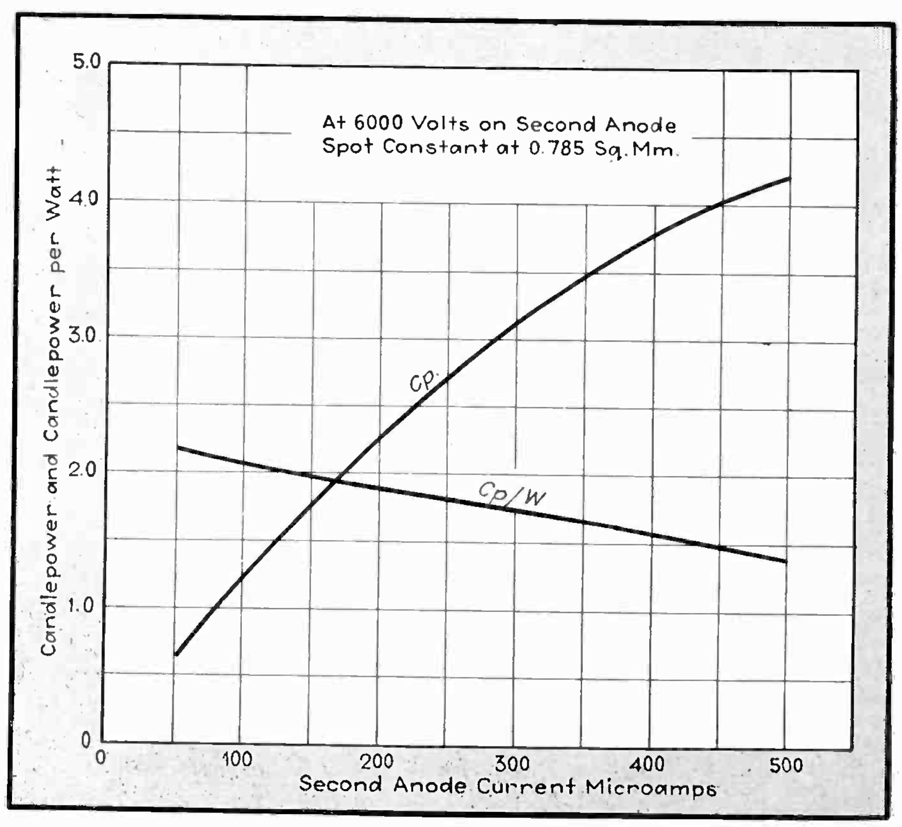


Fig. 3—Luminescent efficiency of willemite as a function of current

After purification the sulfide is mixed with fluxes and fused in a neutral atmosphere to prevent oxidation. The resultant crystalline preparation is ground, sieved and applied to the inside surface of the glass bulb. The glass surface is first coated with either sodium or potassium silicate to make it adhesive and the phosphor is blown on the surface. The excess powder then is shaken off. The processing of tubes having zinc sulfide screens is somewhat more complicated than of those having willemite screens. This is due to danger of oxidation of the sulfide when baked in air. 450°C. seems to be the maximum baking temperature for zinc sulfide screens.

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where CP is the total candlepower output, A is a constant characteristic of the phosphor, I is the bombarding beam current, V is the total potential through which the electrons have fallen and V_o is a certain constant value of potential also characteristic of the phosphor and which is often called "dead voltage". Observations on a large quantity of television cathode ray tubes with willemite screens and several experiments especially made for determination of light output of willemite

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The results of experiments performed on tubes scanned by beams of 2,000—20,000 volts are:

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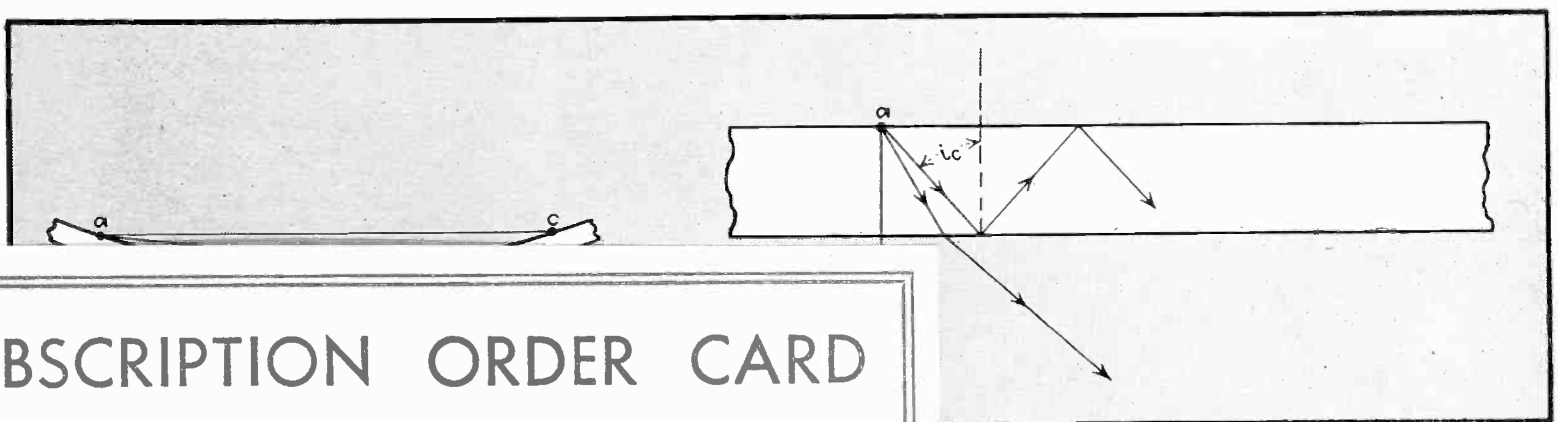

Fig. 5—Halation effect due to internal reflection

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(3) Potential of a thin (of the order of one milligram per square cm) willemite screen under bombardment depends upon the base on which it is deposited. Willemite on a metal base departs farther away from the beam potential than willemite on glass.

(4) The current density of the scanning spot appears to be the factor of largest importance in determining the potential of the willemite screen in each particular case.

(5) The transverse conductivity of thin willemite screen under electron bombardment is ample for maintenance of both sides of the screen at approximately equal potentials.

(6) The light output is a linear function of beam voltage with beam current density kept constant, as was formulated by Lenard in 1903.

Contrast of the Reproduced Picture

In general, vision is caused by two factors: a difference in color and a

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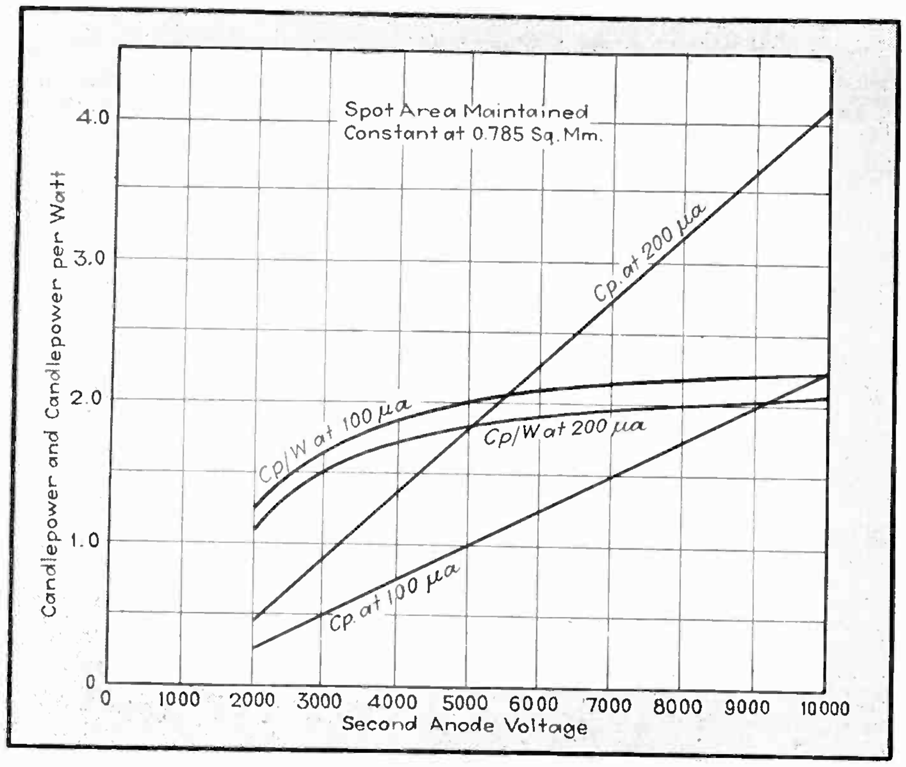

Fig. 2—Luminescent efficiency of willemite as a function of voltage

in the U. S. near Franklin Furnace, N. J., and is suitable for use in television cathode-ray tubes. The variations of the impurities contents, however, render the natural mineral rather undependable. In the first decade of this century W. S. Andrews of the General Electric Company succeeded in producing synthetic willemite with manganese as activator. Most of the modern tubes made in this country use synthetic willemite for luminescent screens. Manganese is still considered as the most suitable activator for it. The colors of fluorescence and of phosphorescence of the best known type of willemite are green and yellow.

Synthetic willemite is prepared by mixing suitable proportions of zinc oxide, silica, activator and flux and fusing it in a furnace into a uniform substance. After cooling the resultant silicate is ground, sieved, and put into a solution, which is applied to the inside surface of the tube. The willemite thus obtained is a glass-like inorganic substance capable of withstanding without decomposing all the temperatures that the tube has to undergo to insure a long life. These temperatures reach as high as 500°C. in vacuum and 550°C. in air, to secure an optimum outgassing and annealing of the glass. The two commonly used methods of application to the walls of a tube are, first, spraying with a suitable binder, and second, settling from a solution and slowly decanting.

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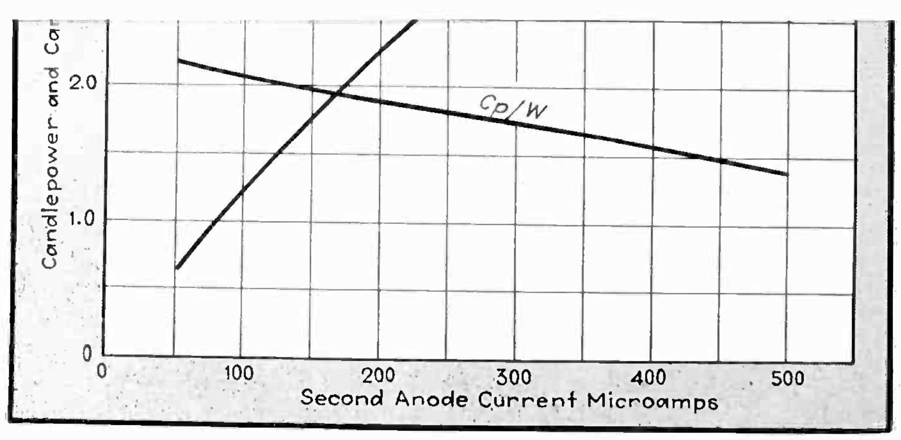

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The predominant color of luminescence of zinc sulphide is blue. By varying the ingredients of this phosphor it is possible to obtain screens having almost white luminescence with very small traces of either pink or blue color.[4]

The efficiency and persistence characteristics of sulfide phosphors vary just as much as their spectral characteristics. For television purposes, however, there are available a number of very satisfactory sulfide phosphors. In general it may be said that screen efficiency of good zinc sulfide is very little different from that of willemite; usually somewhat lower than the latter at low current densities and higher at high current densities. In other words it can be said that willemite shows signs of saturation at lower current densities than zinc sulfide.

In 1903 Lenard[5] formulated a relation which later became known as Lenard's equation for light output from luminescent materials under electron bombardment. It is of the form:

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where CP is the total candlepower output, A is a constant characteristic of the phosphor, I is the bombarding beam current, V is the total potential through which the electrons have fallen and V_o is a certain constant value of potential also characteristic of the phosphor and which is often called "dead voltage". Observations on a large quantity of television cathode ray tubes with willemite screens and several experiments especially made for determination of light output of willemite screens as a function of electron beam current and voltage, have led to the conclusion that Lenard's equation holds[6] for willemite screens in television cathode ray tubes under normal operating conditions. The only stipulation needed is that the current density of the luminous scanning spot would be kept constant.

In general, the behavior of a luminescent screen in a tube is determined by the following factors: first, the velocity of the electrons in the beam; second, the secondary emission characteristics of the luminescent material (phosphor) itself; third, the secondary emission characteristics and the potential of the base on which the phosphor is deposited; fourth, the conductivity of the phosphor, and fifth, the electron beam current.

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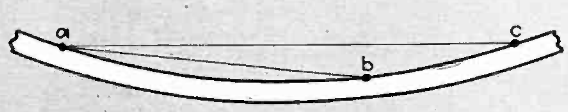

Fig. 4—Loss of contrast due to curvature of screen

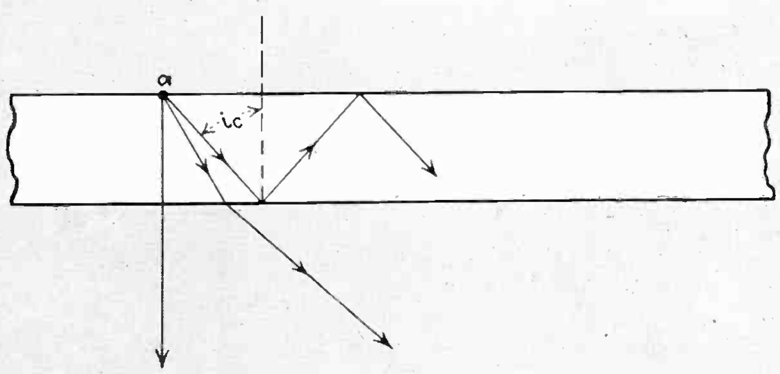

Fig. 5—Halation effect due to internal reflection

Contrast of the Reproduced Picture

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difference in brightness of objects. In television reproduction, however, there is no difference in color, so the difference in brightness is the only factor which makes television reception possible. Brightness contrast or simply contrast is the term used to designate the difference in brightness. Contrast is usually given as a number resulting from division of brightness of the brighter object by the brightness of the darker object and is a plain numeric. Illuminating engineers say that two adjacent surfaces of the same color will appear as one if the difference in their brightness is less than one per cent.

The maximum degree of contrast of received picture obtainable with a given television system depends mostly on the type of tube used. This of course holds true only when the video signal strength is sufficient and the receiving system is capable of providing sufficient amplification. Room illumination of course also affects the contrast.

Several factors limit the maximum contrast obtainable in television reproduction. The importance of the individual factors varies with different types of tubes. In approximate order of their importance, these factors are as follows:

(a) *Curvature of the luminescent screen.* Referring to Fig. 4 showing a cross-section of a conventional tube, if a point "a" corresponds to a dark portion of a generally bright picture, then points "b" and "c" will directly illuminate point "a". The degree of this illumination is directly dependent on the curvature of the screen and the brightness of the rest of the picture. Naturally the contrast will be the best for a bright spot on a black field and the poorest for a dark spot on a bright field.

(b) *Halation.* If a point "a" on Fig. 5 is brightly illuminated, the rays from it will go through the clear glass wall of the tube. They will be refracted according to the well-known laws of optics. The refraction will take place for all rays falling on the glass-air boundary at angles ranging from normal to that surface up to the so-called critical angle. For the critical angle and angles smaller than that, total reflection will take place.

Total reflection takes place when a ray of light passes from a medium of index of refraction μ_1 into a medium of index of refraction μ_2, provided that μ_1 is larger than μ_2 and the sine of the angle of incidence i is equal or larger than μ_2/μ_1.

In the example in Fig. 4 total reflection will take place when:

$$\sin\ i \geqq \mu_2/\mu_1 \geqq .666 \qquad (1)$$

or for an angle of incidence:

$$i_c \geqq 42^\circ \text{ approx.}$$

Considering that N lumens of light are emitted by an elementary area of a perfectly diffusing surface of willemite on glass, the index of refraction of which is equal to 1.5, the number of lumens I_1 that go through glass is:

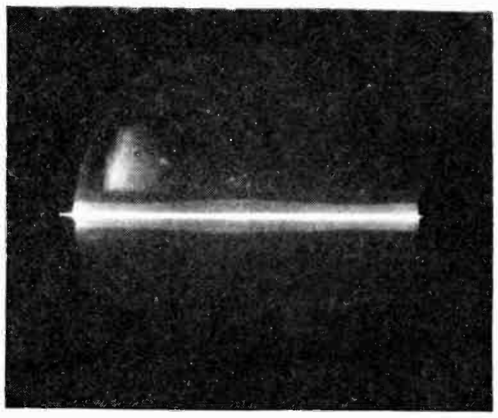


Fig. 6—Photograph of halation effect

$$I_1 = N \int_{\theta=0}^{\theta=2\pi} d\theta \int_{\phi=98^\circ}^{\phi=90^\circ} \cos\ \phi \sin\phi\, d\phi = .448\ \pi N \text{ lumens} \qquad (2)$$

The number of lumens I_2 reflected back into the glass is:

$$I_2 = N \int_{\theta=0}^{\theta=2\pi} d\theta \int_{\phi=0}^{\phi=90^\circ} \cos\ \phi \sin\phi\, d\phi = .552\ \pi N \text{ lumens} \qquad (3)$$

in equations (2) and (3) θ and ϕ are the usual angle variables of a spherical system of coordinates. The fact that 55 per cent of the light emitted is thrown back at the willemite screen does not mean that all of it will be contributing to a loss of contrast. Willemite is a glass-like substance with an index of refraction of around 1.7. Therefore, wherever willemite is in optical contact with the glass, the totally reflected ray will emerge from glass and illuminate the willemite screen. Naturally not all the area of glass is in optical contact with willemite and in the areas between the crystals of willemite the light will be totally reflected again and will propagate inside of the glass away from the illuminated point "a", without impairing the contrast. The totally reflected rays will not reach the luminescent screen in the immediate vicinity of the original point "a". The nearest place to the point "a" where these rays will fall upon willemite is along the circumference of a circle of radius r determined by the relation:

$$r = 2h\ \tan\ i_c \qquad (4)$$

where h is the thickness of the glass and i_c is the critical angle of the combination. For most glasses used in tubes, μ is around 1.5 and $i_c = \tan\ 42^\circ = 0.9$. For most of the practical cases therefore an approximate relation will hold:

$$r = 1.8\ h \qquad (5)$$

The halation circle is the brightest at the radius given by Eq. (5), is dark inside and is gradually diminishing in intensity at larger values of the radius.

The effects of the halation on the reproduced picture are: first, it reduces the general contrast of the picture by scattering light over the whole surface of it and, second, every bright object of the reproduced picture appears surrounded by a bright line at a distance r. In Fig. 6 is shown a photograph of a bright line surrounded by halation as reproduced on the end of a conventional tcr tube.

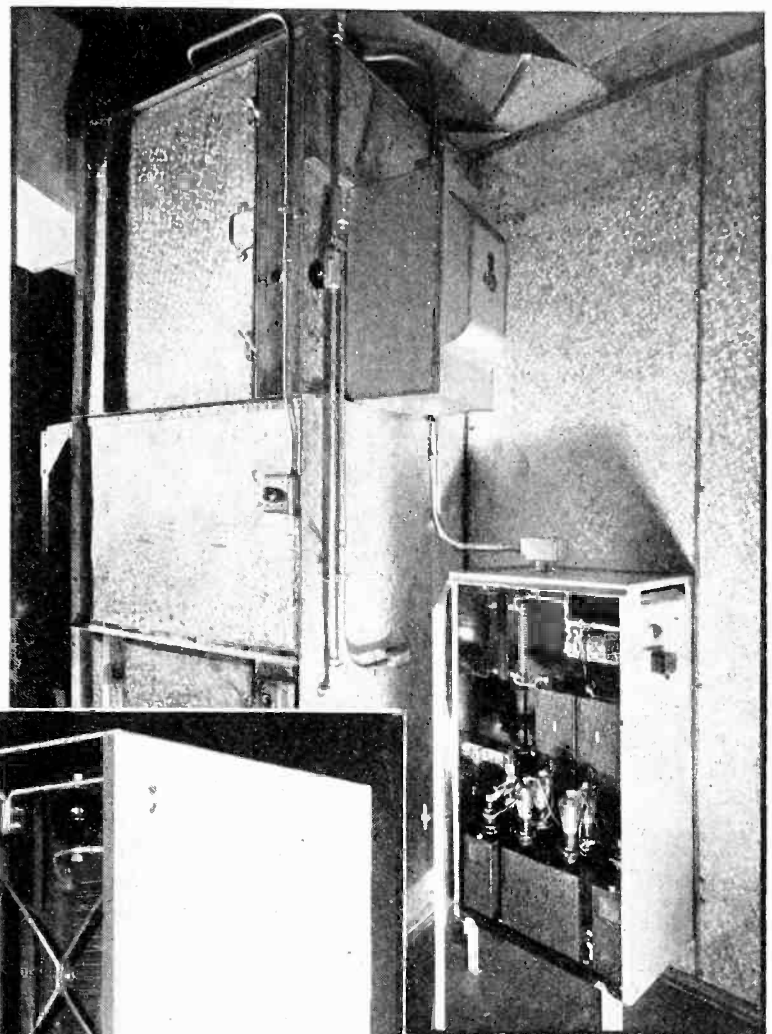
Equations (4) and (5) hold accurately for flat glass. For glass with a certain curvature, such as in conventional tubes, the value of r is somewhat larger depending on the degree of curvature. The fact itself that 55 per cent of the light emitted is lost should not be overestimated in importance because it cannot be used anyhow, since an observation of a picture from an angle of 45° and more away from normal is inconvenient.

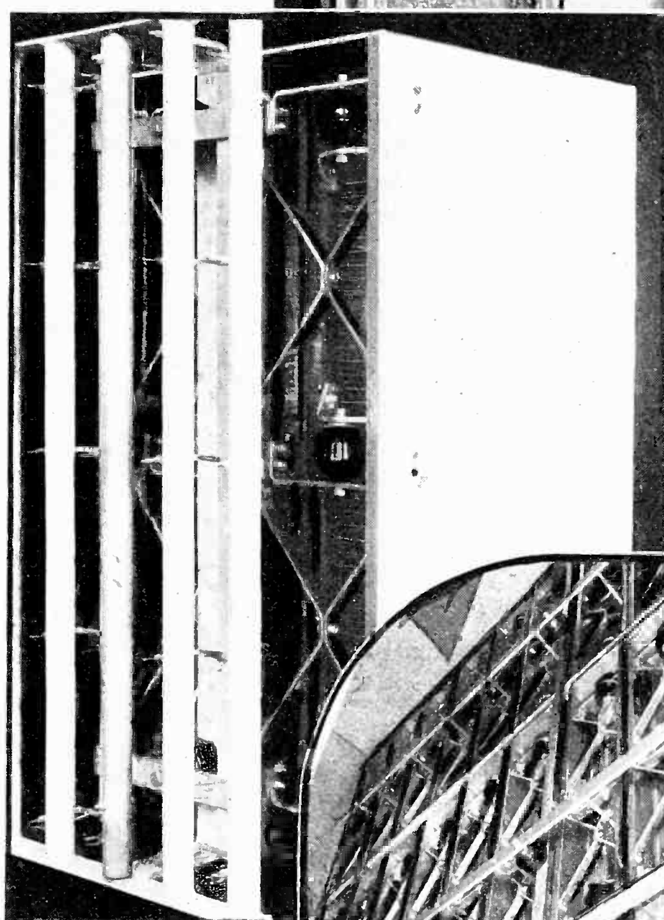
(c) *Stray Electrons.* Stray electrons striking a luminescent screen with sufficient velocity will cause a loss of contrast. The sources of stray electrons are as follows: first, cold emission from the electron gun; second, secondary emission from the

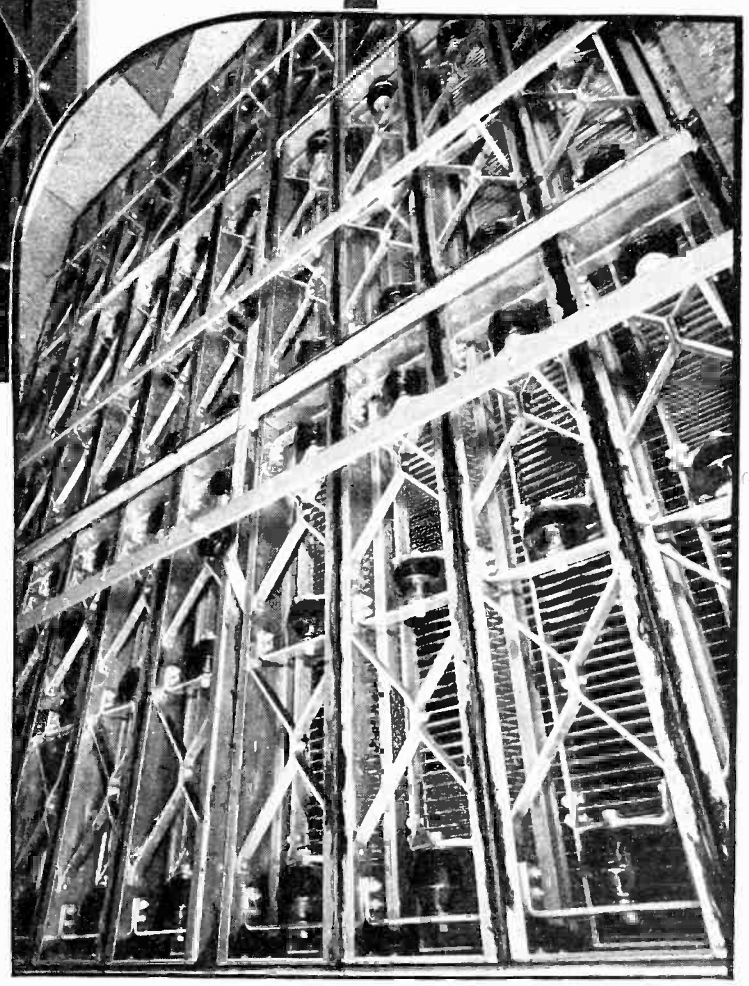
(*Continued on page* 85)

Cleaning Air With High Voltage

New Westinghouse installation at the Field Building, Chicago, treats 272,000 cubic feet per minute, using 18 rectifier supply units to ionize air and collect particles





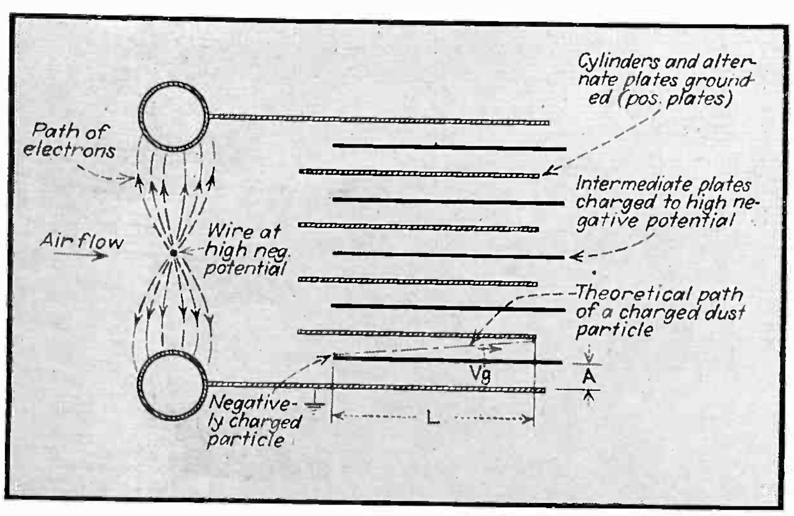


Upper right, a vertical-flow unit through which air is passed for cleaning. The high voltage power supply feeds an adjacent unit

Right, a cleaning section. The rods, with fine wires between (see diagram below), are charged to 12,000 volts, and ionize the air, which then passes between parallel plates (at rear) charged to 5000 volts. The field between the "collector cell" plates urges the charged dust particles to the positive plates, where they adhere

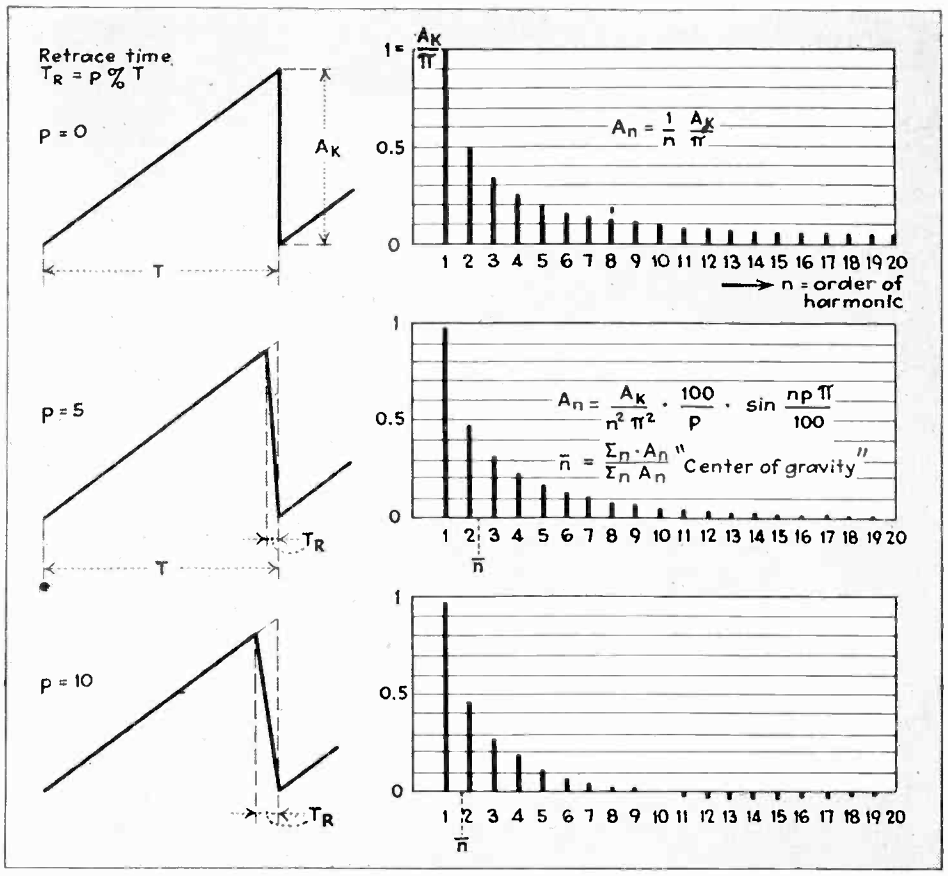
Lower right, the clean air comes out here. A collector cell assembly seen through an inspection door

Below, the principle of the cleaner: 12,000 volts applied between a fine wire and the nearby rods, causes an intense electric field at the wire, ionizing the air as it flows past. The dust particles pick up the electrons freed by the ionization and so become charged negatively. Subsequently the particles are collected by the positively-charged plates, taking the path shown. The voltages used are lower than in the Cottrell process, and hence do not produce disagreeable ozone products. The installation will remove 99 per cent by weight of all particles, a total of 600 bushels of dust per year



Distortion

By MANFRED VON ARDENNE



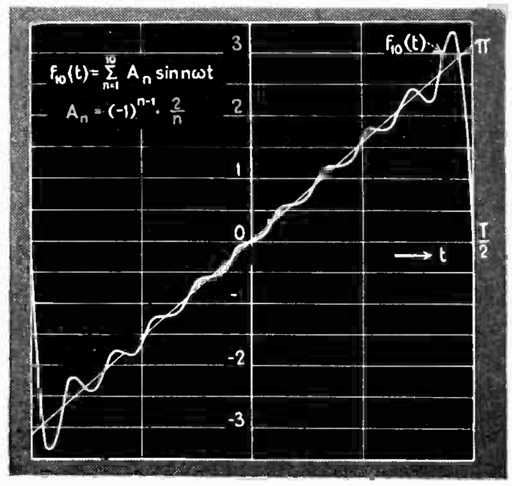


Fig. 1 The frequency spectrum of the saw-tooth oscillations with various retrace times. Fig. 2 (right) Distortion of saw-tooth oscillation with zero retrace time with all harmonics above the tenth eliminated

THE deflection of electron beams with electrostatic or electromagnetic saw-tooth oscillations has attained widespread importance both in cathode-ray television and cathode-ray oscillography. In both these applications, the ratio of retrace time to the total period and the degree of distortion are of highest importance.

To determine optimum design of circuits, for example Kipp* transformer and amplifying stages, the usual method of calculation with complex numbers must be employed. By means of a Fourier analysis, the Kipp curve can be resolved into a series of sinusoidal harmonics and therefore permits the application of the usual a-c theory, which is based on sinusoidal current and voltage waves.

The Frequency Spectrum of Kipp Oscillations

For an assumed Kipp oscillation with an exactly linear increase and zero retrace time ($T_R = 0$), which is equivalent to a discontinuity in the curve, a Fourier analysis shows that the curve can be replaced by an infinite sum of sinusoidal harmonics

$$\sum_{n=1}^{\infty} A_n . sin\, n\omega t \qquad (1)$$

where $A_n = (-1)^{n-1}\dfrac{A_K}{n\pi}$

and A_K is the amplitude of the Kipp oscillation. The alternation in sign of the successive harmonic amplitudes A_n, is due to the selection of the zero axis at the center of the ascending portion of the curve. The amplitudes of the harmonics decrease in inverse proportion to the order of harmonic n. The frequency spectrum up to the 20th harmonic of such a curve is shown in Fig. 1. By properly

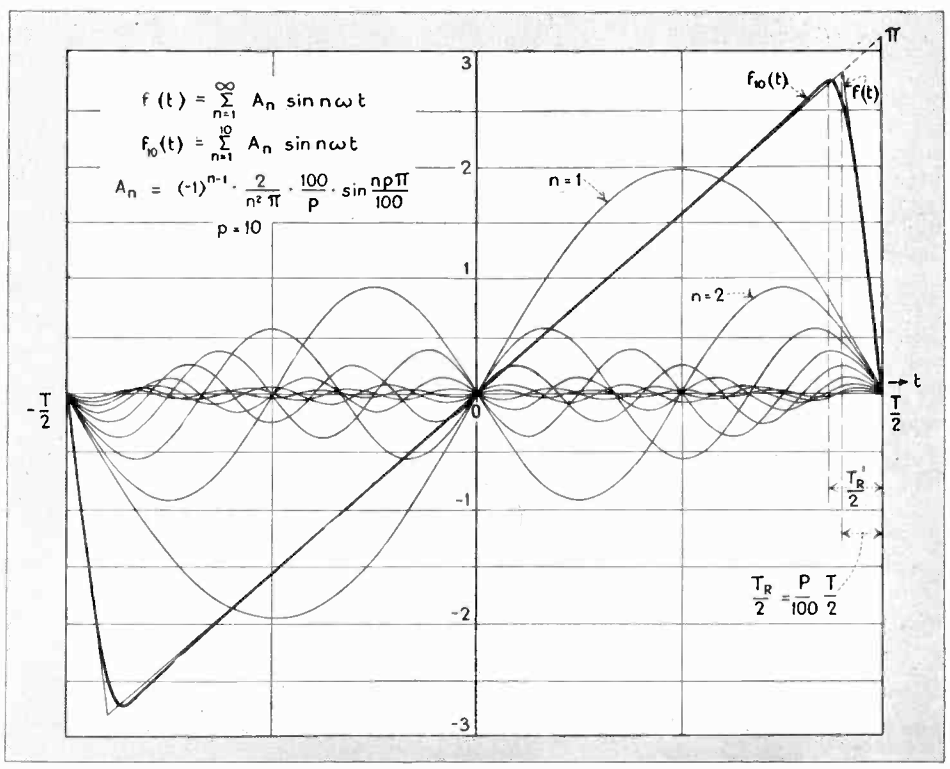


Fig. 3 Synthesis of saw-tooth oscillation from sinusoidal harmonics with elimination of all frequencies whose period is smaller than the retrace time

* Note: Since there is no concise English equivalent of the German "Kipp-Transformatoren-Stufen" and "Kipp-schwingungen verstarkerstufen", the nearest being "relaxation oscillation transformer stage", "relaxation oscillation amplifying stage", it is much more convenient to retain the German word "Kipp" from kippen, to "tip", "tilt", "tip over" etc.

# of Saw-Tooth Wave Forms

Amplitude distribution of frequency spectrum of saw-tooth wave forms with various retrace times is given; effect of eliminating higher order harmonics investigated. Effect of phase shifts of fundamental frequency considered.

choosing the origin the signs of all the harmonics can be made positive.

If a Kipp oscillation with a finite retrace time ($T_R = pT$) is analysed, it is found that the amplitudes of the successive harmonics decrease faster than in the above case. Two examples are shown in the center and bottom curves of Fig. 1. These harmonic amplitudes may be calculated by the formula

$$A_n = \frac{A_K}{n^2\pi^2} \cdot \frac{100}{p} \cdot \sin\frac{np\pi}{100} \qquad (2)$$

using the same origin as in the $p = 0$ case. This equation shows that the amplitudes of the successive harmonics periodically vanish, and leads to the important principle that the first vanishing harmonic occurs for the order of harmonic $100/p$, where p is expressed in per cent.

The appearance of a Kipp oscillation with zero retrace time in which all harmonics above the 10th have been eliminated is shown in Fig. 2. The distortion factor, according to the definition given below, attains extraordinarily high values in this case, because of the poor approximation in the region of the discontinuity.

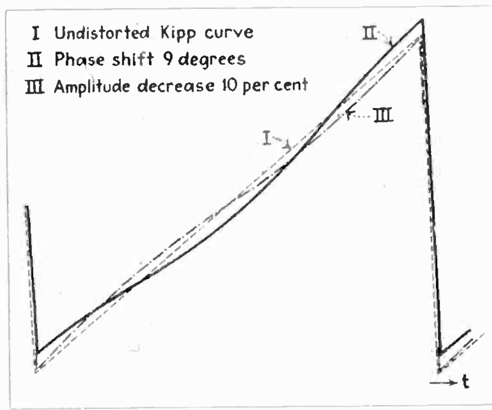


Fig. 5 Distortion introduced by phase-shift and amplitude change of fundamental

A closer examination of the generalized case with a finite retrace time shows that a Kipp curve with small distortion can only be expected if the series is not cut off below the first vanishing harmonic.

The effect of the rapid convergence of the Fourier series with finite retrace time T_R, is made clear in the synthesis of a Kipp oscillation, which is carried out in Fig. 3. Here the retrace time is taken as 10% and the series, as in Fig. 2, is cut off above the 10th harmonic. One sees that those terms following the first vanishing harmonic which have been eliminated can always be neglected, at least for retrace times under 10%; for their elimination results only in a rounding-off of the peak of the curve, which causes only a slight decrease in the true amplitude and a slight increase in the true retrace time, T_R'.

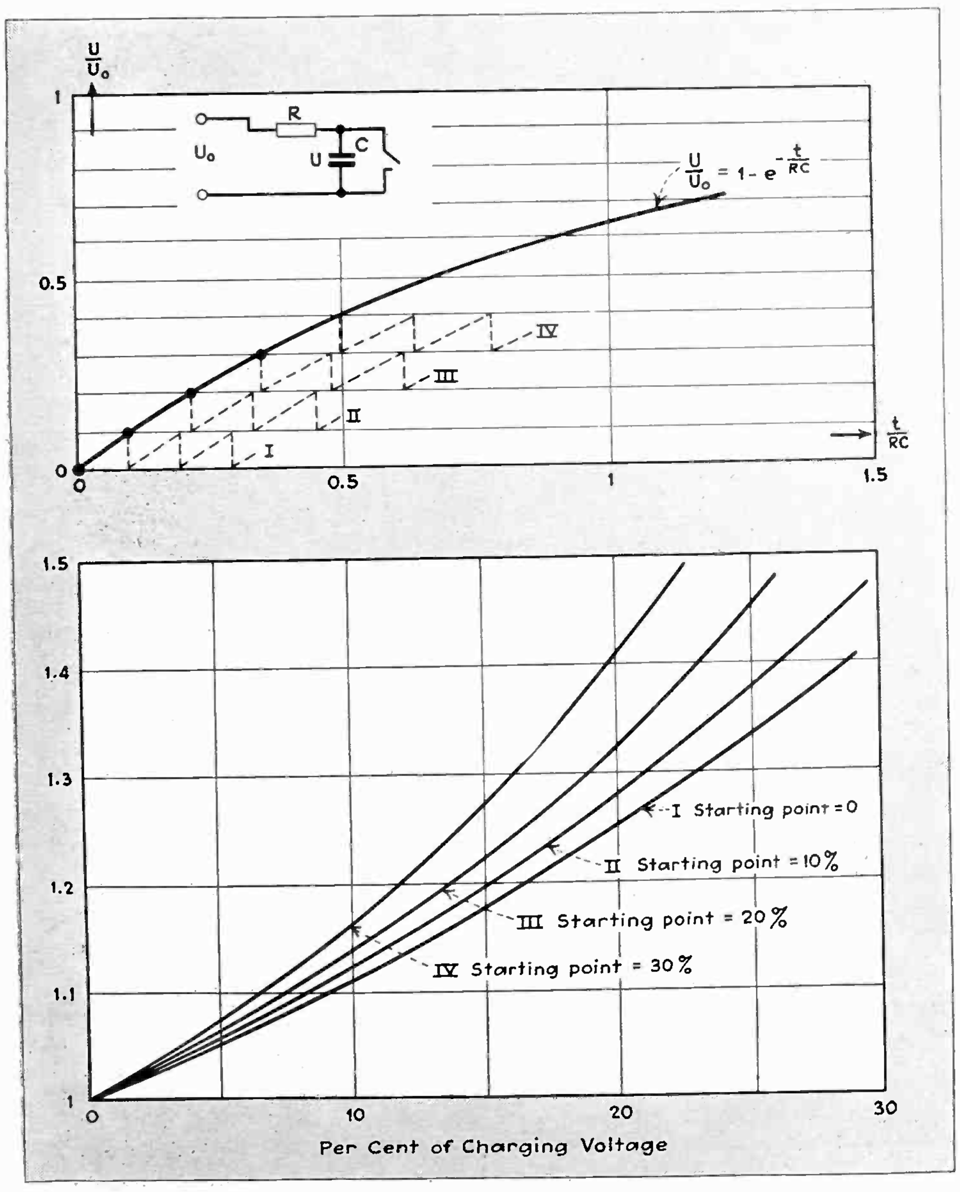


Fig. 4 Distortion introduced by charging a condenser through a resistance

The above considerations lead to two methods of procedure; (1) the retrace time of the impressed Kipp curve may be so chosen that in the circuit under consideration only the harmonics above the first vanishing point are cut off, and (2) by suitable design the retraced time of the impressed Kipp oscillations may be made very short and an amplitude decrease according to equation (2) obtained through the frequency-attenuation characteristic of the succeeding circuit elements. In most cases the frequency-attenuation characteristics of the RC or $\frac{L}{R}$ members will suffice to cause an amplitude decrease which will more or less accomplish this result.

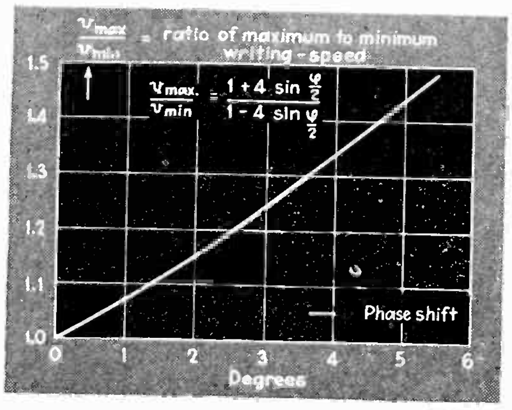


Fig. 6 Distortion factor as a function of fundamental phase shift

The Distortion Factor of Kipp Oscillations

In cathode-ray television, any distortion of the impressed Kipp or scanning curve produces two defects in the image, namely shape and brightness distortion. It is expedient to define the distortion factor as the ratio of the maximum to the minimum "writing-speed" along the ascending portion of the Kipp curve. This definition is useful, because it yields directly the proportions of the image scales.

The production of distortionless Kipp oscillations even in the Kipp generators themselves is attended with difficulties. Non-linearity of current or voltage curves produces curved ascents in the Kipp curve. An especially important case in the production of Kipp voltages is made clear in Fig. 4. Experience with television images produced with scanning waves has shown that a distortion factor greater than 1.10 introduces objectionable distortion of the picture contents. In the example of Fig. 4 the highest permissible percentage increment along the charging curve amounts to 7-9%, depending on the operating point. This example may suffice to make clear the defects of Kipp oscillation production.

Any distortion which is introduced by tubes employed in coupling the Kipp generator to its output circuit is here neglected. By the choice of adequate tubes as well as by the well-known straightening of characteristics with high anode resistances, $R_a >> R_i$, distortions of this type can be excluded. With suitable design, the distortions introduced by the tubes can even be utilized to cancel some of the distortion produced by the generator. In this connection, it should suffice to consider briefly distortions in linear circuit elements which are caused by frequency-attenuation or non-linear phase shift. Special attention will be given to the very important practical case where the fundamental experiences a change in phase or amplitude with respect to the remaining harmonics. This case deserves special consideration because, due to its great amplitude, phase-shift or amplitude attenuation of the fundamental causes especially large deformations of the Kipp curve.

In Fig. 5 curve I shows an undistorted Kipp curve with a retrace time of 5%. Curve II gives the deformation which occurs with a 9° phase-shift of the fundamental; this shift produces a distortion factor of 2. Curve III shows the distortion with a fundamental amplitude decrease of 10%. The distortion due to amplitude attenuation has only slight practical significance, because such attenuation is always accompanied by a phase-shift and as shown below, the influence of the phase-shift always predominates.

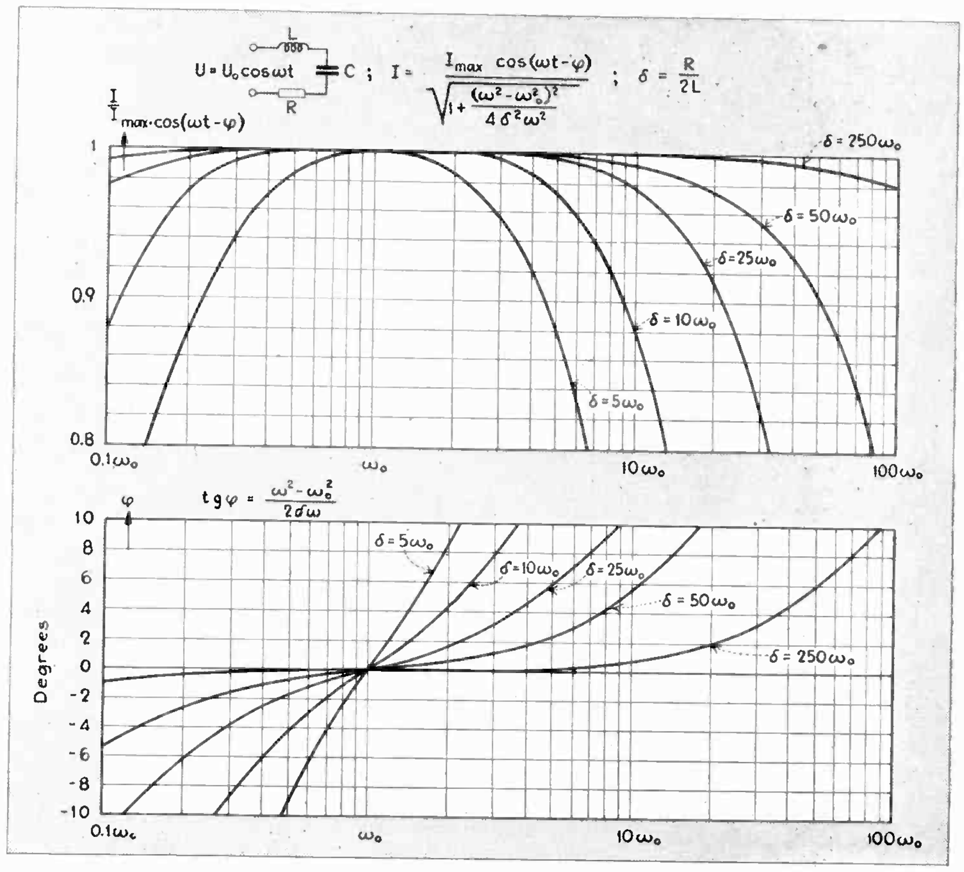


Fig. 7 Phase and amplitude shift of highly damped resonant systems

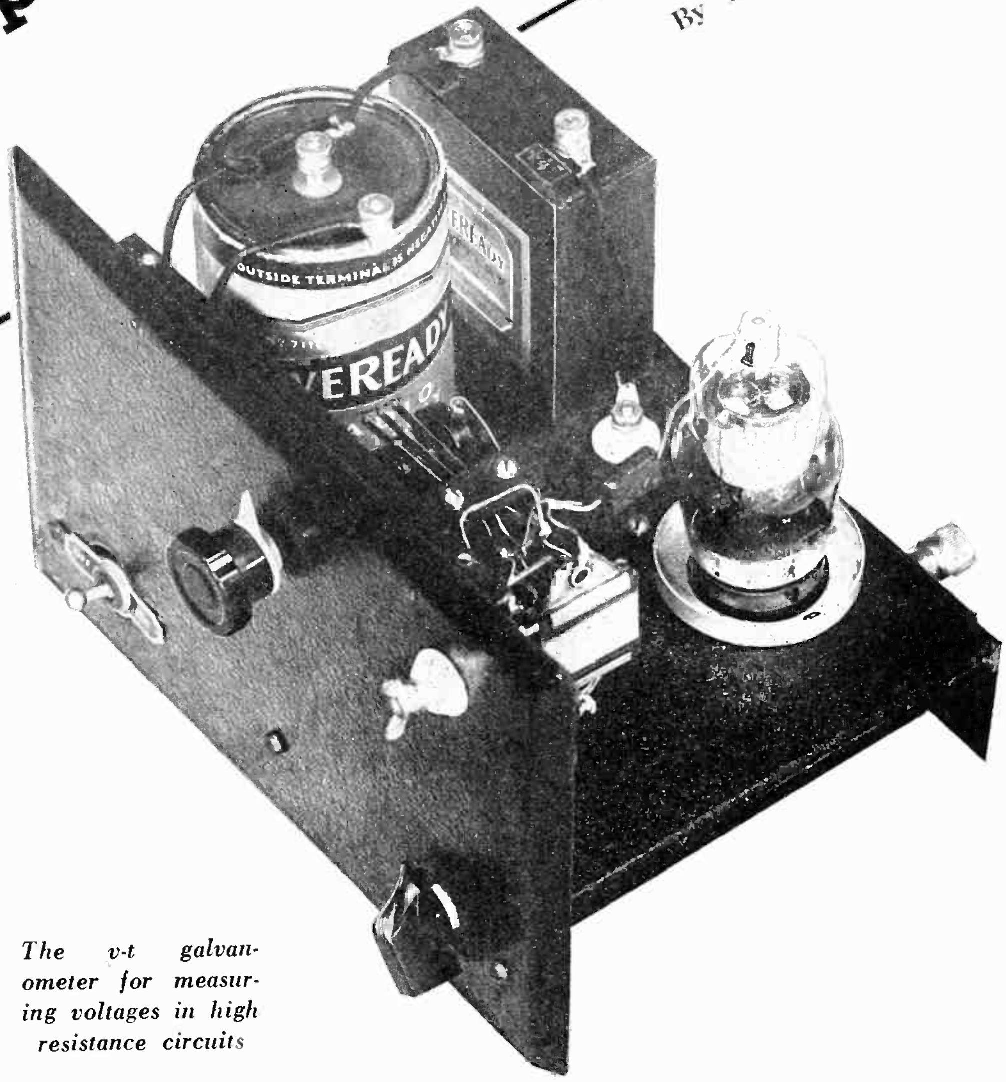
The effect of fundamental phase-shift on the distortion factor is shown by the curve and formula of Fig. 6. Since the distortion factor in television must not exceed 1.1, this phase-shift in the circuit elements coupling the Kipp generator to its output circuit must not exceed 1.4°.

It is well-known that most interstage circuits can be replaced by an equivalent circuit of a highly damped oscillatory circuit. Multistage circuits require only that each of the stages be similar. The calculation of the values involved in

(Continued on page 84)

An Electronic pH Meter

By ROBERT FINLAY



The v-t galvanometer for measuring voltages in high resistance circuits

WHEN the laboratory man asks for bigger and better galvanometer deflections, something has to be done about it. And in this case, there was no departure from the usual story, "the budget just won't stretch far enough to allow the purchase of an extremely high-sensitivity galvanometer". Naturally, this made us look for an electronic gadget, because of the "currentless" minute voltage to be measured. The end of our rainbow proved to be such a simple, efficient "one bulb" circuit, that we are moved to describe it here. We hope it will prove as practical in other uses as it was in this particular application.

The need for this circuit arose in the midst of a chemical research program. Certain pH measurements had to be made with such accuracy that the colorimetric method could not be considered. Attempts to determine the hydrogen ion concentration by measuring the potential difference in the solution by means of the hydrogen electrode and potentiometer were unsuccessful. Results varied. The error was traced to proteins in the solution which poisoned the platinum electrode. On the other hand a quinhydrone electrode required a chemical addition to the solution which was objectionable. The only counter attack was to use a glass electrode, increasing the resistance of the circuit tremendously—in fact, to a point where the available instruments were no longer sensitive. That was when the cry went up for a better mouse trap.

A review of the literature revealed that many excellent electronic circuits had been developed for this purpose. The earlier circuits were the most appealing because of their fundamental simplicity. But somehow or other most of them had later been improved upon. Like the Jukeses and the Joneses, they seemed to have become more and more involved as the years rolled by. The study was interesting—but fearful. It did not lead to any decisive answer.

With the well conceived hope of settling the matter, a trip was made to the Applications Engineering Department of RCA Radiotron Company at Harrison, N. J. There, after listening to our problem, Mr. F. H. Shepard sketched out one of his circuits and it more than met every requirement. As may be gathered from the diagram in Fig. 1, its simplicity permits compactness and variety of construction design; particularly so, with the new portable batteries now available. It also means relatively low cost even though the best materials are used. A glance at the photograph of the chassis will bear this out.

The circuit functions as follows: With the switch S_1 in position p_2 the grid charges itself and condenser C_1 to the floating grid potential of the particular tube being used. This

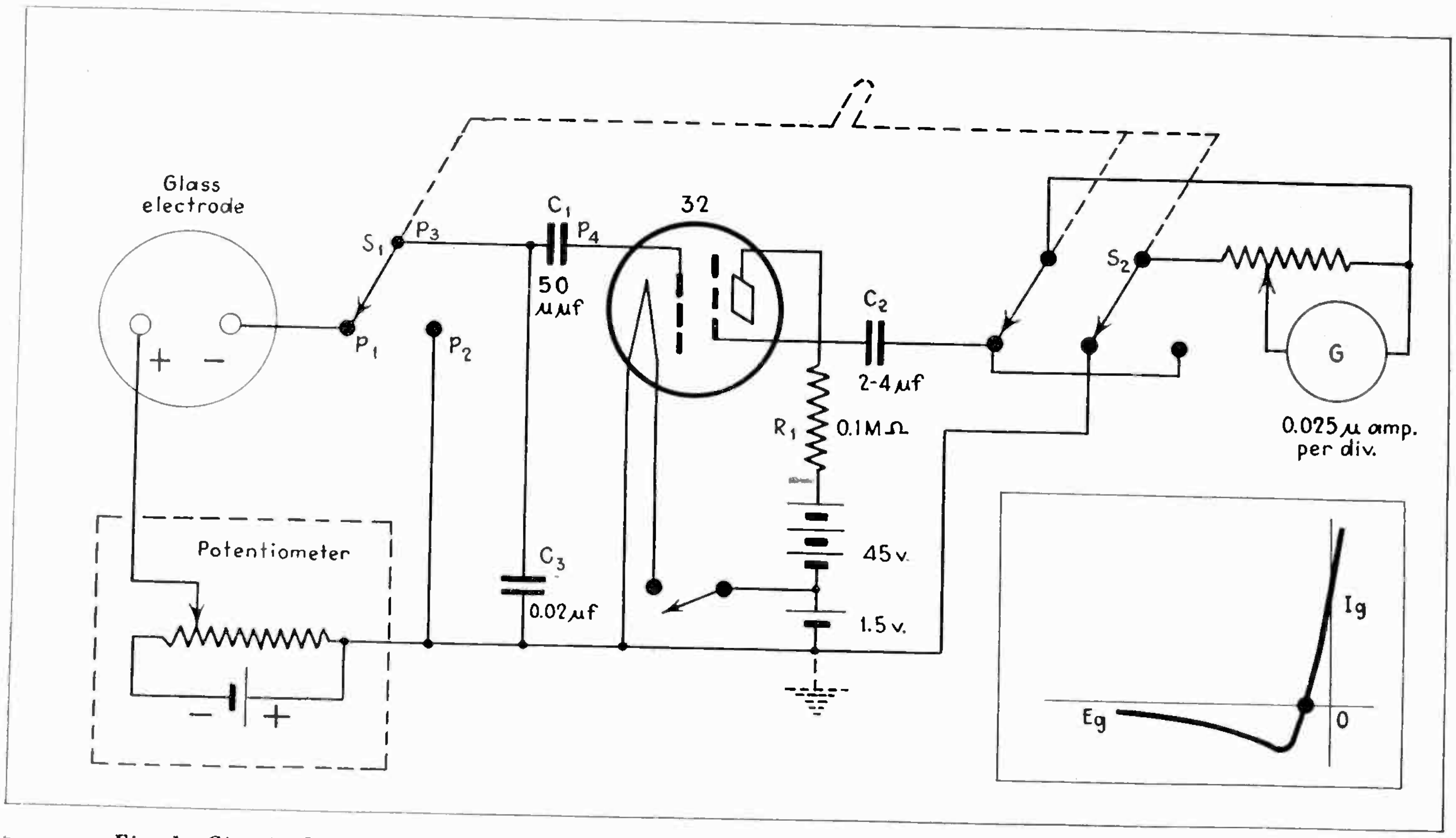


Fig. 1—Circuit diagram of the pH meter. Fig. 2—(Right) Grid current characteristics of vacuum tube

potential is fixed by the point at which the grid current is zero. (See Fig. 2, which shows the well known curve representing the grid current-grid voltage characteristic of a thermionic vacuum tube). It should be noted that the time required to arrive at this stabilization potential is of the order of several seconds, this relatively long time constant resulting from the fact that the high grid resistance is in series with C_1. Consequently, any small but momentary changes in the potential of point p_3 will result in like changes in the potential of the grid (point p_4). Now then, if point p_1 is at some potential other than that of p_2, as we throw the switch back and forth the point p_3 will vary between the two potentials; the grid potential will vary; and the plate current will be varied. Since any plate current variation results in a change of voltage across the plate load resistor R_1, and since this sets up a charging current thru the galvanometer into the output condenser C_2, then it follows that as switch S_1 is thrown back and forth, the charging current will surge back and forth thru the galvanometer, into and out of condenser C_2.

In other words, without considering the function of switch S_2 or condenser C_3 at this time, it will be seen that the circuit is a voltage difference indicator. Any difference in potential between p_1 and p_2 will cause the galvanometer to deflect to right and left of zero successively as switch S_1 is oscillated. As p_1 and p_2 terminate the circuit of the glass electrode and potentiometer, there will be galvanometer deflections unless the potentiometer is balanced so that its e.m.f. exactly opposes the e.m.f. of the cell containing the solution to be measured. Therefore operation of the device only requires that one hand throw switch S_1 back and forth slowly (about one cycle per second), while the other hand turns the potentiometer control until the galvanometer no longer deflects. A balance being obtained, the e.m.f. may be read on the potentiometer. The pH is determined by consulting the e.m.f.-pH reference table for the particular glass electrode being used. In this case a Leeds & Northrup glass electrode having a resistance of about five megohms, was used in conjunction with a L & N Student Type potentiometer.

So much for the mechanical operation and theory of the circuit. In practice, however, there are always kinks. For instance, throwing the switch may generate contact potential or grid pick-up, causing wide galvanometer deflections even though the electrode circuit is balanced. The condenser C_3 takes care of this. In the assembly shown in the photograph, its capacity was rather critical at 0.02 μf. Capacities of 0.01 or less were ineffective; and above 0.02 the sensitivity was impaired. But in the perfect assembly C_3 is unnecessary.

Another practical matter is the direction of galvanometer deflections. In the operation of a device of this sort it is nice to know whether your potentiometer is above or below the balance voltage. This end is obtained by switch S_2 which operates in synchronism with S_1. At each throw S_2 reverses the galvanometer connections so that the current through the galvanometer is unidirectional for a given potential direction between p_1 and p_2. A reversal of potential between p_1 and p_2 will cause the galvanometer to deflect in the opposite direction, thus indicating the potentiometer adjustment.

While galvanometer deflection may be calibrated and read directly as e.m.f., there is likelihood of an observational error due to the difficulty of reading the ballistic throw. However, great accuracy can be obtained when the device is used as a null instrument. Readings can be repeated with a probable error of ± 0.3 mv. Hydrogen-ion concentration has been measured to ± 0.02 pH. But its ready sensitivity to one millivolt, suggests that this simple circuit may find other useful applications in the field of electronics.

Class B R-f Amplifier Chart

A method of calculating power output, plate efficiency, r-f plate current, and d-c plate current from tube characteristics and operating voltages, making use of the "perveance" of the amplifier tube

THE purpose of this reference sheet is to give a simplified graphical and tabular method of determining the performance of Class B radio frequency amplifiers having a parallel tuned circuit coupled to the load. In order to make this sheet as practical and useful as possible to the operating engineer, the underlying theory will be omitted. The results given here have been based on the analysis given in, "An Analysis of Class B and C Amplifiers" by B. F. Miller, in the *Proceedings of the I. R. E.* for May 1935, page 496 and have been adapted to Class B operation by W. Van B. Roberts of the Radio Corporation of America.

Assume:

E_B is the quiescent or operating plate voltage (d.c.),

$E_C = E_B/\mu$ is the grid bias voltage for Class B operation,

E_g is the amplitude of the grid excitation voltage of fundamental frequency corresponding to ω,

$E_p = (E_B - E_t)$ is the instantaneous value of the plate voltage,

E_t is the amplitude of the voltage of fundamental frequency appearing across the tank circuit composed of L and C,

$K' = I_p/E_p^{3/2}$ is the perveance of the triode and is determined from the static tube characteristics for the condition that $E_g = E_c = 0$; I_p is measured in amperes and E_p in volts,

$K = K'R$

R is the resistance of the parallel resonant circuit and load when tuned to the grid exciting frequency $\omega/2\pi$,

I_p is the plate current flowing in the tube output circuit,

$\alpha = 0.457\ K\sqrt{\mu E_g}$,

$\beta = E_t/\mu E_g$,

μ is the amplification factor of the triode and

$\omega = 2\pi f$ where f is the fundamental grid excitation voltage frequency.

The operation of the amplifier is determined through the use of the alignment chart and the circuit factors α and β, which require that the values of K', R, μ, and E_g be known for any given set of conditions, from which E_t can be found. The value of μ for the tube in use can be determined from measurements or from the manufacturers' data sheets. The value of K' is not given by the tube manufacturers but can easily be determined if the static tube characteristics are available. Following along the static curve for $E_c = 0$, the plate current in amperes, I_p, is observed for a plate voltage, E_p, which is high compared with the filament voltage but not sufficiently high as to produce saturation. The value of K' is then given by,

$$K' = I_p/E_p^{3/2}.$$

The value of the resonant impedance of the tank circuit, R, may be determined from methods given in such standard engineering textbooks as Terman's "Radio Engineering" or Everitt's "Communication Engineering". The grid excitation voltage, E_g, can be measured with a vacuum tube voltmeter for a given set of conditions if necessary, but for analyzing the operation of Class B amplifiers, it is usually desirable to let E_g take definite values which may be arbitrarily selected.

Knowing (or assuming) a given set of values for K', R, μ, E_B, and E_g, we calculate

$$\alpha = 0.457\, K'R\, \sqrt{\mu E_g} = 0.457\, K\, \sqrt{\mu E_g}$$

and from the alignment chart determine the value of β corresponding to this value of α. By multiplying β by μE_g the value of E_t is determined. Knowing E_t, the operating characteristics of the amplifier can be determined for the chosen values of K', R, μ and E_g. Thus:

$E_t = \beta\mu E_g$,

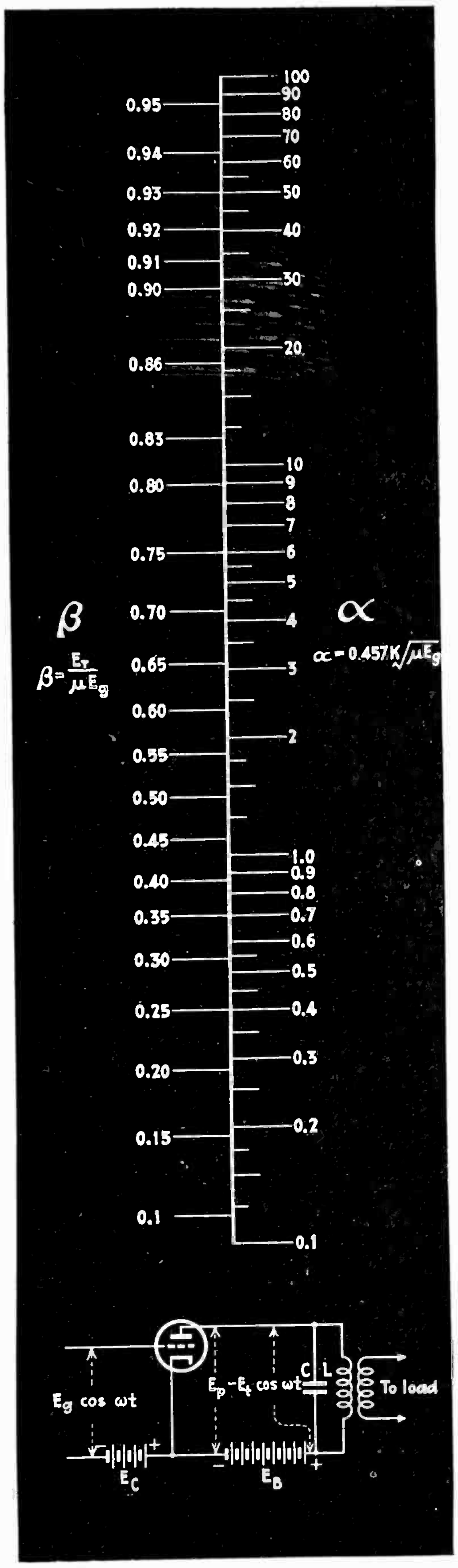
$I_{pw} = E_t/R$ is the amplitude of the plate current of fundamental frequency

$I_{po} = 0.605E_t/R$ is the d-c current flowing in the plate circuit,

$P_o = E_t^2/2R$ is the power output of the amplifier and

$P_i = 0.605E_tE_B/R$ is the power input to the plate circuit.

The analysis underlying this simplified method of calculation is based on the assumption that the plate current is proportional to the 3/2 power of the plate voltage, which is a good approximation in practice. The analysis does not take into account the flow of grid current so that the method can only be used for those values of excitation grid voltages for which μE_g is less than the instantaneous plate voltage given by $E_p = (E_B - E_t)$.



NEW BOOKS

Radio Engineering
(Second Edition)

By F. E. TERMAN. *McGraw-Hill Book Co. New York. (813 pages, Price $5.50).*

ACCORDING to the book jacket over three-fourths of the text of Professor Terman's well known book have been completely rewritten for this new edition; over two-thirds of the illustrations are new. To one familiar with the first edition these changes are apparent. In fact it is a new book made necessary by the changes in the radio art and changes in emphasis occurring in the five-year period between editions.

The present text carries the analysis of many subjects much farther than did the first edition. In many respects it is more practical without losing its value as a text for students. Diode detectors, now used almost exclusively in radio receivers, are well handled and the important practical analysis of the effects of the a-c, d-c ratio has not been neglected. Professor Terman is well known to *Electronics* readers through the papers he has presented through its pages. His forte is the reduction of complicated circuits to simpler equivalent circuits with simplified methods of analysis. Several of these short cuts will be found in the new book.

The entire book is well equipped with bibliographies and other references to the literature. In addition to purely radio principles there is material on sound systems; and a chapter on modern television apparatus. Other sections on antennas, radio aids to navigation, radio receivers, detection, sources of power, etc., will give an idea of the scope covered.—K. H.

Fundamentals of Engineering Electronics

By WILLIAM G. DOW, *Assistant Professor of Electrical Engineering, University of Wisconsin. John Wiley and Sons, New York, N. Y. (604+xiii pages, 100 illustrations, Tables, Appendices, etc. Price $5.)*

THE FIRST IMPRESSION the reader gets from this remarkable book is the stupendous amount of work which has manifestly gone into its preparation. It is the first book with the word "Electronics" in its title which goes deeply into the subject, and it contains information gleaned from a wealth of sources. The collected bibliography at the end of the book contains 52 books and 133 periodical references, which are extensively utilized by cross-references in every portion of the book. The index is 33 pages long. At the end of each chapter is a list of problems, most of which require real effort in solution (no numerical answers are given, however, which lessens the value of the problems to the instructor-less student). The range of subject matter is greater by two or three times than that of any other book on the subject known to this reviewer.

The book is distinctly not intended for the uninformed reader. It assumes a considerable knowledge of calculus and a facility in mathematical thinking which few people, even engineers, possess. The book "pulls no punches". Finding the need for a knowledge of conformal mapping to explain vacuum tube action, the author devotes the first two chapters to the theory and application of this subject. In his preface, Professor Dow refers to this stating that it is "perhaps unfortunate that the most difficult subjects fall naturally very early in the text." This "taking the bull by the horns" is typical of the whole work, and it is at once of great value to the advanced reader who wants thoroughness above all, and an insurmountable obstacle to the reader who merely wants a practical understanding of the ways in which electronics is applied to engineering. For this reason the book seems to be poorly named; it is rather the Fundamentals of Electronic Physics, with examples taken mainly from engineering practice. For the graduate student, under the guidance of a good teacher, the book should stand head and shoulders above other present books.

There is practically no item in electronics, from plasma oscillations to single-tube inverters, which is not covered in these 600 pages, and with a degree of thoroughness which speaks well of Professor Dow's ability as a teacher and as an interpreter of a field not yet too-well-organized. But the book is, with a few Chapters excepted, what college students call "tough". It is a sign, perhaps, that electronics as a science is coming of age.

The Chapter list is as follows:

Introduction, High Vacuum Thermionic Triodes; I Potential Distribution Diagrams; II The Electrostatic Field of a Triode; III Electron Ballistics; IV Cathode Rays; V Space-charge Flow; VI Triodes, Tetrodes, Pentodes; VII Thermionic Cathodes; VIII Work Functions of Homogeneous Substances; IX Energy-Level Diagrams in Metals; X Distributions of Random Velocities of Gas Particles; XI Electrical Effects of Random Motions; XII Amplifier Circuit Principles; XIII Harmonics, Class B and C amplifiers; XIV Amplifier Coupling; Oscillators; XV Atomic Energies; XVI Energy Levels for Particular Metals; Photoelectric Emission and Electromagnetic Waves; XVIII Photosensitive Devices; XIX Electric Arcs and Glow Discharges; XX Plasma Boundary Regions; XXI Mercury-vapor Rectifiers; XXII Single-Phase Circuits Containing Rectifying Elements.

—D.G.F.

Television Cyclopedia

BY ALFRED T. WITTS.

D. Van Nostrand Co., Inc., New York, N. Y. (146 pages, 97 figures. Price $2.25.)

THIS BRITISH BOOK contains an alphabetical list of approximately 600 words and phrases used in present television practice in Great Britain. The definitions are in general accurate and well put, but not so extensive as the title of the book might suggest. In general the author has adhered to terms which apply specifically to television equipment and practice, although there are several which apply more generally to electron tube practice. The differences between British and American terminology are not serious, although many of the common American words, such as pedestal, retrace, sweep circuit, etc. do not appear.

The book is not intended, of course, to be a text, and is therefore not to be used by the uninitiated, since its alphabetical arrangement does not give any idea of the logical sequence of television processes. For the engineer who has a smattering of television knowledge, and who wants to fill in the gaps or to obtain a more accurate and complete understanding of certain words, the book serves a very good purpose.—D. G. F.

Selected Bibliography of Engineering Subjects

Prepared by the Committee on Professional Training, Engineers Council for Professional Development, 33 W. 39th St., New York, N. Y. Price $0.10 each.

THIS SELECTED BIBLIOGRAPHY of engineering subjects has been prepared primarily for those who wish to continue study in engineering and allied fields or build up their own libraries. The bibliography represents a list of books, mostly of college grade, with annotations to indicate the nature and depth of the subject matter. It is published in five sections as follows:

Section I—Mathematics, Mechanics, and Physics.

Section II—Aeronautical and Civil Engineering

Section III—Chemical and Industrial Engineering

Section IV—Electrical and Mechanical Engineering.

Section V—Metallurgical and Mining Engineering.

The form of these bibliographies is similar to the "Electronic Engineers' Library" in the April 1937 issue of *Electronics*.—B.D.

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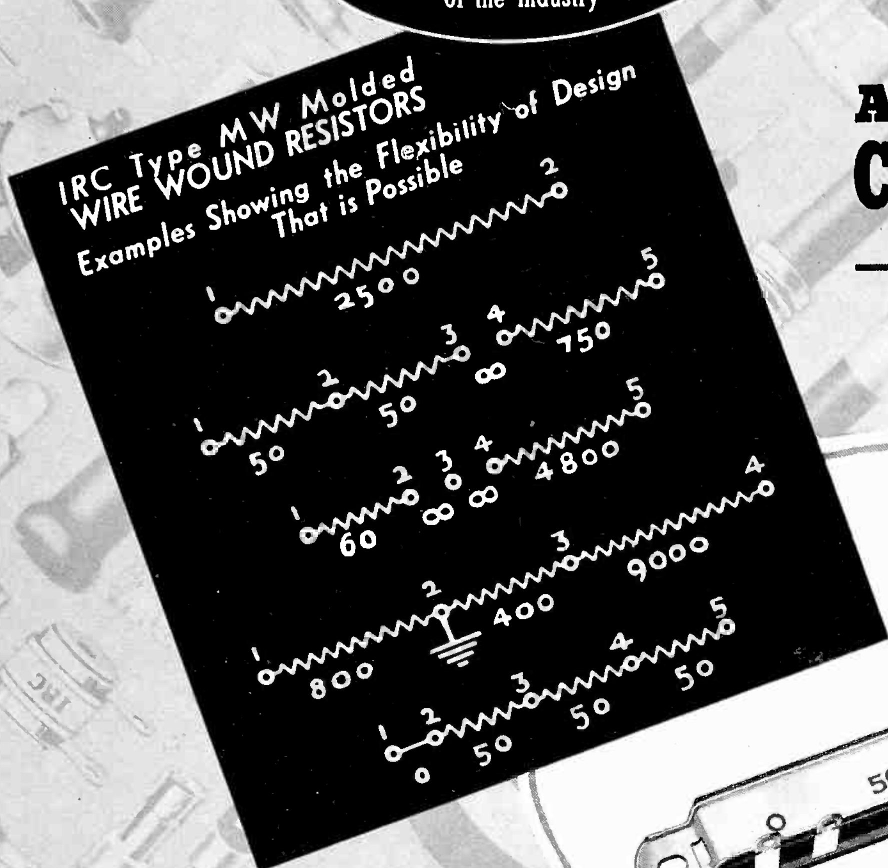

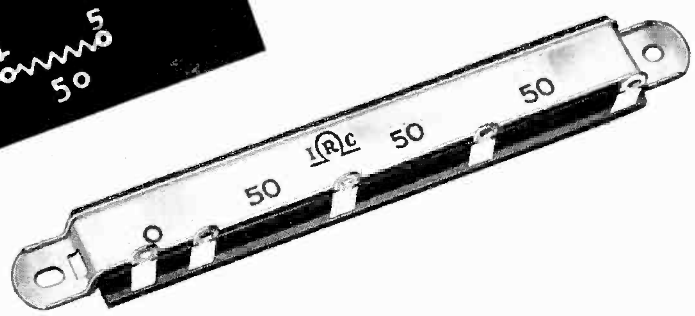

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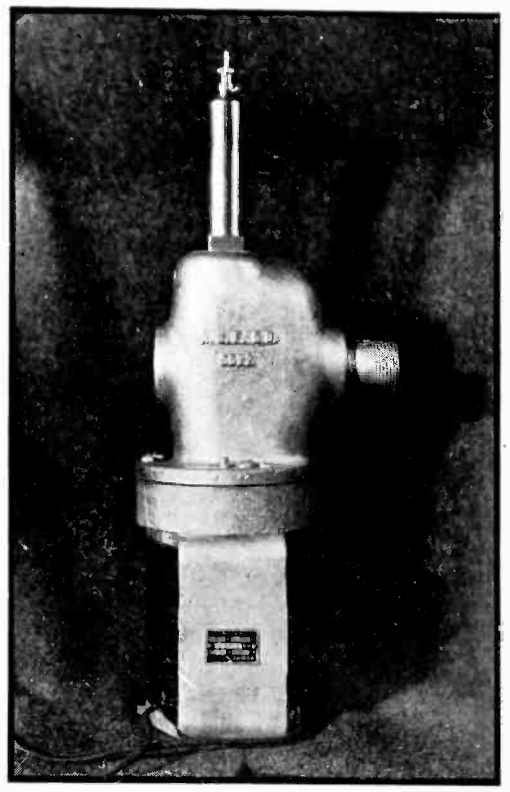
TUBES AT WORK

THIS month's tube applications include a new type of furnace-heat control, a piano-string capacity-operated amplifier, a phototube tabulating and sorting machine, public address on sight-seeing trains, and an amplifier for self-generating photocells



Solenoid-operated fuel valve

A Problem of Measuring The Gas Content of Gas-Filled Incandescent Lamps

A CORRESPONDENT HAS SUBMITTED the following problem to the editors, as one which might possibly be solved by a reader of *Electronics*. Any suggestions will be welcomed.

"For some time we have been attempting to design an apparatus which will determine the percentage of gas in incandescent lamps during manufacture. A mixture of 86 per cent argon and 14 per cent nitrogen is used; we attempt to obtain a pressure of approximately 0.82 atmosphere. The method used heretofore is that of breaking the lamps under water, but this results in considerable shrinkage if each head on a 24-head exhaust machine is tested. During the past several weeks we have been experimenting with an oscillator, placing the glass end of the lamp in a hemisphere of metal connected to the tank circuit of the oscillator. We felt that the presence of gas inside the bulb might produce changes in impedance which could be measured on a vacuum tube voltmeter connected to the output of a detector tuned to the oscillating frequency. This, however, has been unsuccessful. We do not wish an apparatus which will automatically measure the gas pressure, as that is done by regulating valves in the machine. However, when a single port becomes clogged with glass one lamp in every revolution may not get its percentage of gas because of the restriction. If we could measure the amount of gas in each lamp without breaking the lamp, we could then determine whether all lines were open in the machine."

• • •

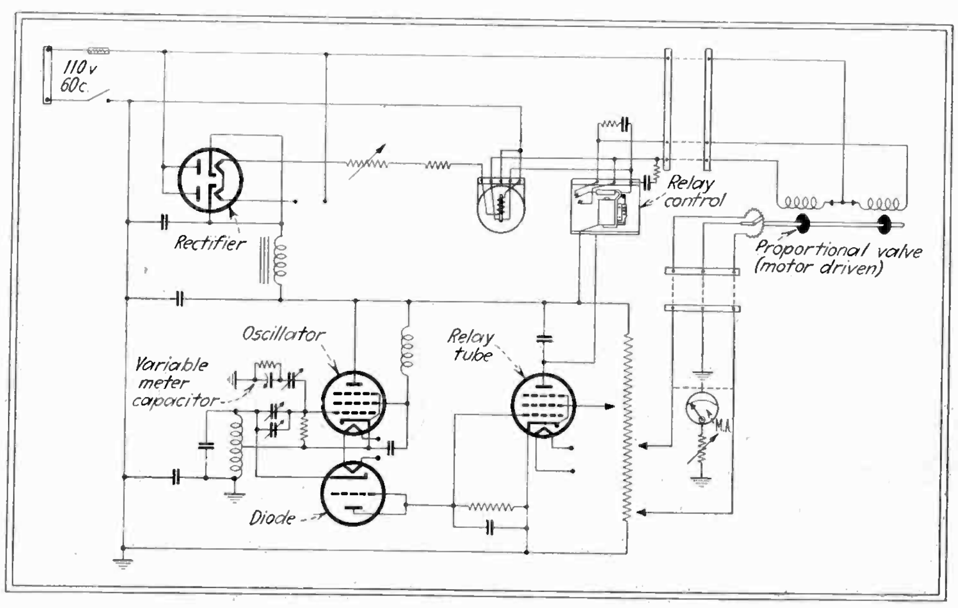
Capacity-Operated Relay Applied to Furnace Heat Control

THE EDITORS ARE indebted to Mr. George A. F. Machlet of the American Gas Furnace Company for the following information relative to a furnace-heat control developed by him and patented under U. S. Patent 2,056,285. The device provides "stepless" control of furnace heat through the medium of a thermocouple element. The thermocouple current actuates a meter (50 millivolts full scale, in typical applications). The meter pointer serves as one plate of a variable condenser. The remaining plate is built into the meter case, on an adjustable insulated mount. By adjusting the position of the second plate to the region of the scale at which control is desired, the capacity between the meter pointer and the second plate increases greatly when the pointer reaches the control position. This change in capacity is used to actuate a capacity-operated relay, developed by F. H. Shepard, Jr., of the RCA Radiotron Division, who cooperated with Mr. Machlet on the circuit problem. The capacity-operated relay is essentially the same as that described on page 38 of the September, 1935 issue of *Electronics*. The output of a Hartley oscillator—whose amplitude of oscillation is controlled by the change in capacity associated with the thermocouple meter—is rectified in a diode and the rectified a-c applied as bias to the grid of a type 43 tube. The output current of this tube actuates the fuel control of the furnace.

Two types of control have been used. One is a simple solenoid-operated gas valve, shown in the illustration. The other is a Minneapolis-Honeywell motor-driven proportional valve, the connections for which are shown in the connection diagram. The complete instrument, including the motor-driven valve control, is shown in the accompanying picture.

The advantage of this arrangement is the fact that the control (using the proportional motor-type valve for fuel control) is continuous ("stepless") over a considerable range. This greatly increases the available sensitivity in the device. The speed with which the device operates, moreover, is very great, so that substantially isochronous operation is obtained. This greatly decreases the tendency of the device to "hunt", that is, to oscillate between two temperatures. The use of a non-mechanical linkage between the temperature-indicating meter and the control makes it possible to secure any desired degree of sensitivity consistent with the thermocouple and meter characteristics. The capacity linkage, in contrast to the photoelectric linkage commonly employed in similar applica-

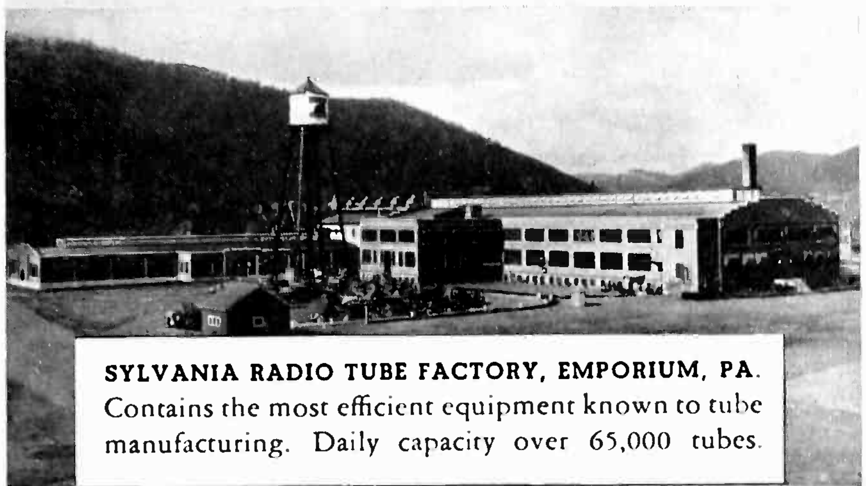
(*Continued on page 48*)



Connection diagram of the furnace control. Variable capacity between the pointer and case of the thermocouple meter actuates the capacity-operated relay

An institution of service to the radio industry

The radio industry...the American radio audience . . . and 119 foreign countries of the world now receiving increasingly large Sylvania shipments . . . all know Hygrade Sylvania as an organization whose amazing growth is the direct result of good and faithful service to the whole radio industry—from the manufacturer right down to the consumer.



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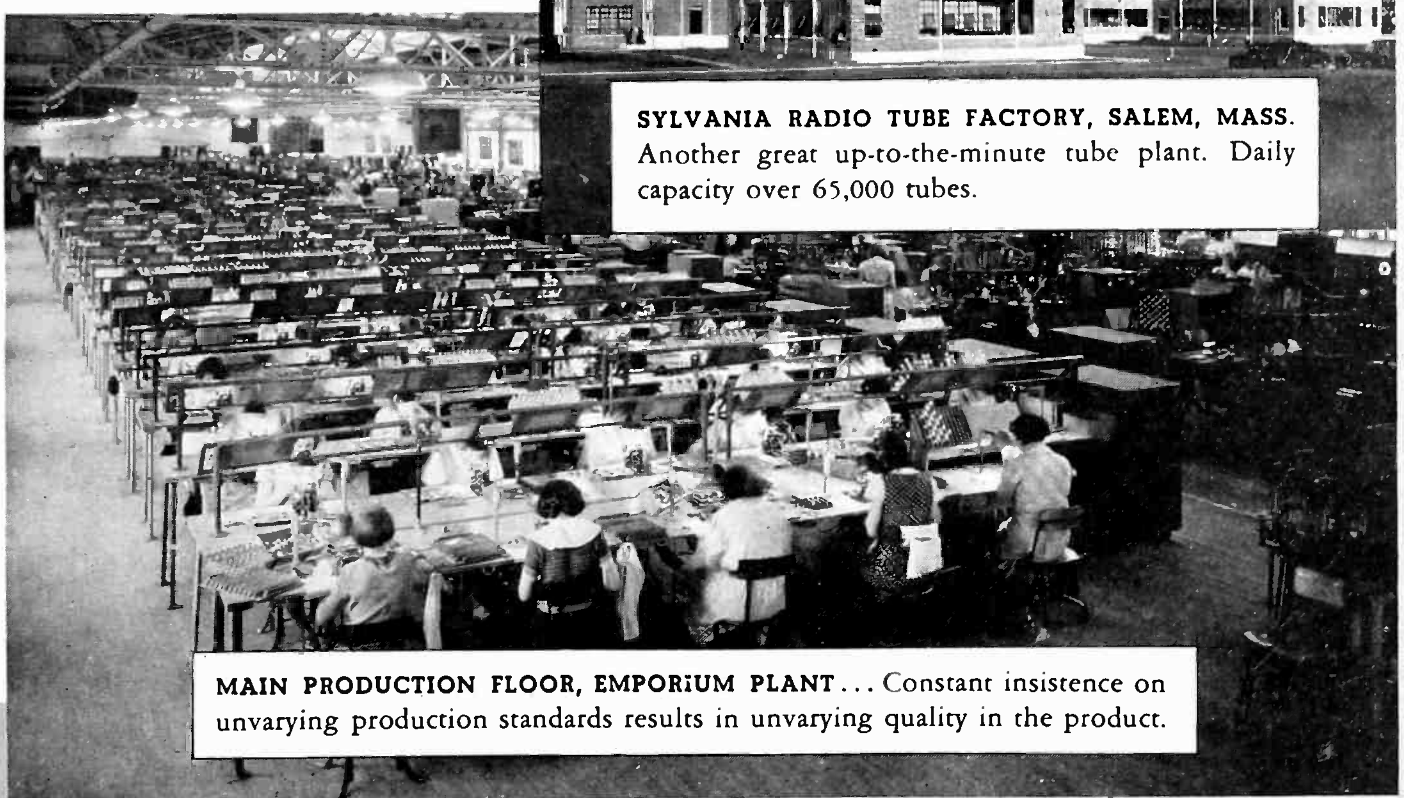

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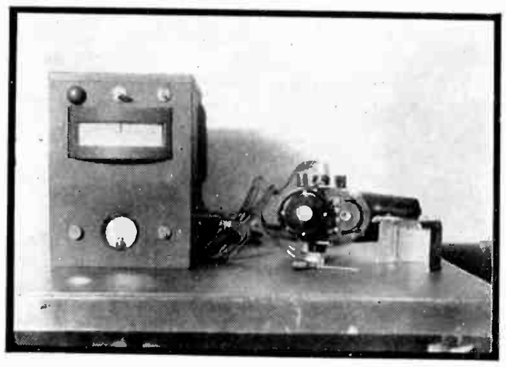
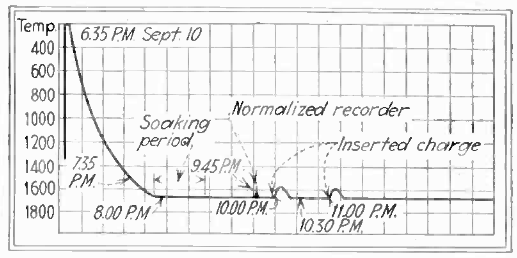
SYLVANIA SET-TESTED RADIO TUBES



Controller and motor valve

tions, permits a range of continuous control, and obviates the necessity of a light source with its attendant maintenance problem.

A typical record of temperature in a



Typical temperature record

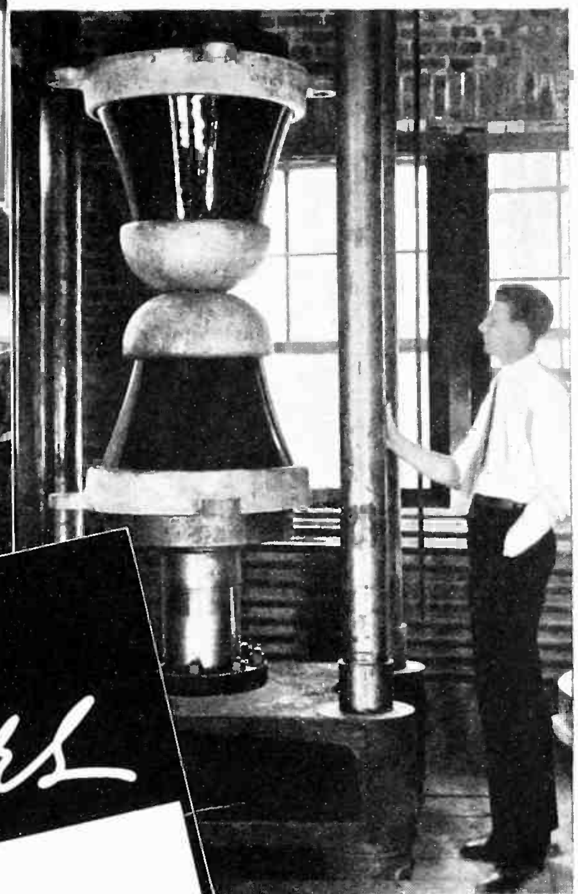
furnace controlled by Mr. Machlet's device is shown. It will be noticed that the recovery of temperature after the insertion of each charge occurs within a short time, and that the temperature is maintained uniform thereafter.

• • •

Electronic Piano Produced Commercially

THE PRESENT VOGUE for small musical instruments has resulted in a considerable effort to improve the tone and volume within a restricted sounding board area. The electronic principle developed by Benjamin F. Meissner and demonstrated before the institute of Radio Engineers last year has been successfully applied to this problem and has recently been demonstrated before a musical trade exhibition.

Underneath each string is a narrow conductor supported on insulators and separated from the strings just far enough to prevent contact when the strings undergo their most violent vibration. A high voltage is supplied between the conductor and the string, thus providing a polarizing voltage whose value is varied as the string vibrates. The oscillating voltage so generated is amplified in a conventional amplifier having a peak output of approximately 60 watts. The gain of this amplifier is controlled by a swell pedal, in place of the conventional pedal of a piano. Controls are available at the keyboard for regulating volume and tone. Tone quality of this combination is equal to if not actually superior to that of a large concert grand piano. With the amplifier disconnected the tone of the piano alone is so weak as to be unsatisfactory even in a small room.



At left, radio frequency generator and equipment for flashover, heat run, corona point, loss and capacitance determinations. Right, three million pound radiator base insulator being proof-tested in hydraulic testing machine.

proving ground for radio *Insulators*

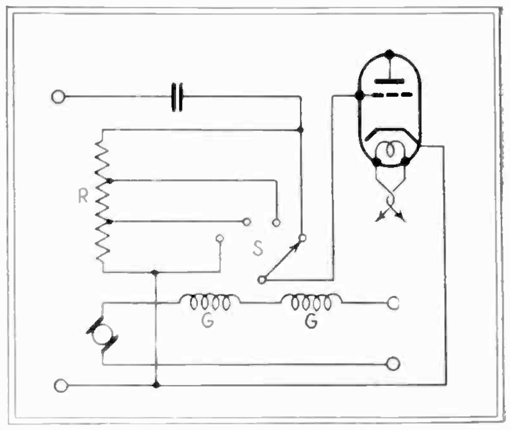
Early in the history of radio transmission, Lapp established testing laboratories to aid in the development work on radio insulators. As a result, Lapp has been able, year after year, not only to provide insulators that meet advanced requirements of broadcasting technique, but also to anticipate new needs—indeed, to contribute to the growing knowledge of the science. Many of the newer ideas in radio insulators and consequent improvement in broadcasting have been Lapp conceptions, worked out in close co-operation by engineers of Lapp and of structure and equipment manufacturers. Lapp Bulletin 137 tells an interesting story of Lapp porcelain coils and insulators for tower footings and guys. If you do not have a copy, write for it today.

LAPP INSULATORS

LAPP INSULATOR CO. INC — LE ROY - N.Y. - U.S.A.

Volume of Auto-Radio Increases With Speed of Car

ACCORDING TO a recent issue of *Wireless World*, the British have finally dealt with the fact that the volume required of an auto-radio is much greater when the speed of the car is high than at lower speeds. In recent British Patent (No. 450,606), it is suggested that a centrifugal governor connected to the transmission gear be used to contact several points on the potentiometer resistance, as shown in the diagram, which would control the amount of input to the amplifying tube. Thus the loud speaker volume is made to rise and fall in sympathy with the running speed of the car.



Switch S is controlled by the car speed

• • •

Phototubes Used In Sorting and Tabulating Machine

A NEW DEVICE for tabulating from business records has been devised by M. E. Gould, of Washington, using a rectangular bank of 200 phototubes to register indexing impulses projected upon them from a motion picture projector whose film contains the records. Each frame of the film resembles a punch-card of the conventional tabulating machine, except that each punch hole is replaced in the film by a square black dot impressed photographically on the film. The position of these black dots on each frame indicates the classification and other data relative to that particular record. By projecting the pattern of dots from each frame on the phototube bank, relays connected to the phototube can be made to take tabulated totals as the film is run through the machine. The relaying system, consisting of telephone type relays operated from thyratron tubes, will operate at extremely high speeds, 2,000 per minute or more. The advantage of this method of filing records (on film) is the relatively small space required, only 1,000 separate reels being required for as many as 84,000,000 individual records. Also the continuous film strip prevents loss or improper filing of individual records.

CAMPBELL'S
329 ADAMS AVENUE
SCRANTON, PA.

August, 7, 1937

Scranton Radio Supply Co.
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Scranton, Pa.

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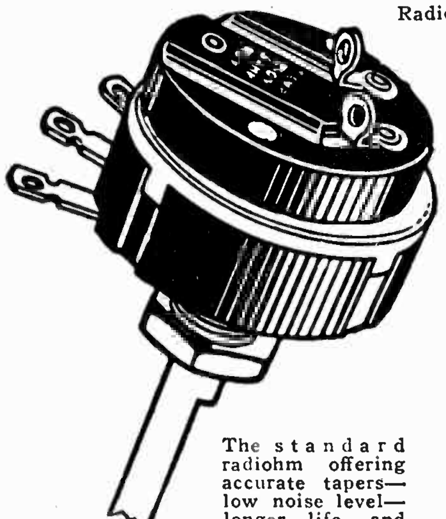
Yours sincerely,

RADIONEER

'100% Centralab'

-thanks Scranton Radio Supply Co. for sending this on!

MR. J. F. CAMPBELL
Radioneer of Scranton, Pa.



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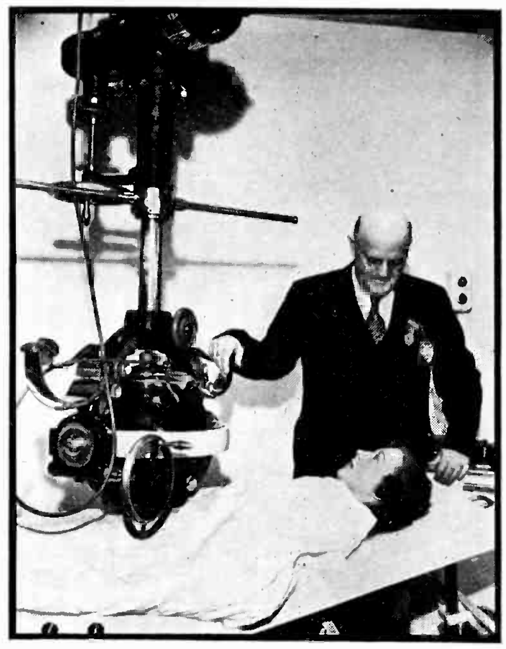
RADIUM BOMB



A five-gram radium bomb, used in the treatment of cancer, demonstrated by Dr. Frank Neal at the International Congress of Radiology at Chicago. The radiation (gamma rays) escapes through the bottom of the sphere

• • •

Note on Video Amplifier Design

(*Electronics*, August 1937)

In the above article the establishment of a definite limit as to phase distortion was rather brief and in one point an error occurred on the writers' part.

A rectangular or trapezoidal shaped pulse (such as obtained in synchronizing signals or in scanning across lines) suffers little distortion if the first ten harmonics are transmitted with phase shift proportional to frequency and the relative amplitudes preserved.

Thus a pulse $eF(t)$ would suffer little distortion if

$$eF(t) = KE_1 \sin(\omega t + \alpha) + KE_2 \sin(2\omega t + 2\alpha + KE_{10} \sin(10\omega t + 10\alpha)$$

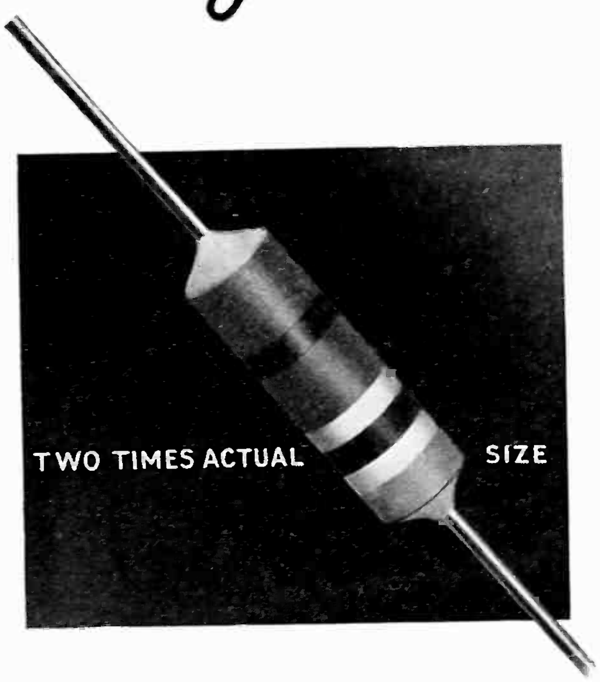
where $K =$ any number and $\alpha =$ any angle.

However if the tenth harmonic suffered an additional phase shift of π radians over that of 10α radians the distortion would probably be greater than if the harmonic were not transmitted. There is of course a possible but not probable case where the additional phase shift might be a multiple of 2π radians and yet no distortion of wave form would occur. This case need not be considered.

Evidently the limit of variation from linearity of phase shift is something less than $\pi/2$ radians for the tenth harmonic in relation to the funda-

They'll retain their normal ratings

UNDER SEVERE CONDITIONS



"The fact that Erie Resistors more nearly retain their normal values under all sorts of operating conditions is a big help to us.

It means we can use one make of resistor throughout the complete assembly line. We won't have to worry about humidity in the grid leaks where there isn't much load, too much load in the plate circuits, or the effect of sudden voltage fluctuations in other circuit locations.

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$10\alpha + \pi/2$ the maximum variation in phase delay T is

$$T = T_{10} - T_1 = \frac{10\alpha + \pi/2}{2\pi \times 10f} - \frac{\alpha}{2\pi f} = \frac{1}{40f}$$

where f is the lowest frequency in a band from f to $10f$ cycles per second. Therefore, for the higher video frequencies (.25 to 2.5 Mc) the variation in phase delay should be less than 0.1×10^{-6} seconds. For the low frequencies (30 — 300 c.p.s.) the variation should be less than 1/1200 second.

In the above article Equations (9), (10), and (11) should be corrected to read

$$\frac{1}{T} = \omega^2 R_F C_F \quad (9)$$

where T is in seconds and ω is 2π times the lowest frequency to be transmitted. When this is 30 c.p.s. and the maximum variation in phase delay T for ten stages is

$$\frac{1}{10} \times \frac{1}{1200}$$

seconds per stage, we have

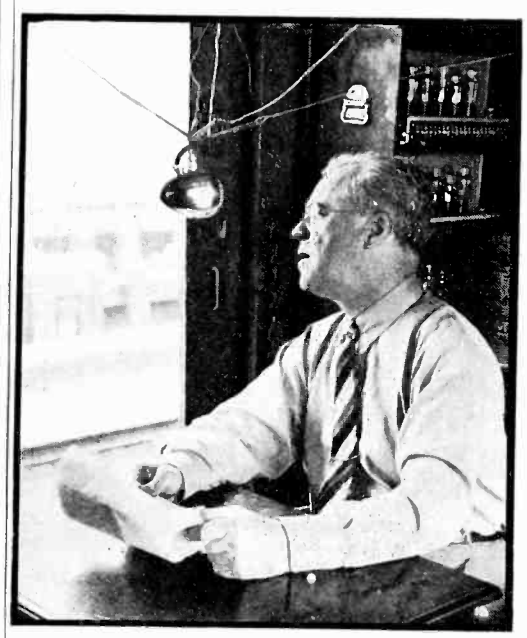
$$R_F C_F = 0.34 \quad (10)$$
$$R_{gl} C_c = 0.34 \quad (11)$$

R. L. Freeman.

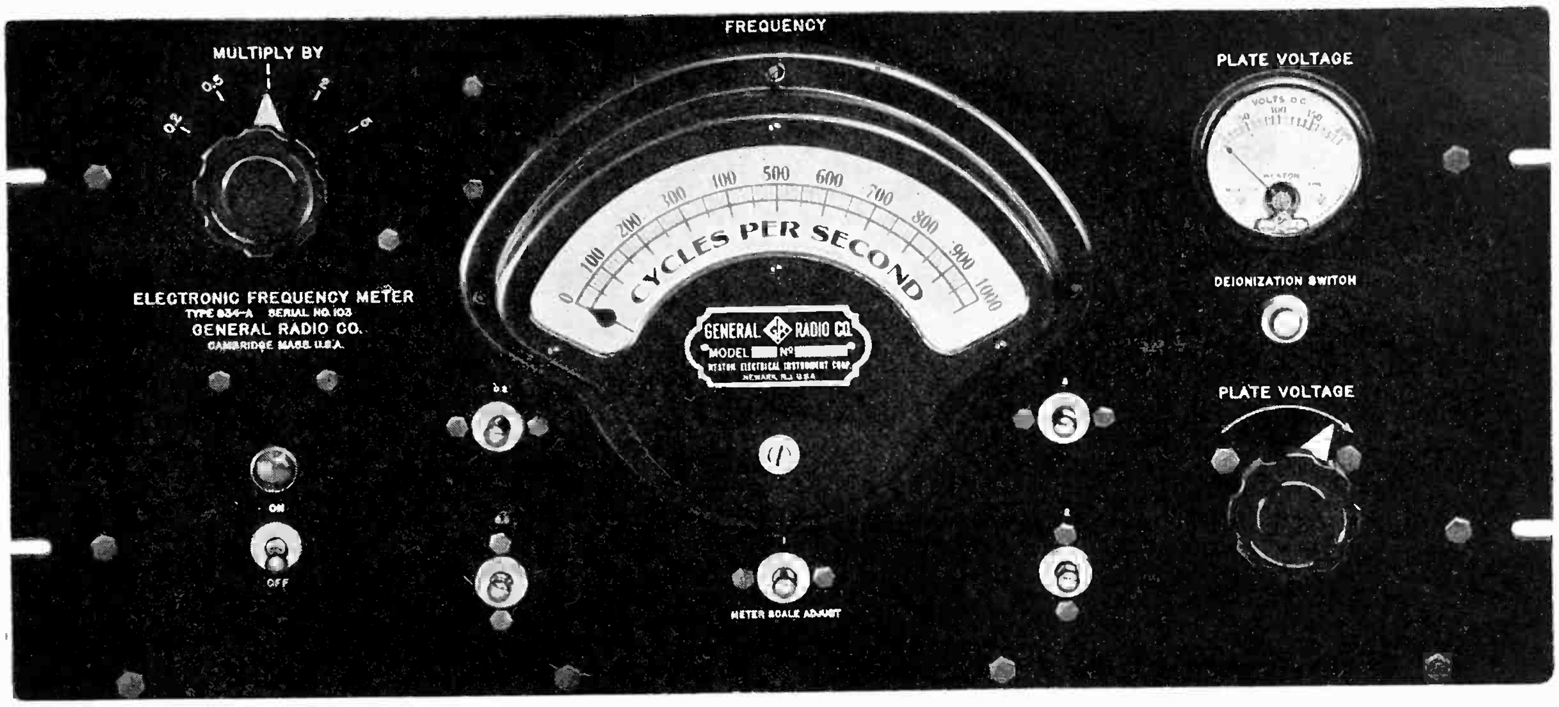
• • •

New Jersey Railroad Installs P.A. System on Sightseeing Train

Sightseeing trains run by the Central Railroad of New Jersey are now equipped with a complete public address system, including an amplifier installed in the baggage car, loud speakers in every car, and microphones



P.A. installation on Jersey Central train



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This instrument is especially useful in laboratory or production testing where routine measurements of frequency have to be made rapidly and accurately either on a large number of devices or continuously on a single instrument.

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- Noise Measurements and Analysis
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- Tele-metering
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The Type 834-A Electron Frequency Meter is entirely self-contained and operates from a 110-volt, 60-cycle a-c power source. Price, complete with vacuum tubes, fuses, spare pilot lamps, 115-volt cord and plug assembly and multipoint connector: $250.00

Write for Bulletin 191 for complete data

GENERAL RADIO COMPANY

Cambridge, Mass.

BRANCHES: New York, Los Angeles, San Francisco

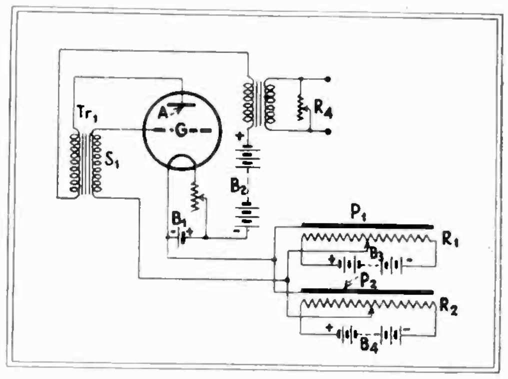
MANUFACTURERS OF RADIO AND ELECTRICAL LABORATORY EQUIPMENT located at strategic points. The guide of the sightseeing train sits in the baggage car and describes points of interest along the right-of-way, to the passengers throughout the train. A microphone is also installed in the locomotive and is used to enable the passengers to enjoy an occasional word from the engineer and the fireman, and to listen to the various noises present in the cab, such as the whistle, bell, and escaping steam from the safety valve. The dining car waiter announces dinner with chimes via the system; in between times, music is played for the passengers.

As part of the routine of the sightseeing excursion, an extensive script is prepared in advance containing information on historical points, manufacturing communities, etc., which is read as the train passes these points.

• • •

Two electronic musical Instruments from Germany

THE ACCOMPANYING DIAGRAMS show two simple oscillating circuits designed for the production of musical tones, recently developed in Germany. The single-tube instrument shown consists of a bias battery B_3, a potentiometer P_1R_1 which is connected in series between the cathode, the grid of the tube, and the secondary of the transformer TR_1. By depressing the bar P_1 at various points along its length the amount of bias voltage connected to the grid may be controlled. The grid bias in turn controls the amount of plate current flowing through the primary



Connections of the "Hellertion" music generator

transformer TR_1 and this in turn changes the inductance of both windings, by saturating the iron core of the transformer. This change in inductance influences the frequency of operation, the oscillation being sustained by the connection between the plate and grid circuit through the transformer. The output of the device taken from the plate circuit is directed to an amplifier tube. The strip P_1 is a leather-covered conductor so mounted that it may be depressed at various points by the finger of the musician, who is thus enabled to change the pitch of the instrument.

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...et base, and eliminate a brass insert and machine screw. This saved two and a half cents per unit. Also a more secure assembly was attained.

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located at strategic points. The guide of the sightseeing train sits in the baggage car and describes points of interest along the right-of-way, to the passengers throughout the train. A microphone is also installed in the locomotive and is used to enable the passengers to enjoy an occasional word from the engineer and the fireman, and to listen to the various noises present in the cab, such as the whistle, bell, and escaping steam from the safety valve. The dining car waiter announces dinner with chimes via the system; in between times, music is played for the passengers.

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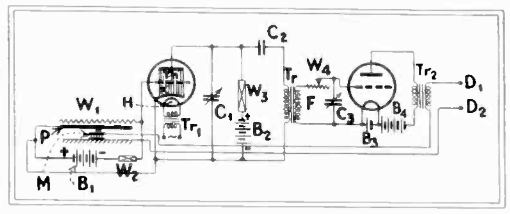
The two-tube device shown in the diagram contains a gas-filled triode whose grid bias is controlled in the same manner. That is, by pressing a conductor on a resistance strip (PW_1). This change in bias influences the duration of each current pulse through the tube, which in turn controls the frequency of the relaxation oscillator in the anode circuit. (C_1W_3). The voltage appearing across this resistance capacitance combination is amplified in the tube following, whose



The "Trautonium" uses a thyratron to produce different tones

output is controlled by adjusting resistance W_4 and condenser C_3. The volume of the instrument is controlled by the carbon button microphone M connected in series with the final output, which is compressed by the musician as he manipulates the keyboard.

Transformer Amplifier For Barrier Photocell Applications

THE EDITORS HAVE RECEIVED the following information from Mr. A. W. Clement of Chicago concerning the use of a transformer coupled amplifier in connection with a barrier type photocell, which makes use of the 120-cycle flicker produced by 60-cycle current in a small mazda bulb. The bulb used is the No. 55 (6.5 volts, 1.45 candlepower) mounted in a reflector from a flashlight. Since the filament of this bulb has very low thermal inertia the alternating component of the light output is relatively high, approximately 12 db. more than that available from a 21 cp. bulb. The application was for burglar alarm. The bulb mounted in the reflector is used to excite a barrier cell. Since these self-generating cells are of low impedance the connecting line between the cell and the amplifier can be of the most simple type. The amplifier consists of an input stage (type 6J7), a power stage (type 6F6), and a rectifier, type 6C5. The input from the photocell is transformer coupled to the 6J7 stage, which in turn is impedance coupled to the power stage. The amplifier is tuned to 120 cycles throughout. The output of the rectifier will produce about 10 milliamperes current d-c in a 500 ohm relay, when the output from the photocell is 1 millivolt. At high levels the output is limited to approximately 12 milliamperes to prevent relay saturation. Regeneration is also utilized in the amplifier by connecting a small winding on the rectifier transformer in series with the cathode of the first stage.

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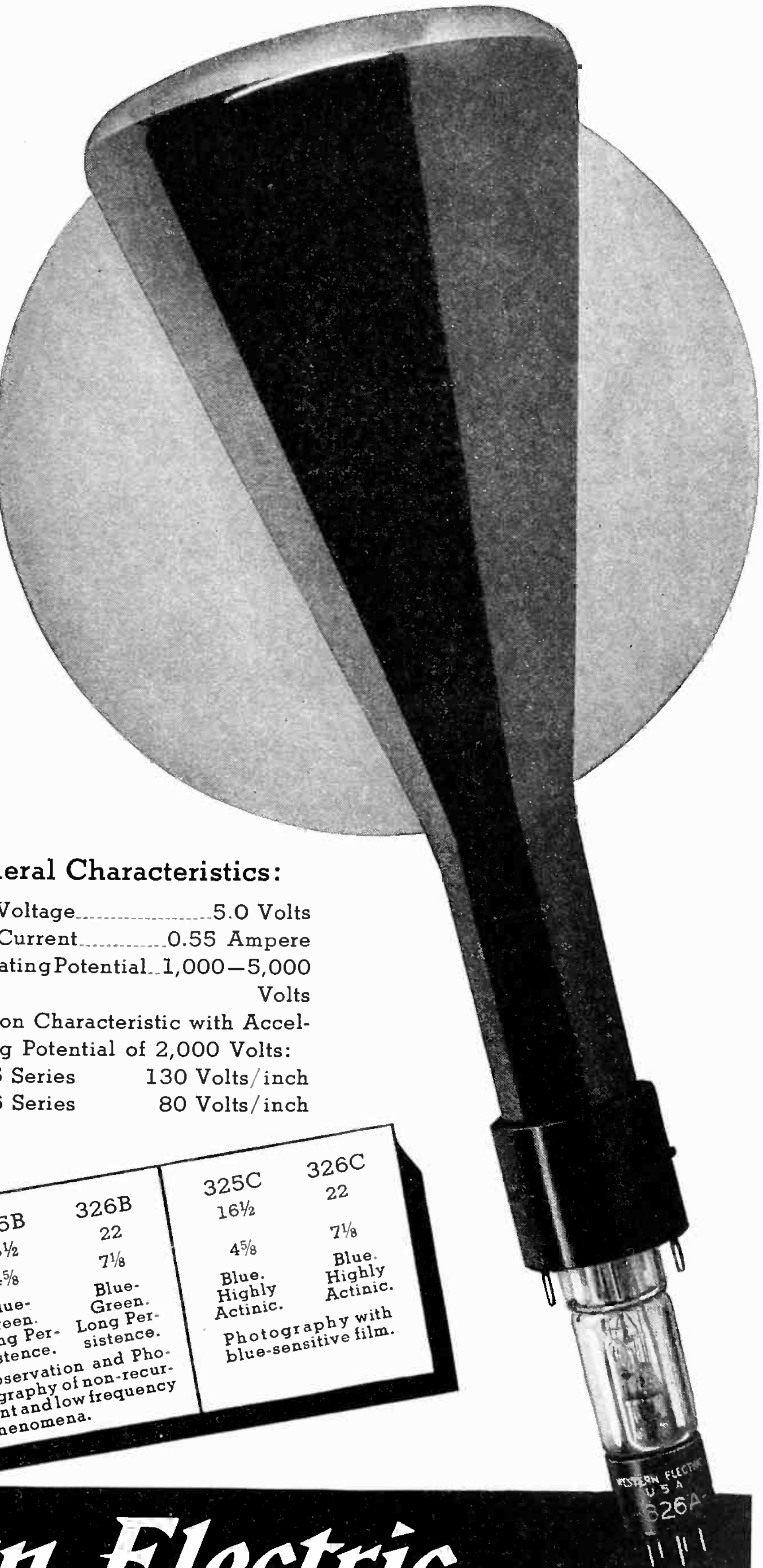

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General Characteristics:

Heater Voltage....................5.0 Volts
Heater Current..........0.55 Ampere
Accelerating Potential..1,000—5,000 Volts
Deflection Characteristic with Accelerating Potential of 2,000 Volts:

325 Series	130 Volts/inch
326 Series	80 Volts/inch

	325A	326A	325B	326B	325C	326C
Max. Length (in.)	16½	22	16½	22	16½	22
Max. Screen Size (in.)	4⅝	7⅛	4⅝	7⅛	4⅝	7⅛
Fluorescent Characteristics	Green. Medium Persistence.	Green. Medium Persistence.	Blue-Green. Long Persistence.	Blue-Green. Long Persistence.	Blue. Highly Actinic.	Blue. Highly Actinic.
Application	Visual Observation. Photography with green-sensitive film.		Observation and Photography of non-recurrent and low frequency phenomena.		Photography with blue-sensitive film.	

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THE ELECTRON ART

EACH month the world's technical literature is scanned to see what physicists and engineers are doing with tubes, for presentation in tabloid form to Electronics' readers.

Recent Developments in German Cathode Ray Tubes

By BERTHOLD SHEFFIELD

A CATHODE RAY TUBE with a screen 2 in. in diameter, surface grinding of the exterior screen surface, and a new ceramic base which eliminates the usual basing process at the factory, are among some of the recent improvements in cathode ray tubes developed by the Leybold & Von Ardenne Oscillograph Co. of Germany.

The use of a ceramic base rather than the usual glass pressed stem has brought about the reduction in length of from 2½ to 4 in. depending upon the type of tube with which this new base is used. The entire structure of the small 2-in. tube, base included, is hardly longer than the glass press of the ordinary present-day tube. The electrode terminals are heat processed along the periphery of the ceramic base. Through the use of this new ceramic socket the usual basing operations at the factory are eliminated and the electrical safety factor is raised because of increased separation between contact.

Another innovation which is used on the 2-in. tube as well as other types of tubes is the screen, which is ground to a plane to allow the making of measurements directly on the screen. This feature is further useful in connection with simple magnifying lenses, for these reproduce accurately only objects in one plane.

Recent British Radio Development

RECENT DEVELOPMENTS in British radio equipment, as evidenced by the exhibit at the Radio Manufacturers' Association held in London, August 25 to September 4, include as their chief feature television sets and all-wave radio receivers. Almost a score of miniature television theatres were available at this fair and the public was able to make comparisons between the various types of receivers offered for sale.

Recently the all-wave receiver has come into general use and the superheterodyne circuit is the leader in this field. Standard all-wave superheterodyne receivers are available from about $45 and up, and according to reports, are much superior to receivers sold at almost double the price several years ago. There is considerable evidence that television and sound broadcasting will develop as complimentary rather than rival services so that the effects of increased interest in television upon the prices of radio receivers has not been marked.

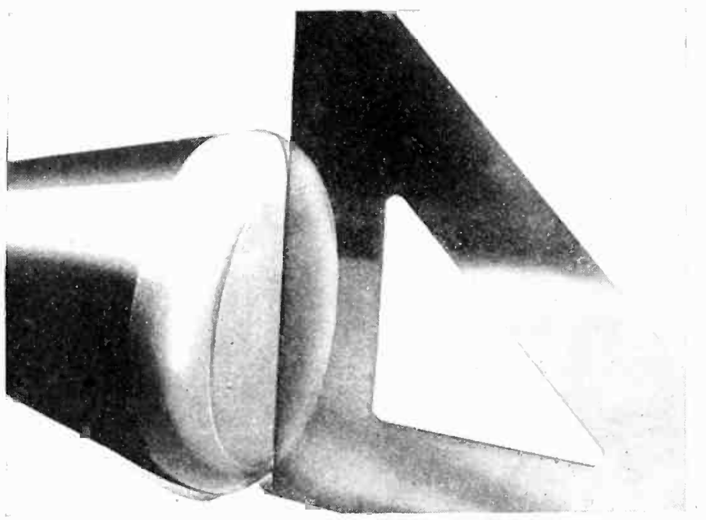
As is also true of this year's American radio receivers, a rather considerable emphasis is placed on tuning dials and controls of British radio sets. A number of models are also featuring variable selectivity in the intermediate frequency amplifier. The quality of reproduction has been improved over the receivers of last year and some models are available with phonograph, turntable and piezo-electric crystal pick-up for record playing.

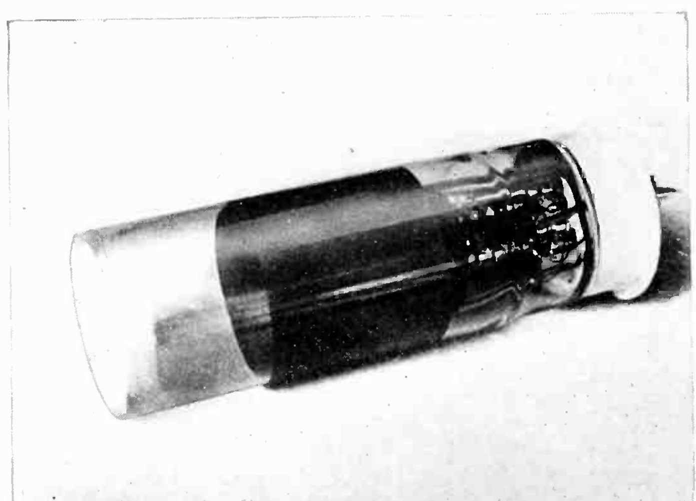
Considerable interest was shown in television receivers and models are available from about $300 to more than $800. It is claimed that at least some of the models available use a cathode-ray tube which gives a brilliant black and white picture of good detail and which may be used in daylight rather than in a darkened room. The size of the television image is reported in a number of cases to be larger than the 5 x 7 in. images which have been seen in this country. Some of the receivers produce images approximately 8 in. by 10 in. Another receiver provides a picture almost 14 in. by 11 in.

Electrotechnical Journal

THE OFFICIAL OVERSEAS edition of the *Journal of the Institute of Electrical Engineers of Japan* makes its appearance as Vol. 1, No. 1 for June 1937 as the *Electrotechnical Journal*. It is published in English, deals with Japanese technical advances in both the communication and power fields and gives some attention to research problems in electronics—that borderline region where engineers and physicists work hand in hand. By and large, the *E.T.J.* is for the English speaking Japanese electrical engineer approximately what *Electrical Engineering* is to the American electrical engineer.

The timely editorial on the first page states, in part: "Intimate contact between this country and other countries has been greatly handicapped by the barrier of conspicuous difference in language. However, it is felt to be highly desirable to surmount this barrier and to bring about deeper mutual knowledge and clearer understanding and to contribute, even if only a little, to international goodwill and the development of civilization". In fulfilling these aims, we wish the *E.T.J.* every success.





Recent improvements in Von Ardenne cathode ray tubes include a plane screen, as shown at the left where the end of the tube is placed in contact with a draughtsman's triangle. A two-inch cathode ray tube with ceramic base is shown at the right

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Mathematical Treatment of the Grid Bias Resistor

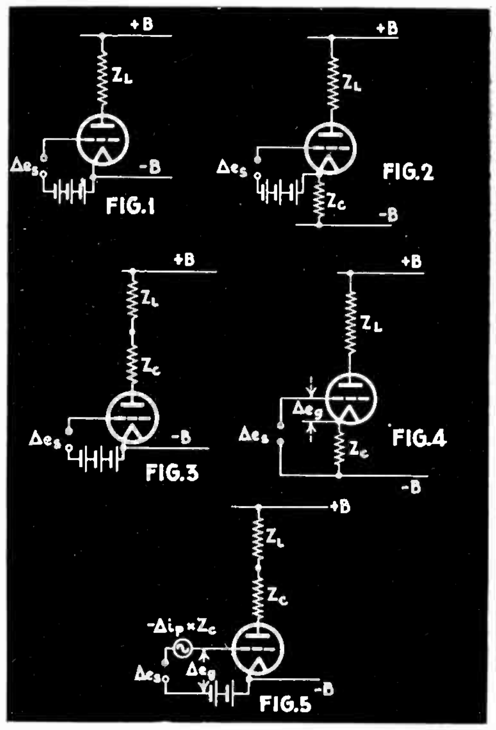
By W. *Richter*
A. O. Smith Corp., Milwaukee, Wis.

THE MOST WIDELY USED method of obtaining grid bias for amplifier tubes consists of passing the plate current through a resistor connected to the cathode. This so-called bias resistor must be shunted by a condenser to prevent degenerating effects at low frequencies. It is desirable to make this condenser as large as possible, but on the other hand not much is gained by going beyond a certain point. The following treatment is offered because it gives in a simple way the exact effect of the presence of any impedance in the cathode circuit.

According to the equivalent plate circuit theorem the introduction of a voltage Δe_g on the grid is equivalent to introducing $\mu \times \Delta e_g$ in the plate circuit. In Fig. 1, where a bias battery is used, the voltage Δe_g is equal to the signal voltage Δe_s. The current change in the plate circuit will therefore be

$$\Delta i_p = \frac{\mu \times \Delta e_s}{Z_l + R_p} \quad (1)$$

where μ is the amplification factor and R_p the plate resistance of the tube, while Z_l is the impedance of the load, which must be combined vectorially with R_p in the above formula.



In Fig. 2 we have an intermediate step; an impedance Z_c has been placed in the cathode circuit but the signal is still introduced with respect to the cathode. It is easily seen that the influence of Z_c is the same as that of Z_l as both simply reduce the actual plate voltage across the tube. The plate current change in Fig. 2 is therefore given by

$$\Delta i_p = \frac{\mu \times \Delta e_s}{Z_l + Z_c + R_p} \quad (2)$$

and Fig. 2 could be replaced by Fig. 3.

The actual circuit is shown in Fig. 4. The difference between it and Fig. 2 is that the actual voltage Δe_g put to the grid is not equal to the signal voltage Δe_s any more, but equal to the latter minus the voltage drop across Z_c caused by the plate current. If we therefore introduce in Fig. 3 another voltage in series with the signal voltage, equal to $\Delta i_p \times Z_c$ and opposing Δe_s we will then obtain the actual current for Fig. 4. Fig. 5 shows this fictitious circuit by which Fig. 4 can be replaced.

We have now

$$\Delta e_g = \Delta e_s - \Delta i_p \times Z_c$$

$$\Delta i_p = \frac{\mu \times \Delta e_g}{Z_l + Z_c + R_p}$$

$$= \frac{\mu (\Delta e_s - \Delta i_p \times Z_c)}{Z_l + Z_c + R_p}$$

Solving this for Δi_p we obtain:

$$\Delta i_p \left(1 + \frac{\mu \times Z_c}{Z_l + Z_c + R_p}\right) = \frac{\mu \times \Delta e_s}{Z_l + Z_c + R_p}$$

$$D\, i_p = \frac{\mu \times \Delta e_s}{(Z_l + Z_c + R_p)\left(1 + \frac{\mu \times Z_c}{Z_l + Z_c + R_p}\right)}$$

$$= \frac{\mu \times \Delta e_s}{Z_l + Z_c + R_p + \mu Z_c}$$

$$= \frac{\mu \times \Delta e_s}{Z_l + R_p + (\mu + 1) Z_c} \qquad (3)$$

Comparing this with equation (1) it shows that placing an impedance Z_c in the cathode circuit is equivalent to putting $\mu + 1$ times this impedance into the plate circuit, in series with the load impedance Z_l.

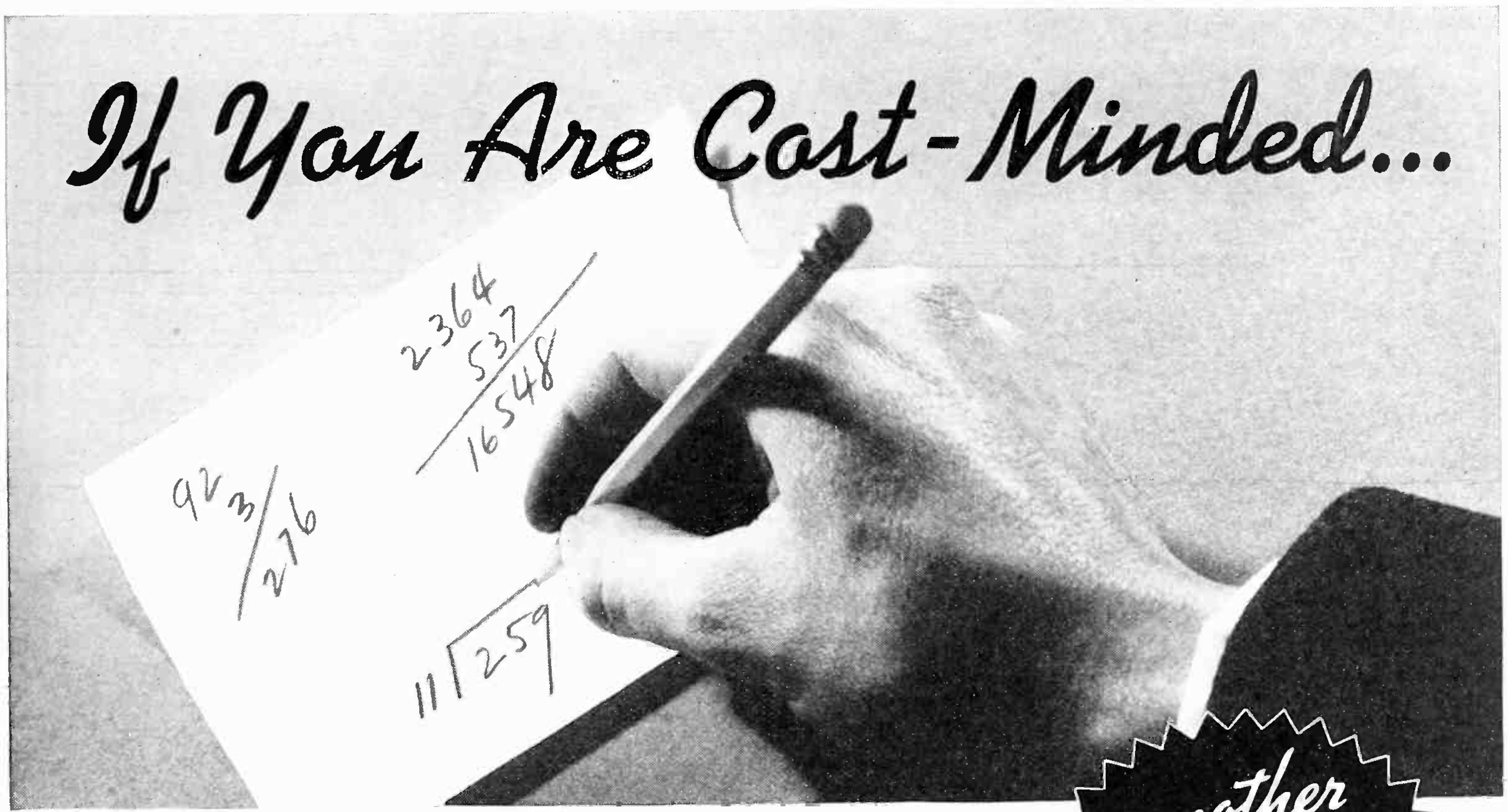
This opens up interesting possibilities. Thus it will be possible for instance by putting an inductance in the plate circuit to bring it to resonance with the condenser in the cathode circuit. Likewise inductances placed in the cathode circuit have the same effect as a much larger inductance in the plate circuit.

• • •

Bridge Balance Indicator

In making bridge measurements it is common practice to use a head set (preferably with an amplifier tuned to the frequency of the current used for making measurements) and to make adjustments aurally. A method of using a visual indicator for determining bridge balance is described by R. L. Garman in the September issue of the *Review of Scientific Instruments,* under the title "A Bridge Balance Indicator." In the introduction it is pointed out that a good bridge balance indicator should be constructed so that the minimum as well as the maximum points of complete balance may be determined with precision.

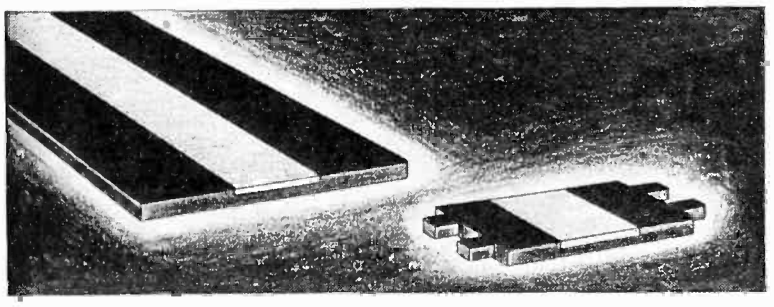
If You Are Cost-Minded...

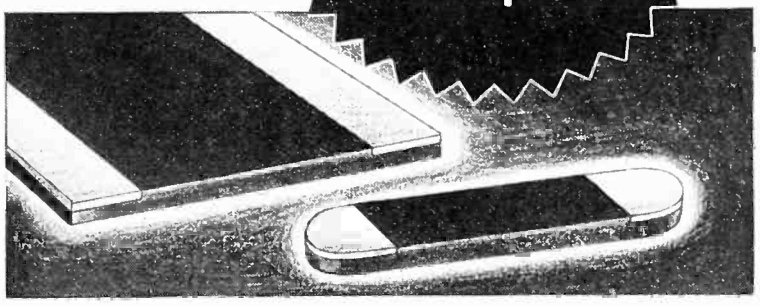


another WILCO Development

...You can't overlook

WILCO INLAY and OVERLAY Contact Materials





MANY users of electrical contacts are finding in Wilco Inlay and Overlay Materials a good opportunity to save money—and at the same time, increase the efficiency of their product. They save money—because the amount of precious metals required is reduced to a minimum.

They save time—because they simplify assembly and require no riveting. And they increase efficiency—because they become an integral part of the contact mechanism Dependable? Absolutely—for the base metal and precious metals are perfectly fused into a single strip. Even battering won't break them apart! Send for complete information.

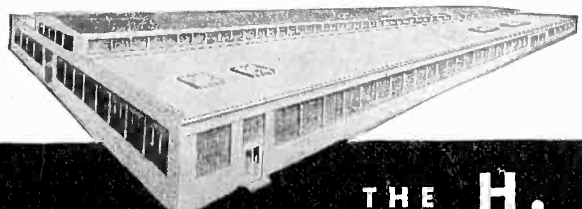
WILCO THERMOMETALS

(THERMOSTATIC BI-METALS)

Important News to Radio Manufacturers:

Did you know that Wilco Thermometal is now being used successfully to compensate for changes in the dielectric constant produced by temperature variations—thus compensating for drift? Our engineering staff will be glad to confer with you regarding this phase of your manufacturing—no obligation, of course.

In addition, send for the Wilco Blue Book of Thermometals, describing the complete line of Wilco Thermometals, and listing their characteristics.



THE H. A. WILSON CO.

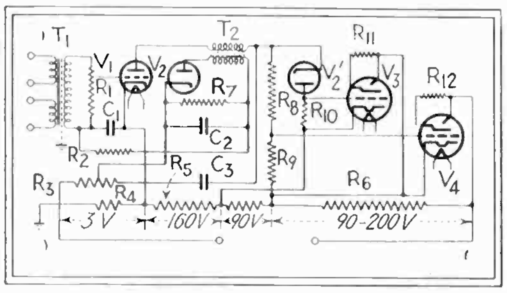
105 CHESTNUT STREET, NEWARK, N. J. BRANCH OFFICES · CHICAGO, ILL. · DETROIT, MICH.

Refiners and Workers of Platinum, Gold and Silver · Precious Metal Contacts · Wilco Thermometals (*Thermostatic Bi-metals*)

WILCO

The visual bridge balance indicator described operates by rectifying and filtering amplified signals from the bridge, and applying the resultant direct voltage to an indicator tube. The accompanying schematic wiring diagram shows the connections for this bridge balance indicator using electron ray tube indicators.

By means of the transformer *T1*, voltage from the bridge is applied to the grid of the high μ which serves as both an a-c and a d-c amplifier. After amplification the alternating voltage is impressed on the diode by means of



Bridge balance indicator diagram

transformer *T2* where a rectified voltage is applied to the resistor *R7* to the grid of the amplifier tube, *T1*, in such a direction as to decrease the steady plate current component of this amplifier. By means of the network *C1, R2, C2*, the a-c components are filtered out and a direct voltage is maintained at the grid of *V1* which is approximately equal to the peak voltage at the diode.

The function of the diode *V2* current is to prevent the grid of the indicator tube *VT3*, from becoming positive when the plate current of tube *V1* is reduced to cut-off. The indicator tube *V3* is used to determine the exact condition of balance of the bridge but when this range of operation is extremely small approximate balance is indicated by the electron ray tube *V4*. The resistor *R9*, across which the voltage for the input of *V4* is obtained, is so tuned that a current approximately 820 microamperes (the lower range of operation of *V3*) will produce a voltage drop just high enough to close the spector of this tube. When cut-off obtains for tube *V1*, the sector on *V4* will be fully opened, whereas the sector will just close for maximum current of the amplifier tube.

The final balance is nidicated by means of the tube *V3*. The only operation necessary to use this circuit as a bridge balance indicator is to adjust *R3* (with zero input voltage) until the sector on *V3* is almost closed. This instrument is now connected to an a-c bridge, this sector angle will become a minimum when the bridge is balanced; at all other points the angle will be greater than the minimum. If the bridge is not completely balanced for phase angle, *R3* may be readjusted in the direction to offset the residual deflection permitting *V3* to operate on scale.

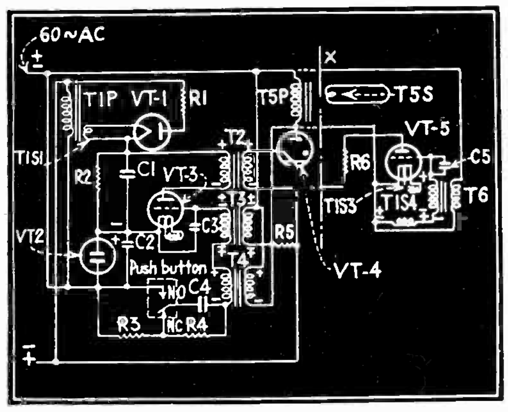
Thyratron Control Magnetizer

A METHOD OF EMPLOYING thyratrons in a control device for magnetizing permanent-magnet materials, especially magnets having small air gaps, is described by H. W. Lord in an article "A Half-Cycle Magnetizer with Thyratron Control" in the September issue of the *General Electric Review.*

The half-cycle type of control may be used to advantage when no source of direct current is available and when the magnets to be energized are of the variety easily adapted to the multi-turn coil and iron-core method of magnetizing. The schematic wiring diagram of a unit for magnetizing material in this manner is shown.

Briefly the operation of this circuit is as follows:

Capacitor *C1* is charged through the rectifier tube *VT-1* and glow tube *VT-2* from the a-c supply. Capacitor *C2* is charged through *R2* from the same rectifier circuit to a potential determined by the voltage drop across tube *VT-2*. The voltage across *C2* is applied as a negative bias to the grid of thyratron tube *VT-3* through resistors *R3* and *R4* and the secondaries of transformers *T4* and *T3*. Transformer *T3* in conjunction with resistor *R5* functions as a peaking transformer whose secondary introduces a peaked voltage into the grid circuit. The positive peak of this voltage occurs soon after the start of the positive half-cycle of sinusoidal voltage impressed on the anode of ignitron tube *VT-4* from the line through coil *T5P*. With the switch in the normally closed position, most of the peaked voltage from *T3* appears across *R3* as the impedance of capacitor *C3* to the peaked wave is low compared to that of *R3*. The negative bias voltage supplied by *C3* is high compared to the slight ripple voltage introduced across *C3* by *T3* under this circuit condition and tube *VT-3* is therefore kept in a nonconducting state.



A magnetizing impulse through the coil *T5P* is obtained each time the normally open contact is closed after opening the normally closed contact. When contact normally open is closed resistor *R3* is shunted by capacitor *C4*. The capacity of *C4* is large compared to that of *C3* so the peaked wave from *T3* now appears principally across $C3$. The peak of this voltage is greater than the negative bias supplied by $C2$, so thyratron tube $VT\text{-}3$ will be rendered conducting during the first positive peak from $T3$ following the closing of the normally open contact. Conduction of $T3$ permits capacitor $C1$ to discharge through the primary of transformer $T2$, the secondary of which impresses a positive-impulse voltage on the ignitor of ignitron tube $VT4$ of sufficient magnitude and duration to form a cathode spot on the mercury pool. Since the phasing of the peak voltage from $T3$ with respect to the line voltage is such that this firing impulse occurs soon after the anode of tube $VT\text{-}4$ has gone positive, tube $VT\text{-}4$ will conduct from anode to cathode for the remainder of the half-cycle, impressing full line voltage across coil $T5P$ for this period. The resultant impulse of high current through $T5P$ induces a strong magnetic unidirectional field which may be used for magnetizing purposes.

Advantages claimed for the thyratron-control magnetizer are (a) compactness, (b) inexpensive operation, (c) rapid operation, (d) low power consumption because of the short duration of time in which the unit is operative, (e) adaptability to automatic machine methods.

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MANUFACTURING REVIEW

News

✦ Orders received by the General Electric Company during the first nine months of this year, have amounted to $305,276,556, an increase of 44 per cent over the $211,891,038 received during the same period last year, President Gerard Swope announced recently. Orders received during the third quarter of 1937 amounted to $88,010,937, compared with $74,922,441 during the corresponding period last year, an increase of 17%. The first quarter in the first nine months of this year was the largest of any corresponding period since 1929.

The sales billed by G.E. during the first nine months of 1937 amounted to $260,773,533 compared with $189,263,156 during the corresponding 1936 period, representing 38 per cent. Profit available for dividends for the first nine months of 1937 amounted to more than $39,663,000 or an increase of 50 per cent over that of last year. Dividends of 40 cents per share were paid for each of the three quarters of 1937.

✦ In order to provide for an expansion of development and manufacturing program of the Allen B. DuMont Laboratories, Upper Montclair, N. J., the laboratories have registered the proposed sale of 20,000 shares of $1 par stock with the S.E.C. Starting in the production of cathode ray tubes on a small scale in 1930, Mr. DuMont has built up his organization to the point where additional manufacturing facilities are required.

✦ The new television transmitter of the Columbia Broadcasting System is being given its first power test at Camden, N. J., and will probably be ready for delivery to CBS in New York shortly after the first of the year. The transmitter will be installed on the 73rd and 74th floors of the Chrysler Building where it will provide television programs from the Grand Central Station studios now being built by Columbia. The sound and picture portions of the television transmitter have a rating of 7½ kw. each.

✦ New York City's new two-way radio system for fire boats was formally put into operation October 5 and makes possible communication between the City of New York and each of its nine fire boats. The equipment was designed, built and installed by the General Electric Company.

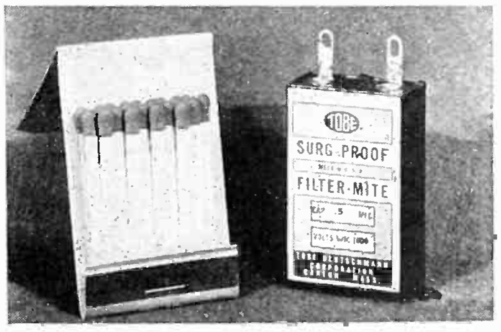
✦ The entire factory of the Fairchild Aerial Camera Corporation has recently been moved to 8806 Van Wyck Boulevard, Jamaica, L. I., N. Y.

✦ Expansion of its engineering department for its routine engineering activities as well as an expanded research program is announced by the Clarostat Manufacturing Company, 235 Sixth Street, Brooklyn, N. Y.

New Products

Filter Condenser

A SMALL SIZE paper dielectric condenser is announced by the Tobe Deutschmann Corporation, of Canton, Mass., under the name of "Filtermite." Capacitances between 0.05 mfd. and 4 mfd. are available in 1,000 and 600-volt d-c ratings. The illustration shows a 0.5 mfd. condenser with a rating of 1,000 volts.



Catalog & Literature Service

Manufacturers' literature constitutes a useful source of information. To make it easy to keep up to date, "Electronics" will request manufacturers to send readers literature in which they are interested.

1. **Tube Gain.** *The Engineering News Letter* No. 42, published by the Hygrade Sylvania Corporation, Emporium, Pa., gives a tabulation of gain values based upon performance of available voltage amplifier tubes.

2. **Double Triode.** Technical data has been released by the Raytheon Production Corporation, 55 Chapel Street, Newton, Mass., on the 6F8G twin triode amplifier.

3. **Tube Data Sheets.** Engineering data sheets for the type 211B, 203A, 203H, 845, 805, 833, 276A and 261A for enclosure in their catalog (mentioned in the October issue of *Electronics*) is available from the Amperex Electronic Products, Inc., 79 Washington Street, Brooklyn, N. Y.

4. **Police Radio Equipment.** A 20-page bulletin on "Police Radio Telephone for the Small City or Town," is available from the Western Electric Company, 195 Broadway, New York City.

5. **Aircraft Receiver.** A new bulletin issued by the Western Electric Company, 195 Broadway, New York City, describes and illustrates the type 20 aircraft receiver and accessories which are being introduced for receiving the 500 kc. international distress frequency.

6. **Oscillograph.** The type 168 all-purpose 5-in. cathode ray oscillograph is described in a 4-page bulletin issued by the Allen B. DuMont Laboratories, Inc., Upper Montclair, N. J.

7. **Electrical Control Equipment.** Catalog 4071-A of the American Automatic Electric Sales Company, 103 West Van Buren Street, Chicago, describes relays, stepping switches, electric counters and a wide variety of similar control apparatus for electrical purposes.

8. **Underground Cable.** Bulletin UC-2 dealing with concentric type cables for direct earth installation on single phase systems has just been announced for distribution by the General Cable Corporation, 420 Lexington Avenue, New York City.

9. **Coaxial Cable.** A single page folder is available from the Transducer Corporation, 30 Rockefeller Plaza, New York City, describing a new low loss coaxial cable known as CO-X.

10. **Mica Insulating Material.** A 20-page catalog on "Micabond" insulating material is announced for distribution by the Continental Diamond Fibre Company, Newark, Del.

11. **Insulating Material.** The properties of ceramic insulating materials are listed in a chart released by the American Lava Corporation, Chattanooga, Tenn.

12. **Vibrators.** A folder on vibrators for d.c. voltage step-up and d.c.-a.c. conversion, as reprinted from the September issue of *Electrical Manufacturing*, is available from the Electronic Laboratories, Inc., 122 West New York Street, Indianapolis.

13. **Radio Transformers.** To facilitate the easy selection of radio transformers and chokes, the Jefferson Electric Company, Bellwood, Ill., has published a 16-page catalog, No. 372-R.

14. **Broadcast Components.** A 48-page catalog of power and audio frequency transformers and related equipment for broadcast and other audio services is available from the United Transformer Corporation, 72 Spring Street, New York City. A wide variety of curves of U.T.C. transformers and design information is included in this bulletin.

15. **Condenser Catalog.** The Cornell Dubilier Electric Corporation, South Plainfield, N. J., has issued catalog No. 153-A, a comprehensive folder listing transmitting condensers.

16. **Vibration Pickup.** Literature describing its complete line of vibration pickup is available from the Brush Development Company, 3311 Perkins Avenue, Cleveland, Ohio.

17. **Line Voltage Switch.** A 4-page folder showing some of the typical uses of a new line voltage switch is available from the National Acme Company, Cleveland, Ohio.

18. **Pyrometers.** Catalog No. 1101C describes high speed photoelectric action pyrometers manufactured by the C. J. Tagliabue Manufacturing Company, Park & Nostrand Avenues, Brooklyn, N. Y.

19. **Paging System.** A 4-page bulletin describing an automatic paging system is available from the Babaco Company, 447 West 19th Street, New York City.

20. **Battery Life.** A 24-page bulletin entitled "The A.B.C. of Radio Battery Life", providing information for radio dealers and service men on the subject of radio batteries is available from the National Carbon Company, New York City.

21. **Telecord.** A 4-page bulletin describing the dictaphone Telecord, an electric recording instrument for continuous recording of speech or other sounds, is published by the Dictaphone Sales Corporation, Graybar Building, New York City.

22. **Clear Reception.** Under the title of "Clear Reception" a folder on the subject of background noise suppression is offered by the Aerovox Corporation, 70 Washington Street, Brooklyn, N. Y.

23. **Service Manual.** A 208-page service manual, the major portion of which is devoted to the listing of replacement parts for radio receivers has recently been published by the Clarostat Manufacturing Company, Inc., 281 North Sixth Street, Brooklyn, N. Y.

24. **Non-Inductive Resistors.** A folder describing non-inductive resistors having a normal accuracy of 1 per cent has been released by the Cinema Engineering Company, 7606 Santa Monica Boulevard, Hollywood, Calif.

ELECTRONICS **November**

Please request manufacturers to send me, without obligation, literature identified by numbers circled below.

1	2	3	4	5	6	7	8	9	10	11	12	13	14
15	16	17	18	19	20	21	22	23	24	25	26	27	28
29	30	31	32	33	34	35	36	37	38	39	40	41	42
43	44	45	46	47	48	49	50	51	52	53	54	55	56

NAME .... TITLE ....

COMPANY ....

ADDRESS ....

CITY .... STATE ....

Television Tubes

RELEASED for distribution October 15, the Radiotron Division of the RCA Manufacturing, Harrison, N. J., announces two kinescopes for experimenters and amateurs who wish to construct experimental receiving equipment. Although the manufacturers are careful to point out the experimental status of these tubes, the announcement of the commercial availability of two kinescopes indicates unmistakably that television has been brought one more step closer to general use.

The RCA kinescopes announced are the types 1800 and 1801, both of which are of the electromagnetic deflection type and employ viewing screens on which pictures appear with a yellow hue. The RCA-1800 has a 9" screen while the RCA-1801 has a 5" screen. According to technical data released by RCA both tubes have a heater voltage of 2.5 volts and draw 2.1 amperes. A medium 6 pin base is used for the 1800 and a medium 5 pin base for the 1801. The former tube has a maximum second anode voltage of 7,000, a focussing electrode voltage of 2,000, maximum, with a maximum screen input of 10 milliwatts per sq. cm. The screen input rating for the 1801 is the same as for the 1800 but the maximum second anode and focussing voltages are 3,000 volts and 1,000 volts, respectively. Both tubes employ fluorescent screens of medium persistence.

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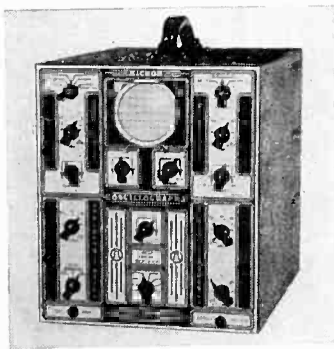
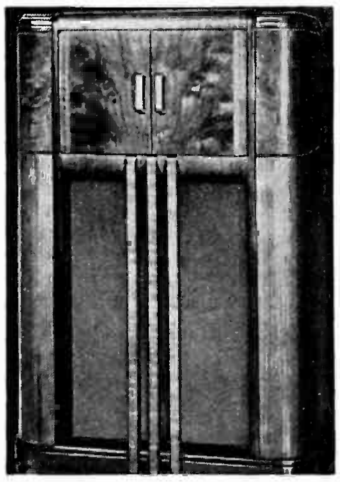
Oscillograph

SELF CONTAINED demodulator, high sensitivity, amplifier for horizontal sweep expansion, and cathode ray tube rotation adjustable by means of a flexible mounting, are some of the features claimed for the new model RFO-4 oscilloscope recently announced by the Hickok Electrical Instrument Company, of Cleveland, Ohio.



High Frequency Receiver

AFTER A YEAR of development the Hammarlund Manufacturing Company, Inc., 424 West 33rd Street, New York City, announced a console to house their



"Super-pro" professional receiver. The receiver housed in the console is identical with the standard model and may be available to cover the range of 7½ to 240, 15 to 560 or 15 to 2,000 meters.

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Vibrator Power Supply

TO MEET the demand for a 12-volt vibrator power supply to be used on airplanes, buses, and motor boats for radio transmitters, receivers, and other scientific apparatus, the P. R. Mallory & Company, Inc., of Indianapolis, announce their new Vibrapack model VP-G556. This unit delivers a nominal maximum output of 300 volts at 100 milliamperes.

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Inter-Communicating System

THE MODEL 105 Teletalk developed by the Webster Electric Company, Racine,

Wis., is a loud speaker inter-communicating system where inter-communication between a central and from one to five remote points is desired, either selectively or as a group.

Call System

Two new inter-communicating call systems, one of which requires no connecting wires, are announced by the RCA Manufacturing Company, of Camden, N. J., to signal the entry of this company into the expanding field

of office communication equipment. One of these systems uses direct wire connections between the various stations in the system, the other is a carrier-operated device using the power line as the transmission medium.

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Indicating Paint

Paint which changes color when exposed to heat, the color change of which is either permanent or retroactive and which is available in a wide variety of temperature and color ranges have been developed by the Eskalin Company, 572 Greenwich Street, New York City. Permanent or retroactive color changing inks are also available.

It is impossible to resist the suggestion that a retroactive paint applied to metal tubes would guard against many a burnt finger.

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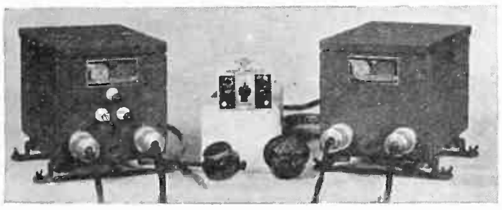
Aircraft Radio Equipment

A new aircraft transmitter and four new receivers have been announced by the RCA Manufacturing Company,



Camden, N. J. The 20-watt transmitter is capable of 100 per cent modulation for telephone transmission or may be used for C. W. transmission. All four receivers have three frequency bands, 195 to 420 kc., 490 to 1,400 kc., and 2,300 to 6,700 kc.

Signal Generator

RECENTLY ANNOUNCED by the Hickok Electrical Instrument Company, Cleveland, Ohio, the model PSG-15 signal generator has its output calibrated directly in microvolts. It provides a range of one-half microvolt to 100,000 microvolts at radio frequencies from 85 kc. to 28 mc. or from 0 to 2 volts at audio frequencies.

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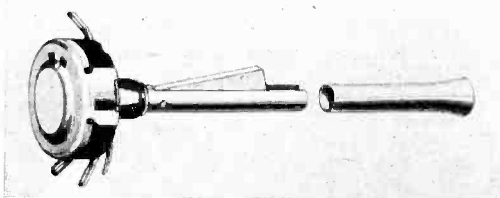
Volume Control

A NEW LINE of universal replacement control available with or without switch in resistance values of ¼, ½, 1 and 2 megohms has recently been announced by Centralab, 900 East Keefe Avenue, Milwaukee, Wis. All are tapped for tone compensation.



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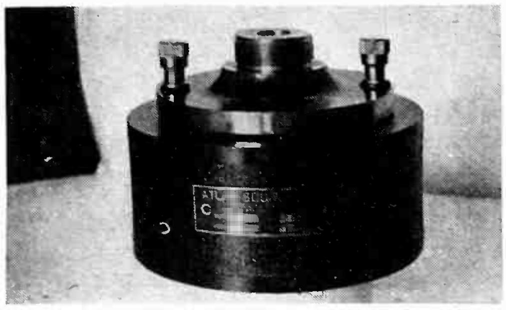
Four-Stage Amplifier

A 35-52 WATT amplifier using eight tubes in four stages, mixing two microphones and phonographs and suitable for use with any type of microphone is the model 835 amplifier recently announced by the Operadio Manufacturing Company, St. Charles, Ill.

20-Watt Speaker

A PERMANENT MAGNET dynamic speaker with an operating power rating of 20



watts has been developed by the Atlas Sound Corporation, 1451-39th Street, Brooklyn, N. Y.

BACKTALK

Middle C

Last spring you sent out a questionnaire asking, among other things, for matter suitable for editorial treatment. At that time I contemplated suggesting that you undertake to dispel the idea, rather current among engineers, that the present practice is to tune the middle C of the piano to 256 cycles/second. Then in May your Spectrum Chart appeared. This worthwhile chart we feel is injured by the following errors, which occur in connection with the "Audible Spectrum".

The musical instrument ranges appear to have the identical errors incorporated in a chart published about ten years ago; namely, every one of the woodwind ranges has something wrong. Although a piano keyboard is indicated, frequencies are shown computed on the just scale, instead of the tempered scale usually associated with the piano. Worst of all is the fact that the frequencies are given on the basis of physical pitch.

There has been much misunderstanding, which has been perpetuated by the continued appearance of such charts as the one under discussion. It is unfortunate that a magazine purporting to provide accurate information should give musical instrument ranges based on a pitch standard that is not, and with the exception of specially tuned instruments, never has been the standard for musical performance.

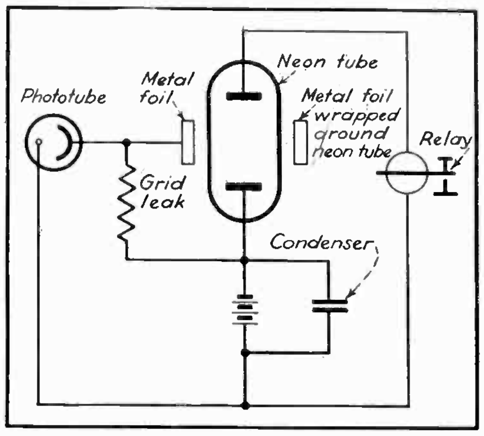
A range chart recently prepared by this company comes nearer to showing actual musical usage. A coming issue of the magazine of the American Standards Association is, I understand, to carry an article pertinent to this matter.

ROBERT W. YOUNG,
Physicist,
C. G. Conn, Ltd.

Questions and Answers

10. Brooklyn—*Is it possible to use an ordinary neon tube in the place of a "grid-glow tube"?*

[A] Yes. If a metal foil is wrapped around the outside of the bulb, and if a critical potential between 90 and 135 volts is applied to it and a photo tube, and if the cell is illuminated by a source of light, a discharge will take place between the inner electrodes of the neon tube which is sufficient for many purposes, and if not, a low impedance relay may be placed in series with the inner electrodes.



11. Glendale, Calif.—*Am interested in a radio picture transmission system and would like to use the silver emulsion on the film as a contact but find it to have a high resistance. Is it possible to increase the conductivity?*

[A] It is possible to deposit a metallic film of silver on the silver image with

Solution 1

Pyrogallol	50 grains
Citric acid	125 grains
Water	10 ounces

Solution 2

Silver nitrate	100 grains
Water	10 ounces

Flow over the surface of the wet film with Solution 1, and after a few minutes add a few drops of Solution 2. This may be repeated as many times as is desired to get the desired thickness of silver. Metallic copper may be electroplated on the silver image in the customary fashion.

An alternative method is to place the print or negative in contact with a copper plate in the presence of a mild silver solvent such as dilute hypo or ammonium chloride solution. It seems to work best with chloride papers. The silver image plates out on the copper. X-ray films which are rich in silver ought to give better results.

British Patents

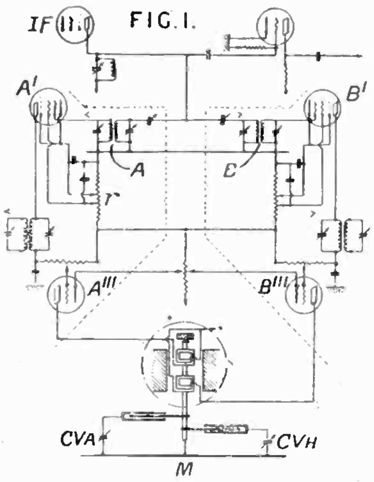
Radio Circuits

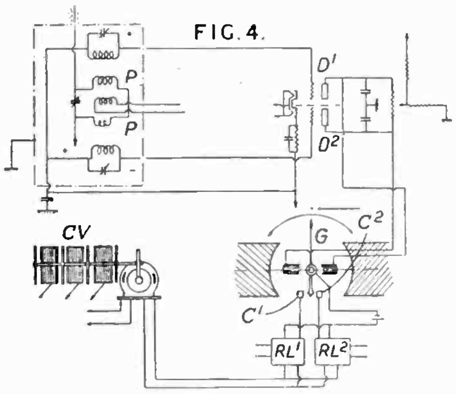
Electric resonant units. A quarter-wave-length resonator of compact construction and compensated to prevent variation of frequency with temperature. Marconi Co. No. 460,118; 460,119.

Tuning system. In a superheterodyne using an aperiodic aerial input, the variable tuning of the receiver is located exclusively in the local oscillator circuit of the first tube and is remotely situated therefrom. E. K. Cole, 460,305.

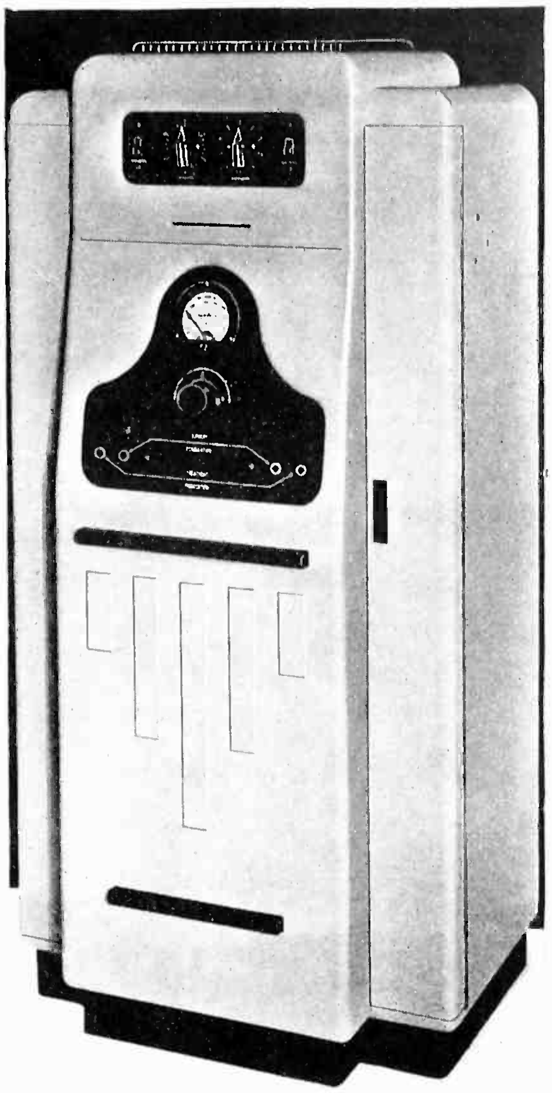
Band Widening system. Means for expanding the band width symmetrically about the carrier and a second means to expand it unsymmetrically with respect to the carrier to select more of one sideband than the other. Hazeltine Corp. No. 460,821.

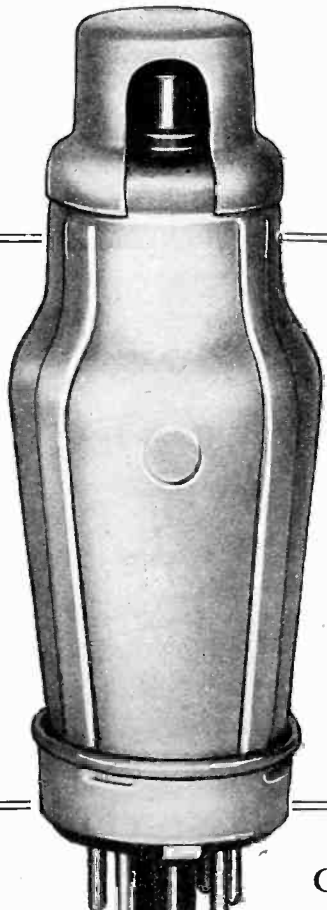
Automatic tuning. The tuning elements of a manually-controlled receiver are automatically kept in exact tune to the desired frequency by an error detector embodying circuits resonant above and below the desired frequency and acting in opposition on a regulating member. G. Henry. No. 460,987.





Antenna system. Improvements in matching and coupling an antenna to a wireless receiver when a two-wire transmission line is employed. Hazeltine Corp. No. 462,872.





PATENT SUITS

1,997,051, B. A. Engholm, Loud speaker, filed Feb. 5, 1937, D. C. N. J., Doc. E 5671, *Rola Co.* v. *Best Mfg. Co., Inc.*

2,007,253, W. A. MacDonald, Wave signaling system, filed Feb. 9, 1937, D. C., E. D. Va., Doc. E 393, *Hazeltine Corp.* v. *Stewart-Warner Corp.*

1,881,324, H. E. Metcalf, Signal reproducer, D. C., N. D. Ill., E. Div., Doc. 12713, *The Magnavox Co.* v. *Transformer Corp. of America.* Dismissed for want of prosecution Oct. 13, 1936.

1,958,031, E. L. Bresson, Radio receiving system, appeal filed Apr. 15, 1937, C. C. A., 2d Cir., Doc. —, *W. Avery et al.* v. *Davega-City Radio,* Inc.

1,403,475 (*a*), H. D. Arnold; 1,403,-932, R. H. Wilson; 1,507,016, L. de Forest; 1,507,017, same; 1,618,017, F. Lowenstein; 1,702,833, W. S. Lemmon; 1,811,095, H. J. Round, filed Apr. 12, 1937, D. C., N. D. Calif. (San Francisco), Doc. E 1466-R, *R.C.A. et al.* v. *Cavalcade Radio Corp. et al.*

1,403,475 (*b*), H. D. Arnold; 1,465,-332, same; 1,507,016, L. de Forest; 1,507,017, same; 1,573,374, P. A. Chamberlain; 1,618,017, F. Lowenstein, D. C. Minn., 4th Div., Doc. E 2962, *R.C.A. et al.* v. *Karadio Corp.* Consent decree holding infringement by defendant; injunction Apr. 17, 1937.

ADVERSE DECISION

In interferences involving the indicated claims of the following patents final decisions have been rendered that the respective patentees were not the first inventors with respect to the claims listed:

Pat. 1,855,055, J. K. Johnson, High frequency transformer, decided March 20, 1937, claims 1 and 8.

ADJUDICATED PATENTS

(D. C. Md.) Lowell and Dunmore patent, No. 1,455,141, for radio receiving apparatus, claims 1 to 4, 7, 13, 14, and 18 *Held* invalid and not infringed. *Lowell* v. *Triplett*, 17. F. Supp. 996.

(D. C. Md.) Dunmore and Lowell patent, No. 1,606,212, for power amplifier, claims 1 to 9 *Held* valid and infringed. Id.

(D. C. Md.) Dunmore patent, No. 1,635,117, for signal-receiving system, claims 9, 11, and 12 *Held* invalid and not infringed. Id.

(C. C. A. Md.) Maibohm patent, No. 1,930,980, for variable electrical resistor and switch, claims 5 to 8 *Held* invalid. *Maibohm* v. *RCA Victor Co.*, 89 F.(2d) 317.

BRITISH TELEVISION RECEIVER

In television sets, as in sound receivers, the British buyer now has a wide choice. Above is a $100) Philips model

Trilinear Coordinates

ALTHOUGH PERHAPS first used extensively in metallurgy to represent the property of ternary alloys, trilinear coordinates are finding extensive application in other fields. A system of trilinear coordinates as a means of classifying electron tubes was published in *Electronics* in May, 1934. A more general discussion of the problem, together with the mathematical background facilitating the construction of trilinear coordinate charts, is discussed by Howard Aiken in the July issue of the *Journal of Applied Physics*, under the title "Trilinear Coordinates." In this article, two tube classification charts are shown in which the electrical characteristics of a tube may be indicated by properly locating a point on the chart. In order to cover a wide range of variables, logarithmic rather than linear scales are used. In one of the charts, a single point specifies for a given tube its transconductance, its plate resistance, and its "durchgriff" or $\frac{1}{\mu}$. In another chart, which is really one of quadlinear rather than trilinear coordinates, it is possible to locate for a given tube the characteristics of amplification factor, plate resistance, mutual conductance, and a figure of merit defined as the product of the amplification factor and the mutual conductance.

Phonograph Pickup Tracking Error

(*Continued from page 23*)

tion due to skidding. Moreover, such distortion would likely be more displeasing and might entirely mask the latter.

It now remains to consider the effect of tracking error on record wear. It is believed that the effect of changing the line of action of the needle force against the groove walls by the usual tracking angle is negligible because the direction of this line of action is constantly changing anyway as the groove progresses past the needle point. The possibility of wear due to change in the tracking angle during playing appears to have some theoretical foundation. The needle is continually being ground to fit the groove and a rapid change in tracking angle tends to maintain a freshly sharpened cutting edge at the point of contact. A mitigating factor, however, is the possibility that the shift in bearing point as the needle follows a curve (see Fig. 8) may have a "rounding off" effect on the cutting edge. The fact that our 1930 experiments did not reveal this or any other effect of a comparatively large tracking error; the support given to this result by the later analysis; and the widespread acceptance in this country of phonographs with conventional pickup arrangements, leads to the conclusion that ordinary amounts of tracking error are negligible in their practical effect. More experiments and better methods of measurement are required to settle this question more definitely.

[1] E. A. Chamberlain, "Correct Pickup Alignment"; *Wireless World*, 3-26-30.

[2] Ralph P. Glover, "A Record-Saving Pickup"; *Electronics*, February 1937.

[3] J. M. Bird and C. M. Chorpening, "The Offset-Head Crystal Pickup"; *Radio Engineering*, March 1937.

[4] L. J. Sivian, H. K. Dunn and S. D. White, "Absolute Amplitudes and Spectra of Certain Musical Instruments and Orchestra." *Jour., Acous. Soc. Am.*, Vol. 2, Jan. 1931, p. 155.

[5] Frank Massa, "Permissible Amplitude Distortion of Speech in an Audio Reproducing System", *Proc. I.R.E.*, May, 1933, p. 682.

[6] H. A. Frederick, "Vertical Sound Records; Recent Fundamental Advances in Mechanical Records on Wax", *Jour. S.M.P.E.*, Feb. 1932, p. 141.

News Pictures By Wire

(*Continued from page 17*)

A carrier of 1800 cycles is produced by chopping the light beam rather than by introducing a carrier tone in the electrical portion of the system. On this carrier are superimposed sidebands of about 800 cycles corresponding to the picture signal. All frequencies below 1 kc. are suppressed.

Synchronization is maintained through the use of temperature controlled fork driven oscillators. Although about 20 minutes are required for the forks to reach their equilibrium temperature, satisfactory transmission is obtained with the forks "cold." The equipment operates from 110 volts a-c or d-c.

For portable work the fork driven synchronizing oscillator, amplifiers, and other tube equipment forms one unit, whereas the scanning unit forms the other. The drums are protected against light, so operation may be carried out in daylight.

Times Wide World

The Times Wide World equipment, is intended to be used by photographers rather than by engineers, so that every effort has been made to simplify operation. Several times, when necessity demanded, a photographer sent in pictures without any more instruction concerning the operation of the equipment than was contained on the case of the transmitting unit. At present the Times Wide World system includes 40 portable transmitting units and fixed equipment in 15 cities. The portable transmitting equipment requires only a 6 volt storage battery for complete operation; it does not depend upon 110 volt circuits.

On the transmitting drum, the Times system makes use of the floodlighted picture, and makes selection of the desired picture element in the phototube optical circuit. In the receiving end, the latent image is built up through the use of a neon gaseous discharge tube.

The transmitting equipment operates from a 6 volt battery which drives two generators. One of these provides the plate supply for the amplifying tubes; the other generates 1800 cycle current for the carrier. The carrier serves the double function of getting the picture signal through the telephone circuit and of providing the synchronizing signal, for the drum in the receiver is driven by the amplified carrier current. Synchronization through the use of transmitting the carrier occasionally produces drift or skewness when carrier telephone circuits are employed because the demodulated signal frequency is not always exactly of the same frequency as that fed into the phone circuit. A drift compensator forms a part of the Times system to get around this trouble.

The normal scanning speed is about 7 in. per second, the scanning pitch is 96 lines per inch and from 4 to 4½ sq. in. of area are scanned per minute. The drums are constructed to take pictures up to 7" x 9". The range between the black and white portions of the picture is 7 db. as against about 20 db. in other systems.

Phasing is readily accomplished at the receiving end by aligning a slot in the receiving drum with the phasing flash which occurs in the neon lamp when the white phasing spot in the transmitter is scanned.

Western Union

Western Union does not maintain a picture transmission service, but it has opened a telegraph facsimile service between New York and Buffalo and Chicago. Although this service is neither intended nor recommended for the transmission of half-tone pictures, it has been put to this use and has produced useable results, and for this reason merits passing mention in this story. It is hoped to cover the Western Union facsimile system in an early issue of *Electronics*.—B.D.

References:

"Three Color Picture Sent by Wire" by Walter L. Bassett
Editor and Publisher, June 5, 1937.
"A New Telephotograph System" by F. W. Reynolds.
Electrical Engineering, Vol. 55, pp. 996, September 1936
Bell System Tech. Jour., Vol. XV, pp. 549–574, October 1936
"Radio Progress During 1936, Part IV"
Proc. I. R. E., Vol. 25, No. 2, pp. 199–203, February 1937.
"The Last Word in Telephotography" by John Mills
Bell Telephone Quarterly, Vol. XIV, No. 1, pp 13–22, January 1935
Radio Engineering Handbook, McGraw-Hill Book Co.
Electrical Engineers Handbook—Communications and Electronics, John Wiley & Sons.

Distortion of Saw Tooth Wave Forms

(*Continued from page 38*)

such equivalent circuits need be considered no further here. The equivalent circuit damping can be varied within wide limits in transformer and resistance-coupled amplifying stages, by the effective damping of the tube resistance in the former and by proper values of the coupling elements in the latter. The relation between this damping and the phase-shift with respect to the resonant frequency of the system can be evaluated from Fig. (7), the curves of which are drawn for a few characteristic damping values. As shown in Fig. (1), the "center of gravity" of the Kipp frequency spectrum lies near the second harmonic for average values of retrace time. From Fig. (7) and the relations given there, it follows that after the resonance frequency of the equivalent circuit is adjusted to the "center of gravity" of the Kipp spectrum, a damping value can be assigned which is just sufficient to cause a critical phase-shift of the fundamental, i.e. 1.4°. This constitutes a solution to the problem of a coupling network or amplifying stage for Kipp oscillations.

Summary

The amplitude distribution of the frequency spectrum of Kipp oscillations with arbitrary retrace times is stated. The effect of eliminating or attenuating the higher order harmonics is investigated. The elimination of all frequencies whose period is smaller than the retrace time is discussed as the most important special case. The effect of a phase-shift of the fundamental with respect to the other harmonics on the distortion factor of originally linear Kipp oscillations is extensively discussed.

• • •

Rochester Fall Meeting

WE'LL BE LOOKING for you at the Rochester Fall Meeting of the I. R. E. and R. M. A., November 8-10, at the Hotel Sagamore.

Screens for Television Tubes

(Continued from page 34)

electron gun; and third, reflected secondary electrons from willemite itself.

Cold emission from the electron gun results from insufficient polishing and rounding off of sharp edges of the gun and should not be present in a well-designed and well-made tube,

Secondary emission from the electron gun is caused by the electrons striking the masking aperture of the gun. If the focusing field penetrates as far as the stopping aperture then the random moving secondaries will be drawn by the field into the region of second anode, and eventually may strike the screen, causing a loss of contrast. This effect is never present in a well-designed tube.

The third source of stray electrons, i.e., the reflected and secondary electrons from the willemite itself, is practically negligible. The number of reflected (high velocity) electrons is so small that their effect is hardly detectable. The velocity of the majority of the secondaries on the other hand is also too small to excite the screen.

(d) *Direst reflection of light.* Reflection from other parts of the tube are another factor contributing to the loss of contrast. The glass bulb itself reflects only around 10 per cent or less of light falling on it. More serious offender is the conductive coating of the second anode which, even when covered with carbon or graphite, reflects a considerable amount of light.

Editor's note: The complete table of contents of the book from which these abstracts were taken is as follows:

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(Copy for new advertisements must be received by the 26th of the month to appear in the issue out the following month)

LEGAL NOTICE

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACTS OF CONGRESS OF AUGUST 24, 1912, AND MARCH 3, 1933

Of Electronics, published monthly at Albany, N. Y., for October 1, 1937.

State of New York } ss.
County of New York }

Before me, a Notary Public in and for the State and county aforesaid, personally appeared D. C. McGraw, who, having been duly sworn according to law, deposes and says that he is the Secretary of the McGraw-Hill Publishing Company, Inc., publishers of Electronics, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, as amended by the Act of March 3, 1933, embodied in section 537, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are: Publisher, McGraw-Hill Publishing Company, Inc., 330 West 42nd Street, N. Y. C. Editor, Keith Henney, 330 West 42nd Street, N. Y. C. Managing Editor, Donald G. Fink, 330 West 42nd Street, N. Y. C. Business Manager, H. W. Mateer, 330 West 42nd Street, N. Y. C.

2. That the owner is: (If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding one per cent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a firm, company, or other unincorporated concern, its name and address, as well as those of each individual member, must be given.) McGraw-Hill Publishing Company, Inc., 330 West 42nd St., N. Y. C. Stockholders of which are: James H. McGraw, 330 West 42nd St., N. Y. C. James H. McGraw, Jr., 330 West 42nd St., N. Y. C. James H. McGraw, James H. McGraw, Jr., and Curtis W. McGraw, 330 West 42nd St., N. Y. C., Trustees for: Harold W. McGraw, James H. McGraw, Jr., Donald C. McGraw, Curtis W. McGraw. Curtis W. McGraw, 330 West 42nd St., N. Y. C. Donald C. McGraw, 330 West 42nd St., N. Y. C. Anne Hugus Britton, 330 West 42nd St., N. Y. C. Mildred W. McGraw, Madison, N. J. Grace W. Mehren, 33 West Grand Ave., Chicago, Ill. J. Malcolm Muir and Guaranty Trust Co. of New York, Trustees for Lida Kelly Muir, 524 Fifth Avenue, N. Y. C. F. S. Weatherby, 271 Clinton Road, Brookline, Mass. Elsa M. Wilsey, Madison, N. J.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.) None.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds or other securities than as so stated by him.

5. That the average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the twelve months preceding the date shown above is. (This information is required from daily publications only.)

D. C. McGRAW, Secretary.
McGRAW-HILL PUBLISHING COMPANY, INC.

Sworn to and subscribed before me this 27th day of September, 1937.

[SEAL] H. E. BEIRNE,

Notary Public, Nassau County. Clk's No. 74. N. Y. Clk's No. 102, Reg. No. 8-B-115.
(My commission expires March 30, 1938)

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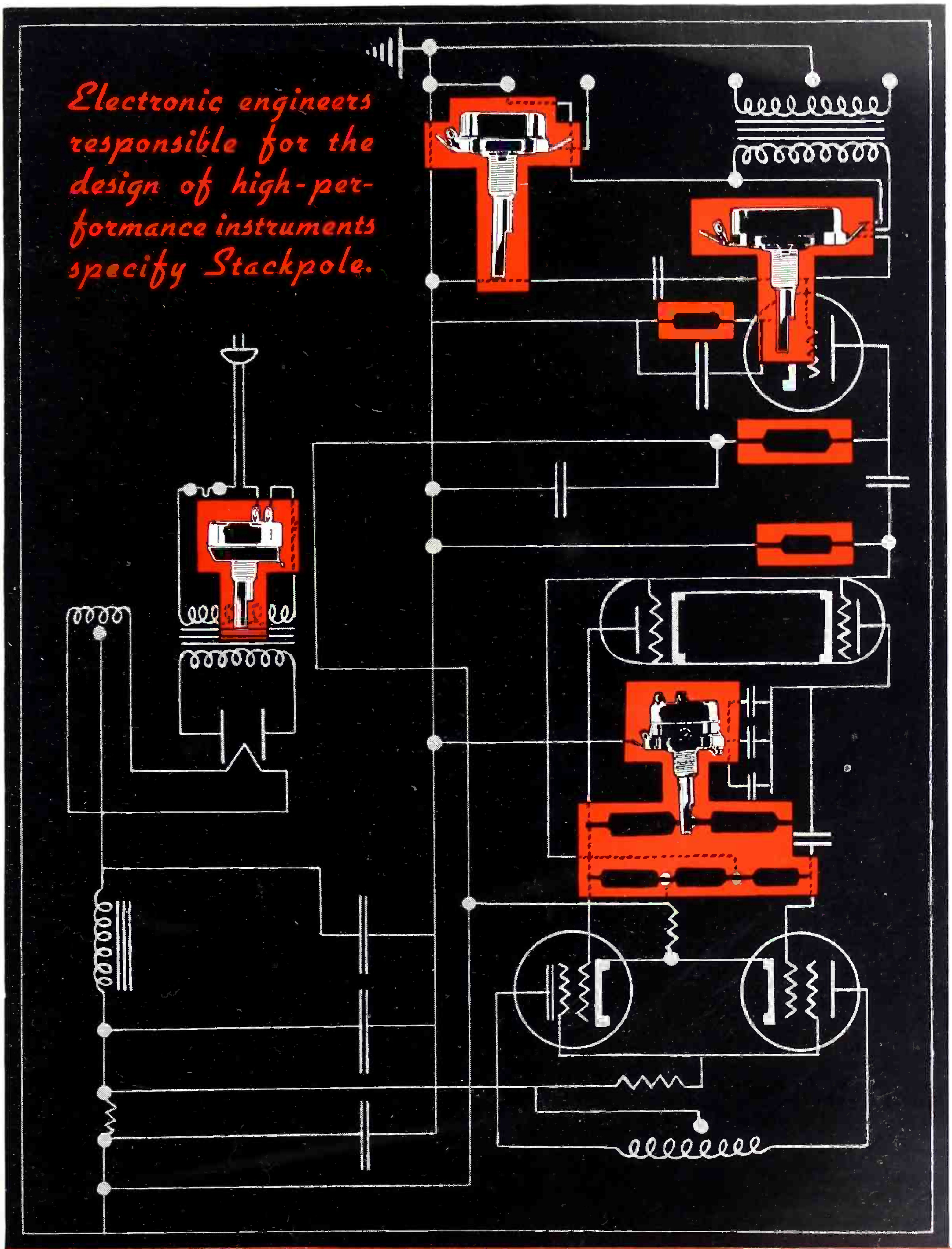
INDEX TO ADVERTISERS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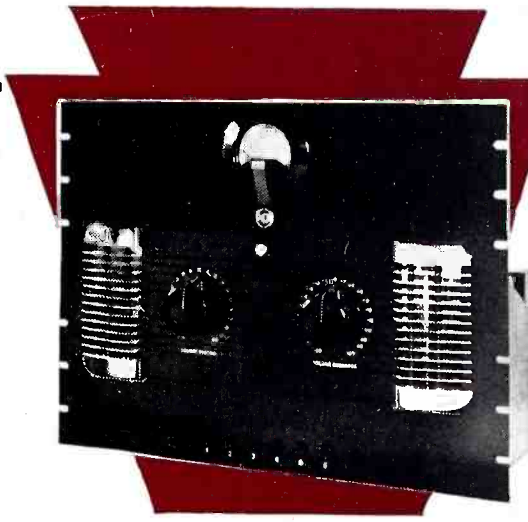

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The 40-D offers the maximum in convenience, too. Having a hinged chassis, it is possible to reach every part for inspection without removing the amplifier from the rack. Tubes are accessible from the front. The Volume Indicator uses the latest illuminated type meter. Components are heavily chromium plated for pleasing appearance and permanence. With all of this, the 40-D is not expensive and will assure you of trouble-free, high fidelity operation.

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Replace weak transmitting and receiving tubes with the tubes preferred by network stations—RCA.

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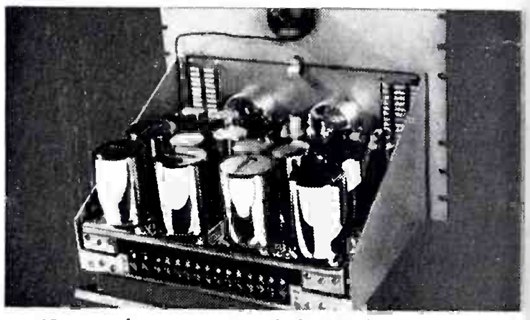

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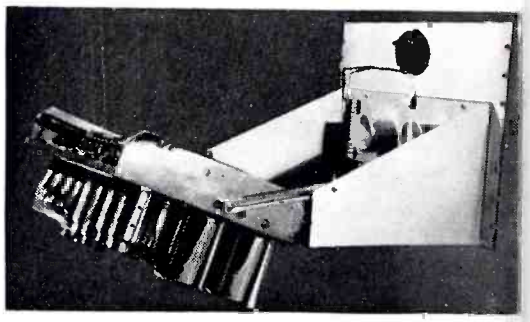

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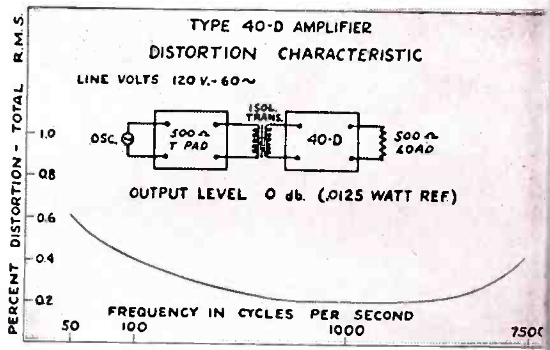
Max. usuable output	+18 db*
V. I. range	− 20 db to + 18 db
Output noise level at normal output (55 db gain)	− 70 db
Output noise level at normal output (full gain)	− 60 db
RMS Distortion (400 cycles) at normal output	0.3%
Frequency response	30 − 17,000 cycles ± 1 db
Tubes used	Two RCA-1603's, Two RCA-89's, One RCA-25Z5, One RCA-6A6, One RCA-76, One RCA-84
Power input	85 watts
Panel height	13-31/32 in.

*12-1/2 MW. Zero level



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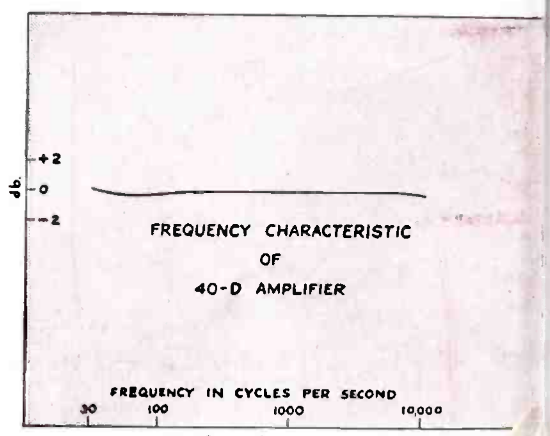

Uniform frequency response