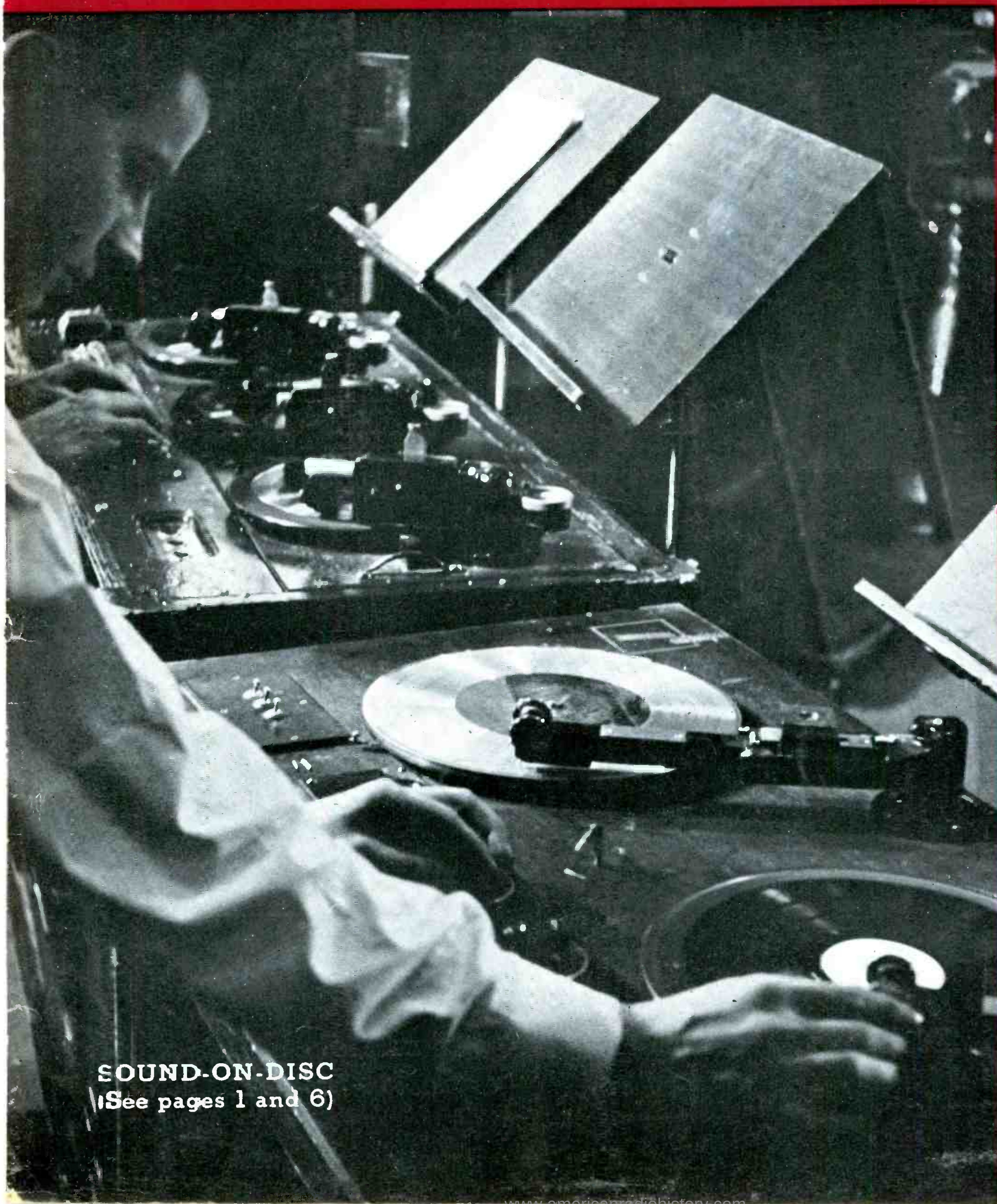
electronics

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



SOUND-ON-DISC
(See pages 1 and 6)

OCTOBER
1936

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ELECTRONICS

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

Contents • October 1936

COVER: *Sound-effect turn-table reproducers at the National Broadcasting Company, a prize-winning photograph taken by A. F. Van Dyck, Engineer in charge of the RCA License Laboratory. Reproduced by permission N. W. Ayer and Son, who sponsored the contest in connection with the program "Eno Crime Clues"*

DEPARTMENTS

Volume 9 . . . Number 10

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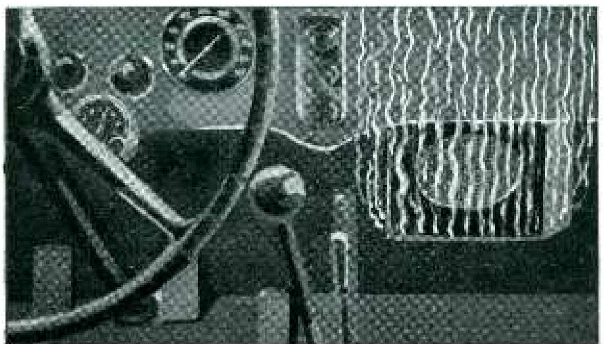

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ELECTRONICS

OCTOBER
1936

KEITH HENNEY
Editor

Crosstalk

▶ **UNIVERSAL TUBE** . . . In 1935 American tube manufacturers introduced nearly 100 new types of tubes. This pace has been continued thus far in 1936 if one includes all the various permutations possible by using old tubes in new envelopes, new tubes in old envelopes, and so on.

Harries Thermionics Limited, England (see "Critical Distance Tubes," May 1936, *Electronics*), now announces an all-stage tube which will fit any socket in a radio receiver. It employs the principles discussed in the article by Mr. Harries in May and is the result of six years' work. A bulletin indicates that it can be used as frequency changer, power output tube, i-f, r-f and a-f amplifier, can be built in glass or metal, and has good characteristics for any of the usual tube positions. Its grid-to-plate capacity is 0.001 micro-micro-farads. Apparently Mr. Harries has rolled a good many tubes up into one bottle.

▶**RADIO SHOW** . . . The New York show looked much like shows of other years, except—Grunow and Midwest showed telephone-dial type of tuning. Midwest, by the way, has a current saver, a device which permits reducing the power taken from the light wires after the set is properly warmed up. Emerson displayed one of the niftiest portables we ever saw, plus some very nice cabinet work. Fada, among others, seems to be going strong for small cabinets made out of molded materials, white, red, green, black.

▶**FACTORY** . . . One of the McGraw-Hill publications is *Factory Management and Maintenance*, better known as *"Factory."* The August issue is devoted to telling the story of what industry means to America, and it is an issue that marks a high-water mark in technical trade publishing. The 90-odd pages of editorial are printed in three colors in the form of charts showing such pertinent matters as the relation between sales and prices, how wages have gone up faster than prices, industry's tax bill, industry's profit, how much industry pays its executives, how technical advances increase jobs., etc.

▶ **ACOUSTICAL SOCIETY** . . . October 29–31 the Fall meeting of the Society takes place at Hotel Pennsylvania, New York. A symposium on physics in industry occurs on October 29 and 30, on the 30th and 31st will be papers on acoustics and on the night of October 30 there will be a banquet at which Professor John Mulholland, President of the Society of American Magicians will entertain. Industry, acoustics, magic — a comprehensive program.

▶ **GOOD TIMES; BAD TIMES** . . . In February, 1935 the FCC conducted a survey to determine several things, among them the vintage of the average rural listener's radio, the number of tubes, his favorite stations, soil conductivities, relative listener preference for the clear channels versus other station classifications, etc. The result of that questionnaire and survey by Federal Radio Inspectors is now available.

116,000 cards were sent out, 86,000 to names supplied by the AAA and the rest to Fourth Class postmasters to distribute. By March 1st, 46,586 cards were returned, 13,916 not being useful because they were not filled out, or the recipient had no radio, or his radio was not working. Of the 32,671 which were useful 26.1 stated that their radios had been purchased in 1929 or before, 12.7 in 1930, 10.1 in 1931, 12.1 in 1932, 13.8 in 1933, 21.6 in 1934 and 3.6 in 1935. The last year showed up so poorly because this survey was conducted in February of 1935.

It is interesting to note that during the depression nearly 75 per cent of the rural dwellers had found the cash to replace their old radios or to buy new ones. But it is also interesting to note that 26.1 per cent operated sets bought as long ago as 1929.

It is also most worth noting that 76.3 per cent of those answering the postcard and personal surveys indicated that their first choice among all stations was one on a clear channel. Regional stations got a rating of only 20.6 per cent; local stations were down to 2.1 per cent. And yet there has been consistent demand from politicians and others unversed in the engineering facts of life to reduce the number of clear channels and to put several stations on them; stations of the type which now satisfy only 20.6 and 2.1 per cent of rural listeners as first choice stations.

▶ **LAWYERS' FEES** . . . Radio Industry has kept many patent lawyers and expert witnesses happy during its brief history. Recently two manufacturers went to bat in court, one charging patent infringement, the other charging restraint of trade. Both won, both lost to some extent. Appeals are now being taken. Probably money to the extent of $100,000 has been taken out of the radio industry and put into the pockets of non-producers. Imagine what this money, and time, and effort, might have produced if expended in research—or even in sales efforts!

▶**PIONEER** . . . In the death of S. M. Kintner, vice president in charge of engineering, Westinghouse Electric and Manufacturing Company, September 28, industries based on the vacuum tube suffer the loss of a pioneer in communication and of an early and late enthusiast for the possibilities inherent in electrons in motion. His work with Fessenden leading to the heterodyne method of reception brought him the vision of electronics, an insight which grew with the years until he, probably better than any other, saw the capability of the tube to be useful not only in the communication art but to industry as a whole.

SOUND-ON-DISC

Checking frequency response is an important part of the new recording techniques. Above, "Christmas Tree" patterns on a Rangertone frequency-run record adjusted for a peak at 2000 cycles (see text, page 10)

MANY engineers consider that the technical revolution in the phonograph business ended in 1925, when electrical methods of engraving and reproducing were released for general use. The contrast between mechanical and electrical recording at that time was so sharp that this feeling is entirely understandable, but it does great injustice to the work done in improving electrical methods during the past ten years. The latest type of transcription record is, in fact, as far advanced over the first electrical recordings as they were over the mechanically-engraved type.

The improvements in reducing noise level and distortion and in improving uniformity in frequency response are real advances; so much so that it is now possible to produce recordings which are indistinguishable, to the ear, from the original studio pick-up. Not many men outside the transcription business have heard such recordings, it is true, but they are nevertheless being produced whenever equipment, materials, conditions, and the operators' technique are at their best.

The excellence of these and other less ambitious results is based primarily on two factors: first, "industry technique" which comes from a better understanding of the principles underlying good recording without regard to the person doing it, and second, "exclusive developments", which are the guarded property of individual companies. To judge by the uniformly good results now being produced by so many companies, it would seem that the former was by far the most important.

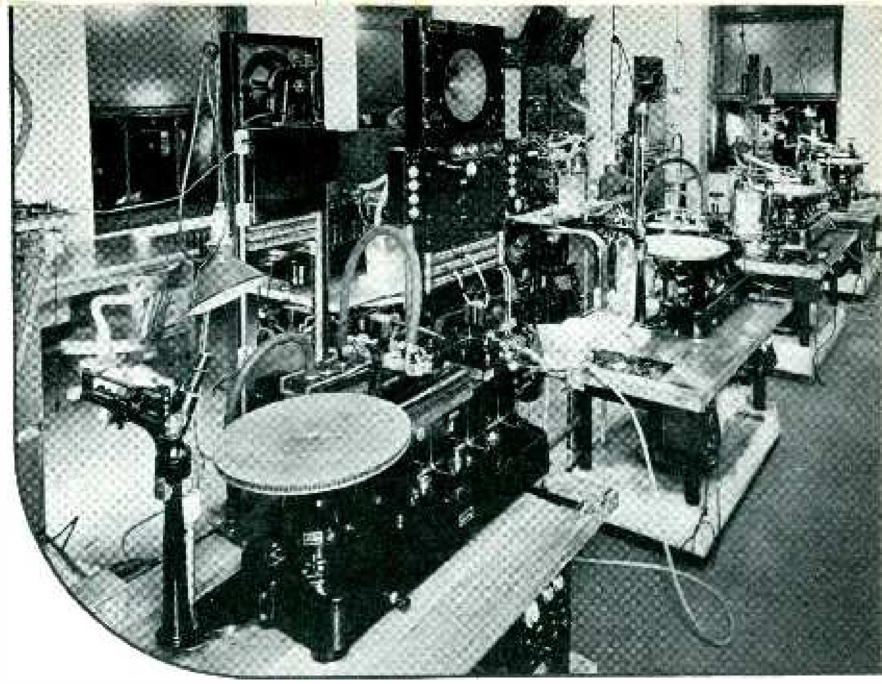
The ambition of any audio reproducing system should be to establish a linear transfer of motion, in amplitude, phase and frequency, between the microphone element at the one end and the speaker cone at the other. In disc-recording, the intervening processes are distinguished by being almost entirely mechanical in nature. Hence they are limited by mechanical considerations, such as the mounting, damping and resonances of the engraving stylus, the viscosity, hardness, resiliency and homogeniety of the record material, the fidelity of the duplicate-pressing process, the constancy of speed of the turntables, the hardness and shape of the reproducing needle, and so on ad nauseam. This does not mean that the electrical elements can be neglected. In fact recording and reproducing amplifiers must have considerably less distortion than straight transmission amplifiers, since practically every mechanical element in the phonograph system is busy making up the difference. But microphones, amplifiers and loudspeakers are the least troublesome parts of the system.

Record Materials

Perhaps the most important improvement, common to all the factors in the industry, is the use of new materials and compositions from which the discs are made. For making the original engraving, wax (metallic soap) is still the best available material and is used for the highest grade work. Wax requires the most paintaking control of working conditions, however, and the original engraving cannot be played back, except by a very light-weight and delicate pick-up, and only with the chance of ruining the recording.

For producing original engravings

The record business has not been sleeping since the Orthophonic days. New materials, new equipment, new techniques now produce transcriptions which are virtually the equal of the original studio pick-up. A review of methods used

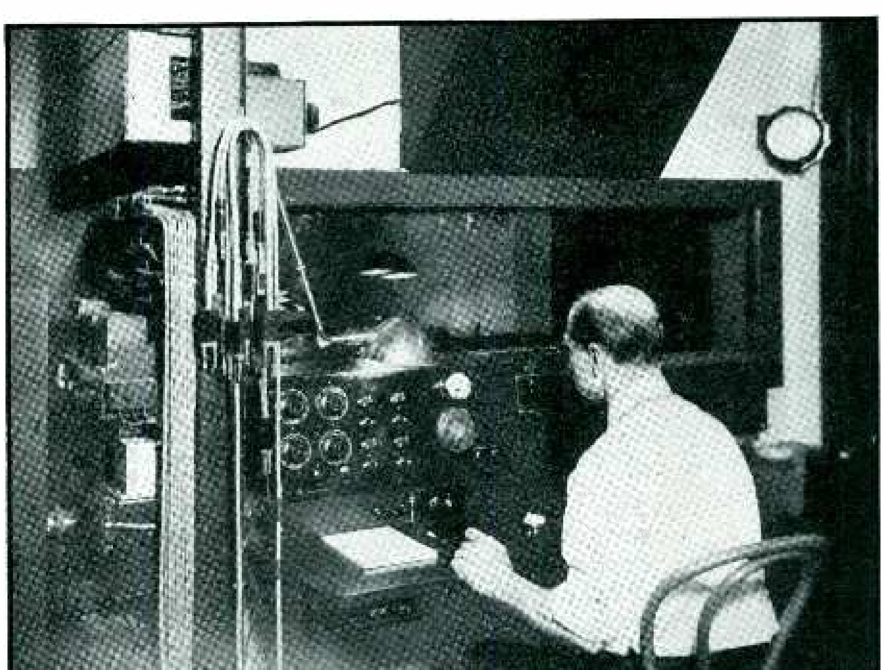


Recording room of the World Broadcasting System where vertical-cut program transcriptions are produced

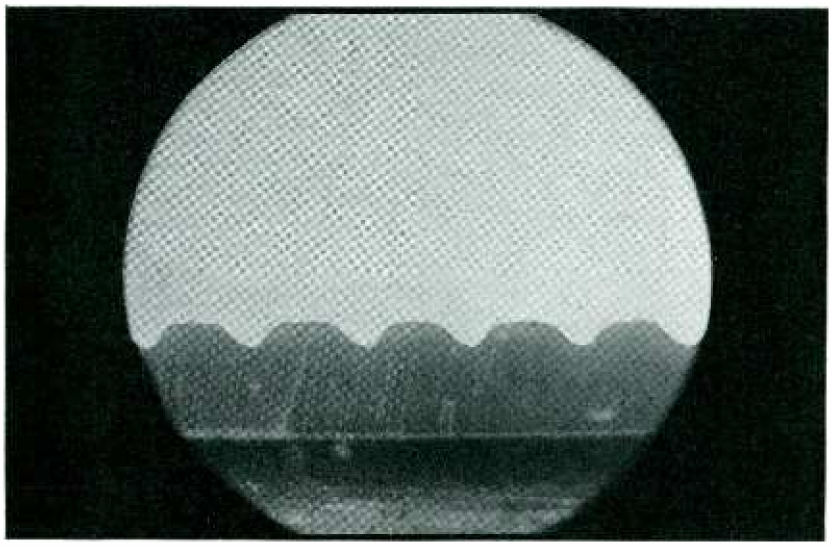
which can be played back at once (so-called direct or instantaneous recording), the most popular material is "acetate", actually nitro-cellulose, which is sprayed or flowed on metal discs. These coated discs are at present widely used for immediate play-back purposes, and give astonishingly good results when properly handled. The nitrocellulose used in the coating is a lacquer very similar to the "Duco" finish used on automobiles; the commonly used term "acetate" is a misnomer, cellulose acetate compounds having a tendency to "tear" when engraved, although they are suitable for making duplicate records by thermoplastic pressing. The shavings which result when nitrocellulose records are engraved are highly inflammable and must be carefully disposed of. The record itself is not inflammable because of the high heat conductivity of the metal base. The lacquer coating tends to become hard when old, but can be softened prior to use by enclosing the disc in an air-tight can with a small amount of organic solvent whose vapor penetrates the cellulose material. After engraving and drying the material regains its former hardness.

Aluminum is also used for the original in some instances, and can be played back with a fiber needle, but only with a quality which is less than that actually present in the recording. One organization has a process for producing acetate duplicates from aluminum originals; the use of steel needles on such duplicates reveals the full quality of the original engraving.

The newest material, considered by many to hold great promise for future improvements in the art, is the vinyl class of compounds, a form of thermoplastic material which combines homogeniety with ductility. The latter property permits the use of an embossing process (as distinguished from engraving), although the engraving process can also be used with it. The difference between embossing and engraving is important, and may prove to be of considerable technical significance. In engraving, part of the material is cut away from the record and removed by the stylus in the form of a thread. This cutting process puts a great burden on the cutting stylus, which must have a perfectly sharp edge to give a clean cut. Also, since part of the material actually parts company with the remainder, there is an irreducible minimum of roughness in the groove which is the present absolute limitation to the reduction of surface noise. In embossing, on the other hand, the stylus may be rounded in shape, and polished. Because of the small area of the stylus the pressure at its point is many tons per square inch, and the material under it, if sufficiently ductile, will *flow* under the pressure, producing a groove by embossing action rather than by cutting. The groove takes the polish of the stylus, and the re-

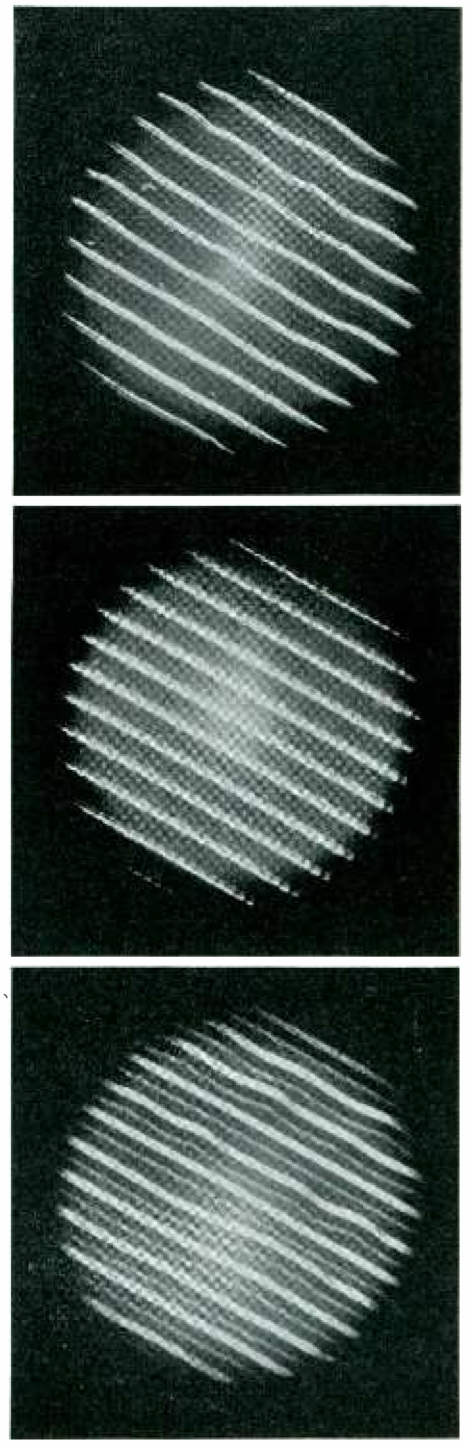


Even closer control of volume range is required for recording than for broadcasting. Above is a control operator on duty at the RCA Victor recording studios in New York



Left, cross-section through an acetate record. Note the assymetry of the grooves, a cutting defect revealed only by microscopic inspection

Below, photomicrographs of lateral-cut grooves. Top to bottom: direct cut in acetate, pressed acetate duplicate (8000 cps), direct cut in aluminum, all magnified about 20 diameters. All high grade recording includes microscopic inspection to check groove width, groove surface, and to prevent over-cutting, "echo," etc.



sult is extremely low noise levels.

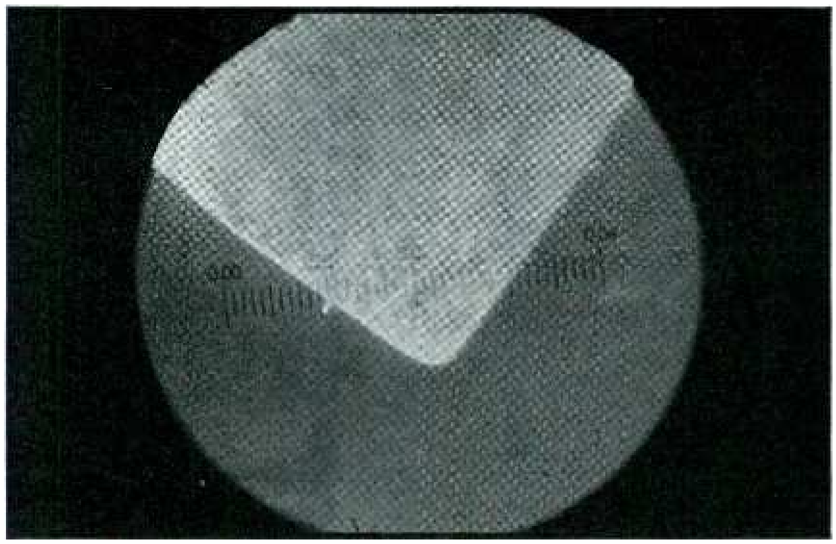
All of the materials used have been chosen with the noise problem in mind. It has been found that the presence of even so fine a material as lamp-black, used for coloring nitrocellulose discs, adds appreciably to the noise level. Cleanliness, particularly freedom from dust, is another important factor. The best achievements in recording so far have produced a noise level from 50 to 60 db below the maximum signal; the average record however has only a 35 db spread between noise and signal, compared with 60 to 70 db in the best broadcast stations using direct studio pick-up.

Duplicate pressings are required for use by the general public or by syndicated groups, such as broadcast stations. These pressings are made of a variety of materials. Ordinary phonograph records are made with a high grade of shellac, with certain abrasive fillers. The abrasive adds considerably to the noise level, but is necessary to keep the needle from cutting into the shellac. Actually the abrasive grinds the needle point to the shape of the groove, thereby distributing the weight of the pick-up over the widest available area and reducing the pressure to the point where no injury, beyond normal wear, is done to the record. Commercial records of this kind, while greatly improved over the original electrical recordings, are not suitable for high quality work unless scratch-filters are used to remove the high percentage of needle hiss and surface noise.

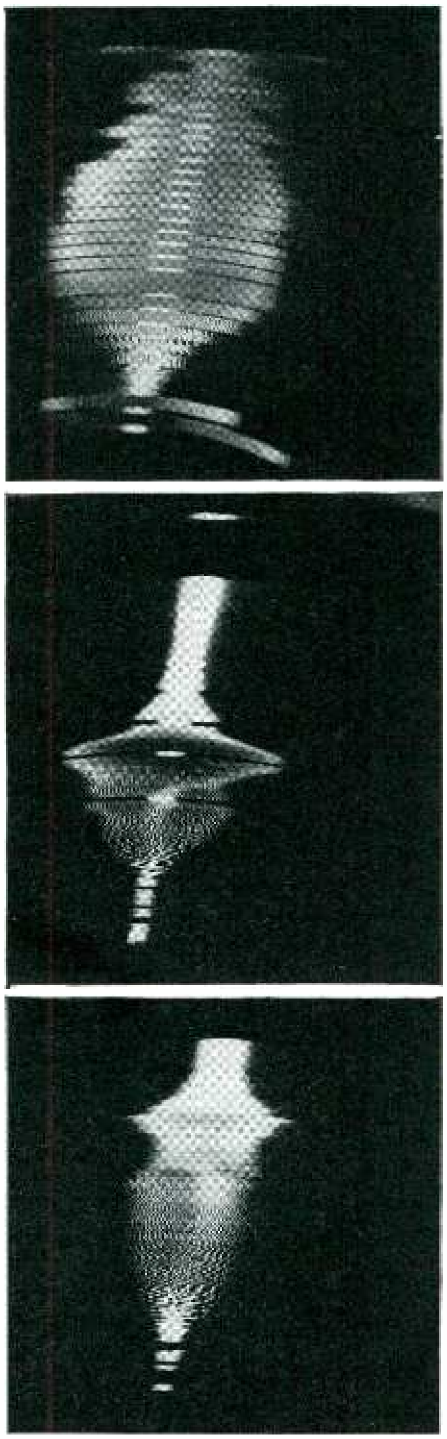
Duplicates for high quality use, such as program transcriptions, are made usually from cellulose acetate or vinyl compounds. Both of these materials are free from abrasives and are as homogeneous as it is possible to produce them, to a degree in fact, where the residual inhomogeniety is so small that it does not contribute to the noise level. They are thermoplastic, that is, they flow under the proper conditions of heat and pressure.

The duplication process is one of the outstanding examples of plastic technology. In the wax process, the original wax engraving is first given a microscopically thin coating of metal, either by dusting with metallic powder, or by the finer processes of depositing silver from a solution of silver nitrate, or by sputtering pure gold on the surface. This metal coating is used as one electrode in an electroplating bath, in which a sheet of copper, 1/16 to 1/32 inch in thickness is deposited on the wax. The copper and wax are then separated, a process requiring considerable skill. The copper plate, which is the negative of the original wax, may then be used to stamp duplicates from shellac, acetate or vinyl compounds, depending on the intended use. If great numbers of duplicates are required, additional stampers are made from the copper master by the same process of electrodeposition. In general it may be said that the duplicating process reproduces everything on the original wax engraving to such a fine degree that the only observable difference is in the materials, one wax, the other a harder, more durable plastic. It has been

A cutting stylus, magnified about 50 diameters. This photograph and the cross-section view opposite were taken by George Saliba of the Presto Corporation



Below, "Christmas Tree" reflections from the surface of frequency-run records. Top, aluminum disc produced by Fairchild-Proctor, showing flat response to about 6000 cycles; Middle, experimental acetate cut by Captain R. H. Ranger, showing pronounced peak at 2000 cps. Bottom, same, made with adjustments to throw peak up to 6000



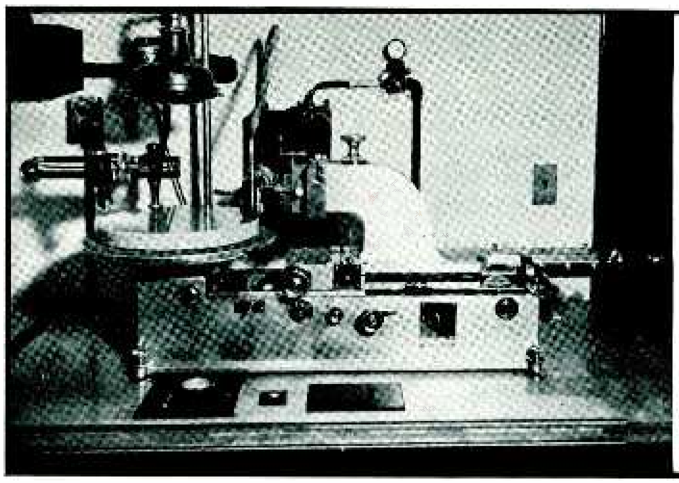
found that in electroplating, lines only 0.00002 in. in width can be reproduced, and the transfer from electroplated stamper to acetate duplicate is nearly as good.

Frequency Responses, Cutter to Pick-up

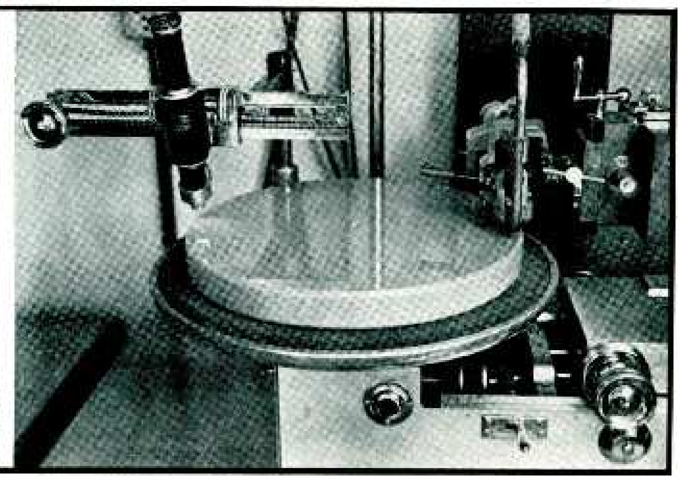
The most universal, but by no means the only essential, means of establishing the performance ability in recording systems is an examination of the frequency response curves produced by various components. The microphone and amplifiers which feed the cutting head are measured in the conventional manner with a standard sound source, beat-oscillator and output meter or cathode-ray oscillograph. The output of the amplifier, at the terminals of the cutting head, is often extremely flat, say from 40 to 10,000 cps within plus or minus 2 db.

The cutting head, however, is a different breed of cat. All cutters are down some 15 db at 40 cycles, by design and with malice aforethought. Since, for a given voltage input, the amplitude increases as the frequency decreases, it is found that below 300 cycles the amplitude becomes so excessive that the cutter tends to cut into the adjacent groove, producing "over-cutting" or the equally disagreeable echo effect which comes from a distortion of the adjacent groove. This problem can be overcome by using widely spaced grooves, but at the expense of much less recording time per disc. By limiting the response of the cutter so that it has a gradually falling characteristic below 300 cycles, the groove spacing can be made 100 lines per radial inch or more, up to about 150 lines per inch, without overcutting and without reducing the level of voltage fed to the cutter. The loss below 300 cycles can be made up at any subsequent part of the circuit, from the pick-up to the loudspeaker itself. Usually a bass-boosting circuit in the pick-up amplifier is used.

From 300 to about 3500 cycles any cutting head worth the name is fairly flat. Above 3500 cycles, a flat characteristic is achieved only by careful design. Good lateral-type cutters go to 6500; some vertical cutters perform well at 9000. The cutting head is a mechanico-electrical problem of the highest order. It must have a natural resonance somewhere, since it has mass and stiffness, but if this resonance is in the desired audio range, a flat characteristic can be achieved only by heavy damping, usually with rubber pads, which loads the system in the same way that resistance does in a tuned electrical circuit. But damping uses a great deal of energy, and usually impairs the performance of the cutter at the higher frequencies. Considerable progress, especially in vertical-type cutters, has been made by reducing the mass of the cutter to a marked degree by ingenious design and mounting, thus raising its resonant frequency to a point where the damping can be reduced. But this refinement in design produces a delicate instrument, which must nevertheless cut with pressures of several hundred tons per square inch. Using and servicing such a tool is not



Lateral type wax recorder at RCA Victor studios



Close-up of turn-table and disc, with cutter at right

child's play. One significant type of cutter uses a rochelle salts crystal (in contrast to the electromagnetic drive) as the motor element, and does entirely without damping. Such a cutter has been made to absorb some ten watts of electrical power, and since its efficiency is high, delivers several watts of mechanical power to the groove, on peaks. Crystals have a capacitive characteristic (falling impedance with rising frequency), however, which requires correction in the circuits feeding it, a job usually accomplished by a properly designed transformer.

Determining the frequency response of a cutting head alone (without making a record) is a job seldom attempted, although one of the leading experimenters has done so by fastening a tiny mirror to the stylus and reflecting light into a photocell. Usually the frequency responses of two elements, the cutter and the disc-material, are measured at once, by a very simple expedient. It consists of making a recording of the output of a beat-frequency oscillator, held at constant voltage at the cutter terminals, while varying its frequency from 30 or 40 cycles at the low end to about 8000 at the high end. When the record is complete, it is removed from the turntable and put under a strong concentrated source of light, such as a single 60-watt bulb. The reflection of the bulb as seen in the grooves will produce a peculiarly shaped pattern, given the descriptive name "Christmas Tree". Several examples of these patterns are shown in the accompanying illustrations. The pattern is symmetrical about a radius of the disc, and is actually a graphic representation of the frequency responses of the cutter and material taken together. The radius of the disc is the axis of frequency, the end of the pattern nearest the center corresponding to the lowest frequencies (according to the standard practice at 33 1/3 rpm of recording from the inside of the disc outward). The width of the pattern measured at right angles to the radius is proportional to the amplitude of the undulations of the groove, which in lateral recording corresponds exactly to the depth of modulation. This peculiar optical phenomenon is the result of the fact that the light is reflected over a wider band, the greater the ratio of modulated groove width to groove depth.

Since pick-ups and reproducing amplifiers have usually pretty good characteristics (a typical crystal-type reproducer is flat within plus or minus 2 db. from 40 to 8000 cycles) it is usually sufficient to adjust the cutter head so that from 300 to 6000 cycles, the "Christmas tree" pattern produced has straight sides. If pronounced peaks are present in the pattern, the head may be adjusted, or, as is more usual, electrical filters may be inserted in the line to level them off. A really flat characteristic between the limits of 300 to 6000 cycles is not achieved except by painstaking effort, and the adjustment rarely lasts for long, since the cutting stylus grows dull and must be replaced, or the quality of the disc material changes because of atmospheric conditions. But when everything conspires, the system can be made flat from about 300 to 6500 cycles and the resulting recordings are extremely good, provided that the range from 30 to 300 is properly boosted, and especially if a volume expander (see Electronics, Nov. 1935, page 428) is used to restore the full dynamic range of the original pick-up.

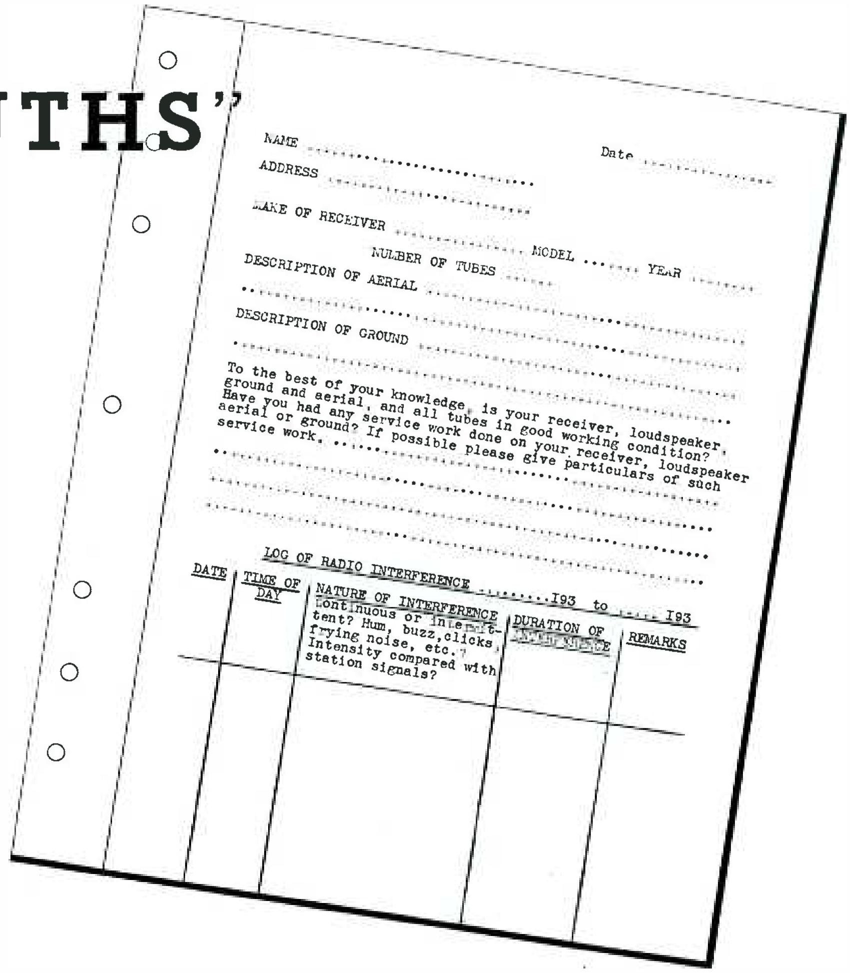
Turntables and Drives

With good materials and duplicating processes available, attention has been given by almost everyone in the business to the all-important matter of turntables and the methods of driving them at constant speed. In communications parlance, the "scale of frequency" of the entire system is dependent on this one factor. Mechanical engineers are free to admit that obtaining constant speed drives, especially where the load on the drive varies both haphazardly (because of the varying depths of modulation) and regularly (as the cutting head travels from the outside of the disc in, or vice-versa), is one of the most difficult problems they have. The speed regulation, for results acceptable to a trained ear, must be better than 0.3 per cent. Actually regulation better than 0.2 per cent. is rarely achieved. In addition to the speed regulation, the average speed must be kept at the correct value, else the pitch of the music is off and since, if the record is a program transcription, it may outlast or run under the time allotted for it.

Average speeds are measured and adjusted by stroboscopic lines or patterns in conjunction with 60-cycle light sources. But speed regulation is not nearly so simple. The brute force

(Continued on page 48)

"3700 SLEUTHS"



NAME .... Date ....

ADDRESS ....

MAKE OF RECEIVER .... MODEL .... YEAR ....

NUMBER OF TUBES ......

DESCRIPTION OF AERIAL ....

DESCRIPTION OF GROUND ....

To the best of your knowledge, is your receiver, loudspeaker, ground and aerial, and all tubes in good working condition? Have you had any service work done on your receiver, loudspeaker aerial or ground? If possible please give particulars of such service work. ....

LOG OF RADIO INTERFERENCE ....I93 to I93

DATE	TIME OF DAY	NATURE OF INTERFERENCE Continuous or intermittent? Hum, buzz, clicks, frying noise, etc.? Intensity compared with station signals?	DURATION OF INTERFERENCE	REMARKS

Citizens of a static-ridden town join hands in a unique effort to ferret out the source of radio-destroying noise

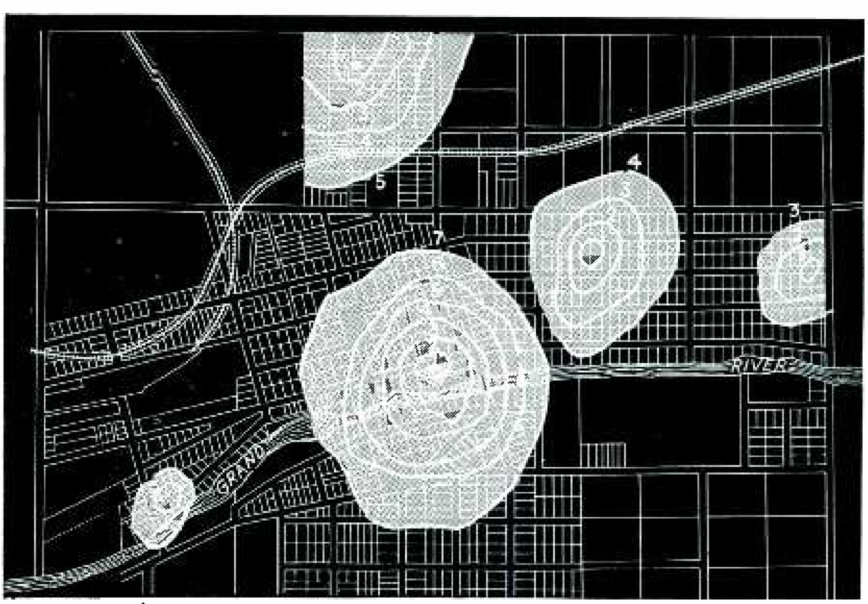
BY F. H. HAM
Fergus, Ontario

IT is doubtful if there is any problem which the radio engineer is required to solve more calculated to tax his mettle than the tracking down and elimination of radio interference. Imagination, logic, technical ability, tact, and above all, patience must be the attributes of the noise detective and frequently even these are not enough. Power and light utilities and the manufacturers of electrical equipment have now recognized the importance of the noise evil and during recent years their cooperation in the matter of maintenance and design has been of inestimable value to the radio industry. It would seem that the problem has now resolved itself into a tracking down of the unexpected—the older appliances, the freak installations, unnatural line faults, even deliberate radiation of interference.

In one town that the writer visited the situation was extremely bad. The general noise level was inordinately high for a community of its size and at any hour of the day bursts of noise were so common and of such volume as to render receivers practically inoperative. Both triangulation and "hot and cold" surveys were tried with only slight success due to the uniform nature of the general noise level and the intermittency of the peaks. True, a few isolated cases of faulty appliances and power leaks were found and corrected but it was felt that only the surface had been scratched as far as the area of the town as a whole was concerned. The surveys did show that a large part of the noise was reaching the receivers through the power wires and they also brought forth plenty of suggestions from set owners. The latter formed the basis of the next offensive. They made suggestions. They evidently wanted the noise cleaned up. Why not let them help to clean it up?

Forthwith were enlisted thirty-seven hundred sleuths, or deputies as you will. A bulletin was prepared which at least mentioned every likely cause of interference and the proper corrective measures. For the homes

(Continued on page 38)



Interference map, showing centers of noise as indicated by citizens' logs of radio trouble

A 20 to 60 mc. Oscillator

A simple general purpose u-h-f unit, useful for extending the range of laboratory and testing equipment to the increasingly important frequencies below fifteen meters. Complete construction data

By A. BINNEWEG, JR.
Oakland, California

MOST available laboratory oscillators do not tune below approximately 15 meters. The construction of the parts in the ordinary oscillators is also such that one cannot construct simply other coils and calibrate for the higher frequency ranges, for it requires special design and construction for operation on frequencies higher than 20 mc. Assuming that an ordinary oscillator tunes from 600 meters down to 15 meters (which is a range of 19.5 mc.), the problem becomes clear when it is realized that the range between 5 and 15 meters is 40 megacycles. To cover properly such a large frequency range it is necessary to design especially for this range. This writer has investigated the possibilities of the various oscillating circuits for use at these higher frequencies and has developed a low-cost oscillator which gives satisfactory results over the 20 to 60-mc. range.

After testing various arrangements, the circuit of Fig. 1 was adopted because of its all-around suitability. The tube used is a Type '30 which consumes only 60-milliampere filament current and will therefore operate for long periods of time from two No. 6 dry cells connected in series. The 20-ohm rheostat shown in Fig. 1 is for this method of operation. If desired, a 30-ohm resistor can be connected across the filament terminals and one can operate from a 2-volt AC source, or from a standard 2.5-volt filament transformer with a suitable rheostat to reduce the voltage to the rated 2 volts. The negative-B lead and the lead from the grid milliammeter should, for AC filament operation, be connected to the filament centertap on the filament resistor. If this is done, there will be only a slight modulation, which in many cases is desirable anyway. The circuit of Fig. 1 will oscillate at frequencies higher than 60 megacycles should this be desired.

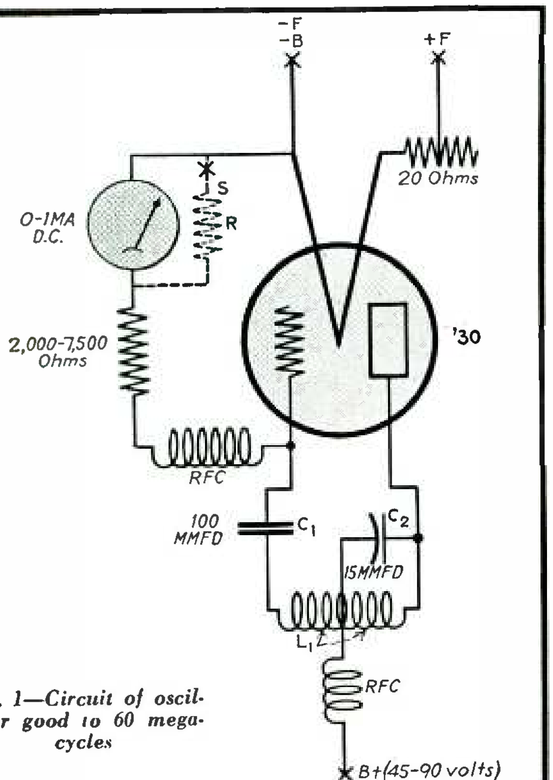


Fig. 1—Circuit of oscillator good to 60 megacycles

The 0-1 grid milliammeter is for the purpose of indicating resonance between the oscillator and any external tuned circuits. For given conditions, the d-c grid current obtained will give an idea of the efficiency of the circuit. The grid current reading will vary with different tubes, different filament voltages and different plate voltages. Should the reading in this meter be too small, reduce the grid resistance; should it be too high, decrease the plate voltage or increase the value of grid resistance. However, it is in general better to leave the plate voltage at a fixed value. At the lower frequencies, the grid current obtained will be higher so that it may be desirable to use a shunt with the grid meter. Such a shunt is as indicated by the dotted lines in Fig. 1. It consists of a small off-on switch *S*, and a shunt resistance *R* of suitable value, connected in series, the series arrangement of these two being shunted across the gridmeter. If, under some conditions, the grid current is too high, the small panel switch *S* can be closed, the shunt then taking part of the grid current.

Both chokes, *RFC*, should be of a special ultra-frequency type, such as a type on the market which consists of a divided winding wound in the slots of an isolantite form. The oscillator inductance, L_1, will depend upon the frequency at which the oscillator is to be used. The specifications of the coils for various frequencies are given later. The coils are center-tapped in all cases. A new plug-in coil system which is easily constructed, and which is suitable for these high frequencies is described below.

The condenser C_1 should be a good, mica molded fixed type, preferably of the "midget" type. Although the value given in the diagram of Fig. 1 is .0001 μfd one can use any value up to about .00025 μfd if the condenser is of the proper construction. The value used, within these limits, will have very little effect on the frequency. C_2 is a 15 $\mu\mu$fd midget type variable condenser shunted across the plate half of the inductance L_1. The ranges of the various coils given are for this condenser connected between coil center-tap and plate.

The possibility of using a variable grid condenser at C_1 is interesting. Of course, the range covered will be comparatively small, if only this condenser were used for tuning, but if one were to use a variable grid condenser in addition to the tuning condenser C_2, a very flexible arrangement results. Two controls make actual calibration of the oscillator difficult, but if the oscillator is used in conjunction with a calibrated wavemeter, one can always refer to the wavemeter to obtain the exact frequency in any event. The tuning which can be accomplished by such a variable condenser (100 $\mu\mu$fd air-dielectric midget type variable condenser), at these frequencies is interesting. The tuning range of the grid condenser at the higher frequencies with some experimental coils is shown by these values: 30.4-33.0 mc; 38.6 to 40.0; 45 to 45.6; 54.6 to 58.0; 58.2 to 61.4. These ranges are all in megacycles and were obtained between about 30 (varied between 25 and 40) and 100 $\mu\mu$fd of the capacity of the grid condenser. In general, the circuit will not oscillate with less than 25 $\mu\mu$fd in this condenser. These frequency ranges are usually rather too small, but one can to advantage sometimes make use of a variable grid condenser for setting a frequency band at the desired point. This might save the trouble of winding a special coil. However, in some cases, for operation near 60 megacycles the frequency ranges may be sufficient.

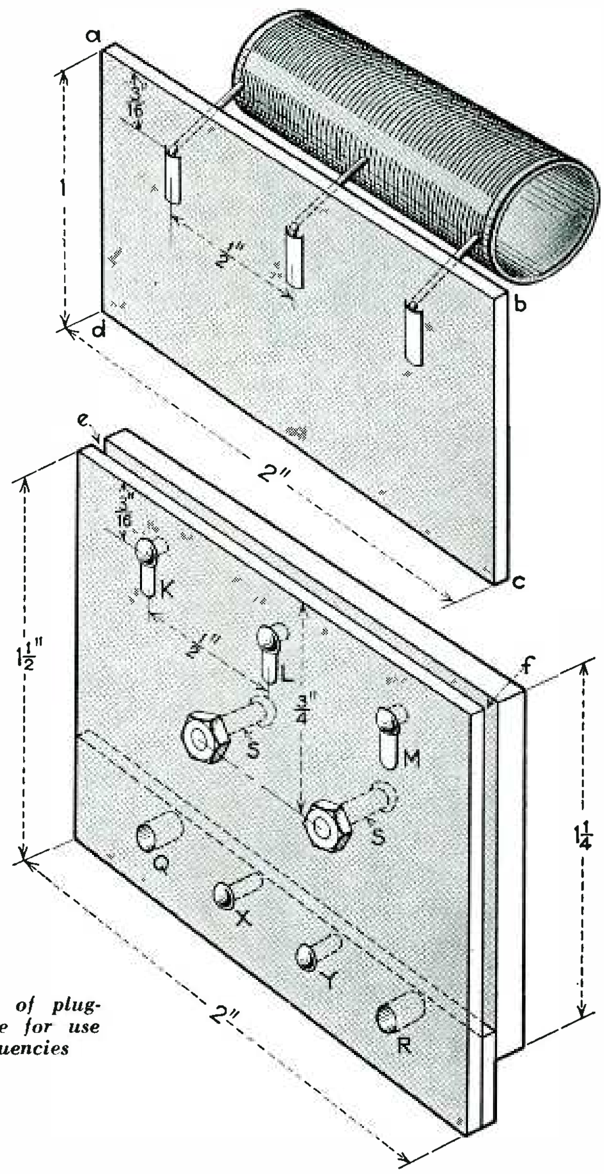


Fig. 2—Details of plug-in coil suitable for use at high frequencies

A New Plug-In Coil System

The usual plug-in coil arrangements are hardly suitable for operation at frequencies much higher than 20 mc. There is too much metal in the usual plugs and jacks, especially when they have to be mounted close together, so that there is too much capacity between leads. This writer has developed a new plug-in system which has been found satisfactory for frequencies as high as 60 megacycles, as shown in Fig. 2. Ordinary bakelite insulation can be successfully employed when using a plug-in system of good design. Special high frequency insulation might give a slightly better result but this is doubtful for this purpose.

The coils are each mounted on a thin piece of bakelite measuring 1 by 2 inches as shown in Fig. 2. The three leads to the coils connect with thin metal pieces which are riveted to the bakelite piece. One can use small rivets or small machine screws. The three contacts are ½-in. apart and 3/16 in. from the top of the piece. One of these supporting pieces is made for each coil. No forms are used with the coils which are wound with the specified size of wire on a rod of suitable diameter which is then removed. The three leads hold the coil securely. This is the most efficient construction for these frequencies. The use of any kind of coil-form greatly reduces the efficiency of the oscillator. Referring to Fig. 2, the coil supporting piece *abcd* is inserted into the jaws of the bakelite clamp *ef*, so that the thin metal pieces on the coil support contact the rivets *KLM* in the bakelite clamp. The coil piece is slipped into the bakelite clamp until it rests on the two crosswise machine screws *S*, *S*. With the bakelite piece in place, the machine screws are tightened. Very good contact is made in this way. To remove the coil, it is only necessary to loosen the machine screws. The small bakelite spacing piece at the bottom of the clamp is held by means of two small rivets *X* and *Y*. The two holes *Q* and *R* allow the coil clamp to be fastened to any convenient point on the oscillator case. The soldering lugs *K*, *L* and *M* allow connections to be made to the parts in the oscillator circuit.

The '30 tube has some advantages over the Acorn tube. It is less expensive and requires only a two-volt, low current drain source.

Oscillator Inductance Specifications

Range of Inductance in Megacycles with condenser as in Fig. 1	No. of turns (total)	Enam. Wire Gage	Diam. of Coil (inches)	Length of Coil Winding (inches)
54-64......	9	20	3/8	1 1/8
45-54......	7	20	5/8	7/8
39-46......	8	20	5/8	5/8
34-40......	12	20	5/8	1 1/4
28-34......	15	20	5/8	1 1/4
24.5-28....	12	18	1 3/16	1 1/4
20-23.5....	13	18	1 3/16	1

The type of inductance indicated here is very flexible in the sense that adjustment is allowed. To

[*Continued on page* 38]

A Noise-reducing Circuit

Old man static has taken a severe beating during the past year. Jim Lamb of QST got in some good licks. Here is another nail for static's coffin, a circuit of particular value for voice modulated signals

By M. G. NICHOLSON

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THE reduction of the effect of certain types of static upon radio reception has been effected in many ways in the past few years. Much of the static encountered in short-wave reception is confined to that generated by electrical motors, etc. In general, the disturbances from such equipment are composed of impulses of relatively short duration as compared with the time between the individual impulses. The noise reduction system to be described here is one which deals with this type of noise.

It has been known for many years that the use of a limiting (overloading) device in a receiver materially improves the readability of radio telegraphy under some types of severe noise conditions. This was usually accomplished either by employing low anode voltage on the last audio stage, or in the case of a tungsten filament tube, limited emission was obtained by lowering the filament temperature. This would result in limiting the noise impulses to a level substantially no greater than that of the signal. Such a system requires close adjustment in regard to the signal voltage applied to the limiting device; furthermore, when a noise impulse is limited, many spurious frequencies are generated of which a large portion are at audio frequencies.

If a limiting device is used which operates at a radio frequency, before detection takes place, the spurious frequencies generated in such a limiting device are easily filtered out before reaching the detector. In this way, a better signal-to-noise ratio is obtained than would be obtained had the limiting device been operated at an audio frequency.

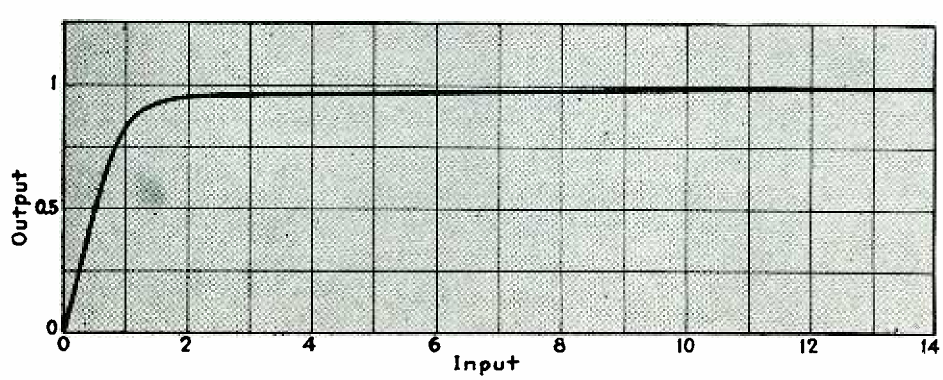
The limiting device used in the system to be described operates at a radio frequency and consists of a linear detector operated as a converter. By operating this linear detector with a limited amount of injected oscillator voltage, the desired characteristic is obtained. Figure 1 shows the relation between the input voltage and the output voltage in arbitrary units. The input frequency and the output frequency differ by the frequency of the oscillator. The relative magnitude of the injected oscillator voltage is shown.

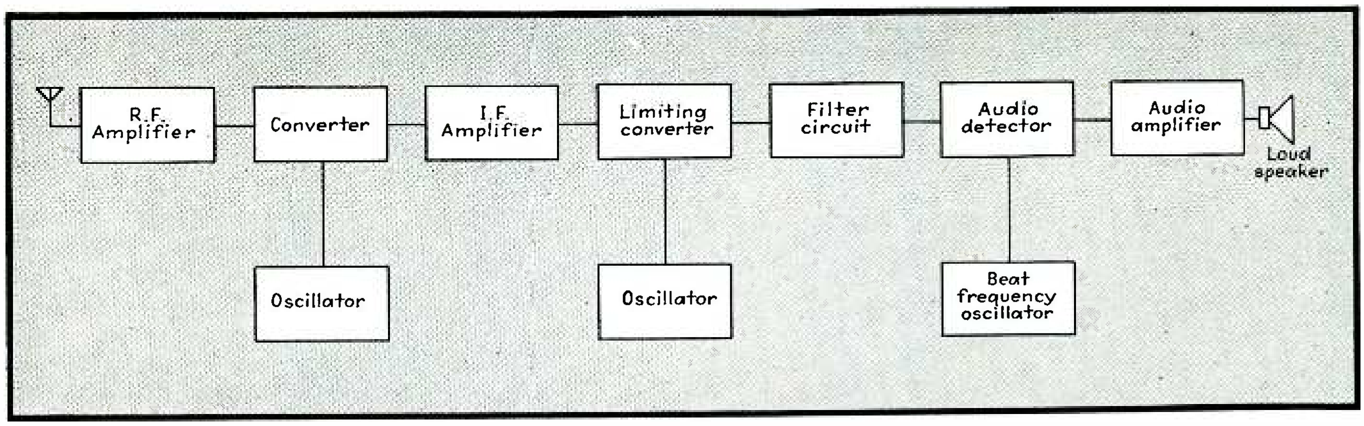
Figure 2 shows in block diagram how this is applied to a superheterodyne receiver designed for the reception of radio telegraphy of the keyed-carrier types. Such a receiver will exhibit two distinctive characteristics: (1) The receiver will appear to have automatic volume control which will follow the keying of the incoming signal regardless of the speed of keying. This will be true for any signal which is sufficiently strong to operate the limiting converter on the flat part of its characteristic (Fig. 1). (2) The noise impulses are held to the same level as that of the signal, provided the signal is sufficiently strong to operate the limiting converter on the flat part of its characteristic (Fig. 1).

A frequency analysis of typical noise impulses indicates a uniform distribution over bands of frequencies many times wider than that accepted by the radio receiver, thus the energy distribution of the noise impulse reaching the limiting converter is that of the selectivity of the receiver up to this point. After passing through the limiting converter, the energy distribution is uniform over the total band width due to the limiting action; furthermore, the peak voltage of the total band width of noise is equal to that of the signal. Since the noise contained within the band width consists of many components of different frequencies scattered throughout the band at any given instant, it follows that if the total voltage resulting from these various noise components, plus the signal voltage, is limited to a given peak voltage, the result will be that no component will have a voltage as great as the limiting value; furthermore, no section of the band will have a voltage as great as that of the total band. Since the signal is confined to a very narrow band width (determined by the keying speed), the insertion of a selective circuit after the limiting converter whose band width is only a fraction of that of the circuits preceding the limiting converter and yet wide enough to pass the signal, will result in a decrease in noise to a value less than that of the signal level by the ratio of band widths of the two sets of circuits, while the signal level will remain unchanged except during a noise impulse.

As an example, let us take a keyed

1 *Relation between input and output voltages of linear detector used as a converter*





2 *Block diagram showing position where the limiting converter in a modern superheterodyne is placed*

signal which requires a band width of one kilocycle. The receiver has a ten kilocycle band-width up to the limiting converter. The band width of the circuits between the limiting converter and the audio detector is only one kilocycle, thus passing the signal completely, but passing only one-tenth of the already limited noise energy. In this way a signal is obtained in which the noise peaks are only a fraction of the amplitude of the signal. Analysis shows that during a noise impulse the signal does not continue to be transmitted through the limiting converter at its normal level, but practically disappears during strong noise impulses. When observing the output on an oscilloscope the signal appears to have a "hole" in it for the duration of each noise impulse.

The system so far considered has been entirely confined to keyed-carrier telegraphy. With special considerations it may be used for telephony (modulated carrier). If the input voltage of the carrier to the limiting converter is kept sufficiently low (not more than half way up the characteristic—Fig. 1), the modulated signal given out by the limiting converter will contain substantially the same modulation as the input. Noise impulses will be limited to a value slightly greater than that equivalent to full modulation of the carrier. If, however, the carrier voltage input to the limiting converter rises to a higher value than half way up the characteristic (Fig. 1), the distortion will rise quite rapidly, and the effective modulation of the carrier will be greatly reduced, particularly on the positive peaks of modulation. If, on the other hand, the carrier voltage is reduced, the noise limiting ability is equally reduced. In practice this will call for a very effective AVC or a manual control so that the limiting converter input can be held closely to the optimum operating point.

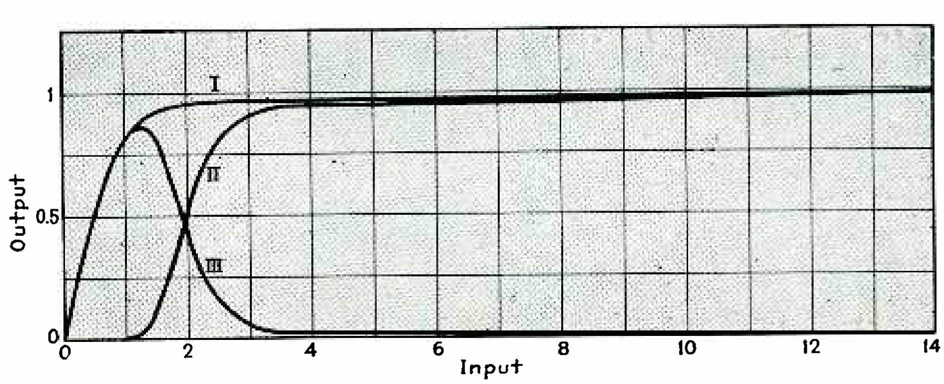
Since the average percentage modulation is much less than one hundred per cent, and the noise can be limited only to an equivalent modulation of one hundred per cent, the result is quite disappointing when compared to the action on reception of keyed-carrier telegraphy. The addition of selectivity after the limiting converter will decrease the noise by the ratio of the band widths, but this does not seem practical in the usual case. Since the selectivity of the receiver up to the limiting converter must be sufficiently sharp to exclude adjacent channel stations, and the circuits following must be sufficiently broad to pass the signal, there is little chance to get any real reduction in noise over and above the action of the system without the aid of additional selectivity.

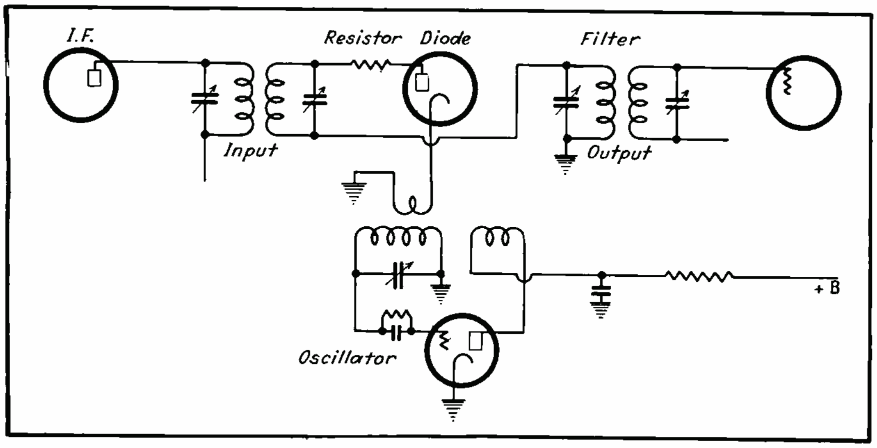
A substantial improvement can be effected by the use of a modified circuit for the reception of radio telephony. If two limiting converters are arranged in a push-pull circuit so that their outputs are in opposition, the transmission will be the difference between the individual outputs. By applying a bias voltage to one of the limiting converters, so as to render it inoperative to a signal (or noise) which is less than that equivalent to one hundred per cent modulation of the carrier, it will contribute nothing to the output. However, for noise impulses several times greater than this critical value, both converters will be operating with their outputs in opposition. The greater the noise disturbances above the critical value, the smaller will be the actual output of the combined converters, since the output of each converter is approaching the same value of output but in opposite phase relations. During a noise impulse the signal practically disappears and the result is a reduced noise output for a medium value of noise impulse input, while a large value of noise impulse input causes a "hole" to be put in the signal with a much reduced noise output. Figure 3 shows the characteristic of such a push-pull limiting converter.

Details of the Limiting Converter

The limiting converter consists of a diode with a series resistor and an oscillator as shown in Fig. 4. The diode itself is essentially a three-halves power device, so in order to approximate linear characteristics a

3 *Push-pull limiting converter. Curves are respectively output of converter, I and II, and combined output, III*





4 *Circuit of limiting converter using a single diode and a resistor and placed between i-f amplifier and second detector*

resistance several times the effective resistance of the diode is inserted in series. This will approximate linearity to a very close degree provided the signal level is several volts or more. At radio frequencies, the diode plate-to-cathode capacitance may have an impedance sufficiently low to have a detrimental effect upon the linearity. The resistance in series with the diode should be as low as possible in comparison with the impedance of the plate-to-cathode capacitance.

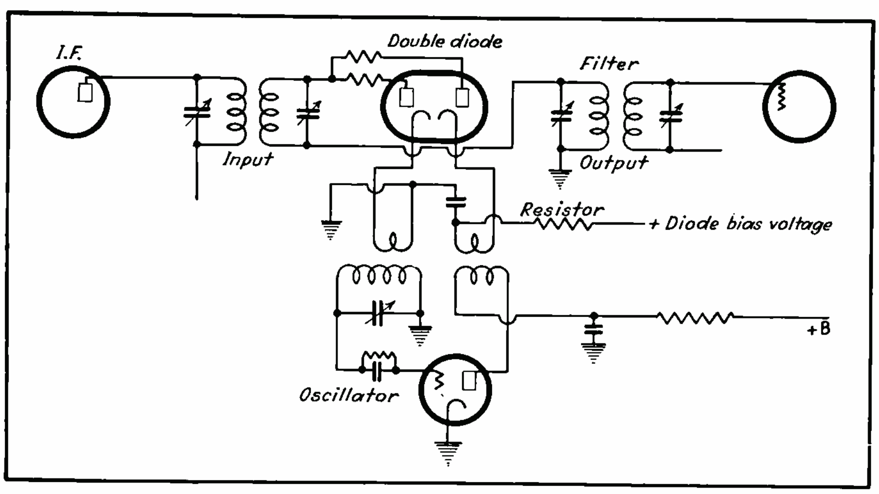
These factors indicate that linearity can be more closely approximated at low rather than high input and injected oscillator frequencies.

Several circuit arrangements of two limiting converters will give the desired cancellation in the output. The input circuit may be push-pull with a parallel output circuit, or a parallel input circuit with a push-pull output circuit, where a single oscillator injection voltage is used in the common cathode circuit. If the oscillator injection voltage is taken from a center-tapped pick-up coil, both the input and the output circuits are arranged in parallel. By splitting this pick-up coil and applying a positive voltage through one-half of the coil to the cathode of one of the diodes, it is inoperative until the combination of the signal voltage and the oscillator voltage is greater than this applied voltage.

As has been pointed out, it is essential to operate the limiting converter about half way up its characteristic (Figs. 1 and 3) to get the most favorable signal-to-noise ratio. This will almost necessitate the use of an AVC which will hold the signal level reaching the limiting converter between narrow limits. Since it is desired to hold the signal to this level, regardless of the amount of noise present, the AVC should be actuated by the signal after it has passed through the limiting converter. If the AVC actuating signal is taken off before it has passed through the limiting converter, peaked noise impulses will AVC the preceding stages to where the signal is at such a low level as to be lost in the noise.

Some means must be used to prevent the system from "blocking" on prolonged noise of high intensity. This "blocking" occurs whenever a lengthy noise surge is balanced out in the push-pull converter for such a length of time that the AVC has had sufficient time to increase the gain of the preceding stages to such a degree that when the noise ceases, the signal reaching the push-pull converter will be so large that it will be balanced out to such an extent that the AVC will be receiving less than normal signal level, thus continuing to raise the gain of the preceding stages. The final result will be no AVC voltage applied to the preceding stages since the push-pull converter has practically no output due to an abnormally large signal being applied to it. This is due to its limiting characteristic.

Since the length of noise impulse to which such a noise reducing system can be effective is probably limited to not more than one-tenth of a second, some means for making the biased diode lose its cancelling out effect after a few tenths of a second would produce a receiver which could not be blocked for more than a few tenths of a second whenever subjected to an abnormally long noise surge. This characteristic can be easily obtained simply by having a condenser and a resistor in the bias supply for the biased diode. Normally the biased diode draws no current when receiving a signal free from noise, and only a small current for a short duration noise impulse. However, for a long duration noise surge the current in the biased diode is much larger. Placing a resistance in series with a bias supply, shunted to ground by a sufficiently large condenser, results in a system which is essentially the same for short noise impulses, but which will build up a large additional bias whenever an abnormally long noise surge is received, thus preventing "blocking." After the surge, the condenser discharges through the resistor, returning to normal voltage within a few tenths of a second.



5 *Push-pull limiting converter using double-diode type of tube. This circuit has advantages cited in the text*

Should Broadcasting Occur in the

500-550 kc. Band?

Channels now used as guard bands protecting antiquated marine transmitting and receiving equipment might be usefully employed to relieve congestion in the broadcast band, and to provide high-quality service

By C. B. AIKEN
Purdue University

THE need for additional frequencies for broadcasting is well recognized by many radio engineers. The band from 550 to 1500 kc. is heavily loaded, and it has been necessary to place shared channel stations so close together that mutual interference is all too common. Studies have shown that, of 382 broadcast stations not included in the "local" classification, 182 are separated by distances smaller than those recommended for night time operation in the tables prepared by the Federal Radio Commission a few years ago. The figures on daytime operation are not so serious, but even here there are 60 transmitters so placed as to run counter to the recommended separations. Most listeners are familiar with the "heaving" and "flutter" effects which result from this overcrowding. In many rural areas, where distance reception must be depended upon, certain channels are rendered entirely useless by interference of this type.

The recent extension of the broadcast band up to 1600 kc. might be expected to relieve this situation somewhat, but it is probable that the demand for new licenses will more than absorb the additional facilities provided. Moreover, the high ground wave absorption will inevitably make the daylight range of the new stations relatively small, and hence the type of service rendered by them will be quite different from that obtained at lower frequencies. When the 1500 to 1600 kc. band has become congested, as it certainly will in time, there will still be need for additional broadcast channels below the present band. The frequencies most suitable for this purpose, because of their proximity to the present band and their useful propagation characteristics, are 520, 530 and 540 kc.

Moreover, it appears that these frequencies are not at present used with maximum efficiency. In view of the steadily increasing congestion in all parts of the radio spectrum and the difficulty in providing for the legitimate needs of the various radio services, inefficient use of any channels is a serious matter. These three channels were originally intended as a guard band for the international calling and distress frequency of 500 kc. and, while so wide a guard may have been necessary in the past, it can hardly be justified today. The elimination of spark sets, together with an improvement in the stability of CW transmitter and in the selectivity of receivers, would make it possible to narrow the marine channel considerably.

It has often been claimed that the use of frequencies between 500 and 550 kc. for broadcasting would be a menace to safety of life and property at sea. But it is also admitted by those who are close to the marine radio situation that a large proportion of radio-equipped ships are provided with apparatus only for the purpose of meeting the Government's requirements and without regard for efficiency. There is no hope, we are told, of persuading the owners of these ships to install modern equipment, since the law does not call for it, and they are content to continue with obsolete sets.

Dr. Aiken, in this article, deals with a provocative subject on which there are many points of view. Readers' opinions, pro and con, are welcomed by the editors

Obviously, these claims cannot both be sustained. Either radio is not necessary to the safety of poorly equipped ships, or else they are themselves contributing to the hazards of life at sea. If a safety device is worth maintaining at all, it is worth maintaining properly, and it cannot reasonably be denied that widespread use of modern equipment on ocean going vessels would reduce the interference now so common in the marine bands and would be an increased protection to the lives of passengers and crews. At the same time, it would make possible the use of 520, 530 and 540 kc. for broadcast stations located in the interior of the country.

When marine radio interests claim that there must be no broadcasting on these frequencies because of the interference which it would cause at sea and, at the same time, admit that many ship owners will not install modern equipment, they are in effect insisting that the ship owners be allowed to dictate the manner in which radio frequencies are used. Here, then, would seem to be a situation which is regulated not by proper governmental authority but by the entrenchment and lack of cooperation of certain commercial interests.

Possible Improvements in Marine Communication

The chaotic conditions existing on the marine frequencies could be greatly improved if all ships and shore stations used crystal-controlled CW or modulated CW sets. At present, the frequency stability of many marine transmitters is so unjustifiably poor that it is essential to use receiving equipment having a very wide passed band. This wide band is ordinarily obtained, not by using the best modern design for maximum selectivity compatible with a specified band width, but by using broadly tuned receivers of very inferior selectivity.

With crystal-controlled transmitters, it would be possible to use receivers having adjustable band width. A superheterodyne with a crystal filter in the i-f amplifier could be used to cut out a vast amount of interference from other stations in the same band. The best practice in receivers used by radio amateurs is far ahead of that now ordinarily found in marine services, and has clearly demonstrated what may be done by the latter in the future. With high stability of frequency control, it should be unnecessary to use a general listening band as wide as 30 kc. All calling could be done within not more than ± 7.5 kc. of 500 kc., and distress calls could be transmitted squarely on the international frequency. Consequently, it should be permissible to regard 507.5 as the maximum frequency involved in general listening conditions, and 515 as the maximum to be used for working. No broadcast interference should be tolerated on 507.5 kc., but a small amount, in certain areas near the coast, might be allowed at 515, since in these areas another working frequency could be chosen.

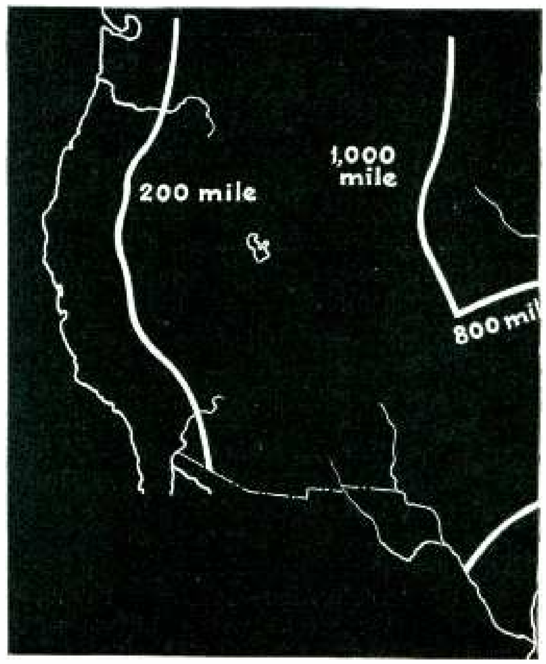
In order to show clearly the possibilities, let us speculate on what the 500 kc. marine picture may be in years to come. Since a large number of ships must be accommodated simultaneously in a given area, the transmitter should obtain its carrier wave in a manner permitting the operator to tune to any frequency from 485 to 515 inclusive, with an uncertainty of much less than a kilocycle. To do this, a master oscillator would operate with crystal control at, say, 480 kc. A stable low frequency oscillator having a tuning range from 5 to 35 kc. would furnish a tone to be mixed with the output of the crystal, the resultant difference frequency being rejected by a high-pass filter, while the sum would be used to actuate the transmitter. Since a high degree of stability (in terms of actual cycles deviation) may be obtained with an oscillator of such low frequency, the radiated carrier could be held to the desired value within an error which should certainly not exceed ± 400 cycles. The nominal frequency could be shown on a calibrated dial, and two stations experiencing "jamming" could agree to shift to a part of the band free from interference at the time. Since the receivers would also be calibrated in kilocycles, it would be possible for one man to tune over the band until he found a clear space, and then instruct the other to tune his transmitter to that frequency. With the short-period stability to be had with modern design, it would be possible for the receiver, employing a crystal filter, to use a band only a few dozen cycles wide when working with a particular station. On the other hand, during a listening watch, a substantially constant response over an interval of, say, 15 kc. could be used.

The precise control of transmitter frequencies would make easier the development of satisfactory automatic alarm systems and would also be of help in times of emergency. In spite of damage to the antenna or to the power stage of the transmitter, it should be possible to maintain the exact frequency by means of the relatively protected crystal oscillator. In fact, a spare crystal unit might well be provided for emergencies.

The improvement in service which would result from the use of such equipment would be so great as to completely change the whole marine operating problem, since the same principles could also be applied to operation in many of the other bands. This would require no great complication in either transmitting or receiving equipment, but would call for separate crystals for each band.

It must be emphasized that the scheme just outlined would not require unreasonably expensive apparatus, nor is there anything about operation on shipboard which would prevent the realization of the suggestions which have been made. Any statements to the contrary, based on experience with the extremely crude apparatus used in the past, are not in keeping with the facts recognized by present-day engineering.

Let us now see what interfering night field strengths might be laid down near the coast by stations located in the interior of the United States. Probably the best information on night field strengths at broadcast frequencies is to be found in the extensive studies of Norton, Kirby and Lester*. Their work shows that a station radiating 50 kw. and located 1000 miles from the coast would lay down an average maximum night field (which is not very different from the "quasi-maximum" night field) of about 0.6 millivolts per meter. Occasional values



Contours of equal distance from the United States' Sea Coasts

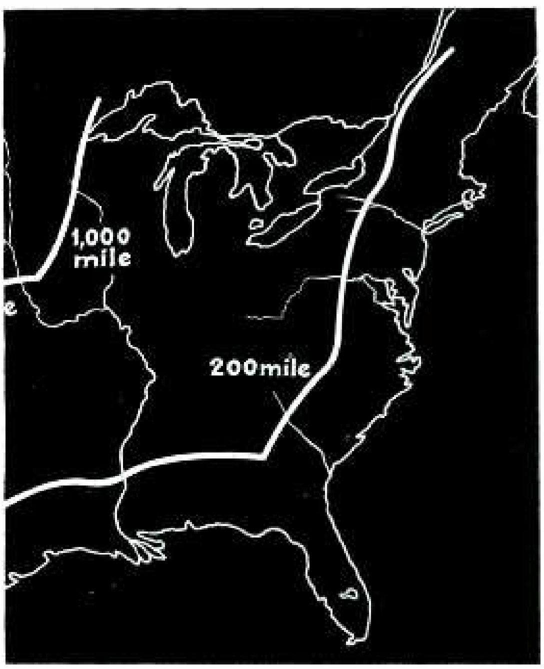
would rise higher than this, but during most of the time the field should be less than 1.0 millivolt per meter. That such a field would not be objectionable we shall attempt to show later on.

Since high noise levels are common in the Gulf, it should be possible to tolerate slightly greater interference there than on the Atlantic or Pacific coasts. Consequently, if a station were permitted 1000 miles from the ocean, it should not have to be removed by more than, say, 600 to 800 miles from the Gulf. To be conservative, we shall adopt the latter separation. In the figure is shown the area included between three contours which are, respectively, 1000 miles from the Pacific, 800 miles from the Gulf, and 1000

*"Analysis of Continuous Records of Field Intensity at Broadcast Frequencies." Proc. I. R. E., vol. 23, pp. 1183-1200, October, 1935.

miles from the Atlantic coasts. It will be seen that this includes the greater part of North and South Dakota, Minnesota, Nebraska, and portions of Kansas and Iowa. This is a considerable area which might well accommodate three 50 kw. stations.

It would not, of course, be essential to use these frequencies for clear channel 50 kw. stations. If 5 kw. stations were used, the maximum average field due to sky waves at night would be only slightly over 1 millivolt per meter at a distance of



Stations inside these lines should not interfere with maritime services

about 350 miles, and would tend to be less than this at both greater and smaller distances. Ground wave propagation would, therefore, largely determine the distances at which the stations would have to be removed from the coast. An examination of the latest curves issued by the committee preparing for the fourth meeting of the C.C.I.R. indicates that for an assumed soil conductivity of 10^{-13} and for 5 kw. radiated at 550 kc., a field strength of 1 millivolt per meter should occur at a distance of about 110 miles. Actually, the conductivity is distinctly poorer than this in most coastal areas, and hence a 100 mile distance should be quite adequate. However, to allow for highly efficient antennas and to reduce daylight interference, a distance of 150, or at most 200, miles from the coast might be required. The 200 mile contour is shown.

If lower powers were used, transmitters might, of course, be placed still nearer to the coast, but it seems unlikely that stations of less than 5 kw. would be assigned to frequencies below 550 kc.

It is quite possible to design a receiver with reasonably uniform response over a 15 kc. interval (extending from 492.5 to 507.5 kc.) and which is 80 db. down at 520 kc. Such a unit would be neither unduly expensive nor difficult to maintain in adjustment, and would be more than capable of satisfactory discrimination against a 1 millivolt per meter field on 520. When a crystal filter was cut in, for working with a particular station, the selectivity would, of course, be increased.

Foreign Stations

It has been claimed in the past that, even though American ships were equipped with up-to-date apparatus, it would be unfair to subject foreign ships cruising near our shores to interfering fields of the frequencies in question, since these vessels might not be equipped with selective receivers and would therefore be placed in a hazardous position in case of emergency. This argument can be met in two ways: first, there is no reason why the development of American communication systems should be handicapped by the unwillingness of foreign operating companies to equip their ships with modern receivers; and second, there are already in existence several broadcast stations between 500 and 550 kc. within possible interfering distance from salt water. These are shown in the table below.

It will be seen that none of these stations is anything like as far from the coast as stations located in the north-central part of the United States would be. Thus, Budapest, on 546 kc. with a power of 120 kw., is capable of causing much more interference to obsolete receivers on the Adriatic than a 50 kw. station on 540 kc. located near St. Paul or Omaha would cause on our coasts. Tartu and Hamar, although of low power, are not far from salt water and would be more apt to cause interference with marine services than would a 10 kw. station on 520 located at, say, Bismark, North Dakota.

The question might be raised as to whether any of these stations use directive antennas to reduce interference with marine services. While no data are at hand, it seems very unlikely that such antennas are used, since, insofar as their application to broadcasting goes, they are largely an American development. Moreover, it is obvious that many of these stations would have to cut down the service rendered over a very wide arc, if any real protection were to be given to ship receivers. Thus, Hamar would have to reduce its radiation through an angle of about 230 degrees; Viipuri, Finland, could hardly prevent interference with any type of antenna; and many of the other stations would have to cut down their radiation through angles varying from 90 to 180 degrees. It is hardly to be expected that broadcast transmitters would be built in this manner.

Aside from the stations listed in the table, we must consider the use

[*Continued on page* 60]

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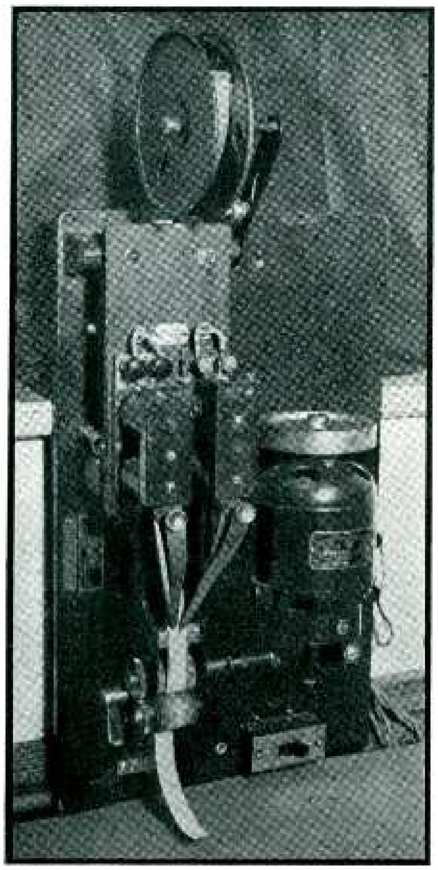
FOREIGN STATIONS OPERATING ON 510-550 KC.

Frequency in kc.	Location	Power	Distance from Seacoast
517.2	Tartu, Esthonia	0.5	75 miles from Gulf of Finland; 80 miles from Gulf of Riga.
519	Hamar, Norway	0.7	115 mi. from Skagerrak; 220 mi. from North Sea.
522	Stalingrad, USSR	10	266 mi. from Caspian Sea; 265 mi. from Sea of Azov (Gulf of Taganrov).
527	Grenoble, France	3.5	130 mi. from Mediterranean.
527	Viipuri, Finland	10	On Gulf of Finland.
527	Ljubljana, Yugoslavia	5.25	45 mi. from Gulf of Trieste; 45 mi. from Gulf of Quarnero.
531	Brzesc, Poland	5	235 mi. from Baltic Sea.
536	Wilno, Poland	50	180 mi. from Baltic Sea.
536	Bolzano, Italy	1	90 mi. from Adriatic.
546	Budapest, Hungary	120	290 mi. from Adriatic.
546.8	Merida, Mexico	0.105	30 mi. from Gulf of Mexico.

Depth-Sounding

Coast and Geodetic Survey uses automatic buoy-transmitters to detect sound from T.N.T. blasts, thus giving echoes from the ocean floor which can be used to chart submarine geography



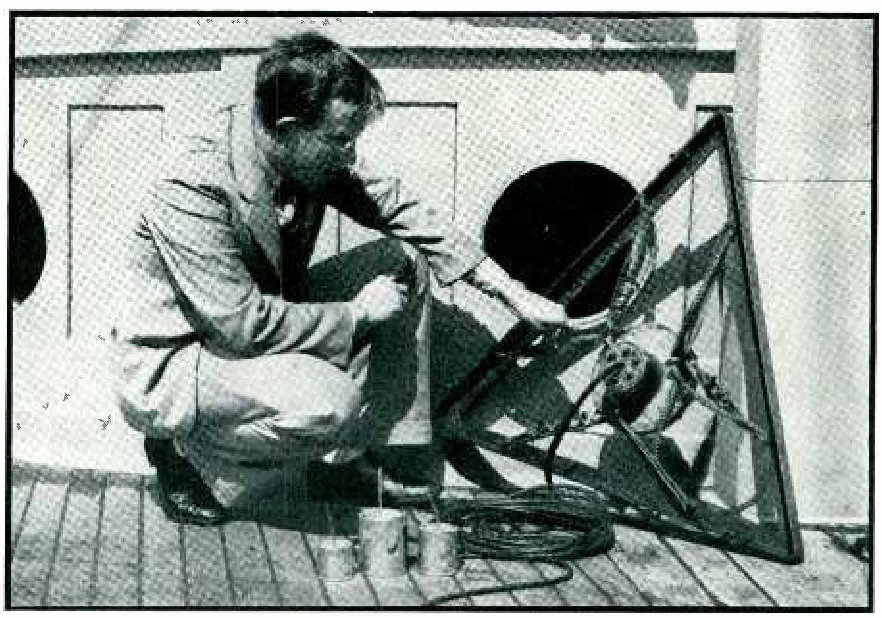
The recording chronograph which marks on tape the time interval between the explosion of the T.N.T. blast and the arrival of the radio signal from the buoy

AUTOMATIC radio transmitters have been used for a variety of purposes in recent months, from exploring the stratosphere in unmanned balloons to reporting weather data from unattended stations in Siberia. The latest use of this type of radio is in connection with the branch of seismology known as depth-sounding. Depth-sounding, without benefit of radio, has been used for many years as a means of determining the depth of the ocean floor, and fathometers working on the depth-sounding principle are in daily use by all large ocean liners.

At the present, depth-sounding methods are being used by the U. S. Coast and Geodetic Survey in charting the ocean floor off the Eastern coast. The last charts of the off-shore approaches to New York City were made in 1882 and 1883; it was found in exploring a recently-discovered gorge in this area that the original determinations of position were in error by as much as three miles in some cases, so it was decided that a thorough recharting of the area was in order.

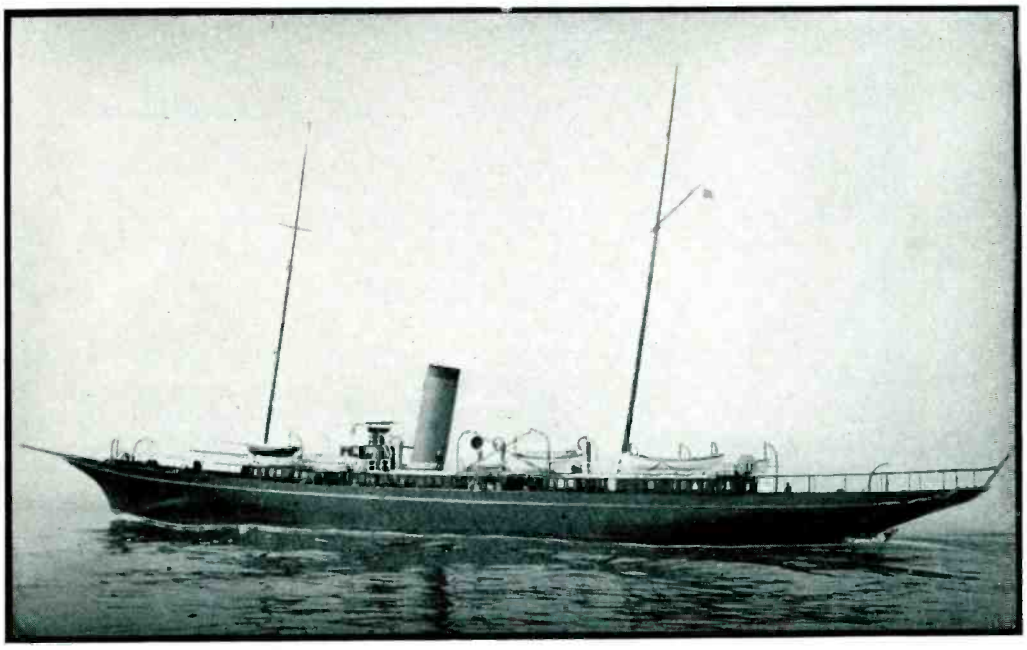
The method used is simple. A blast of high explosive, usually T.N.T., is discharged at a known position under the water. The sound wave (seismic shock) which travels from the blast is reflected from the ocean floor upward to the surface where it is intercepted by sound-sensitive devices (hydrophones) which have previously been set in position for the purpose. These hydrophones may be as much as 45 miles away from the original blast. If the time interval between the blast and the arrival of the sound wave at the hydrophone can be measured, the distance the sound has traveled can be determined from the known speed of sound in water (about nine-tenths of a mile per second). The practice until recently has been to station small boats at the hydrophones and to radio the time of arrival of the sound back to the ship which sets off the blast. The latter ship has a chronograph which records the time of the blast and the time of arrival of the radio signal. Since the time consumed by the radio link is negligible, the elapsed time between the two reference points gives the time of travel of the sound wave.

The small boats used for radioing from the hydrophones are often anchored far from shore in stormy or foggy weather, and there has been considerable danger in manning them, in addition to the expense of



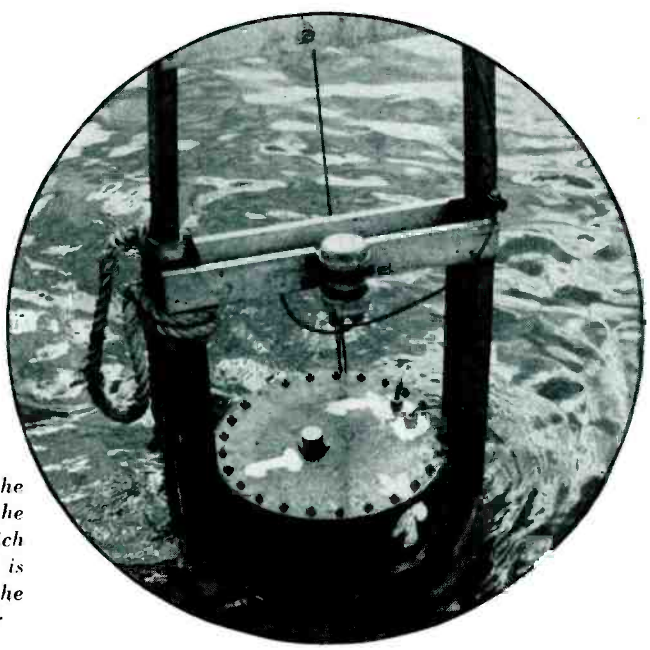
T. J. Hickley of the U. S. Coast and Geodetic survey with the hydrophone unit which detects the arrival of the sound. The three cans in the foreground contain T.N.T. The largest produces an explosion audible for 60 miles

by Radio

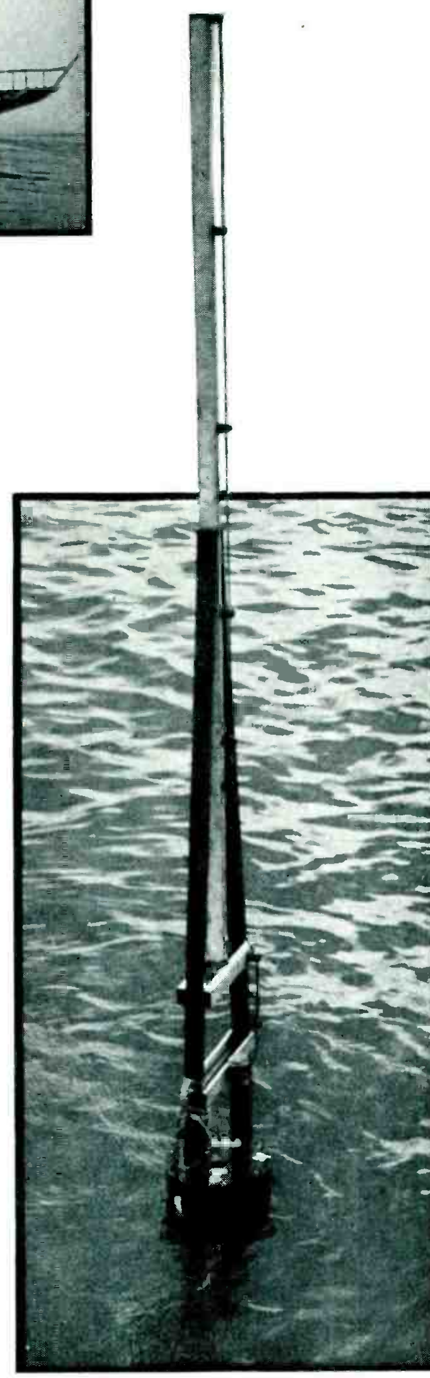


The **Oceanographer,** *formerly* **J. P.** *Morgan's yacht,* **Corsair,** *the base ship for the depth sounding work*

A sono-radio buoy "on location". The antenna extends 20 feet above, the buoy, 15 feet below the surface



Close-up of the unit, showing the oil-barrel in which the transmitter is housed and the automatic relay



maintaining them and their crews. To overcome this problem, Dr. Herbert Dorsey of the Coast and Geodetic Survey developed "oil-barrel" radio stations, consisting of water-tight buoys of barrel-like construction, containing an automatic transmitter and surmounted by a vertical quarter-wave antenna. The hydrophone lies in the water beneath the buoy and is connected to the transmitter by a relay circuit. When the sound wave arrives, the radio transmitter goes into action at once, with a time delay which has been measured and hence can be eliminated from the calculations. The wavelength used is approximately 72 meters. The recorder may mark the arrival of several sound waves, from different parts of the ocean floor, and of course from the direct wave which travels parallel to the surface. Two buoys are usually used at once, in different positions, hence considerable information as to the outline of the ocean floor can be obtained even from a single blast by proper geometrical interpretation of the chronograph records.

Winding the

Details of how to calculate the various factors entering into the winding of universal coils used with such great frequency in modern radio receivers

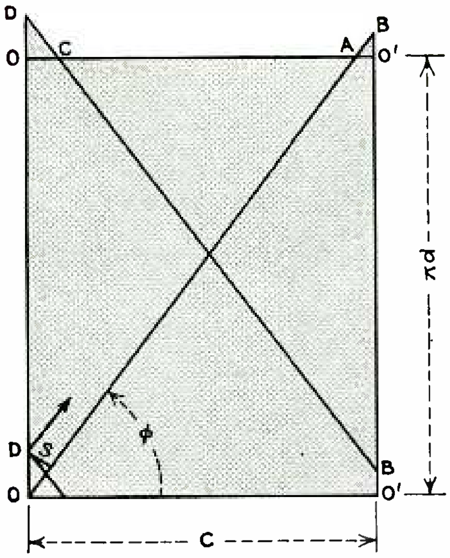


Fig. 1. Developed diagram of progressive winding with one crossover per turn

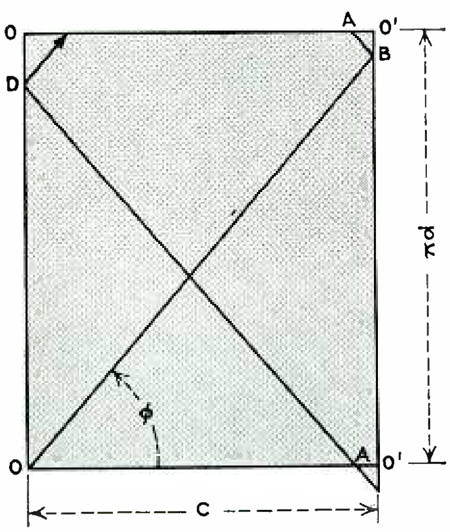


Fig. 2. Developed diagram of retrogressive winding with one crossover per turn

By A. W. SIMON, Ph.D.
Research Physicist, Radio Laboratory, Stewart-Warner Corporation

UNIVERSAL coils are wound so that, as the dowel or form on which the coil is wound rotates, the wire is guided back and forth by a shuttle, which displaces the wire in linear proportion to the angle of rotation from the last point of maximum left or right displacement. This shuttle is actuated by a cam mounted on a shaft, which is geared in a definite ratio to the shaft turning the dowel.

The wire may make one or more crossovers while the dowel makes one revolution; or the dowel may make one or more revolutions while the wire makes one crossover; and it is also possible (and often advantageous) to wind coils where the number of crossovers per turn or the number of turns per crossover is an integer plus a simple fraction, such as $1\frac{1}{2}$, $1\frac{1}{3}$, $2\frac{1}{2}$, etc. Strictly speaking, in the case of the one crossover per turn winding, the wire does not cross over in exactly one revolution, but either in somewhat more (progressive winding), or somewhat less (retrogressive winding) than an exact revolution; and similar relations hold for multiple crosses.

In studying the universal winding, its developed diagram is of great convenience. Figure 1 represents the developed diagram for the case of a progressive winding with one crossover per turn. The trace may be taken to represent the left hand edge of the wire. The wire starts at O, runs across at a definite angle Φ to the axis and has reached the point A when the dowel has made a complete revolution, continues on and completes the crossover at a point B, a distance h from the starting line OO'; then reverses its direction and has reached the point C when the dowel has made two complete revolutions, continues on and completes the second crossover at a point D, distance $2h$ from the starting line OO'. The process is then repeated beginning from a new starting line through the point D, and so on.

In the case of a *retrogressive* winding of one cross per turn (Fig. 2), on the other hand, the wire again starts at O and runs across at a definite angle Φ to the axis but completes the crossover, *before* the dowel has made a complete revolution, at a point B located at a distance h on this side of the starting line OO', reverses its direction and has reached the point A when the dowel has made exactly one revolution, continues on and completes the second crossover at a point D, a distance $2h$ behind the starting line OO'. The whole process is then repeated beginning with a new starting line through the point D, and so on.

It will be noted that in the case of a retrogressive winding the new starting line falls continually behind the preceding one; while in the case of a progressive winding it moves continually ahead. Hence if the wire is wound in a clockwise direction in both cases, in the *retrogressive* winding the layering proceeds in the *opposite*, i.e., the counterclockwise direction; while in the progressive winding, the layering proceeds in the *same*, i.e., also the clockwise direction.

The distance $O'B = h$ might be defined as the *linear advance per crossover*; while the distance $OD = H$ might be defined as the advance per winding cycle or the *winding space*.

If we redraw the developed diagram for a complete winding cycle but ignore the slight advance h per crossover, we obtain the *pattern* of the winding. A knowledge of the winding pattern is really sufficient in most cases to deduce the geometrical characteristics of the coil, such as the number of crossovers per winding cycle, the number of herringbones, etc. The winding patterns for 1, $1\frac{1}{3}$, $1\frac{1}{2}$ and 2 crossovers per turn are given in Fig. 3.

If now we denote by n the number of crossovers per turn, where n is equal to or greater than unity, by q the number of crossovers per winding cycle (obtained from the winding pattern), by c the maximum dis-

Universal Coil

placement of the cam, by d the diameter of the dowel, and by s the distance between centers of two adjacent parallel wires at the dowel diameter, we have:

$$S = H \cos\Phi = qh \cos\Phi. \quad (1)$$

Also we have:

$$C \tan\Phi = \pi d/(n \pm h). \quad (2)$$

If, further, we denote by Θ the angular rotation of the cam, by Ψ the angular rotation of the dowel, by r the gear ratio employed between the cam shaft and the dowel shaft, by x the displacement of the wire parallel to the axis, and by y the displacement perpendicular thereto (on the developed surface) we can put:

$$x = C\theta/\pi \ (3) \text{ and } y = \psi d/2. \quad (4)$$

But the ratio of y to x is equal to $\tan\Phi$ whence we have also:

$$\tan\Phi = r\pi d/2c. \quad (5)$$

Eliminating Φ between Eqs. (1), (2) and (5) we have finally:

$$r = \frac{2}{n}\left[\frac{1 \pm \sqrt{a^2 + b^2 - a^2b^2}}{(1 - a^2)}\right] \quad (6)$$

where the upper sign is taken for a progressive winding and the lower for a retrogressive one, and where a and b are given by:

$$a = s/qc \ (7) \text{ and } b = ns/q\pi d \quad (8)$$

However, since a and b are small quantities Eq. (6) can be written with negligible error in the form:

$$r = \frac{2}{n}\left(1 \pm \sqrt{a^2 + b^2}\right)\left(1 + a^2\right) \quad (6a)$$

Where a and b are defined as above, and n is restricted to values equal to or greater than unity.

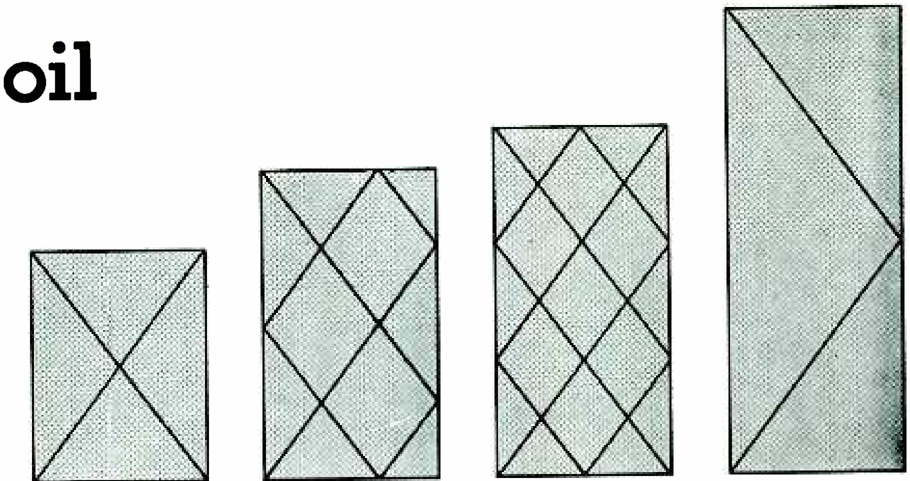


Fig. 3. Winding patterns for 1, 1⅓, 1½, and 2 crossovers per turn

From this equation the gear ratio required in winding a coil can be calculated provided the cam displacement (coil width), dowel diameter, number of crossovers per turn, the number of crossovers per winding cycle (deduced from the number of crossovers per turn) and, lastly, the wire spacing at the dowel diameter are given.

In connection with the latter, i.e., the *spacing* between centers of adjacent wires at the dowel diameter, it is convenient to define a spacing factor f according to the equation:

$$s = f\delta \quad (9)$$

Where δ is the nominal diameter of the wire. This spacing factor can be selected on the basis of other factors such as the mechanical properties of the coil, the distributed capacity of the winding, etc. As regards purely the mechanical properties of the coil, it is found that a value of f equal to 1.25 produces very satisfactory results. Coils wound with this factor are very stable mechanically and have sharply defined, straight walls.

We pass now to a consideration of the significance of the *number* of crossovers per turn and the question of the correct number to be used in a given case. This is determined purely by mechanical considerations, as follows:

In order to wind well, the winding angle Φ must be between certain limits. If it is too small, the component of the tension of the wire parallel to the axis of dowel overcomes the frictional force holding the wire on the dowel, and the wire slides on the dowel toward the center of the winding; while if the angle Φ is too steep, the wire is not "pinned down" properly at the edges of the coil, resulting in a weaving of the wall. Hence, in order to build up a coil as high as possible, number of crossovers must be so chosen that at the dowel diameter the angle Φ is near its *lower* limit; the coil will then build up satisfactorily until Φ attains its upper limit.

Based on the fact that the angle Φ must be near its lower limit, we see, for example, (Fig. 4) that if Φ has the correct value in the case of coil No. 1 of one crossover per turn, coil No. 2, which has *half* the *width*, must be wound with *two* crossovers in order to maintain the same angle;

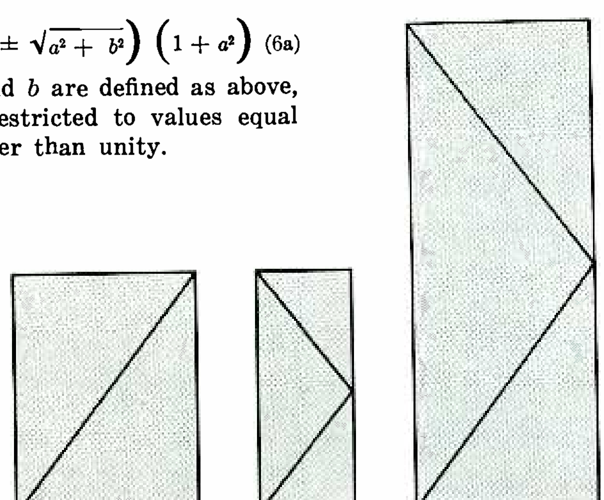


Fig. 4. Effect of width and diameter of coil on the required number of crossovers per turn

while coil No. 3, which has *double* the *diameter* of coil No. 1, must be wound also with *two* crossovers per turn to maintain the same angle Φ. Hence the formula giving the correct number of crosses per turn must have the form:

$$n = kd/c \quad (10)$$

where k is a constant. In practice it is found that 1 crossover per turn is very satisfactory in the case of a $\frac{1}{4}''$ coil wound on a $\frac{3}{8}''$ dowel, which, substituted in Eq. (10) gives $k = 2/3$, so that we can write in general:

$$n = 2d/3c \quad (11)$$

This equation holds over a considerable range of diameters and coil widths.

It should be noted that the number of crossovers is rather critical and for best results should be chosen in accordance with the above formula. Coils can be wound with a number of crossovers slightly less than the formula calls for but never with one greater, since we have chosen k so that Φ shall be at the lower limit.

If the side of a universal wound coil is examined, it is seen to exhibit a definite pattern in the form of a number of "spokes" or "spirals" radiating outward. The nature of this pattern, as well as the number of these spokes or spirals appearing, depends on the gear ratio employed, so that from a knowledge of the gear ratio it is possible to predict whether a radial or spiral pattern will appear in a given case, as well as the actual number of spokes or spirals which will make up the pattern; while, conversely, from a count of the number of spokes or spirals appearing on the side of a coil, the gear ratio employed in winding it can be deduced. (The number of spirals is, however, more difficult to count.)

Of fundamental importance in this connection is the number N of winding spaces of length H per layer of the coil, which is given by the equation:

$$N = \pi d/H = \pi d/qh \quad (12)$$

Solving Eqs. (1), (2) and (5), for $\pi d/qh$ we obtain:

$$\pi d/qh = 2n/q(nr - 2) \quad (13)$$

But the formula for r takes the form:

$$r = \frac{2}{n}\left(1 + p\right) = \frac{2}{n}\left(1 + \frac{1}{P}\right) \quad (14)$$

where p is a small fraction and P its reciprocal, and this gives in turn:

$$(nr - 2) = 2p = 2/P \quad (15)$$

Substituting these values back in Eq. (13) we obtain finally:

$$N = n/pq = nP/q \quad (16)$$

From this equation the number of winding spaces per layer can be calculated provided the number of crossovers per turn, the number of crossovers per winding cycle, and the gear ratio are known.

It is obvious that if N is integral the points of maximum displacement of the wire for successive layers will fall on the same radius giving rise to a *radial* pattern; while if N is not integral they will be displaced in successive layers giving rise to a *spiral* pattern. Two examples will make this clear:

Let us suppose one crossover per turn ($n = 1$, $q = 2$) and a gear ratio of 74/36 has been used. The gear ratio can be written in the form:

$$r = 74/36 = 2\,(1 + 1/36)$$

from which we have, by comparison with Eq. (14), $p = 1/36$ and $P = 36$, whence Eq. (16) gives, $N = 18$. Hence a coil wound with this gear ratio should have 18 spokes in the pattern.

On the other hand, if a gear ratio 72/35 has been used we would have $p = 1/35$ and $N = 17.5$. Hence the points of maximum displacement of one layer would fall half way between those of the preceding thus giving rise to a *spiral* pattern.

Hence by changing the gear ratio by only half a tooth a radial pattern can be changed to a spiral pattern and vice versa.

If we are interested in determining the gear ratio employed in winding a coil from a count of the number N of winding spaces, we solve Eqs. (15) and (16) for r, and have:

$$r = 2\left(\frac{1}{n} + \frac{1}{Nq}\right) \quad (17)$$

For example, if 18 spokes are observed on the side of a coil wound with one crossover per turn ($q = 2$) the gear ratio was:

$$r = 2\,(1 + 1/36) = 74/36$$

A knowledge of N, i.e., the number of winding cycles per layer also enables us to deduce the number of turns per layer and the total number of layers on a given coil.

Since the wires cross over each other in a universal winding, it is necessary to define exactly what is to be understood by the term "layer" as applied to this type of winding, and we shall take the first layer to mean that portion of the winding required to just cover the area of the dowel between the lateral confines of the coil, the second layer that portion required to just cover the area of the first layer, etc. A layer then will be actually two wire in diameters in thickness.

Since there are N winding spaces per layer, 2 crossovers for each winding space, and n crossovers per turn,

[Continued on page 67]

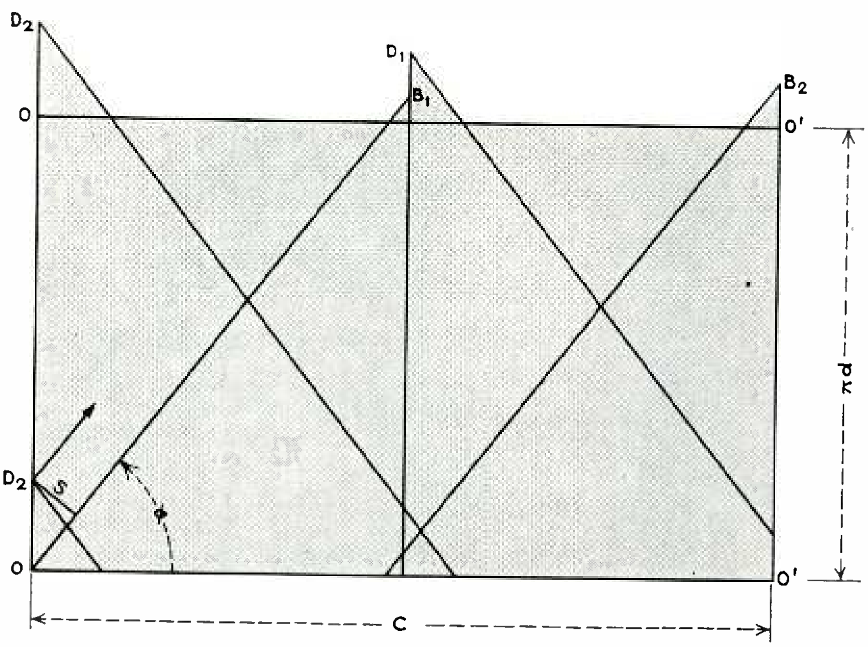


Fig. 5. Progressive winding with two turns per crossover

Humidity

A simple method for measuring the effect of humidity on materials and parts used in radio equipment, the equipment used, and typical results of such measurements

ONE of the annoying problems that nature presents to the design engineer is that of protection against moisture in the air. This problem is annoying because of the continual variability of the amount of moisture in the air, because a great many materials useful in radio (and other) design are very susceptible to moisture but most annoying because of the difficulty of completely preventing moisture from seriously affecting the behavior of many useful materials in radio circuits.

It is largely an insulation problem. Some of the most commonly used materials: paper, silk and mica, are radically changed in their insulating qualities by the penetration of moisture from the air. The phenolic resin materials are affected. Even the ceramics are not immune. Some materials such as rubber, quartz and glass have excellent moisture resisting properties but the majority of the insulating materials useful in radio design must be protected against contact with the air by impregnating or coating them with waxes, oils, varnishes or other moisture resistant materials in order to make them reasonably stable under all weather conditions.

The general humidity problem may be divided into two quite distinct problems:

(1) **Condensation of liquid water on the material surface.** This generally occurs when the humidity is very high and the temperature of the material is slightly lower than that of the surrounding air, and frequently occurs in the morning when the air temperature may be rising and the temperature of the material lags somewhat behind that of the air. This is a surface problem and the general solution lies in providing long surface paths and a type of surface that water will not "wet".

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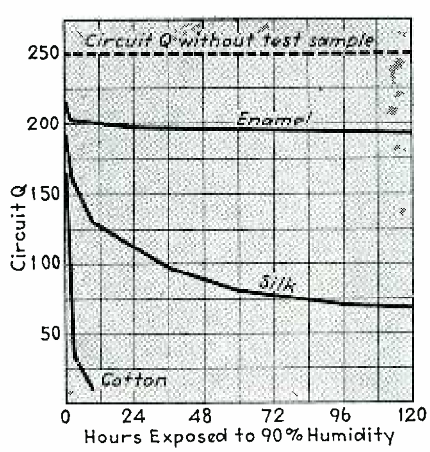
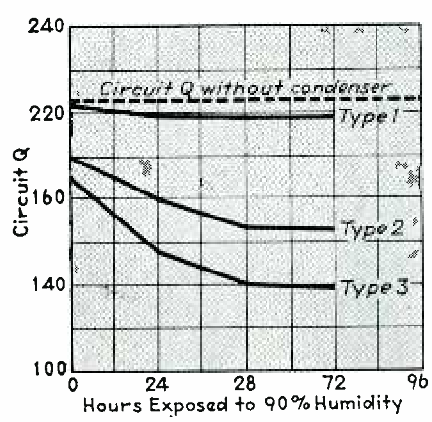


1 *Data showing effect of moisture on wire insulation*



2 *Curves giving effect of moisture on trimmer condensers*

In many cases this problem is not serious because of the fact that in most radio equipment enough heat is produced to maintain the temperature of the equipment at a slightly higher temperature than that of the surrounding air, and under this condition water will not condense. In climates having long periods of humidity, water may condense on equipment when it is not in use and frequently in such locations a small heater or incandescent bulb is placed in or near the equipment and kept burning when the equipment is not in use to maintain the temperature higher than that of the surrounding air. This remedy answers the first problem—condensation of water—but is of only slight help in the second.

(2) **Penetration of water vapor from the air into the material.** This is a relatively slow process, depending of course on the material. Generally the amount of moisture taken up by the material from the air slowly reaches an equilibrium value which depends on the humidity of the air and slowly changes to a new value if the humidity changes. The electrical characteristics change, of course, with the amount of moisture taken up by the material. The general solution of this problem lies in selecting materials which are relatively impervious to moisture or in impregnating or otherwise reducing the amount of moisture that normally highly absorbent materials can take up.

Surprisingly little dependable information is available that is of much value to the design engineer in regard to the change in electrical characteristics of insulations and component parts caused by the penetration of moisture from the air. While a number of manufacturers are making progress in this direction and have improved and developed new radio materials and parts which have been of considerable value in the art and can furnish fairly complete information about the properties of their products that interest the engineer, there are still large gaps in the information available on the effects of humidity on the performance of materials and component parts. In many cases it is up to the designer to find out what will happen to a material or part during the humid summer months or under the extreme conditions existing in southern climates.

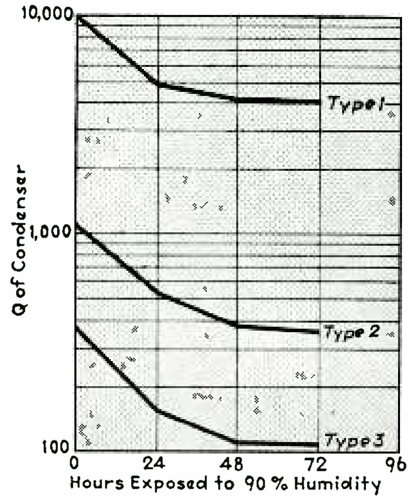
A Simple Method of Measurement

It was to fill in some of the gaps in available information that a simple method was developed for exposing test material or component parts to air maintained at a constant humidity and measuring the characteristics of the material or parts at intervals over a period that may be extended as long as desired with as little attention as possible.

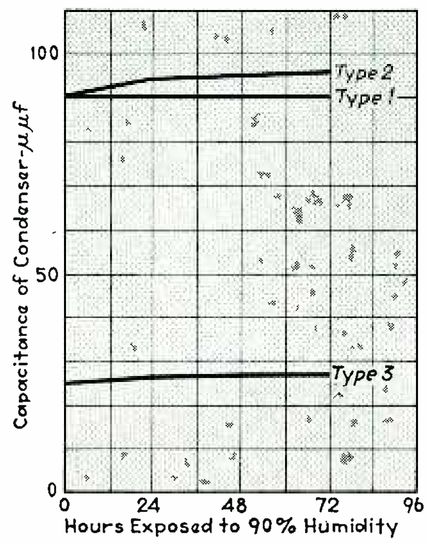
After making a number of tests at different humidities, that of 90 per cent was finally selected as best meeting the requirements of simple maintenance and providing suitable conditions for the majority of tests desired. Humidities near 100 per cent tend to let water condense on the surface of objects, apparently due to small temperature changes and this complicates the effect of moisture penetration by adding a variable surface condition. Lower humidities produce a smaller change in the characteristics of the test material making the measurement less accurate and in the case of production testing sometimes requires a longer test period.

The characteristics of insulating materials affecting radio circuits that change with penetration of moisture are *Q*, or power factor and the dielectric constant. It is generally unnecessary, however, to measure these fundamental characteristics except when studying insulating materials. The majority of tests and especially tests on component parts are more useful when made as comparative tests between two or more similar materials or parts. A simple and accurate method of indicating the changes in these characteristics of test materials or parts which also permits calculating the *Q* and dielectric constant of insulating materials and condensers when desired is to make the test material the dielectric of a small test condenser and to measure the change in tuning capacitance and *Q* of a resonant circuit when the test condenser is connected across the circuit.

For example, Fig. 1 shows the average results of a number of measurements made on three types of wire insulation. The insulation, of course, was not impregnated or treated in any way. Test samples of the three types of wire were made by twisting together pairs of the same wire about four inches long for about half their length, leaving two inch leads for connecting across the measuring circuit. These twisted pairs formed small condensers having a capacitance of a few micro-microfarads, a large part of which was in the insulation of the wire. The capacitances were adjusted to the same value by clipping off the twisted ends.



3 *The Q of trimmer condensers as affected by humidity*



4 *Change in capacitance of trimmer condensers with humidity*

The test samples were measured at room conditions by the method just described and then placed in a small dessicator cabinet in which the air was maintained at 90 per cent humidity. After a suitable interval the samples were removed one at a time, measured at once to avoid their moisture content changing before measurement and were then replaced in the cabinet for another interval of exposure.

The considerable difference in the effect of moisture on these insulations is obvious. It is apparent from Fig. 1 that several days are required for the insulation to become "saturated" although the greatest change occurs within the first 24 hours of exposure. This seems to be characteristic of most materials and makes it possible to obtain very good comparative tests of many materials in a 24 hour period or an over night exposure of 15 to 20 hours.

Effect of Moisture on Trimmer Condensers

A more complete analysis of the effect of humidity on three different types of "trimmer" condensers used commercially in present radio broadcast receivers is shown in Figs. 2, 3 and 4. The curves represent the average measurements made on a number of each condenser type when exposed to air having a humidity of 90 per cent at room temperature (80 degrees F.) for a period of 72 hours. Types 1 and 2 condensers were set at a capacitance of 90 micro-microfarads and type 3, a smaller size, was set at 25 micro-microfarads. Type 1 condensers were air condensers using insulating material only to support the plates while types 2 and 3 were conventional leaf type mica dielectric condensers.

In Fig. 2 are shown the direct measurements of the effect of moisture penetration as indicated by the drop in *Q* of the tuned circuit across which they were connected for measurement. Type 1 is far superior to the other types in initial losses when dry and also in the effect of moisture.

The actual *Q* of the condensers may be calculated from the data in Fig. 2 and the capacitance of the condensers. The average *Q* of each of the three types is shown in Fig. 3. Here the superiority of type 1 in regard to low losses (high *Q*) is again apparent. Even after 72 hours exposure to 90 per cent humidity the average *Q* of this type was over 4,000.

If a type 1 condenser is used to tune an i-f transformer the *Q* of the tuned circuit will be practically the same as the Q of the coil used in the transformer since the condenser Q is high compared to that of most coils used for this purpose. Furthermore the total circuit Q will be little affected by humidity. If, however, a condenser of type 3 is used for this purpose the Q of the combined coil and condenser may be seriously lowered by humidity since the Q of the condenser alone may drop to nearly 100 and if the Q of the coil is about 100 the total Q of the combination may drop to nearly 50.

Another effect of humidity in changing the capacitance of these condensers is shown in Fig. 4. As might be expected the type 1 condensers were unchanged while the type 2 condensers increased from the initial setting of 90 micro-microfarads to an average of 96 micro-microfarads, an increase of nearly 7 per cent after 72 hours exposure and the type 3 also showed an increase in capacitance.

These curves are typical of the useful information that this method of testing provides. In fact the method proved so simple and rapid that in addition to its experimental use in providing valuable design information it was set up as a standard production test for special insulated parts which had to meet very rigid specifications as to low losses and imperviousness to humidity and is in continual use for this purpose.

A very convenient set-up for experimental humidity tests is shown in one of the photographs in use measuring the trimmer condensers previously described. The equivalent consists of a dessicator cabinet such as the Central Scientific No. 3790, a Q-Meter, a 5″ x 7″ photographic developing tray and a few ounces of sodium tartrate.

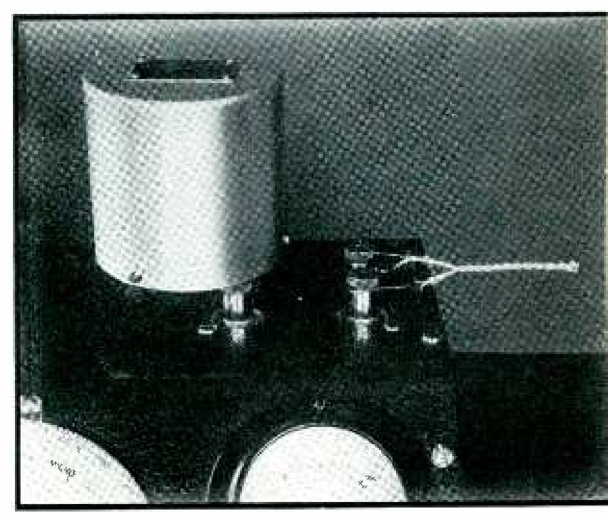
An ounce or two of sodium tartrate is placed in the developing tray and enough water poured on to provide a concentrated solution, indicated by some of the crystals remaining undissolved. The tray is placed in the bottom of the dessicator cabinet. A strip of blotting paper dipping into the solution will provide greater evaporating surface and bring up the humidity more rapidly after putting test samples in the cabinet. The sodium tartrate solution maintains approximately a constant humidity of about 90 per cent. Other solutions may be used if desired to maintain other humidities.

Any component may be placed in the cabinet and exposed to 90 per cent humidity for as long a period as desired without attention. Water lost by evaporation will gradually empty the trap and fresh water should be added when necessary. A convenient time of exposure for comparative or production tests is from 15 to 24 hours, as this permits placing a component in the cabinet one afternoon and checking it the next day.

During highly humid weather it is often useful to have a second dessicator cabinet containing a tray of anhydrous calcium chloride to provide a dry atmosphere, since the room humidity may make it difficult to obtain a "dry" test of materials.

A useful comparative method of testing is to measure a test component "dry", i.e., exposed to normal room humidity unless the humidity is very high; then to place it in the "wet" cabinet for, say, 24 hours and measure the component again immediately on its removal from the cabinet.

The work of Mr. L. O. Cook and Mr. R. W. Knebel, of Boonton Radio Corporation, in improving the technique of humidity measurements and obtaining data for some of the foregoing material is appreciated.



6 *A "twisted pair" in position on the Q-meter for measurement*

5 *Measuring the effect of humidity on trimmer condensers*

A New 6E5 Circuit

New Stromberg-Carlson receivers employ an interesting and useful circuit for tuning indication. By it both weak and strong signals can be tuned in with somewhat greater ease than by means of a meter

By M. L. LEVY

Engineer in Charge
Radio Development Laboratory
Stromberg-Carlson Telephone Mfg. Co.

THE common method of operating the 6E5 tube is, of course, by using the voltage developed by the automatic volume control circuit. The result on a receiver using a double i-f stage and an r-f stage is shown on Fig. 1, curves 1, 2, 3 and 4.

Thus, when full sensitivity is used, by using the entire AVC voltage, the target closes completely at approximately 5,000 μv., but some deflection is noted at 3 or 4 microvolts. Where 3/4 AVC is used, deflection is noted at approximately 15 or 20 and the target closes completely at 20,000 μv., with 1/2 and 1/4 AVC the same trend holds. Therefore, with the AVC voltage as the control grid voltage of the 6E5, if sensitivity is obtained for weak signals, no sensitivity is obtained for strong signals; that is, the fluorescent screen will close completely and no accurate tuning indication is possible. Similar results are obtained with the 6G5, as shown in Fig. 1, curve 5. In neither case (6E5 or 6G5) can good sensitivity be obtained over the entire range of broadcast field strength.

The following circuit (Fig. 2) is a method to remedy the shortcomings of the AVC voltage method of using the 6E5 or 6G5 as a tuning indicator tube.

The 6E5 has a cut-off voltage of approximately 7 volts. Thus, the cathodes of the r-f, modulator and 1st i-f tubes are 7 volts above ground, the second i-f tube is also 7 volts above ground, but is not controlled by AVC. Therefore, the cathode of the 6E5 is connected to the cathode of the 2nd i-f tube and the control grid of the 6E5 is connected to the cathode of the i-f tube. Thus, the maximum effective negative voltage possible on the control grid is 7 volts, so that the screen can never be completely closed, since with full AVC operation when the cathode to ground voltage of the i-f tube is nearly zero, the 2nd i-f tube which is not controlled by AVC maintains a positive cathode potential of approximately 7 volts. The diode circuit for AVC operation is connected as shown, where the cathode of the diode of the AVC circuit is connected to the —3 volt point, so that AVC is applied to the tube at the proper minimum bias.

Curve 6, Fig. 1 is a curve on the same chassis using the circuit of Fig. 2, which shows that the sensitivity is maintained for weak signals and effective and accurate tuning is possible for strong signals. For signal input voltages of 2 to 5 volts on the antenna of the receiver, a perceptible deflection occurs and will not close the target, thus excellent tuning indication is possible for extremely strong broadcast signals.

Figure 3 shows a circuit for using a multi-purpose tube such as 6Q7 in the same manner. The r-f and i-f circuits are similar to Fig. 2, but a problem presents itself in obtaining the AVC voltage, without putting a positive potential on the diode used to obtain AVC, therefore, E_1 is the normal bias for the tube (6Q7 for example). E_2 must be greater than E_3 or a negative potential bias will be set up due to current flowing in the diode circuit. E_2 may be made large enough to effect a delay bias on the AVC diode for its usual advantages, such as allow-

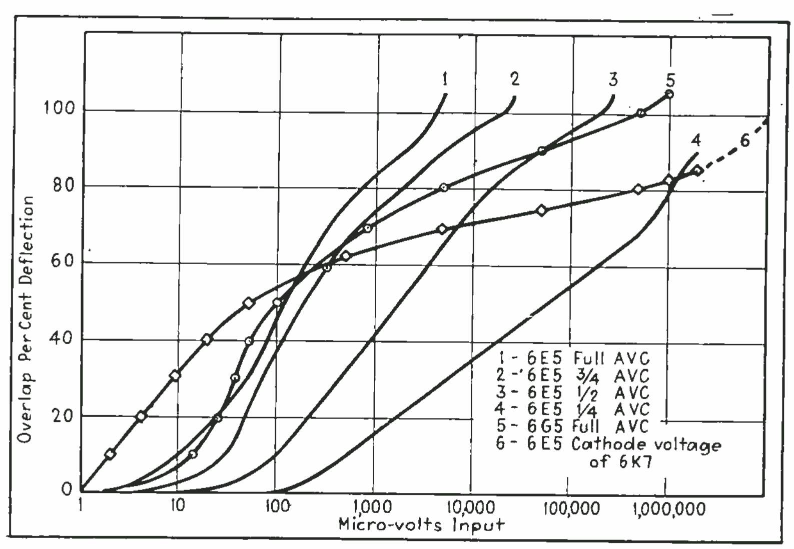


Fig. 1—6E5 and 6G5 characteristics

ing maximum power before the AVC operates to reduce the sensitivity of the receiver. The same circuit operates very satisfactorily with single i-f stage receivers, providing AVC is not applied to the i-f tube or a fixed positive bias may be obtained from a bleeder circuit, but must have quite good regulation and be free from audio modulation effects, so that the tube will not flicker with modulation. Thus, the i-f tube is a good source of that voltage. Voltages from a high current bleeder have also been successfully used when well by-passed for audio. A self-bias for the 6E5 tube cathode has also been used and results are satisfactory, although much closer tolerances are necessary in resistor values.

In ac-dc receivers where the maximum available plate voltage is approximately 100 volts, the grid swing

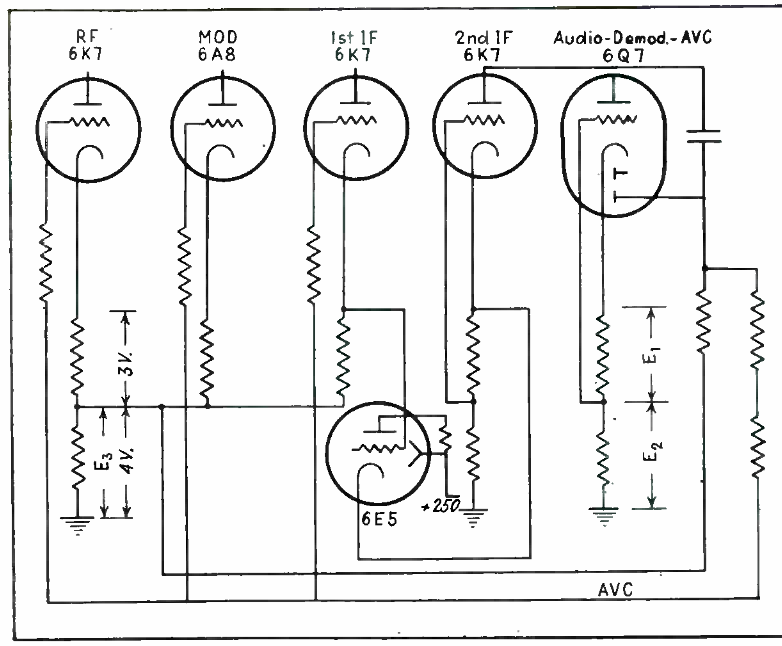


Fig. 3—Operation of the 6E5 indicator tube with a 6Q7

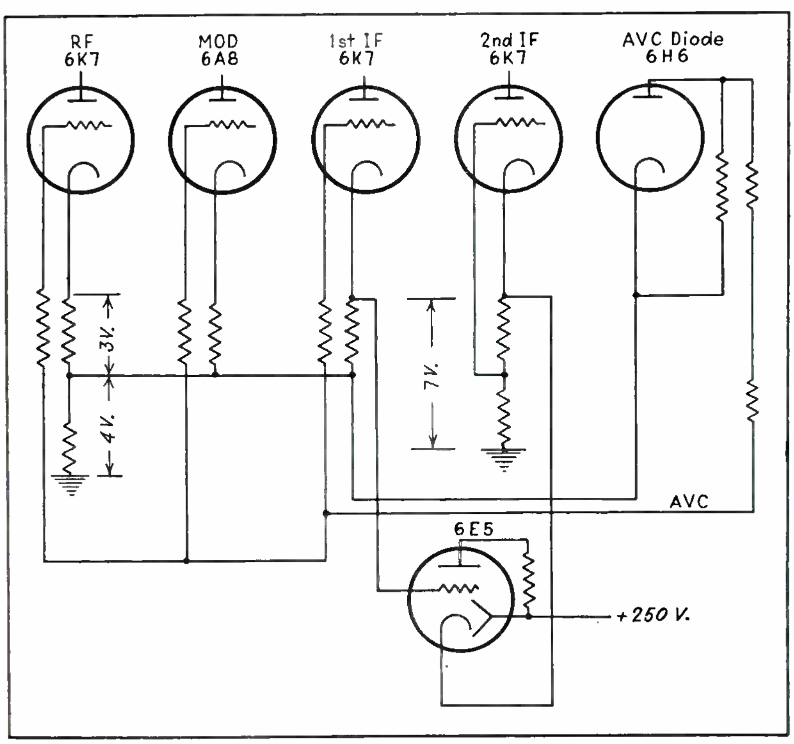


Fig. 2—Circuit showing use of 6E5 with the 6H6 diode

of the 6E5 is about three volts and here the same circuit works quite well. When three volts of bias are used on the tube or tubes controlled by AVC and the i-f tube not controlled by AVC, this method adapts itself very well.

With the circuits suggested in Figs. 2 and 3, the 6E5 tube surpasses in operation as a tuning indicator even the meter, which for years has been the standard of good tuning indicators. Deflection of the fluorescent screen can be detected at weak signals and strong signals can be tuned with great accuracy with the adjustments necessary. The AVC voltage can be any magnitude, since it does vary from receiver to receiver. The plate current of a tube with remote cut-off characteristics, such as the 6K7, proved to be the ideal curve to operate the 6E5, in the manner suggested above.

Where cost is not a factor it is possible to use one or two extra tubes to provide this same operation and allow the rest of the receiver to be normal.

Other methods for reducing bias

Other methods of reducing bias have been tried, such as a stepdown diode transformer, which allows only a maximum of 7 volts to be built up across the diode load resistor, and the results were quite similar to dividing the original AVC voltage. An amplifier tube with remote cut-off seems to solve the problem best, be it a separate tube or a tube controlled in the receiver with some other function, such as a r-f or i-f amplifier tube.

Plan Rochester Fall Meeting

IRE Section announces program for annual meeting to be held November 16th, 17th, and 18th at the Hotel Sagamore. Many outstanding names in radio listed among those to present papers

THE Rochester Fall Meeting, held each fall under the sponsorship of the Rochester Section of the I.R.E., has gained the reputation of attracting lively and enthusiastic gatherings. The papers presented are usually aimed at the radio set engineer, who is engaged in one of the most competitive branches of the industry, and the discussions aroused are usually more than academic in nature. This year the program indicates that the forthcoming meeting, on November 16, 17, and 18, will uphold the reputation, and possibly add to it. Among those listed to present papers are several of the leading practicing and executive engineers in the radio receiver and radio tube business.

The complete program of the meeting is as follows:

Virgil M. Graham, as Executive Chairman, is directing the activities of the Rochester Fall Meeting

Monday, November 16.

9:00 A.M.—Registration.
Inspection of Exhibits.

10:00 A.M.—Technical Session.
Equipment and Methods used in Routine Measurements of Loud Speaker Response
S. V. Perry . . . RCA Mfg. Co., Victor Division

Current Measurements at Ultra High Frequencies
John H. Miller . . . Weston Electrical Instrument Corp.

Theory and Application of Acoustic Networks in Radio Receiver Cabinets
Hugh S. Knowles . . . Jensen Radio Manufacturing Co.

12:30 P.M.—Group Luncheon.

2:00 P.M.—Technical Session.
Shot Effect in Space-Charge-Limited Vacuum Tubes
B. J. Thompson and D. O. North . . . RCA Mfg. Co., Radiotron Division

Automatic Control of Selectivity by Feedback
H. F. Mayer . . . General Electric Company

4:00 P.M.—RMA Committee on Broadcast Receivers.

6:30 P.M.—Group Dinner.

7:30 P.M.—Inspection of Cyclotron at University of Rochester.

9:00 P.M.—"Open House" at Rochester Club, Courtesy of Delco Appliance Corp.

Tuesday, November 17.

9:30 A.M.—Technical Session.
The Federal Communications Commission and the Engineering Division of RMA
T. A. M. Craven . . . Federal Communication Commission

Radio Tubes Today
R. M. Wise . . . Hygrade Sylvania Corp.

Profits from Standardization
L. C. F. Horle . . . Consulting Engineer

12:30 P.M.—Group Luncheon.

2:00 P.M.—Technical Session.
Commercial Television—and its Needs.
Alfred N. Goldsmith . . . Consulting Engineer

Latest Television Standards as Proposed by the Engineering Division of RMA
Albert F. Murray . . . Philco Radio & Television

Survey of Receiver Characteristics A. F. Van Dyck, D. E. Foster . . . RCA License Laboratory.

4:00 P.M.—RMA Comittee on Sound Equipment.

6:30 P.M.—Stag Banquet.
Toastmaster—J. S. Wellwood
Speaker—Henry W. Parker
Subject—Radio Observations

Wednesday, November 18.

9:30 A.M.—Technical Session.
Applications of Nickel to Radio
E. M. Wise . . . International Nickel Co.

Sidebared Suppression in Television Reception
W. J. Poch and D. W. Epstein RCA Mfg. Co., Victor Division

Improvements in the Performance of Cabinet Type Loudspeakers
Benjamin Olney . . . Stromberg Carlson Tel. Mfg. Co.

12:30 P.M.—Group Luncheon.

2:00 P.M.—Technical Session.
Notes on Feedback Amplifiers
R. B. Dome . . . General Electric Co.

Improvements in High Frequency Receivers
J. J. Lamb . . . American Radio Relay League

4:00 P.M.—Exhibits Close.
RMA Committee on Television

A Double-beam Cathode-ray Tube

Simultaneous observation of two phenomena by means of the cathode-ray tube is now accomplished by switching the beams alternately on the screen. By a double-beam tube, this accessory apparatus is made unnecessary

By
MANFRED von ARDENNE
Berlin, Germany

THE simultaneous delineation of several phenomena, either for photographic recording or for visual observation, is one of the most important phases of oscillography. While satisfactory mechanical oscillographs, notably the various types of multi-element loop oscillographs of Siemens and Halske, have been available for several decades, up to the present time only a start in this direction has been made for cathode-ray oscillographs. It is true that the cold-cathode, high potential cathode-ray tube with multiple electron beams for simultaneous oscillography (for investigations on multi-phase systems) has received a great deal of attention for several years.[1] Moreover, the author has conducted experimental work on hot cathode type double beam tubes over a period of several years.[2] Not until the present time, however, after the theoretical considerations had been carefully met, and manufacturing difficulties overcome, has it been possible to introduce a tube of this type capable of meeting the rigid present day requirements.

The difficulty of multiple-beam tracing in a common vacuum tube lies in the necessity for complete exclusion of mutual reactions between the systems. These reactions can occur (a) through interelectrode capacities of the deflecting systems and (b) through space-charge coupling between the two moving beams. Both of these disturbing influences become of greater importance as the frequency of the potentials under measurement increases. The latter

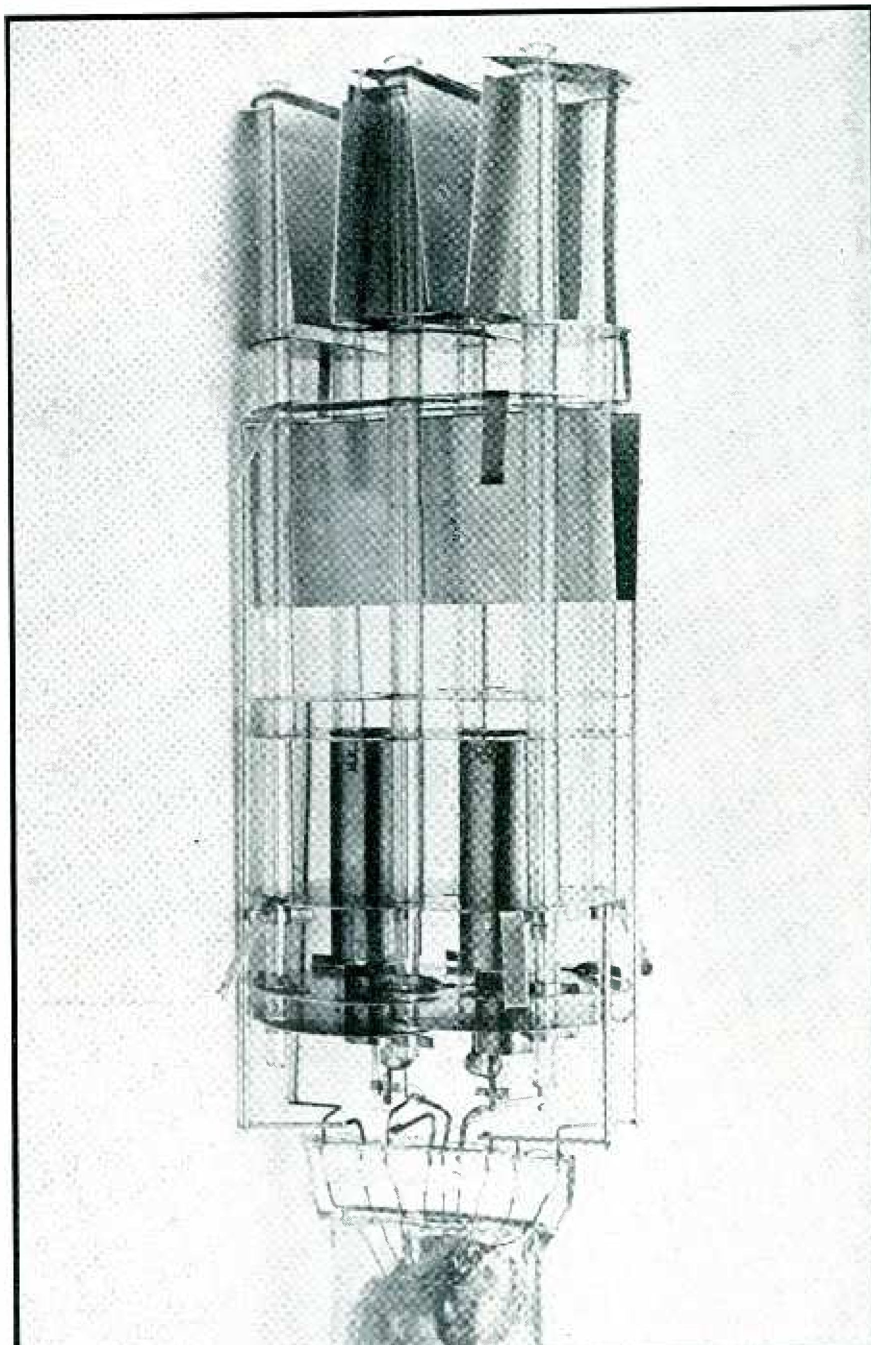


Fig. 1. Mount structure of the double-beam cathode-ray tube. Two separate electron beams are generated without mutual interference with the aid of induced magnetism in the plate

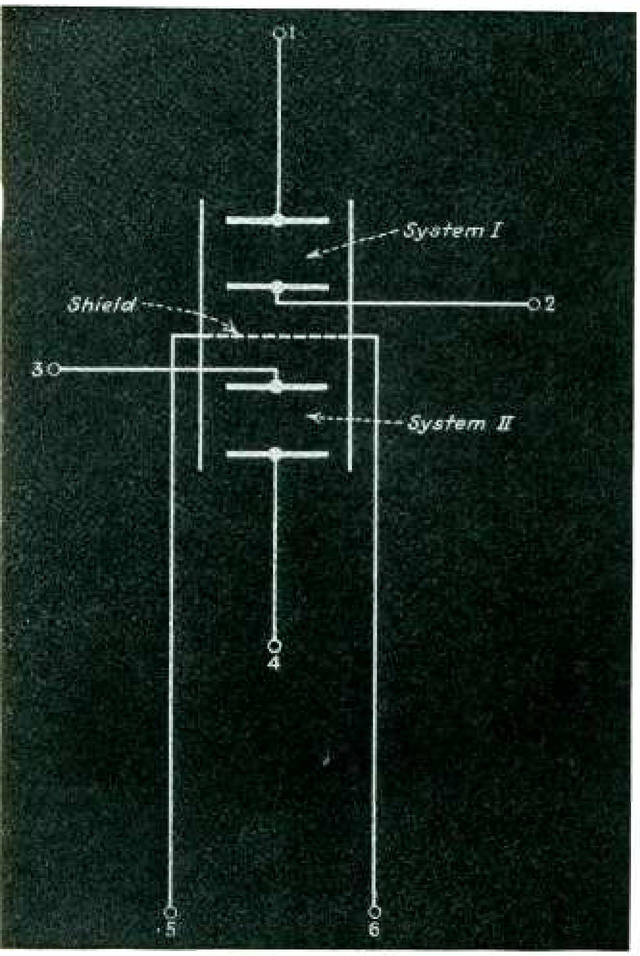


Fig. 2. Deflection systems of the double-beam tube

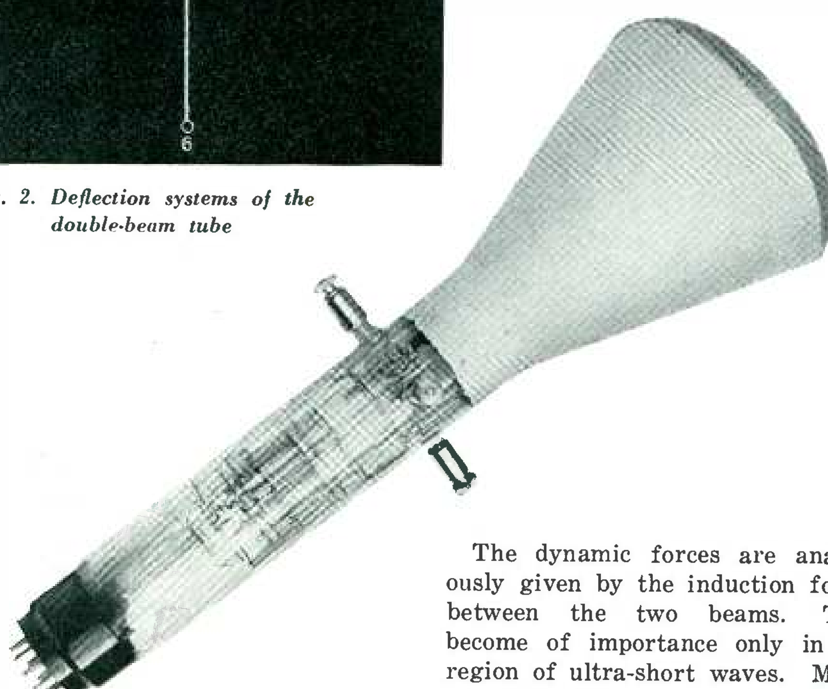


Fig. 3. Double-beam tube with 4 side terminals (Leybold und von Ardenne Oszillographengesellschaft)

effect becomes of much greater importance in gas-filled tubes carrying ionic charges, especially at high beam currents, than in the high-vacuum tubes. It is evident that this effect causes the aspect of the oscillogram to depend on the beam current which is used. In the reactions between the beams, differentiation must be made between the static and dynamic forces.

The static forces can be easily estimated for high vacuum tubes. In the most unfavorable case, that is when the two fluorescent spots coincide on the screen, the space-charge disturbances produced must always be negligible, because in consequence of the distance between the beam producing systems, amounting to several centimeters, the angle between the beams is very large compared to the converging angle of the individual beams.[3] The striction force can be considered negligible in comparison to the space-charge forces for the anode potential used in operation (2,000 to 8,000 volts).[4]

The dynamic forces are analogously given by the induction forces between the two beams. They become of importance only in the region of ultra-short waves. Measurements show these can be neglected from low frequencies up to the region of broadcast frequencies.

Experiments were made on double and triple-beam tubes. The mount system of a factory built high vacuum double-beam tube is shown. The beam-producing systems assembled with a pillar-type construction, are connected in parallel electrically. The cathodes are connected in parallel so that the usual power supply is sufficient to operate the tube without any additional adjustments. Only the intensity-controlling electrodes of the two electron gun systems are brought out with individual leads. This was done for the following reasons:

(a) It is often desirable in the case of partly or completely overlapping oscillograms, to differentiate the two curves in brightness.

(b) It often happens that the individual beams trace out paths which differ considerably in length in a given time interval, (i.e. differ considerably in "writing-speed") so that for equal beam power both photographic recordings and visual observation show great differences in brightness between the two curves. By proper regulation of the individual beam intensities with the intensity controls, the two oscillograms can be adjusted to equality.

(c) Occasionally it is desirable to introduce certain timing marks in the curve forms under investigation. This time-scale marking can be accomplished by the well-known method of applying alternating potentials on the intensity control electrodes.

The potential for the second intensity electrode can be easily obtained from the regular power supply by connecting a potential-divider of about 2 megohms between the cathode and the negative bias taps.

The previously mentioned disturbing inter-electrode capacities between the measuring deflectors are reduced to a minimum by the use of an internal shield in the tube as well

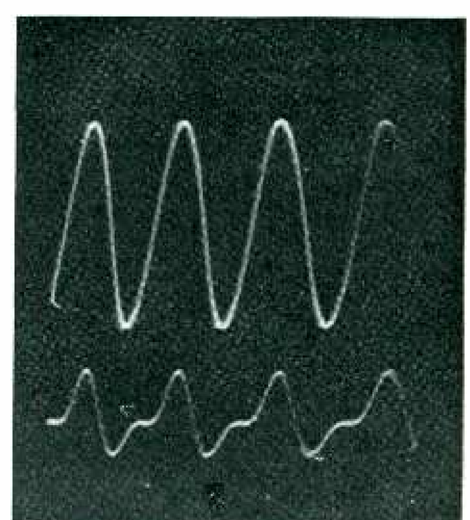


Fig. 4. Double oscillogram with one pure a-c wave

as by direct side terminals in the bulb for each of the four measuring plates. It is obvious that care must be taken to insure complete shielding of the external leads so that the advantages of the tube construction are not defeated in practice. The deflection systems are shown in Fig. 2. All four measuring deflectors are brought out to separate leads to permit the application of potentials which are symmetrical to ground. It may be mentioned in this connection that sufficient spot sharpness is obtained also for unsymmetrical potentials and deflection amplitudes which remain smaller than about one-third the screen diameter. This property is due to the fact that the measuring deflectors are placed on the side of the tube turned towards the shield.

The time-axis deflectors, as shown in Figs. 1 and 2 are formed of a single pair of plates which extend across the tube. For simplicity, these plates are brought out through leads in the press. A view of a double-beam tube supplied with a screen of 18 cm. is given in Fig. 3.

The most important interelectrode capacities between the various electrodes of the deflecting systems are:

$C_{1-2} = 1.5\ \mu\mu f$
$C_{3-4} = 1.5\ \mu\mu f$
$C_{5-6} = 3.6\ \mu\mu f$
$C_{2-3} = 0.3\ \mu\mu f$
$C_{1-4} = 0.05\ \mu\mu f$ (2, 3 grounded)

When pure a.c. is applied to the deflecting plates the oscillogram axes are separated about 4 cm. on the fluorescent screen. A double oscillogram with pure a.c. is shown in Fig. 4. By superimposing d.c. the zero deflection lines of both systems can be made coincident. A typical oscillogram with common axes is shown in Fig. 5.

Since the time scales for both systems are identical in value, it is necessary that the electron guns be so well lined up that the line joining the two fluorescent spots is exactly perpendicular to the direction of the time axis deflections. However, even with the most careful mechanical lining-up it is not possible with the long beam paths necessary, to satisfy this condition sufficiently well so that the deviations can be neglected, for even a displacement of the spot amounting to 1 mm. can be quite disturbing. For this reason one of the diaphram electrodes of each of the beam producing systems is made of a weakly magnetic material. By stroking a permanent magnet along the vicinity of the electron guns, enough residual magnetism can easily be induced to effect the slight required final adjustment of the spot positions.

A characteristic oscillogram with considerable difference in brightness, effected by placing a highly negative bias on one of the Wehnelt cylinders (brightness control electrode), is shown in Fig. 6. In contrast to this oscillogram, that of Fig. 5 was made by adjusting the beam intensities so that in spite of the considerable difference in "writing-speed" the oscillogram brightnesses were equalized.

In the previous oscillograms the fundamental frequency was 10,000 cycles. A further oscillogram in which the frequency was raised to 30,000 cycles is shown in Fig. 7. This photograph at the same time offers proof that no noticeable reaction of the beams has occurred, for the fluorescent line inscribed in the main oscillogram shows no sign of any waviness. Since no disturbances are produced in the oscillograms at normal beam powers for overlapped oscillograms, this is also true for adjacent oscillograms.

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2. M. V. Ardenne, "Die Kathodenstrahlenröhre," Julius Springer 1933, p. 108, fig. 132.
3. M. V. Ardenne, "Contribution on the construction of a high vacuum Braun tube for television and measurements." *Zeitschr. f. Hochfrequenztechnik* Vol. 44, No. 5, p. 168, 1934.
4. L. H. Bedford, "The Comparative properties of soft and hard cathode-ray tubes," *Jour. Sci. Inst.* Vol. 13, No. 6, p. 178, 1936.

EDITOR'S NOTE: For recent American work on this development, see Hughes, Fluxation Selector for double-trace Cathode-ray oscillograph. *Rev. Sci. Instruments*, 1936, Vol. 7, No. 2, p. 89; and Tarceaux, Duplex Cathode-ray oscillograph, *Rev. Sci. Instruments,* 1935, Vol. 6, No. 6, p. 171. Mr. Allen Du Mont states that he has made several double beam tubes of this general type.

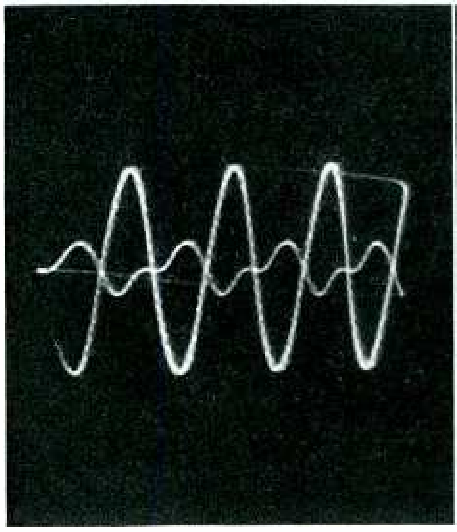

Fig. 5. Overlapping oscillograms produced with superimposed d.c.

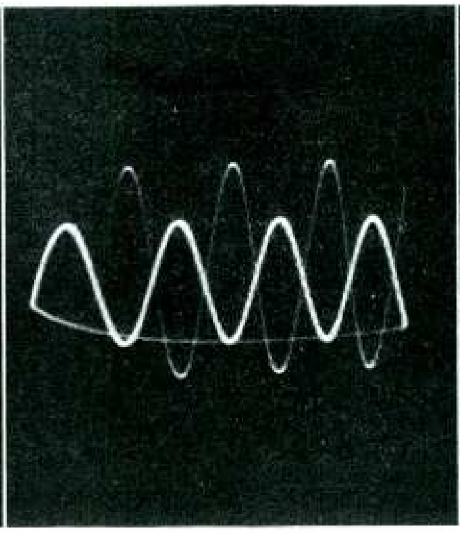

Fig. 6. Brightness differences produced by bias control of one emitter

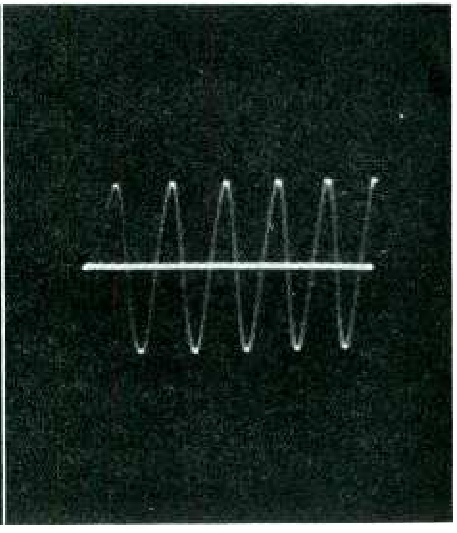

Fig. 7. 30,000 cycle wave, showing independence of the two beams

Views and Reviews

Handbook of Engineering Fundamentals

BY O. W. ESHBACH, *E. E., M. S., Editor-in-Chief, and 40 contributors. John Wiley & Sons, Inc., New York, 1936. 1081 pages; illustrated; 6 by 9; $5.00.*

THIS IS THE FIRST volume in the proposed new Wiley Engineering Handbook Series. Mathematics, physics and chemistry are the fields dealt with in the new volume designed to present a complete summary of the facts pertaining to the fundamental theory underlying engineering practice.

The first section presents a selection of mathematical and physical tables, including new and revised tables of the American Handbook series.

Other sections offer such features as: the presentation of dimension systems, systems of units, standards, and introduction to the theory of dimensional analysis; fundamentals of theoretical mechanics and mechanics of materials; the modern theory of fluid mechanics as applied to the fields of hydraulics and aerodynamics; engineering thermodynamics, the theory of the electric, magnetic and dielectric circuits and their application to generalized networks and transient theory; the fundamental principles of general chemistry, chemical tables and industrial chemistry; the principles of light, acoustics and meteorological phenomena; an extensive handbook treatment of the properties of metallic and nonmetallic materials with reference to features of manufacture and use; and a discussion of the elementary legal aspects of contractual relations.

Innured, as we are to the vast amount of work attached to technical book writing and publishing, this reviewer is appalled at the labor that must have gone into the preparation of this 1000 page book. Its format is such that larger type than usual is used, its pages are attractive, and some care has been exercised to reduce eye fatigue.—K.H.

Short Wave Wireless Communication

BY A. W. LADNER and C. R. STONER, *Third edition. John Wiley & Sons, Inc., New York. (452 pages, 258 illustrations, $4.50 postpaid.)*

THE RAPID CHANGES of the art set a hard choice before the author of a short wave radio book. Should he desire to make his book immediately useful in practical communication it is necessary that he state constants and dimensions of transmitters and receivers, but unfortunately such descriptions date the book and compel periodical revisions. On the other hand the complete avoidance of such data reduces the book to a bloodless discussion of principles, which some readers cast aside in favor of a more virile paper-bound annual issued by some magazine. The proper compromise between the two courses is a matter of pure opinion. In considering the work of Messrs. Ladner and Stoner one finds that the material is very good, that it is very well presented, and that it may be no more than a personal opinion that the text has tended toward the academic while reaching for soundness and permanence. Where mathematics appears it is used for the proper purpose, and never to avoid plain English. Thus it is used in moderation, and profitably. The discussions are exceptionally lucid, as is to be expected from professional teachers of good standing, in a book twice revised. The discussions of antennas, and of tube-effects are exceptionally well done. Altogether this is a good piece of work, deserving thoughtful readings.—R.S.K.

RADIO REQUIRED FOR ALL MOTOR LIFE-BOATS

Two-way radio equipment is now compulsory on motor life-boats of all passenger liners. This typical equipment is installed on the S. S. Pennsylvania

Source Book in Physics

BY WILLIAM F. MAGIE, *Professor of Physics Emeritus, Princeton University. McGraw Hill Book Company, New York. (620. p., illustrated; Price $5.00.)*

THIS BOOK, one of a series in which selected abstracts from the original papers of the famous men of science are presented for the general technical reader, should be invaluable to anyone working in physical science. The field covered is broad, including mechanics, the properties of matter, sound, light, magnetism and electricity, of which the latter four are of particular interest to those in electronic work. Abstracts from the work of such men as Helmholtz, Faraday, Michelson and Morley and the workers in electricity from Gilbert, through Maxwell, Hertz, Roentgen and the Curies are presented.

The material has been chosen with evident care so as to present a survey of the entire field of physics in the words of the men who have pioneered. The book is of great value from an historical point of view, of course, and serves well to show how the early workers in the field grasped the fundamentals of the subject. Certain parts of the book can be read for recreation, but this is not true of the entire work since many of the original presentations are sufficiently difficult to require serious study. Such study, however, will reward the reader with a more thorough understanding of the principles involved than would be obtained in many cases by simply reading the standard texts.

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[Continued from page 11]

there were lamps, heating-pads, irons, oil burners, curling irons, fans, cleaners, polishers, mixers, washing machines and pumps with older types of motors, etc., etc. For the industries there were motors, generators, rectifiers, interrupters, relays, welders. For the utilities there were loose lamps, partial grounds through trees and guy wires, broken insulators, corona discharge. The point was emphasized that an appliance or piece of equipment sparking unnaturally is not working right, it is not at its highest efficiency; in other words, it is adding dollars and cents to the power bill all the time it is in that condition. Mention was also made of various types of high-frequency apparatus that might cause interference. Since corrective measures in many cases took the form of condensers or filter devices a supply of these was obtained from a jobber. These were resold at standard retail prices and the difference just took care of the preparation and distribution of the bulletins. As there was no radio parts dealer in the community it was felt that this was in no wise contrary to the ethics of the engineering profession. The bulletin was delivered into the hands of every householder in the community and a copious supply was left at utility and industrial plants.

The heart of the bulletin was a table or log which householders were asked to carefully fill in for a period of one month and then return. The response was most gratifying as over 85 per cent of the homes in the community faithfully completed and returned their logs.

Entries in many logs were obviously the result of defective receivers or equipment. These were sifted out and their writers introduced to a competent local service man to the complete satisfaction of both parties. The remaining entries bore a striking uniformity in various parts of the community. The town was divided into definite zones and these in turn into divisions corresponding to the original surveys. Scale maps were obtained for each zone and colored pins were stuck in the map to correspond with various log entries. It was soon found possible to plot lines between points of the same interference intensity or character. We have called these lines "isorads" meaning "equal radiation" for want of a better name. (See accompanying map. In practically every case the center of the innermost isorad narrowed the search down to a matter of a hundred feet or so.

A few of the sources of noise were unusual enough to bear relating in the off chance that they may be encountered elsewhere.

A certain maiden lady of the community was in the habit of using a radiation heater in her bedroom on cold winter nights. As not infrequently happens, the element burnt out just at the connection to the receptacle but there was just enough contact or lack of contact left to sustain a merry little arc any time the heater was on. Soon neighbors began to complain of radio interference at definite hours. Our worthy spinster quickly sensed that it was a case of cause and effect and decided that it was too good a weapon to lose. As a result on warm Summer evenings at 10 p. m. or any other time the gentle soul was annoyed by her neighbor's radios she started her private transmitter and kept it going until the radios were turned off. Eventually the good thing came to an end, as good things usually do, when a fuse gave up the ghost. The electric service man was deaf to her pleas to leave the heater as he found it.

A second case rather forcibly brought home the other side of human nature. An old couple was nearing the end of life's twilight when the aged lady died. As a perpetual memorial the old gentleman kept a light burning continuously in the room they had shared. The isorads definitely spotted the little home as a source of interference. The most intense search aided by the very finest co-operation from the old man failed to localize the trouble. As a last resort it was decided to check over the house wiring. On going upstairs the remembrance lamp was, of course, seen. A flip of the switch, the tungsten arc was broken, the interference stopped. The old gentleman got a new lamp—the finest that could be obtained.

A source of interference that periodically blanketed the entire town was finally found to be a boy, a transformer, a Tesla coil. The 8 inch spark that resulted was beautiful to look at but what it did to the local radios was just too bad.

UHF Oscillator

[Continued from page 13]

change a tuning range, simply pull the winding apart slightly, or compress it slightly. To show how much the frequency can be changed by this method, consider these values:

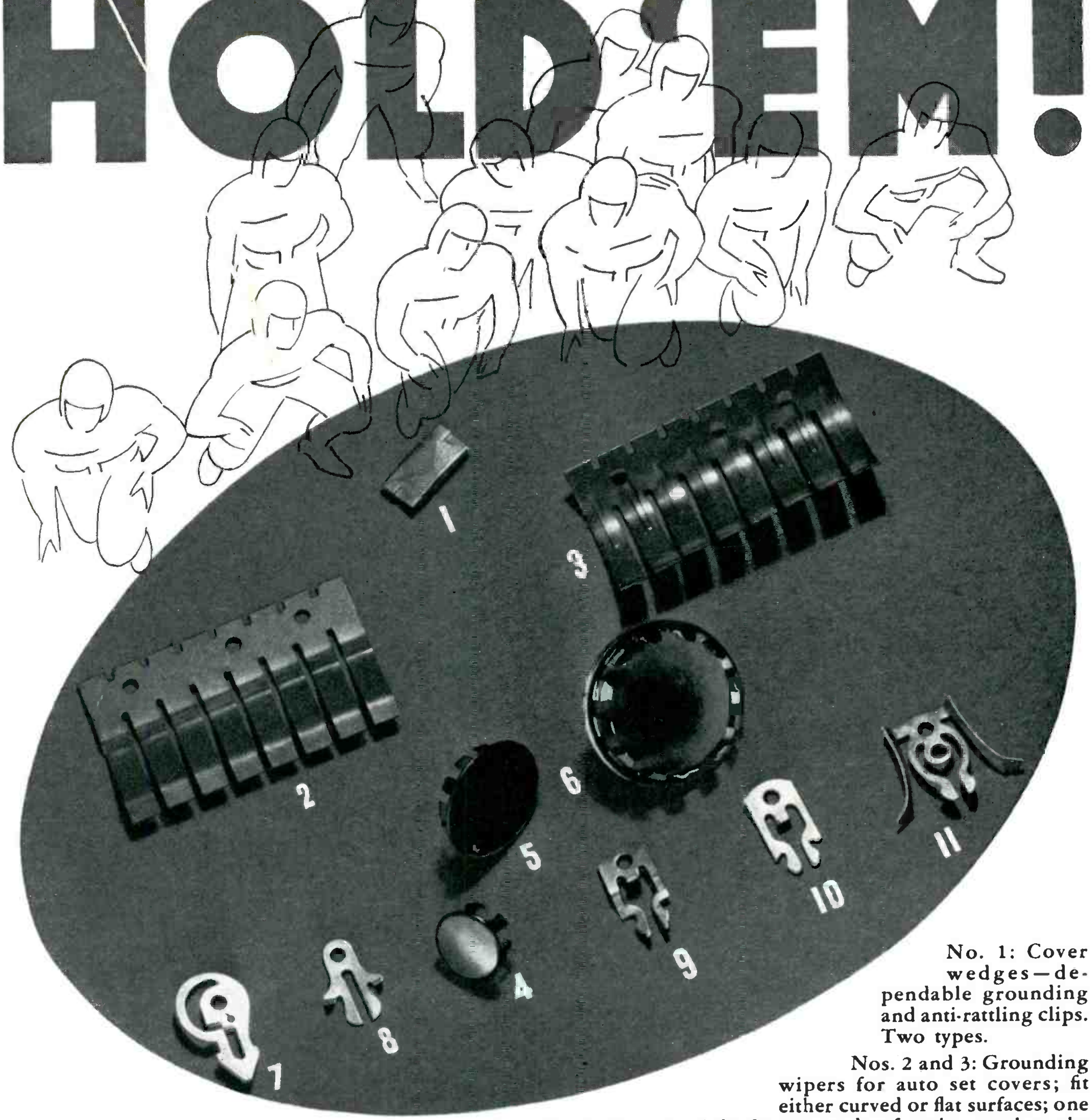
Winding Length (inches)	Turns and Wire Gage	Minimum Megacycles	Maximum Megacycles
1	12 No. 20 ga.	32.5	38
1 1/8	12 No. 20	34	40
3/4	8 No. 20	42	48
9/16	8 No. 20	39	46

From the above values, it is clear that any of the coils specified can be readily adjusted to the desired frequency range in spite of the high frequency and in spite of any possible small circuit differences which may be present in the particular oscillator constructed by the reader.

This oscillator because of its low cost, can be used as a separate high-frequency unit for extending the useful range of any existing oscillator for use at lower frequencies. One should be careful in constructing this oscillator to make sure that all leads are as short as possible and the parts specified are used.

The frequency range of the oscillator can be easily checked by listening to harmonics in it from a lower, known frequency source. If another oscillator tuning to 15 meters is available, it is easy to check frequencies. Set the 20 to 60 mc. oscillator near the other and place a pair of headphones in the plate circuit of the 20 to 60 mc. oscillator. With the lower frequency oscillator set so that it tunes between about 20 and 10 megacycles, it is very easy to calibrate the high frequency oscillator. It is also possible to use a simple regenerative receiver and tune in radio stations sending at a known frequency for calibration and comparison, using harmonics.

HOLD'EM!



No. 1: Cover wedges—dependable grounding and anti-rattling clips. Two types.

Nos. 2 and 3: Grounding wipers for auto set covers; fit either curved or flat surfaces; one to eight fingers made of spring steel or the newly developed hardened carbon steel.

Nos. 4, 5 and 6: Plug buttons, various sizes and types. Masking adjustment holes ⅛" to 1¼".

Nos. 7, 8, 9, 10 and 11: Can holders—just rivet on shield can—snaps in and stays put. Saves labor—no nuts and washers. No. 8; Removable type. Nos. 9, 10, and 11 "stand off" type, permits air gap at base—definitely holds round or square can .015 inches from chassis. No. 7 "pull down type" holds shield can tight to chassis metal, eliminates rattle, vibrations—assures grounding contact.

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TUBES AT WORK

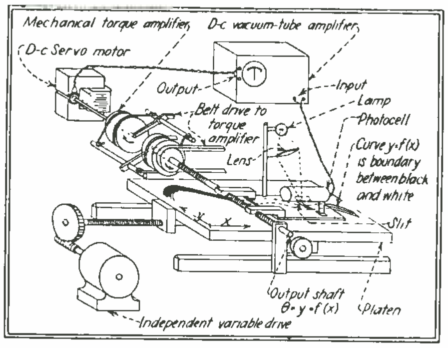
A photocell that follows a plotted curve, methods of using electron diffraction for determining the size of particles, are among the developments this month

An Automatic Curve Follower

A DEVICE WHICH automatically follows the boundary of a curve plotted on drawing paper is described in "An Automatic Curve Follower" by Hazen, Jaeger, and Brown in the September 1936 issue of the "Review of Scientific Instruments." The curve follower was developed as part of a research project at M. I. T. which will culminate in the building of an improved form of the differential analyzer which has been in use for a number of years in solving differential equations. The curve follower can also be applied to the automatic cutting of cams or templates.

The curve which the device is to follow is drawn on a good quality of drawing paper, or where the effects of paper shrinkage must be reduced to a minimum, on thin sheets of aluminum. The curve is drawn as a silhouette, so that the curve is the boundary between a highly reflecting surface and a blackened light absorbing surface. The curve is placed on a platen which is continuously displaced along a pair of rails by means of an independent variable motor drive.

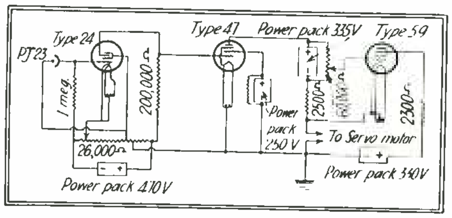
The output shaft of the curve follower (see Figure), whose angular displacement should correspond at any instant to the value of the dependent variable, drives a screw thread located parallel to the axis of the ordinates or dependent variable. This screw controls the motion of a carriage on which is mounted a lamp, a phototube, and a slit through which the curve boundary is viewed. The carriage and platen are initially adjusted at one end of the curve so that the slit, which measures about 1/16 inch by 1/4 inch, bridges approximately equal portions of the reflecting and absorbing surfaces of the curve boundary. Thus, the curve to be followed is approximately in the middle of the slit. For this position of the slit, the amplifier is adjusted so that the output current to the servo-motor is zero. As the platen moves along the tracks beneath the carriage, any deviation of the curve boundary from the center of the slit varies the relative areas of reflecting and absorbing surfaces viewed through the slit. This modifies the phototube current as the light reflected into the cell changes,



The mechanical set-up of the curve follower

and results in operation of the servo-motor in such a direction that the carriage is moved into a new position of balance.

The optical system consists of an automobile lamp and condensing lens fixed to focus on the curve through the slit. This provides a high level of illumination of the curve boundary, the reflected light of which is received by the phototube. When the curve is drawn on the usual grades of drawing paper, a displacement of the platen by 0.025 inch results in a change in phototube current of about one tenth of a microampere.

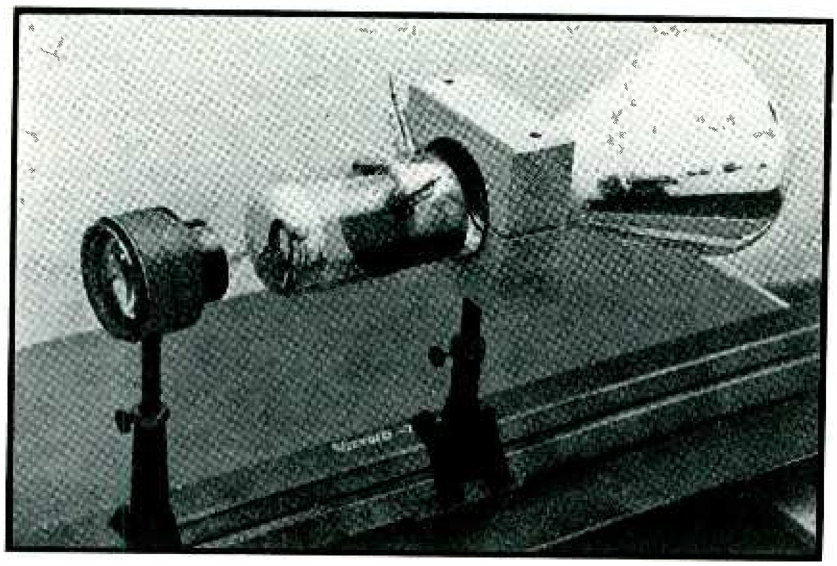


The d-c amplifier which drives the servo-motor

The servo motor is operated from the d-c amplifier using a Type 59 output tube. The motor consists of a magnetically strong field structure in which rotates a hollow brass cylinder on which the armature coils are supported. The armature coil is stationary inside the cylinder which holds 9 armature coils, each of which consists of 800 turns of No. 43 B. & S. guage wire. This construction gives a very light rotating element having a small moment of inertia, so that the motor can accurately and quickly follow variations in the current in the phototube. To enable a small motor of this type to drive a mechanism requiring considerable torque requires the insertion of a mechanical torque amplifier between the shaft of the servo motor and the output shaft.

The output of the d-c amplifier is made relatively free from small line

A GERMAN VERSION OF THE ELECTRON TELESCOPE



Manfred von Ardenne of Berlin has constructed an electron image transferring device very similar to Dr. V. K. Zworykin's electron telescope (see Electronics, January 1935). The focussing anodes of the original tube have been replaced by a spiral of resistance material sputtered on the inside of the tube

Erie Resistor

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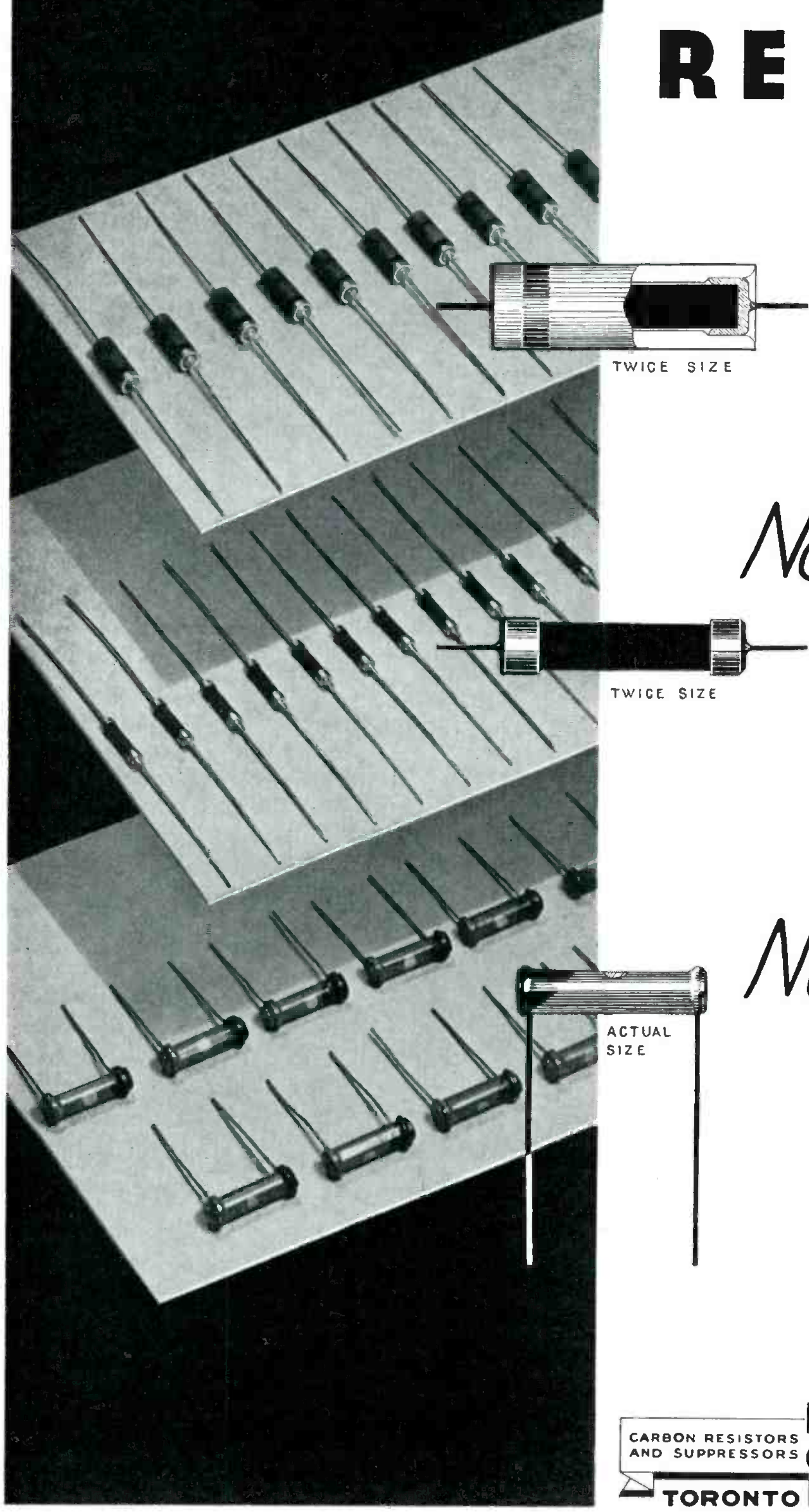

Insulated

Body is insulated by a pre-formed, uniform ceramic wall that will withstand 3,000 volts A.C. without insulation breakdown. Entire unit is sealed with moisture-proof wax for humidity protection.

Non insulated

WITH LEADS IN LINE WITH AXIS OF BODY

Same as the insulated type but with ceramic sleeve omitted. The only non-insulated resistor with leads parallel to the resistance body that is as mechanically strong as the insulated type of corresponding design and rating.

Non insulated

WITH LEADS PERPENDICULAR TO AXIS OF BODY

These resistors are recognized for their all-round excellent operating characteristics. Their resistance units are made from the identical composition of raw materials and operate with the same high efficiency as the other two types of Erie Resistors illustrated above.

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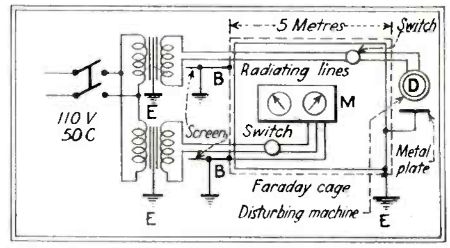
voltage variations by a suitable choice of the ratio of control grid bias voltage and screen grid voltage so that a change in grid bias due to line voltage fluctuations is compensated by an opposite change in the screen voltage which maintains the plate current constant.

Progress in Measuring and Preventing Artificial Static

(MICHEAL ADAM) The well-known specialist reviews some problems of man-made static as they appear from reports presented to the fifth French National Congress for the Prevention

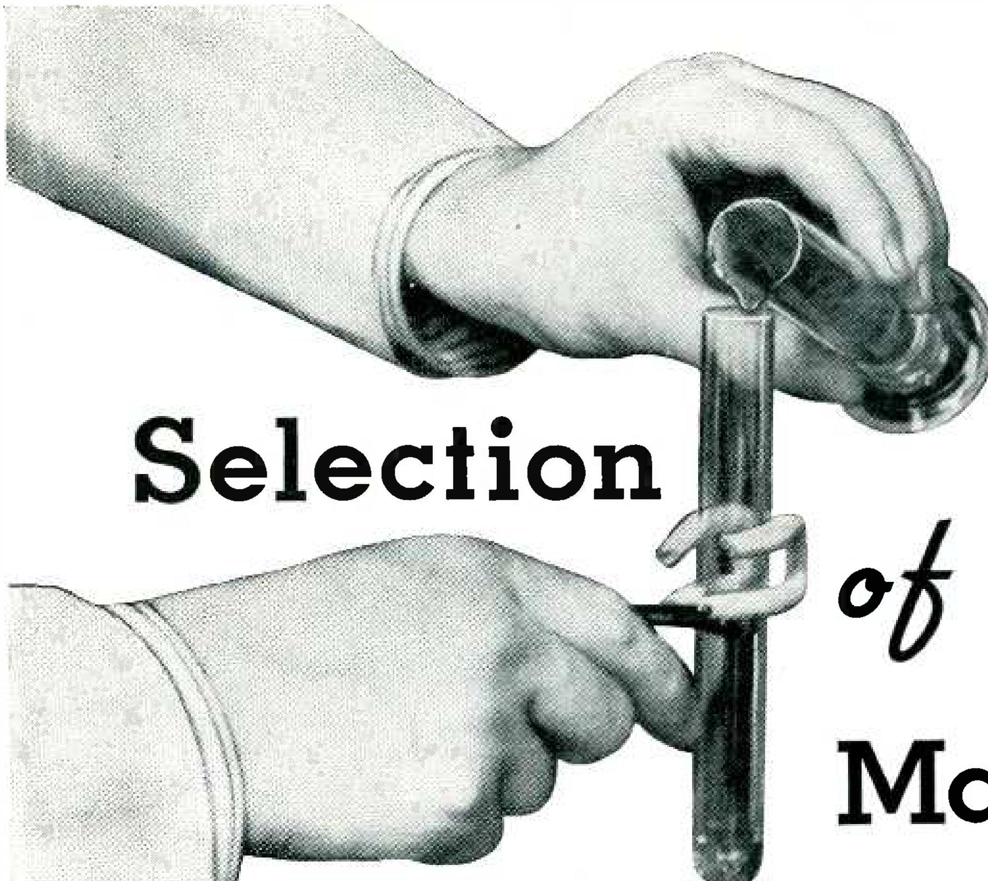


of Static held in Paris on June 20, 1936.

The volume which this work has reached in various countries is indicated by the fact that in Germany the official organization for suppressing static uses 1,200 trucks and 65 lighter cars, and employs 3,000 persons. (Genie Civil 109 No. 9 159–162. No. 10. 182–184. 1936).

PROTON VS. PROTON

Dr. L. R. Hafstad with the apparatus used at the Carnegie Institution to measure the force of repulsion between two hydrogen nuclei (protons) when separated less than two ten-billionths of an inch



Selection of Materials

upper limit beyond which particle size cannot be satisfactorily estimated from ring width is about 150 Angstroms (15 millimicrons), corresponding at camera length 50 cms. to a ring "breadth" of 0.2 mm. (between parts at half the central maximum intensity). For the same camera length a particle size of 30 A would correspond to a ring breadth of about 1 mm., and a particle size of 5 A (equal to one or two normal lattice spacings of a crystal) to a ring "breadth" of about 6 mm., i.e. an actual ring width of more than a centimeter, which would be still visible for strong rings. At this stage, however, the finest state of subdivision is approached—namely, the Beilby layer or random aggregation of atoms, with closest distance of approach in the order of 1 — 2 A.

Using an accelerating voltage of 70,000 volts, Finch and Wilman[2] obtained diffraction patterns from thin films of graphite formed from an aqueous dispersion of colloidal graphite and have deduced the corresponding size of graphite particles.

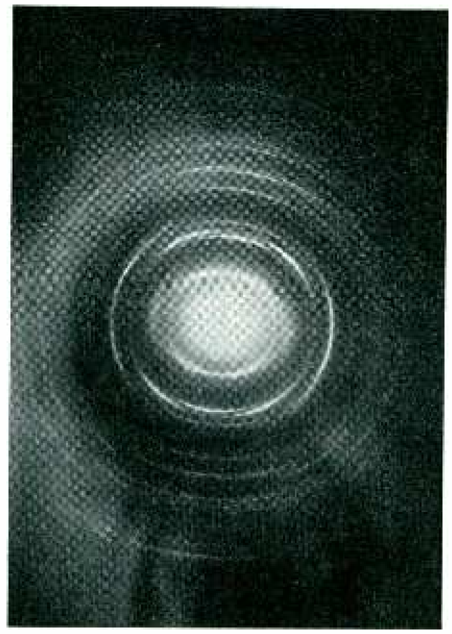


Fig. 2. Colloidal graphite: specimen inclined to beam

Fig. 1 is a transmission diffraction pattern. The mere fact of its having been obtained indicates that the particle thickness of graphite could not have been much less than 100 Angstroms, since with greater film thickness the pattern rings would, for the most part, have been obliterated by multiple scattering effects. The great intensity of certain rings compared with that of others and the "arcing" of the pattern rings when the film is inclined to the beam (see Fig. 2) shows that most of the graphite crystals have settled out with their bases in contact with the surface, i. e. the planes of hexagonally arranged carbon atoms are parallel to the surface.

From the definition of the rings and from their thickness, Finch and Wilman conclude that the average width of the crystals is probably much more than 10 millimicrons; that is to say, the crystals or particles are of a flat, tile-like structure.

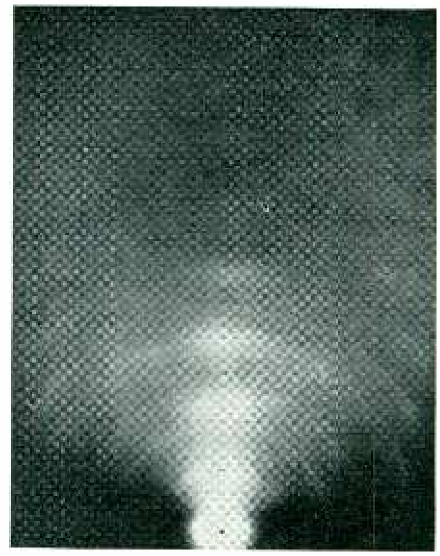


Fig. 3. Pattern obtained from grazing beam

Figure 3 was obtained by examination of a colloidal graphite film by a grazing electron beam, Finch and Wilman indicating that the diffusion of the central series of "blobs" suggests that the thickness of the graphite crystals is much less than 10 millimicrons and more probably of the order of 2 millimicrons.

[1] "Diffraction of Electrons," Electronics, page 290, September, 1935. "Nature of Metal Surfaces Revealed by Electron Diffraction," Electronics, page 50, February, 1936.

[2] Trans. Faraday Soc., vol. 31, part 9, 1935.

DR. DE FOREST CELEBRATES

The inventor of the audion talking into the original transmitter, used by WWJ when it first went on the air, on the occasion of the sixteenth anniversary of the Detroit station

within the small tolerance of 0.2 or 0.3 per cent. Coupling from the filter to the turntable is accomplished by carefully machined gears, by direct drive, by rim drive (a small rubber wheel running against the inside of the rim of the table) or by belts. The relative advantages of these different systems have been widely argued in the industry, but in general the heavier the drive and the more precision workmanship put into it the better it is. Portable recording machines, which are very popular and becoming more so, impose very severe restrictions on the turn-table drive but most of the units available do a very good job nevertheless.

These complicated drives are necessary in both recording and reproducing, but especially in the former case, since the power of cutting is on a much higher level. Turn-table drives for home use are much less elaborate, of course. The two standard turn-table speeds, 33 1/3 and 78 r.p.m. are now divided rather sharply, the former for transcription type records, the latter for general purpose records sold to the general public. The wavering quality noticeable in the first 33 1/3 drives has been overcome so that in properly designed equipment there is little choice between the two speeds, although it is always easier to record the higher frequencies at higher groove-speeds.

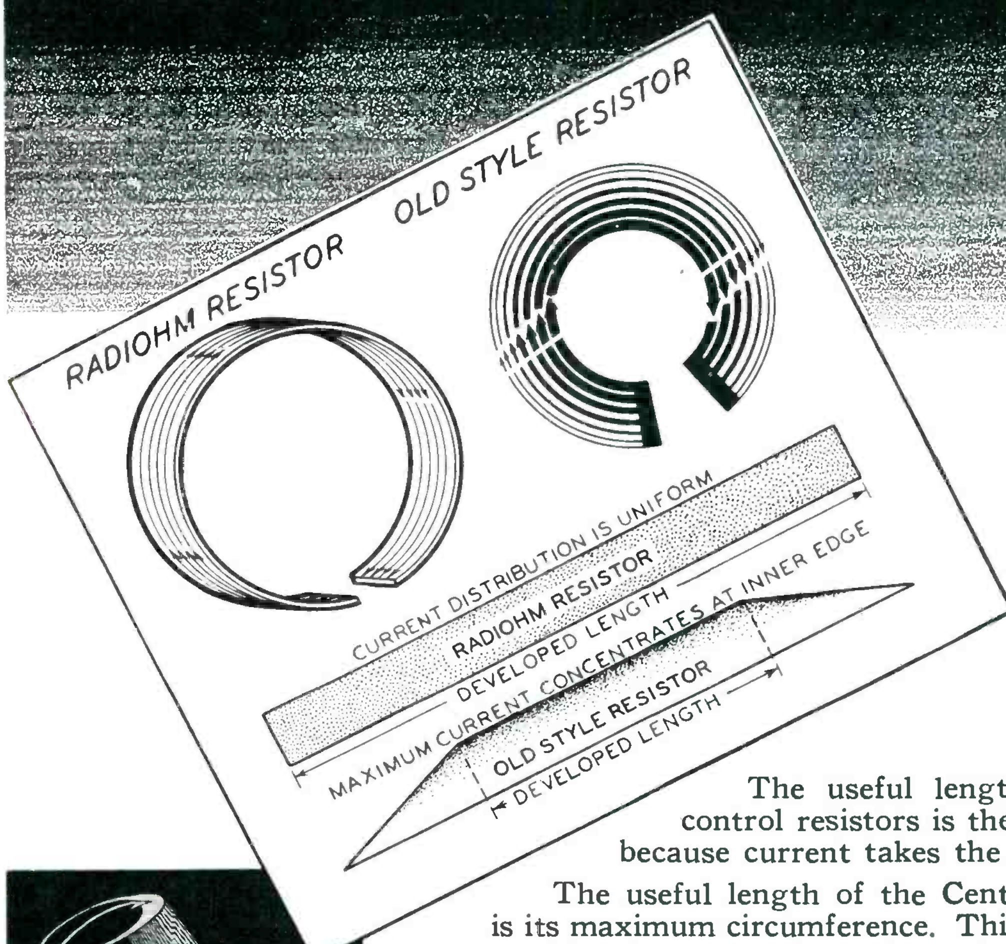
Vertical vs. Lateral Type Records

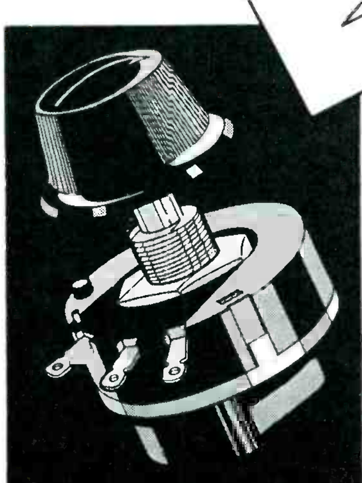
There is little doubt in anyone's mind that the best recording today is being done by means of the vertical (hill-and-dale) method of engraving and reproducing, which was developed at the Bell Laboratories for ERPI, and is now being used by several outside concerns on a license basis. There is, however, considerable discussion of the exact reason for the superiority of the vertical records. In this system, the engraving stylus moves in a vertical direction, and the groove depth varies with the modulation, whereas the groove depth is constant in lateral cut records. The groove width is constant (more or less) in the vertical system, hence closer groove-spacing can be tolerated, and considerably more playing time put on the disc. Since there is no danger of cutting into adjacent grooves, greater depth of modulation may be tolerated, theoretically, up to the limits of the ability of engraver to penetrate the wax of the disc. But practically, much greater amplitudes are not always realized because the stylus is working against the wax on the down stroke, but against only its spring suspension on the upstroke, whereas both halves of the cycle are equally resisted in the lateral-cut system. Also, of course, the amplitude cannot be so great (with respect to the position at rest) that the stylus jumps clear of the surface of the wax.

The success which has attended the use of the vertical system cannot be wholly explained by inherent technical improvements. Rather it seems likely that the improvement is largely in establishing a *system*, all parts of which are under close engineering control, and in expending much energy in refining the engravers and reproducers (to a point incidentally, where they can be maintained only by experts). The vertical type cutters are a marvel of workmanship; they cut a groove at 9000 cycles as well as they do at 300. The wax original and the plastic duplicates used are the best materials available. The reproducers use a special sapphire stylus which is designed to match the groove with precision, but which cannot be replaced or even adjusted except by an expert. The noise level, reduced by care in engraving and the use of proper materials, is claimed to be a full 60 db below the maximum allowable signal, which is considerably higher than that possible in lateral records.

The vertical method will, it appears, be restricted to commercial use since the parts of the system require constant and expert supervision and service. This commercial business is no small item. Counting both vertical and lateral program transcriptions, last year some $15,000,000 worth of program time was sold by broadcast stations to advertisers who used recorded programs, and the business may increase fifty per cent this year. Perhaps two-thirds of this business is in vertical-cut recordings. But, for all that, the lateral records are making such great strides that the gap between the two systems is closing. Which will eventually prove the best is at least an open question.—D.G.F.

WHERE THE LONGEST WAY 'ROUND IS THE BEST WAY AFTER ALL





The useful length of old style volume control resistors is the smallest circumference because current takes the shortest path.

The useful length of the Centralab Radiohm resistor is its maximum circumference. This length is twice that of an old style control of equal outside diameter and represents the relative volume control efficiency.

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RADIOHM

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.

English Translations of German Books on Short-wave Therapy

FOR SOME TIME only available in the German version, two recent books on the production and use of short-waves are now available in English. They are:

"Short-Wave Therapy." By Dr. Erwin Schliephake. Authorized English translation by Dr. R. King Brown from the second and enlarged German edition. (238 pp.) London: The Actimic Press Ltd. 1935. 21 sh.

"Foundations of Short-Wave Therapy."

"Physics and Technics" by Dr. Wolfgang Holzer.

"Medical Applications" by Dr. Eugen Weissenberg, translated by Justina Wilson and Charles M. Dowse (228 pp.) London: Hutchinson's Scientific and Technical Publications, 1935. 12 sh. 6 d.

Schliephake's book deals mainly with the application of high-frequency electrical oscillations to the treatment of disease. The second book devotes much space to a description of the methods of producing electrical oscillations of very high frequency and the heating effects they produce.

• • •

Sum and Difference Distortion in Pentagrid Converter Oscillator

TWO ENGINEERING bulletins have been issued recently by the Ken-Rad Corporation, both of them of interest to circuit engineers. The first covers the subject of "The relation of modulation products with multi-tone signal to harmonic distortion with mono-tone signal in audio amplifier analysis." It is pointed out that speculation has been rife with respect to the general subject of distortion produced in an amplifier when more than a single tone is impressed on it. Because so little has been done of a quantitative nature, engineers have been prone to believe that modulation products are not of much importance. At the same time they have been inclined to question whether an analysis of an amplifier with a single tone is of much value.

The paper then described laboratory measurements on the output of a typical system showing the modulation products obtained with two frequencies. Conventional harmonic measurements were also made with a single input frequency proving that the modulation products obtained with a multi-tone signal are related to the harmonics measured with a single frequency.

The second bulletin bearing on pentagrid converter considerations relates the difficulties discovered in the field with oscillators. The criteria for good oscillation are discussed and suggestions made as to the remedies to apply when trouble occurs.

These bulletins may be obtained from Ken-Rad.

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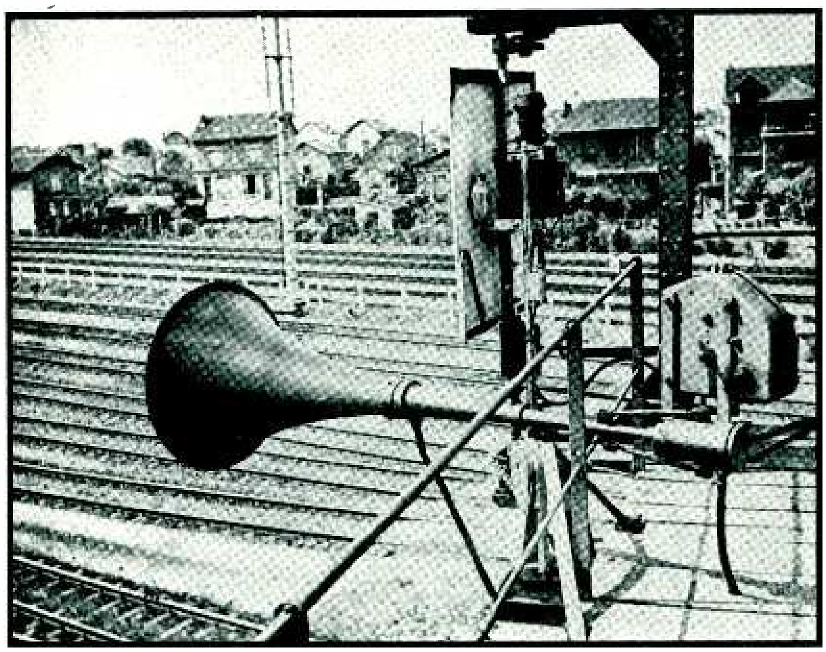
PUBLIC ADDRESS FOR THE FRENCH RAILROADS



Both photoelectric controls and loudspeaking addressographs (above) have recently been installed in French railroad yards to prevent accidents and facilitate dispatching. Outside the audible range of the horn, short wave radio is used

Amplification by r. f. Pentodes

(W. KLEEN AND H. ROTHE, TELEFUNKEN LABORATORY) Any tube may be characterized by its grid controlled conductivity K, its internal resistance R, and its amplification factor A. Theory and experiment show that each of these values depends on the one hand on the dimensions and position of the electrodes, their influence appearing in the constants a, b, d in the formulas, and on the other hand on the plate current i and the plate voltage v as shown in the table

	Triodes	Pentodes
$K =$	$ai^{1/3}$	$ai^{1/3}$
$R =$	$d/ai^{1/3}$	bv/i
$A =$	d	$abv/i^{2/3}$
$KA =$	$ai^{1/3}/d$	$a^2bv/i^{1/3}$

The constant a lies between about 0.6 and 1.8, the constant b between 0 and 20 for directly heated pentodes and between 20 and 40 for indirectly heated pentodes, d may be taken as between 5 and 100 for the present purpose. At very low currents the values of a and b for pentodes become quite variable.

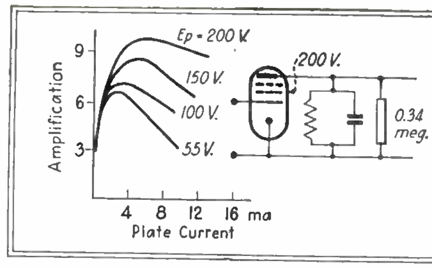
Triodes differ therefore from pentodes in that the amplification factor of pentodes depends not merely on the dimension and position of the electrodes but also on plate current and voltage, and in that the mutual conductance K and the internal resistance R are not directly related.

The difference between the performance of pentodes and triodes (neglecting feedback) appears clearly

IT TOOK THIS COMPANY ONLY A YEAR AND SIX MONTHS TO BECOME KNOWN AS THE ONLY CONCERN ABLE TO MEET CERTAIN TUBING SPECIFICATIONS. THE STATEMENT WAS MADE BY A MAN NOT KNOWN TO US—BY A MAN WE HAVE SINCE BEEN HAPPY TO SUPPLY WITH THE TUBING HE NEEDED FOR A VERY SPECIAL PURPOSE.

◆

A GOOD MANY USERS OF *SMALL SEAMLESS TUBING* KNEW EARLY IN 1935 THAT THE SUPERIOR TUBE COMPANY OF NORRISTOWN, PENNA. (25 MILES FROM PHILADELPHIA, 100 MILES FROM NEW YORK CITY) HELD A UNIQUE PLACE IN AMERICAN INDUSTRY—THAT ITS ORGANIZATION DOES THINGS WITH METALS *REGULARLY* THAT LABORATORIES FIND DIFFICULT.



Relation between plate current and amplification in a tuned plate pentode circuit

when the voltage amplification V is computed for a tube which has a tuned circuit as load in the plate lead, the ohmic resistance being equal to r. In this case

$$V = K\frac{Rr}{R+r}$$

On introducing the values of K it is found that with the triode the amplification increases with increasing current, but tends towards a constant value, d. In the case of the pentode, however, the amplification passes through a maximum when the current is equal to the fairly low value bv/r, and R equal to $2r$. It is useless to increase the plate current above this value.

A similar difference between pentodes and triodes results when a tapped coil is used and the lead from the plate connected to a point between the ends of the coil, which acts therefore as an autotransformer of ratio u:1. In the triode as well as in the pentode the highest voltage amplification is obtained when the connection is so chosen that $u^2r = R$, where u has to be smaller than unity in order to prevent distortion. With pentodes, however, the amplification increases with decreasing current, and the internal resistance R becomes so high at low currents that R is always larger than r. The theoretical maximum cannot be reached, so that tapped coils should not be used with pentodes. The same conclusions hold when selectivity is taken into consideration. (Telef. rohre No. 7:109–131. 1936).

• • •

RADIO EXPORTS REACH PEAK LEVEL

A. J. G. SMITH

THE RISE OF RADIO to the status of a major manufacturing industry is one of the most striking developments of late years. The importance of radio in international trade is no less marked, as in the short period of one decade from the time the first stations went on the air official returns show that the total exports of radio goods from the principal producing countries totals over $85,000,000 per annum. From the depression which followed the peak

SHAKEPROOF

THE *Triple-Action* LOCK!

Tapered-twisted TEETH PROVIDE POWERFUL 3-WAY LOCKING PRINCIPLE

● Designing engineers, everywhere, are enthusiastic over the sensational locking action of Shakeproof's new tapered-twisted teeth. The positive protection against the damaging effects of vibration that this new principle makes possible assures perfect performance for any metal product. No more loose nuts or screws—no more costly customer complaints due to faulty lock washers. Shakeproof Lock Washers are the answer to any locking problem because they never let go!

EVERY METAL PRODUCT SHOULD BE "SHAKEPROOFED"!

Right now is the time to go over your lock washer specifications. Make certain that your products enjoy the protection that only Shakeproof can give them. Keep all connections tight—permanently—with this powerful, triple-action lock and you can be certain that the performance of your products—the satisfaction of your customers—and the effectiveness of your sales program will be materially enhanced. Decide now to test Shakeproof—mail the coupon below for your free test ring today!

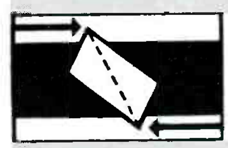
SHAKEPROOF LOCK WASHER CO.

Distributor of Shakeproof Products
Manufactured by Illinois Tool Works

2539 N. Keeler Ave. Chicago, Illinois

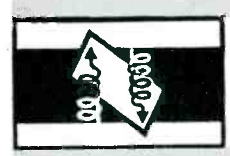
IN CANADA: Canada Illinois Tools, Ltd., Toronto, Ont

Now! POSITIVE RESISTANCE TO ANY LOOSENING FORCE



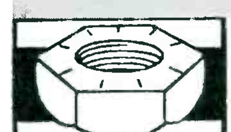
1 STRUT-ACTION

When a nut is turned down against a Shakeproof Lock Washer the teeth instantly bite into both nut and work surfaces. Thus, a sturdy strut is placed between the nut and the work, setting up a powerful leverage against any backward movement of the nut.



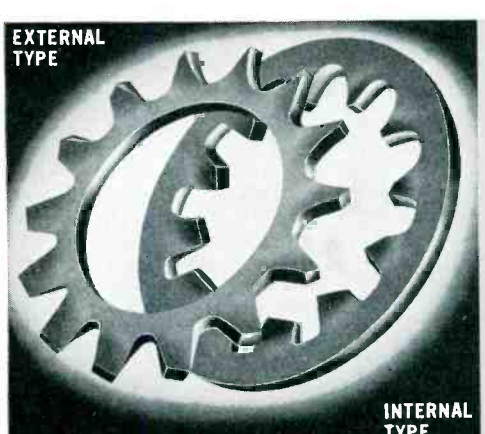
2 SPRING-TENSION

When the teeth bite in, a powerful spring-tension is immediately in force. This is produced by the exclusive design of the twisted teeth which allows the body of the washer to resiliently cooperate in keeping the contact permanently tight.



3 LINE-BITE

The tapered shape of the teeth also assures a substantial line-bite at initial contact. As vibration increases, this bite becomes deeper, which makes the locking force even greater, and keeps the connection absolutely tight.



U. S. Patent Nos. 1,862,486
1,909,476 1,909,477
1,419,564 1,782,387
1,604,122 1,963,800
Other Patents. Patents Pending. Foreign Patents.

SHAKEPROOF LOCK WASHER CO.
2539 N. Keeler Avenue, Chicago, Ill.

Gentlemen: We wish to test your Shakeproof Lock Washers on our own products. Kindly send us a free test ring immediately.

Firm Name ....

Address ....

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

Signed by .... *Title* ....

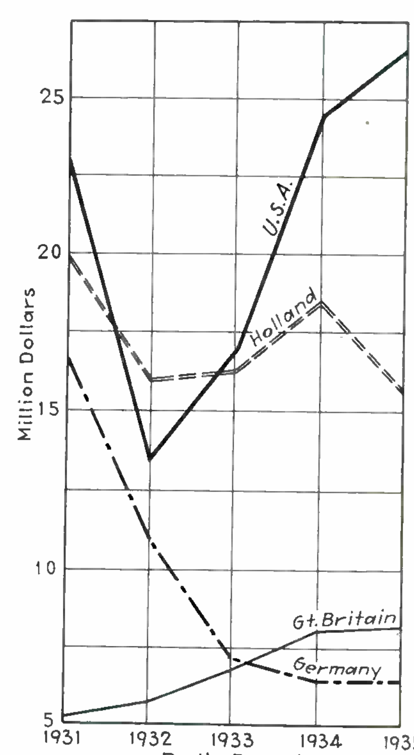
year of 1929, most all countries of the world are now recovering, and this recovery is having its effect upon the radio export trade.

The four chief countries exporting radio goods in any considerable volume are the United States, Holland, Germany, and Britain, in the order named. In 1935 these four countries exported radio goods to a total value of over fifty-five million dollars. The course of such trade during the past five years is shown by the following table, showing exports in millions of dollars:

Year	U.S.A.	Holland	Germany	Gt. Britain
1931	22.6	20.	16.6	5.1
1932	13.3	15.8	11.	5.8
1933	16.6	16.3	7.3	6.8
1934	24.8	18.4	6.5	8.
1935	25.4	15.8	6.5	8.1

To avoid unnecessary complications in these figures, the conversion has been made on the basis of par exchange. In order that the trend of trade may be followed more readily, such results are also summarized in the chart. It is interesting to examine the position of the four countries in a little more detail.

U. S. A.—The achievements of our own radio industry in export markets are fairly well known, and the record on the whole has been one of continual expansion, varied by two sensational drops in 1932 and 1833, from which the trade has now entirely recovered. Moreover our radio trade has been remarkable for the tenacity with which



Exports for four countries for the period 1931–1935 on the basis of par exchange.

• BARE WIRE • ARMORED CABLE • CRESCENT INSULATED WIRE • BUILDING WIRE •

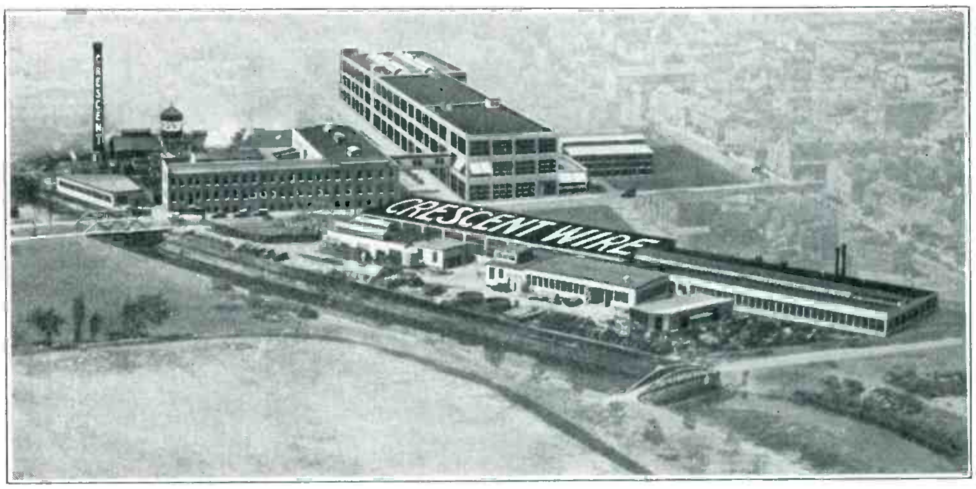
RUBBER POWER CABLE • LEAD ENCASED CABLE • PARKWAY CABLE • VARNISHED CAMBRIC • SIGNAL CABLE

CRESFLEX NON-METALLIC SHEATHED CABLE • SERVICE ENTRANCE CABLE • MAGNET WIRE • WEATHERPROOF WIRE

RADIO MANUFACTURERS!

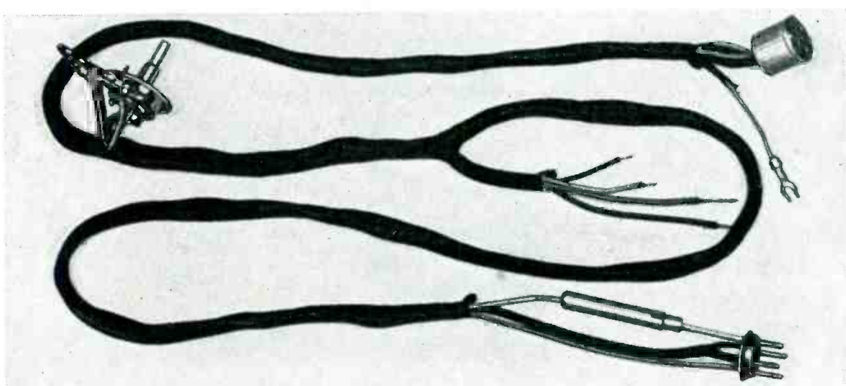
Here is the **CRESCENT** *Factory*

that makes



COMPLETE CORD SETS

WITH PARTS—READY TO INSTALL



TRADE MARK

RECEIVER CORDS
ASSEMBLY CORDS
ANTENNA CORDS
SHIELDED CORDS

Think of the economy, convenience and safety of buying your cord sets already assembled, complete with switches, sockets, fittings, etc.

CRESCENT COMPLETE CORD SETS are making big savings for Radio Manufacturers. We specialize in this work—Every set carefully tested and inspected—100% perfect cords guaranteed.

Send us your blueprints for prices on quantity production. Address Department E.

WRITE US—We will be glad to show you samples of work we are doing. Address Department E.

CRESCENT
INSULATED WIRE & CABLE CO. INC.
TRENTON, NEW JERSEY

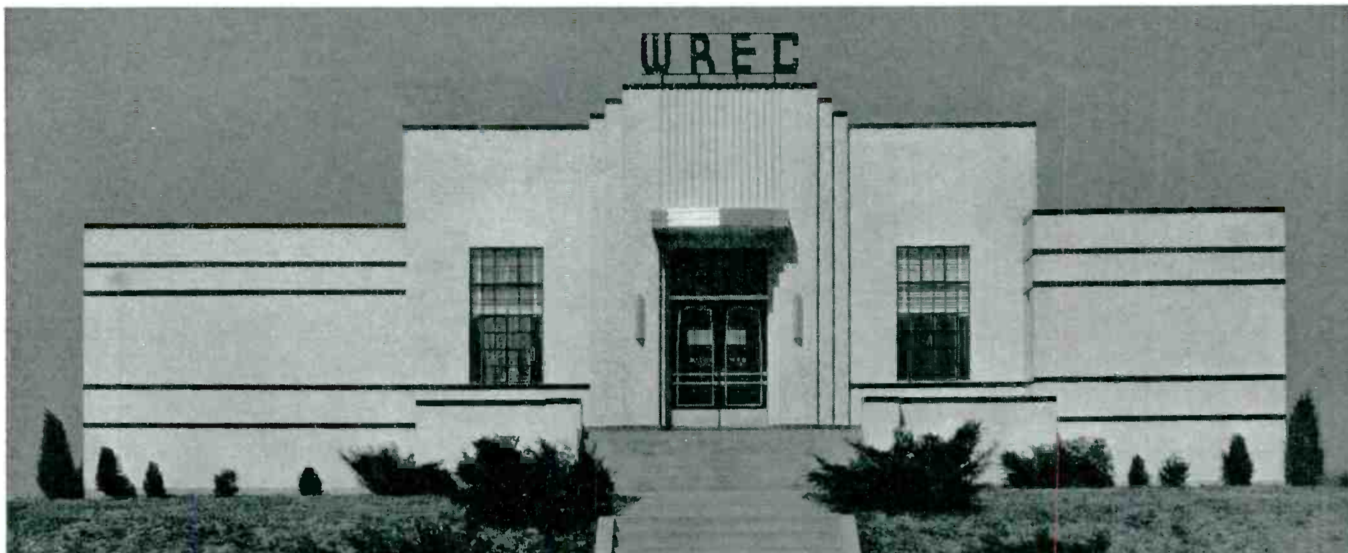
• FLEXIBLE CORDS • RADIO WIRES • ENDURITE SUPER-AGEING INSULATION •

the main markets have been held, approximately 70% of the total having invariably been done with other countries in the continent, the most important customers having been Canada.

HOLLAND—In some respects the position of Holland in the radio trade has been the most interesting of all. In the early stages of the industry (up to about 1925) it was merely an important importing country, and in fact it is still the most important buyer of German radio, from which country it took approximately $1,135,000 last year. Since 1926, however, mainly due to the enormous growth of a single Dutch manufacturing concern, Phillips Gloelampenfabrik N.V., of Eindhoven, the radio exports have steadily grown until in the peak year of 1929 Dutch exports reached a level higher than any other country, including the U.S.A. From that high level of approximately 33¾ million dollars, exports have dropped considerably, and during the last five years they have reached what is apparently going to be their normal level of between sixteen and twenty million dollars per annum. This is below the level of the U.S.A., but it is still more than double the German figure. Dutch trade in this respect is all the more remarkable as it has been effected under the disadvantage of a steady adherence to the gold standard. In the initial stages of this trade, however, Great Britain was the largest purchaser taking approximately 60% of the total exports followed by the Netherlands East Indies with about 17½%.

MOST POWERFUL CYCLOTRON

Said to be the most powerful atom gun yet built, this "electron whirligig" recently developed at the University of Michigan has a voltage of 6–7 million volts, a new record. (See Electronics, Nov. 1935)



A Model of Broadcasting Efficiency

RADIO STATION WREC · MEMPHIS · TENNESSEE

Two Truscon Vertical Radiators combine with the most modern transmission equipment to make radio station WREC a model of broadcasting efficiency. Operating on the directional system, WREC can concentrate its maximum assigned power with high fidelity modulation in selected areas of greatest population density. The results are what may be termed "Custom-Built Broadcasts" whereby an advertiser can have his program concentrated in "wanted" areas and eliminate practically all interference from other stations on the same frequency.

Truscon Vertical Radiators are important factors in maintaining high standards of signal transmission and reception. Night fading is practically eliminated. Structurally, Truscon Vertical Radiators, although entirely self-supporting, have exceptionally high factors of safety to resist the terrific stresses and strains of ice and wind.

For complete information about the commercial and technical advantages of Truscon Vertical Radiators, communicate with Truscon Steel Company, Youngstown, Ohio, or direct with the Truscon office located in your vicinity.

> Other Truscon Products used in WREC's new transmitter house:
>
> Steel Casements
>
> Open-Truss Steel Joists
>
> Ferrobord Steel Roofdeck
>
> Diamond and Rib Lath
>
> *Catalogs on Request*

TRUSCON STEEL COMPANY, YOUNGSTOWN, OHIO

TRUSCON VERTICAL RADIATORS

GERMANY—A five-year survey will suffice to show how the export trade of this country has gone down. The depression following on 1929 was not immediately apparent in the export field, and the real drop in radio exports did not commence until 1932, from which point the drop has been very marked, in spite of all the devices of export subsidies and compensating trade agreements with which the German government has endeavored to support the trade.

Like other countries, the radio export trade of Germany flows along certain well marked channels. The majority of the trade, as might be expected, is done with adjacent European markets. Last year, Holland was the most important customer, taking approximately 17% of the total, the next largest buyer being France, with a little over 9%.

GREAT BRITAIN. The one feature of the British radio export trade is its steadiness, though it is of comparatively little value. The main markets are the British overseas countries within the empire, more particularly Australia and the Union of South Africa. Exports to Canada are only $85,000, which is trifling compared with American exports to that destination. A remarkable feature is that the departure of sterling from the gold standard in 1931 did not result in any big increase in radio exports.

Britain was by far the largest customer for German radio goods, but since the departure of that country from the gold standard such purchases declined from 15½% in 1931 to a little over 3% in 1935.

500-550 Kc. Broadcasting

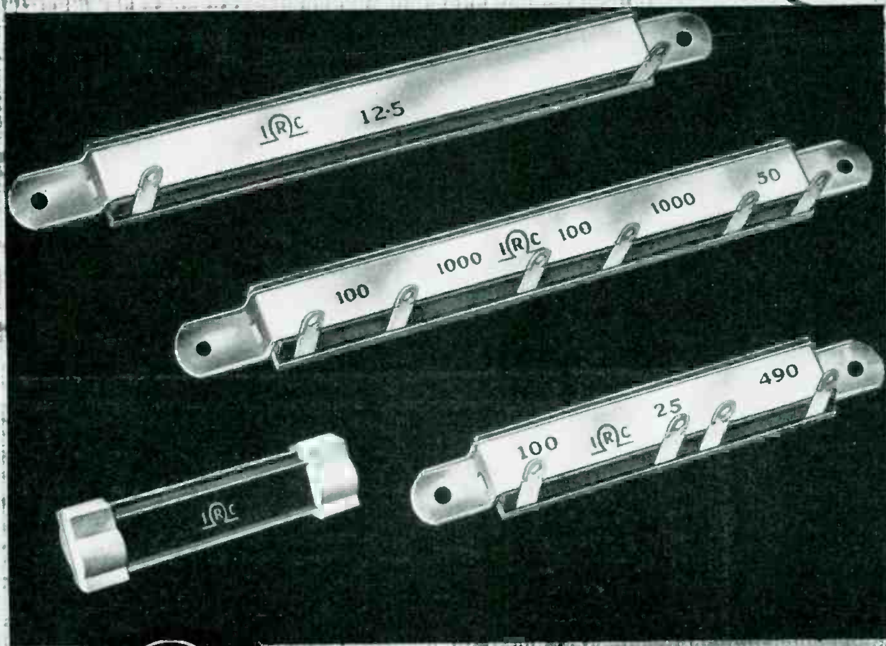
[*Continued from page* 19]

of this frequency range by Canada. There are already Canadian stations on 530 and 540 kc., of 1 kw. power, and another station is planned for 520. Either Canada should be allowed to employ increased power on these frequencies, thereby making them completely useful to her as exclusive channels; or she should give up one or more of them to relatively high-power stations in the interior of the United States; or these channels should be shared with low-power American stations. It is believed that one of the first two possibilities is to be preferred to the third, since the longer waves should not be wasted on low-power (i.e. local) stations.

If the United States refuses to use the valuable properties of these frequencies, it is only a question of time before Canada, and perhaps Mexico, will either increase the power or the number of their stations operating in this band. Such action might easily subject our maritime services to interference over which the American government would have no control, and which might become much more serious than that resulting from a well engineered system of allocations laid out either for the United States alone, or for the three countries together.

Interference to Naval Services

There remains the question of interference to naval services operating between 500 and 550 kc. If such services were to work on 525, 535, and 545, using over-all band widths of 3600 cycles for telephone communication, it is believed that the interference which they would encounter would not be very serious. It would be due entirely to the sidebands of the distant transmitters and would, therefore, be intermittent in character, even at times of highest field strength. It is estimated that in the case of 50 kw. clear channel stations this interference would have an effective value of the order of 30 to 100 microvolts per meter at night. In daylight, it would, of course, be entirely absent. If 5 kw. shared channel stations were used, in the manner which has been suggested, the interference might be slightly higher. The report of the committee on question 9 proposed for the fourth meeting of the C.C.I.R. indicates that a field of about 1200 microvolts per meter is necessary for satisfactory aviation telephone service. It is, of course, true that communication can be carried on at times with much lower fields, but it cannot be regarded as dependable, and it would seem that an interfering field of 100 microvolts should be tolerable. Moreover, for operations well out to sea, the interference would be of lower intensity. In any event, our naval services will eventually be interfered with to at least this extent by increased use of 520, 530 and 540 kc. in other countries, unless the United States puts in a claim for them.



DESTINED TO WORK RADICAL CHANGES IN ENGINEERING CONCEPTS

IRC
REG. U.S. PAT. OFF.
Initiative — Resourcefulness — Cooperation to advance the interests of the industry

INSULATED
WIRE WOUND RESISTORS

New . . . Modern . . . Practical!

Important developments in IRC INSULATED Wire Wound Resistors pave the way for a distinctly new line of engineering thought. For instance . . .

. . . Moulded in phenol compound—impervious to the elements—constructed for exceptionally rapid heat dissipation—can be used up to full wattage rating without excessive temperature rise—available in six standard lengths and almost limitless types and ranges up to 20 watt load. Type MW Resistors (shown above) are the most completely protected, most adaptable wire wound resistors ever presented.

Many combinations of ranges may be had in one unit to simplify production, to save time, money and space.

TYPE BW INSULATED LOW RANGE WIRE WOUNDS

. . . Completely insulated, small ½- and 1-watt wire wound resistors similar in appearance and size to the famous Insulated Metallized Resistors and low in cost. Made in values from ¼ ohm to 2,800 ohms.

WRITE for the IRC Resistor catalog.

INTERNATIONAL RESISTANCE COMPANY
401 North Broad Street, Philadelphia, Pa.

MAKERS OF RESISTANCE UNITS OF MORE TYPES, IN MORE SHAPES FOR MORE APPLICATIONS THAN ANY OTHER MANUFACTURER IN THE WORLD

MANUFACTURING REVIEW

News

✦ **Simpson Electric Company**, a new manufacturing and sales organization, has a new line of radio instruments, service equipment and electrical measuring devices. This organization is headed by Ray R. Simpson, former President of the Jewell Electrical Instrument Co., and the other personnel consists of men formerly associated with Mr. Simpson in the design and manufacture of similar equipment.

✦ **Bruno Laboratories, Inc.** is now licensed to manufacture public address equipment under the U. S. patents owned or controlled by the Western Electric Co., Inc., and the A. T. & T., by virtue of an agreement with the Electrical Research Products Inc. This license specifically covers p.a. systems, including velocity microphones, amplifiers and loud speakers.

✦ **General Electric Company** announces the appointment of S. J. Garahan as manager of sales for the cable section of that organization. Mr. Garahan, who has been in the employ of G. E. since 1904, has been affiliated with the cable division for many years.

✦ **The Shallcross Manufacturing Company**, manufacturers of precision wire wound resistors, decade resistance boxes, bridges, test equipment and switches, have moved into their new daylight, fireproof factory. The new factory at 10 Jackson Ave., Collingdale, Penna., has three times the former floor space which will greatly enhance the facilities of production.

✦ **General Cable Company** has recently appointed Howard E. Eagleston, formerly Pacific district manager, as general sales manager, with headquarters at 420 Lexington Avenue, New York City.

✦ **The Turner Company**, Cedar Rapids, Iowa, announces the appointment of the L. G. Cushing Co., 540 N. Michigan Ave., Chicago, Ill., as its Illinois representative.

✦ **Cornell-Dubilier Corporation** Jobbers Division, is now located at the new plant and offices at South Plainfield, New Jersey.

New Products

General-purpose Amplifier

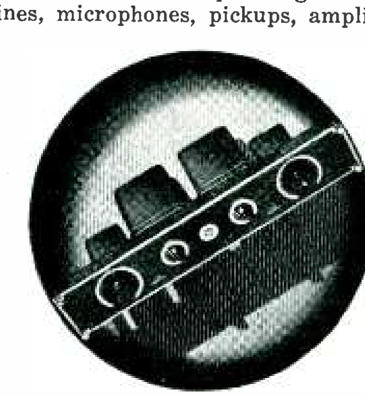
General Radio Company announces a new amplifier, type 814-A, for use as a general-purpose instrument. This instrument has a very low battery drain, because of the use of 2-volt pentodes and will operate from small dry batteries. It is of the resistance-capacitance coupled type, covering the range from 18 cycles to 10,000 cycles with a variation of less than plus or minus 2 db in gain. Provision is made for inserting a parallel resonant circuit in the grid circuit of the last stage in order to modify the frequency response of the amplifier. A jack is provided on the panel for connecting the resonant circuit. This arrangement provides good selectivity at most bridge frequencies in the audible range, and results in discrimination against harmonics and a greatly decreased noise level. General Radio Company, Cambridge, Massachusetts.

Power Rheostat

The new D-150, a continuously variable power rheostat, is 4 inches in diameter and 1½ inches deep behind the panel. The resistance wire is wound on a toroidal ceramic core and coated with a high quality vitreous enamel. All live parts are separated from the shaft and base by an air space or ceramic insulation. The contact shoe is of metal-graphite composition and travels on the inside circumference of the ring where the turns of the winding are necessarily most closely spaced. The shoe has a narrow face that insures a smooth variation of resistance and freedom from unsteadiness due to shift of contact from one side of the shoe to the other. A coiled pigtail, one end molded within the shoe, has its other end solidly riveted to the central stationary terminal so that the only sliding electrical contact is that between the shoe and the winding itself. The rheostat has a free air rating of 150 watts. It conforms to the Underwriter's Labs. and NEMA specifications based on a maximum temperature rise of 250 degrees. The single hole type requires a ⅜ inch hole in the panel. Standard bushing will permit mounting on panels up to ¼ in. thick. Hardwick-Hindle, Inc., 40 Hermon Street, Newark, New Jersey.

Equalizer

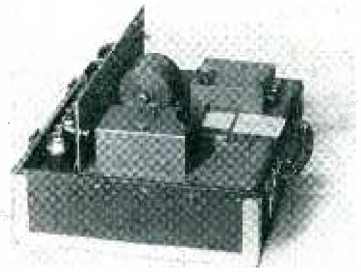
United Transformer Corporation has released a universal equalizer for broadcasting and recording service. This unit is of a depressed chassis rack panel construction. It incorporates separate controls for high and low frequency equalization. A switch is provided on the low end control to obtain maximum equalization at 25, 50 or 100 cycles. Another switch is used for the high frequency end at 4000, 6000, 8000 and 10,000 cycles. Calibrated T type attenuators are used for low frequency equalization and high frequency equalization, permitting accurate control from 0 to 25 DB. This unit is recommended for use in equalizing broadcast lines, microphones, pickups, amplifiers,



and other radio equipment. This equalizer is also applicable to standard amplifiers for home and PA service where overall high fidelity is essential. United Transformer Corp., 72 Spring Street, New York City.

High Speed Level Recorder

An automatic power level recorder which covers a wide range of intensities has been announced for distribution by the Sound Apparatus Company, 150 W. 46th. St., N. Y. City. Interchangeable potentiometer for



power level measurements are available having range of 0-25 db in ¼ db steps; 0-50 db in ½ db steps; 0-75 db in ¾ db steps. This device is in portable, completely a-c operated. It has wide application for measurement, such as measurement of reverberation time of studios, theaters, etc; routine sampling measurements of loud speakers in factories; measuring characteristics of recording and reproducing heads.

Triode

The new Amperex HF100, a transmitting type triode, is one of their new offerings. The tube, patterned after the HF200 and HF300, has these char-

acteristics: Filament voltage 10 volts; filament current 2 amperes; amplification factor 23; grid to plate transconductance at 100 ma. 4200. The maximum plate power output is 170 watts at 20 mc. or lower; 100 watts at 60–75 mc; 60 watts at 120 mc. The tube is 7½ in. high, with a bult diameter of 2 1/16 in. The base is the standard UX-4, with prong for filament connections only. Amperex Electronic Products, Inc., 79 Washington St., Brooklyn, New York.

QX Checker

Boonton Radio Corporation, Boonton, New Jersey, has placed on the market a new instrument designed especially for the inspection and testing of coils and condensers at radio frequencies. This instrument makes it possible to make comparative tests a part of routine factory inspection. Simplicity of appearance, with oversized dials and well-expanded scales carefully positioned, reduce eye-strain and fatigue of operation. The principle of the QX checker is similar to the Q meter. It contains an r-f oscillator utilizing plug-in coils or inductors. A portion of the oscillator voltage is introduced in a circuit consisting of the internal Q tuning condenser system, a vacuum-tube voltmeter and an external coil. The external coil is an accessory, required only when checking condensers. In checking coils, however, the coil being checked takes the place of the accessory coil mentioned. The capacitance range that can be checked, together with available accuracy, is as follows:

0 — 100 mmfd.	± 0.1 mmfd.	to 50%
100 — 500 mmfd.	± 0.1 %	to 10%
500 — 1000 mmfd.	± 0.1 %	to 5%

The checker operates on 95–125 volt 50–60 a-c supply. Power consumption approximately 50 watts. Panel lamp indicates when QX checker is in operation.

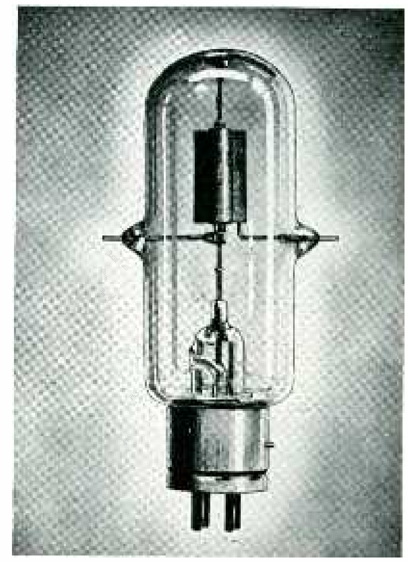
Photoelectric Relays

G-M Laboratories, Inc. of Chicago announces a line of d-c photoelectric relays for operation on 115 and 230 volts to supplement their a-c line. These units are available with 2 inch and 3 inch lens apertures, with rectangular cell apertures and no lenses, and with no apertures, the latter being for use with separate cell housings.

Another G-M product is a new low cost, a-c relay. Known as Type A relay it can be supplied for operation on voltages from 2 to 230 volts, 25 to 60 cycles. It can be furnished with four pairs of contacts, has a capacity of 10 amperes per contact. Bulletin No. 164 contains full information of these relays.

Transmitting Tube

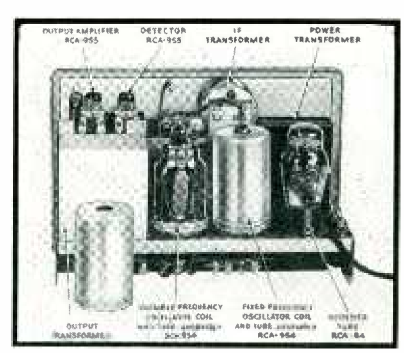
Heintz & Kaufman, Ltd., South San Francisco, California, has a new Gammatron, type 154, a low-voltage tube for the amateur. This tube is approximately 6¾ in. in length and has a straight-sided glass envelope 2 in. in diameter. It has the standard UX base, and grid and plate leads of rigid



tungsten rods extending through opposite sides of the glass envelope in position for convenient wiring. The grid and plate are of tantalum to insure freedom from gas throughout the life of the tube. The ratings are as follows: Filament voltage, 5.0 volts; filament current, 6.5 amps; plate dissipation 50 watts; plate voltage 1500 volts (max.); plate current 175 ma. (Max.); Grid current 30 ma. (Max. average); plate resistance 1750 ohms; amplification constant 6.7.

Oscillator

A new variable a-f beat frequency oscillator has been announced by RCA Manufacturing Company, Camden, New Jersey. This device uses acorn 954



tubes as the oscillators which operate in the region of 350 kc. The unit is self-contained, weighs 10¾ pounds, and, including five tubes, lists at $64.50.

Phase Rotation Indicator

FERRANTI ELECTRIC INC., 30 Rockefeller Plaza, announce a new addition to their line in the form of a small 2½" Phase Rotation Indicator weighing less than 13 ounces.

This instrument consists of a small three-phase induction motor mounted in a bakelite case and fitted with an aluminum disc, which instantly indicates the direction of phase rotation on a three-phase supply. The portable model which can readily be carried in a pocket, is fitted with three 30" leads having crocodile clips of different colors.

These instruments can be used on voltages of from 110 to 550 volts, 25 to 125 cycles, and are extremely useful wherever it is necessary to know the phase rotation of a three-phase circuit.

Instruments for switchboard mounting can also be supplied in either of the 2½" flush or projecting patterns.

Complete descriptive information is contained in List IN.8 which will be gladly sent upon request.

Electrical Stethoscope

WESTERN ELECTRIC COMPANY is now manufacturing an electrical stethoscope the purpose of which is to enable physicians to amplify heart sounds and distinguish murmurs or unusual significant sounds. The device, consisting of an amplifier with a special microphone, is applied over the heart. Impulses picked up are fed into the amplifier, the output of which passes into a receiver arranged for attachment to the earpieces of the conventional type of stethoscope. The amplifier has a maximum gain of 60 db. and is sufficiently powerful to operate an additional receiver. A potentiometer in the amplifier adjusts the loudness of the hear sounds to the desired intensity. Model 3A is completely assembled in a fabrikoid bound case, the overall dimensions of which are 12½ in. by 8¾ in. by 4¾ in., and the weight of which is 14 pounds.

Literature

✦ Equalizers and filters. A bulletin containing complete analysis of various types of filters and their application, with schematics and frequency curves. Data on simple equalizers, resonant equalizers, universal equalizers, divider networks, band pass filters, high Q coils, low and high pass filters. A limited number of copies are available. Application should be made to the United Transformer Corp., 72 Spring St., N. Y. City.

✦ Silicon. Republic Steel Corp., Cleveland, Ohio, has published a spiral-bound book on Silicon sheets and coiled Silicon strip. Lists the grades available, with applications, and illustrates by graph the induction curve and magnetization and permeability of each grade.

✦ Condensers. Engineering catalog of condensers, No. 3C published by Solar Mfg. Corp., 599 Broadway, N. Y. City. Contains informative charts, specifications and data for engineers, and photographs of fixed capacitors of many types.

✦ Photoelectric Devices. Photobell Corporation, 96 Warren Street, N. Y. City, have issued sheets illustrating and describing their electric eye door signal, and Model K electric eye control unit.

✦ Measuring Equipment. Catalog J of General Radio, dated September 1936, is again a beautiful example of catalog making. From cover to cover it is interesting and instructive. Illustrated with excellent photographs (including a close-up series of the processes of making a signal generator) each of its 170-odd pages contributes information on the many products made by this long-established firm—including several items the average reader will never have seen describer before.

✦ Radio Devices. A catalog of condensers, r-f chokes, coil forms, microphones, chassis bases, insulators, tuning dials, and other parts. Published by Bud Radio, Inc., Cleveland, Ohio.

✦ Insulating Materials. William Brand & Co., 268 Fourth Ave., N. Y. City, have just issued a catalog listing the various types of electrical insulating materials produced by their organization, and giving a treatise on the origin of these materials, their histories, and uses.

✦ Relays. Weston Electrical Instrument Corp., Newark, N. J., has a booklet devoted to descriptive data on their sensitive, power, sensitrol and time delay relays. They also have available small pamphlets on their photronic cell, smoke alarm, and illumination control relays.

✦ Service Data. Radio & Technical Publishing Company announce publication of a second edition of Ghirardi's "Radio Field Service Data." For use by service men on the job or in the shop. This is loose-leaf, and contains greatly enlarged data on all spots covered by the first edition.

✦ Precision Instruments. Loose-leaf catalogue describing accurate testing equipment, decade resistance, high voltage multipliers, precision wire wound resistors, etc. Sent upon request. Shallcross Mfg. Co., Collingdale, Pa.

✦ Receiver Service Sheets. Servicing data on Remler models 45 and 60 radio receivers, with circuit diagrams on each set. Remler Company, Ltd., 2101 Bryant Street, San Francisco, Calif.

✦ "Durez." Booklet on Durez resins for coating, bonding, insulating, waterproofing, etc. Describes and illustrates actual applications. Published by General Plastics, Inc., N. Tonawanda, N. Y.

✦ Polyiron. Data Sheet No. 536, published by Aladdin Radio Industries, Inc., covers types of commercial, air-craft, amateur and experimental products in which Polyiron is used. Gives specifications and list prices of representative products in the Aladdin line. Aladdin Radio Industries, Inc., 466 W. Superior St., Chicago, Ill.

Coil Winding

[*Continued from page 24*]

we have as the number t of turns per layer:

$$t = 2N/n \quad (18)$$

If then we denote by l the total number of layers in the coil (each of depth 2δ) and by T the total number of turns in the coil, we have:

$$l = T/t = nT/2N \quad (19)$$

For example, the two coils cited above will have 36 and 35 turns per layer respectively.

So far we have restricted n, the number of crossovers per turn, to values equal to or greater than unity. We consider next how our formulas are modified provided n is less than unity. In this case, however, it is more convenient to speak of the number m of turns per crossover (rather than the number of crossovers per turn) where $m = 1/n$ is now restricted to values greater than unity.

The special case of $m = 2$ is illustrated in Fig. (5). The wire starts again at O, runs across at a definite angle Φ to the axis, and completes the first crossover at a point B_1 a distance h from the starting line OO', continues on and completes the second crossover at a point B_2 a distance $2h$ from the starting line OO', then reverses its direction and completes the third crossover at a point D_1 distant $3h$ from OO' and finally completes the fourth crossover at a point D_2 distant $4h$ from OO', whence the process is repeated with a new starting line through the point D_2, and so on.

Provided we now define h as the advance per turn (instead of the advance per crossover) and q as the number of turns per winding cycle (instead of the number of crossovers per winding cycle), we have in general:

$$S = H \cos \Phi = qh \cos \Phi \quad (1a)$$

$$c \tan \Phi = m(\pi d + h) \quad (2a)$$

$$\tan \Phi = r\pi d/2c \quad (5a)$$

Eliminating Φ there results:

$$r = +2m(1\ a \angle^2 + b^2)\,(1 + a^2) \quad (6a)$$

where a = ms/qc and b = s/qπd (7a, 8a).

The corresponding formulas for the number N of winding spaces and the gear ratio in terms of N, are:

$$r = 2m(1 + p) = 2m(1 + 1/p) \quad (14a)$$

$$N = 1/pq = P/q \quad (16a)$$

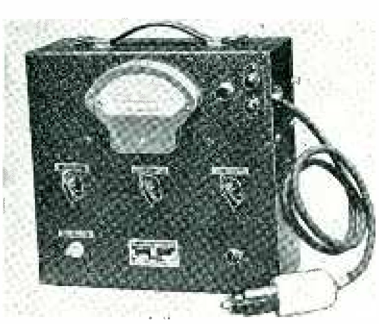
$$r = 2m(1 + 1qN) \quad (17a)$$

While values of m greater than 2 are not much used in radio work, they are used in winding string and twine, or in general where the width of the coil is large in proportion to its diameter (flat coils).

In conclusion it might be noted that the gear ratio formulas given in this paper have been successfully tried to date on 150 different combinations of wire sizes, cam (coil) widths, dowel diameters, and crossovers per turn; in fact on wire sizes ranging from No. 22 to No. 38, cams from 1/16" to 3/4", dowel diameters from 1/4" to 1 1/4", and crossovers from 1/2 to 8 per turn. A gear ratio calculation takes about 10 minutes and the coil always winds perfectly the first time.

Combination Vacuum-tube and Peak Voltmeter

CLOUGH-BRENGLE COMPANY, 2815 W. 19th St., Chicago, Ill., has developed an instrument in which is embodied a vacuum-tube voltmeter of high sensitivity and input resistance of 10 megohms, and a peak voltmeter of the "slide-back" type, operating from a self-contained power supply. When used as a vacuum tube voltmeter, a range of 0–1.2 volts rms is covered by direct connection to the tube (Type 6F5 metal) grid without any shunts. The voltmeter tube is placed at the end



of a 30-in. cable, making possible direct connection to the tube grid-cap in the circuit, the potential of which is to be measured, without capacity effects. As a peak voltmeter, ranges of 0–10 and 0–100 are provided without external power supply, for use in measuring avc, c-bias, and potentials where no current drain is permissible. Priced at $42.50 net, complete with all tubes.

Velocity Microphone

THE NEW VELOCITY microphone of Amperite Corporation, as described by the manufacturer, embodies the latest and best technique in microphone design. It gives studio type reproduction at unusually high outputs. It is acoustically designed to eliminate any possibility of cavity resonance. Triple shielding is used to prevent the pickup of any stray field. Shock absorption at two different points eliminates all mechanical vibration. A switch is provided for turning the microphone on and off—and a new cable plug having a positive locking device permits disconnecting the cable at the microphone. Having been the first manufacturers to use the new nickel alluminum magnets, they are of course included in this latest design of microphone. Obtainable with either low or high impedance outputs in either gunmetal or chrome finishes. Its streamlined, compact and modern design will harmonize with most surroundings.

Electric Phonographs

ELECTRO-ACOUSTIC PRODUCTS COMPANY, Fort Wayne, Indiana announces a new line of electric phonographs including The Concerto, Playfellow and Phonette. The phonette is a radio attachment

with a self-starting constant speed motor, crystal pickup, with volume control. Encased in an attractive walnut case, and conveniently attached to any radio. For use on standard 60 cycle house lighting circuits, and available for universal operation, a-c or d-c, if desired.

Vacuum Tube Voltmeter

TRIPLETT ENGINEERS HAVE DEVELOPED a new self-calibrating voltmeter, with accuracy independent of changing tube values. This instrument has a new tube bridge circuit, whereby the tube characteristics are stabilized with the circuit, irrespective of the tube emission values. It will answer many pur-

poses in measuring low a-c and d-c voltages without current drain. This voltmeter has a twin instrument. One of the instruments is a sensitive galvanometer, indicating when the bridge is in balance; the other is a three-range voltmeter with linear scales reading in peak a-c and d-c voltages. Ranges are 2.5, 10 and 50 volts. Model 1250. Net price $33.34. Triplett Electrical Instrument Co., Bluffton, Ohio.

Literature

✦ **"Laytex."** U. S. Rubber Products, Inc., 1790 Broadway, N. Y. City, has issued a handy manual on Laytex, for use by engineers, contractors and designers when specifying wire and cable installations. It gives graphs and tables indicating characteristics of Laytex and detailed information for proper applications.

✦ **Dry Rectifiers.** New Rectox booklet, describing the selection and application of Rectox copper oxide rectifiers for changing a-c to d-c without moving parts or chemical reaction. Published by Westinghouse Electric & Mfg. Co., E. Pittsburgh, Pa. Copies available upon request to manufacturer. (Bulletin No. B-2078).

✦ "Coppercote." Pamphlet describing new protective coating of pure metallic copper, for iron, steel, wood, concrete and other surfaces. American Coppercote, Inc., 480 Lexington Ave., N. Y. City.

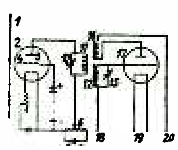
✦ Recording. Booklets issued by Presto Recording Corporation, 139 W. 19, N. Y. City, on their instantaneous recording equipment and discs, giving technical information, illustrating special uses and giving instructions for cutting discs.

PATENTS REVIEW

PATENTS indicate trends. Next year's radio circuits, applications of electron tubes for non-communication purposes, new tube types, new materials, may be discovered by following United States and British inventions.

Radio Receiver Circuits

Ultrahigh frequency receiver. W. R. Koch, RCA. No. 2,037,799. See also



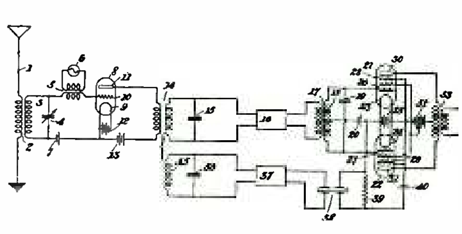
No. 2,039,897 to Ernst Gerhard, Germany.

Diversity reception. Producing and maintaining a predetermined phase displacement in the energies collected from several sources, combining the energies, detecting the combined phase displaced energies and translating the detected energies. M. G. Crosby, RCA. No. 2,042,831.

Conversion system. Means for eliminating the effect of regenerative action on the conversion gain of a frequency changer system. H. A. Wheeler, Hazeltine Corp. No. 2,042,-571.

Frequency conversion system. A method of radio reception which includes picking up r-f energy, locally generating energy, frequency multiplying the locally generated energy to a value in frequency such that the multiplied frequency energy when heterodyned with the picked up energy produces a beat equal in frequency to the frequency of the locally generated energy. R. E. Mathes, RCA. No. 2,041,846.

Receiver system. Means for selecting the carrier frequency from the modulated carrier by a circuit selective to the carrier frequency only, and a circuit resonant at carrier fre-



quency and adapted to suppress all side-band frequencies, the latter circuit being connected to the selector circuit, and a combining circuit including two translating devices, impressing the amplified modulated carrier upon the devices in opposite sense and impressing the carrier from the resonant circuit upon the devices in the same sense. E. A. Tubbs, assigned to F. C. Talmadge. No. 2,040,221.

Amplifier Circuits, Etc.

Frequency range converter. Converting electrical oscillations of a primary range of frequencies into electrical oscillations of a secondary range of frequencies different from the first. The apparatus comprises two resonant circuits capable of resonating over different frequency ranges. Electrical oscillations are impressed upon one of the circuits whereby the effective resonant frequency of the other of the circuits is determined by the frequency of the oscillations in the first circuit. G. W. Walton, London, England. No. 2,041,036.

Carrier augmentation. Collecting side band modulated carrier energy, converting the energy to intermediate frequency energy, augmenting the amplitude of the carrier of the intermediate frequency energy with respect to its associated side bands, rejecting one of the side bands and subjecting the resulting energy to linear detection. W. S. Barden, RCA, No. 2,041,040.

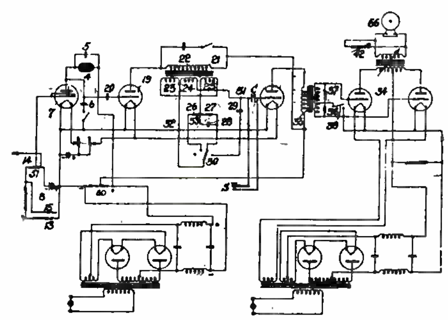
Detector circuit. A variable tube detector in an arrangement for automatic amplification control. J. K. Johnson, Hazeltine Corp. No. 2,041,291.

Band pass circuit. Patent No. 2,037,614 and No. 2,036,981 to R. A. Braden, RCA, and No. 2,040,426 to J. L. Bonanno, RCA, on a constant band width system. See also No. 2,043,774, W. v. B. Roberts, RCA.

Electron Tube Applications

Power control circuits. No. 2,037,-567, an electron discharge device control system. Charles Ehrensperger, Brown Boveri & Co. No. 2,036,286, a light control system, T. H. Long, WE&M Co. No. 2,036,708, Frank G. Logan, Ward Leonard Electric Co. No. 2,036,844, C. H. Willis, an electron tube commutator system. No. 2,036,264, a motor control system, A. D. Forbes, Westinghouse E&M Co. No. 2,039,044, an alternating current regulating circuit, E. R. Wolfert, Westinghouse E&M Co., and No. 2,039,043, illumination control system, W. F. Westendorp, G.E. Co.

Electrical musical instruments. No. 2,036,691 to V. Gourov, Russia, using gas-filled tube. No. 2,039,659 to R. H. Ranger, Newark, light sensitive cell system. No. 2,039,651, Nicholas Langer, Budapest, using glow discharge tubes, condensers, etc. No. 2,039,201, F. Trautwein, Berlin, comprising two generators, one producing damped and the other undamped waves. No. 2,036,892, Gilbert Smiley, Pratt Read & Co., consists of supplying through an amplifier an oscillation of audible frequency and



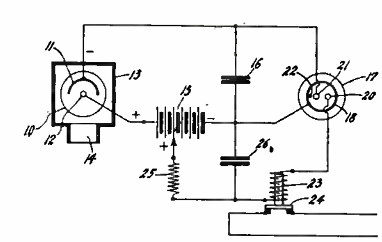
No. 2,036, 691

varying the grid operating potential to vary the harmonic content. No. 2,038,-996, John Hays Hammond, Jr., a device for reproducing with instrumental accompaniment a sonorous effect, comprising an instrument playing roll having phonographically recorded thereon a sonorous effect.

Motor signal system. Photoelectric control set-up. A. D. Miller, Fort Wayne, Ind. No. 2,039,604.

Oscillator. A circuit arrangement for preventing a composite tuned system from oscillating at the resonant frequency of one of the tuned circuits. N. P. Case, Hazeltine Corp. No. 2,036,-319.

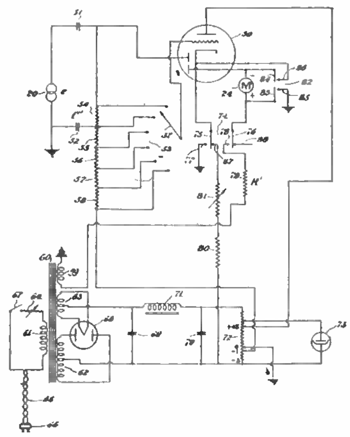
Radiation measurement. Means whose resistance varies with variation in intensity of radiations, a condenser charged from a source of electrical potential, a grid glow tube, etc., arranged



so that the rate of breakdown of the glow tube is a function of the radiation. H. C. Rentschler, Westinghouse Lamp Co. No. 2,037,925.

Photographic printing system. Use of a photo-electric system for controlling printing as a function of the quantity of light transmitted through a negative. J. A. Jameson, Canton, Ill. No. 2,038,430.

Electrical meter. A high resistance alternating current meter of vacuum tube type, comprising a duo-diode-



triode tube with rectifier power supply. A. W. Barber, Premier Crystal Laboratories, Inc., New York. No. 2,039,267.

Patent Suits

1,573,374 *(a)*, P. A. Chamberlain, Radio condenser; 1,707,617, 1,795,214, E. W. Kellogg, Sound reproducing apparatus; 1,894,197, Rice & Kellogg, same; 1,728,879, same Amplifying system, filed Mar. 23, 1936, D. C., N. D. Ill., E. Div., Doc. 15091, *Radio Corp. of America et al.* v. *B. Olshansky et al.*

1,573,374 *(b)*, P. A. Chamberlain, Radio condenser; 1,707,617, 1,795,214, E. W. Kellogg, Sound reproducing apparatus; 1,894,197, Rice & Kellogg, same, filed Mar. 23, 1936, D. C., N. D. Ill., E. Div., Doc. 15095, *Radio Corp. of America et al.* v. *A. Smith et al.*

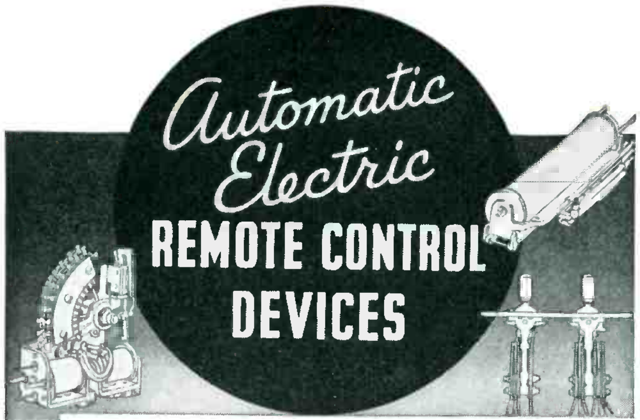
1,382,738, M. C. Latour, Amplifying apparatus, filed May 19, 1936, D. C., N. D. Ill., E. Div., Doc. 15207, *Latour Corp.* v. *Zenith Radio Corp.*

1,405,523, M. C. Latour, Audion or lamp relay or amplifying apparatus, filed May 19, 1936, D. C., N. D. Ill., E. Div., Doc. 15208, *Latour Corp.* v. *Zenith Radio Corp.*

1,251,377, A. W. Hull; 1,297,188, I. Langmuir; 1,573,374, P. A. Chamberlain; 1,728,879, Rice & Kellogg, D. C., S. D. Calif. (Los Angeles), Doc. E 462-M, *R. C. A. et al.* v. *H. C. Block (Custom Built Radio Mfg. Co.).* Decree pro confesso June 8, 1936.

Adverse Decisions in Interference

Pat. 1,763,380, C. E. Trube, Electric coupling system, decided May 18, 1936, claims 3, 4, 5, 6 and 8.



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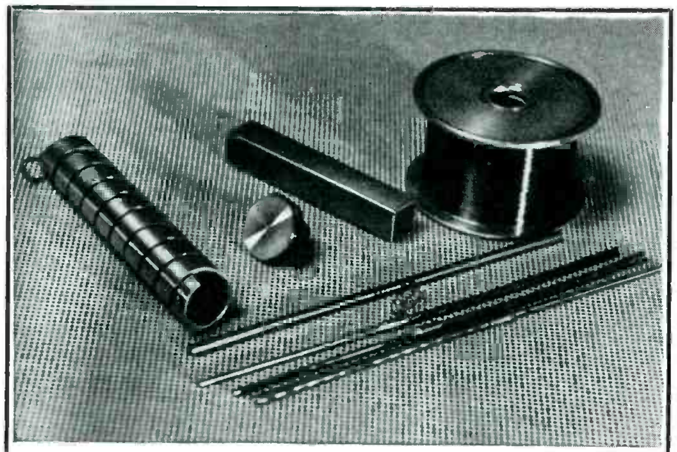

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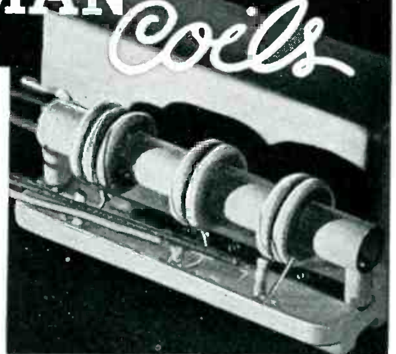

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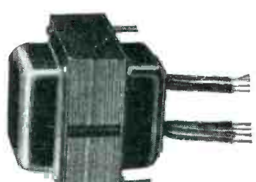

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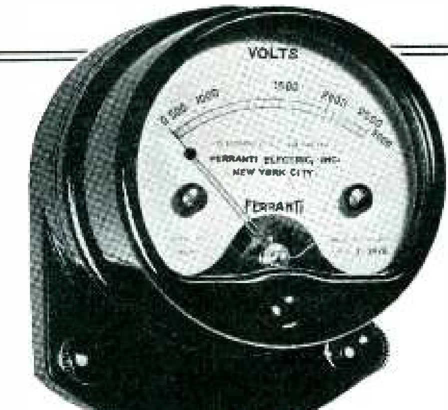

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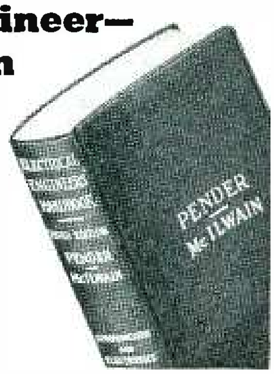

Electrical Engineers' Handbook

COMMUNICATION and ELECTRONICS

HAROLD PENDER, Ph.D.
Editor-in-Chief

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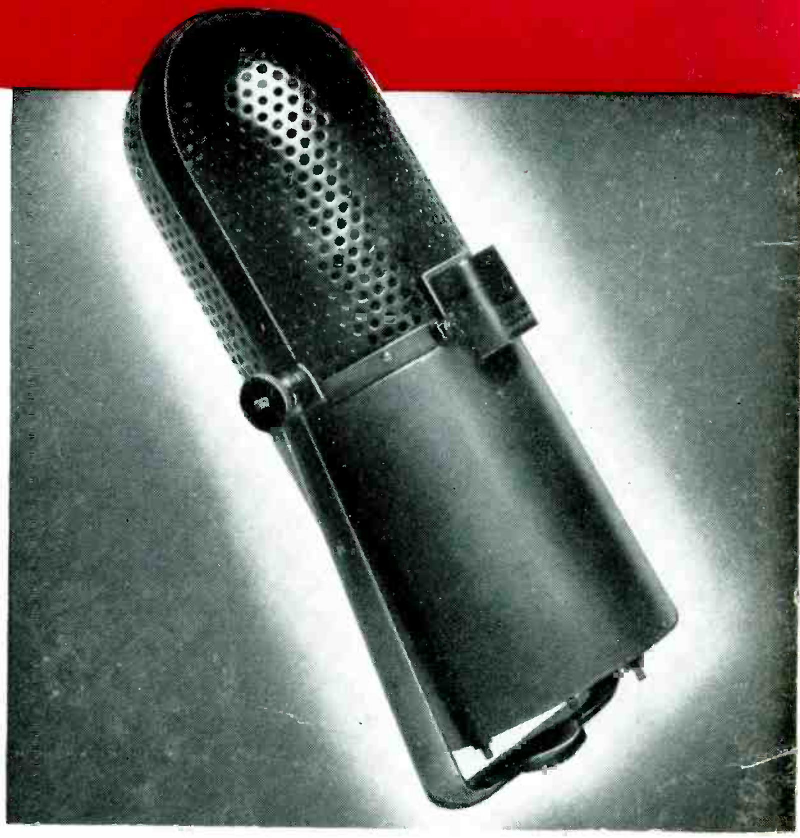

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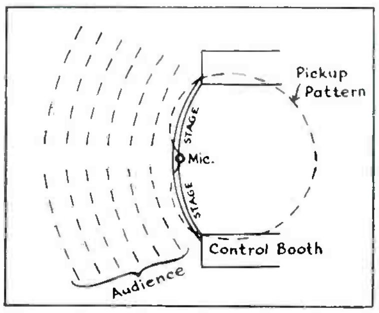

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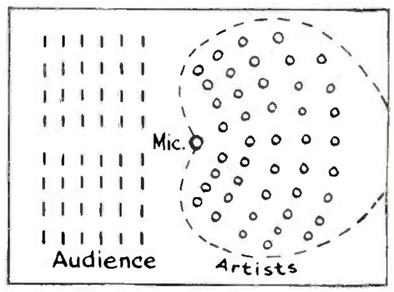

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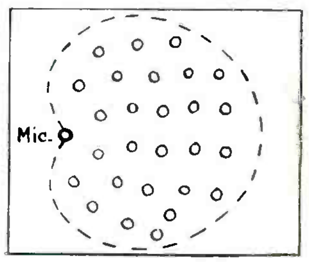

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