RADIO BROADCAST

JANUARY, 1929

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The contents of this magazine is indexed in *The Readers' Guide to Periodical Literature*, which is on file at all public libraries.

AMONG OTHER THINGS. . .

THE next—the February—issue of RADIO BROADCAST will appear figuratively in new clothes. A famous designer is at work on an attractive new cover which will make RADIO BROADCAST more easily recognizable when you try to pick it out of the mass of others on the newsstands. The text will be set in a type which is easier to read and which presents a more attractive appearance than the type we now use. For those who are interested in such things, the present type face is Cadmus and the new RADIO BROADCAST will be set in Bodoni. Bodoni is a decorative type also notable because it is "easy on the eyes." The contents is in for some improving at the same time and we shall ask you to await the February issue for a complete announcement of that.

TELEVISION occupies a good part of radio discussion these days and we want to be sure that our attitude on the subject is clear. "Television," unfortunately, means one thing to one man and something altogether different to the next. Television, like radio broadcasting, may be considered experimentally or in respect to its entertainment value—something the general public will find satisfactory. Television of entertainment value is certainly *not* here and is not in prospect for some little time. Articles in this magazine have outlined the difficulties to be overcome before "program television" can be attained. On the other hand, *experimental* television *is* here. What most people mean when they say the word now is merely experimental television. We do not intend to fill this magazine with articles on the subject when there isn't much to say, but we shall not fail to give those who are interested in experimenting with it as much useful information as we can. We certainly do not discourage experimenting, but in television it should be made perfectly clear that such it now is, and that on a limited scale.

NO NEW feature we have added to RADIO BROADCAST in the six years of its history has created anything like the favorable response that the special pages for the radio service man have produced. Many interesting manuscripts have been received and we hope that others who also have ideas which should be set down on paper and sent on for our consideration will become suddenly ambitious and send us their contributions.

THE present issue contains a wide selection of articles of interest: Boyd Phelps on "Unscrambling Television," Joseph Morgan on dynamic speakers, K. W. Jarvis on receiver performance, the Laboratory Staff on an a.c. operated tube tester, "The Service Man's Corner," Carl Dreher on "Sound Motion Pictures," and "Photographic Data for Broadcasters," Kruse on short-wave topics, the push-pull a.c. P. A. amplifier, are some of the most important. We are proud to offer these articles for they are all exclusive, interesting, and accurate to the last degree.

FEBRUARY RADIO BROADCAST will contain, among other things, an article by Dr. L. M. Hull on "Overall Measurements on Broadcast Receivers," a striking story by Boyd Phelps on how amateur television has been accomplished, a remarkable story by the Labaratory on the value of filtering in audio amplifiers, several valuable experimental articles on short-wave work and—a host of other features.

—WILLIS KINGSLEY WING.

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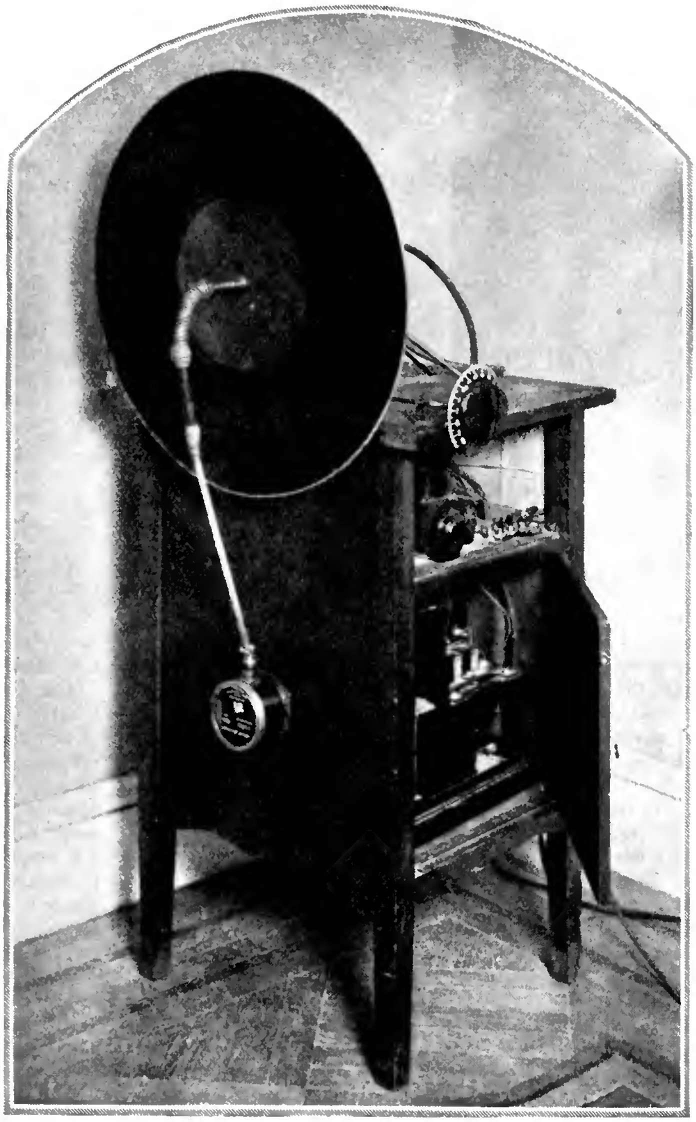
A Kite Antenna Used in Early Radio Experiments

This picture shows an unusual piece of radio apparatus which was used by Guglielmo Marconi during his trans-Atlantic radio tests in December 1901. The large kite which is held by G. S. Kemp, Marconi's first assistant, was employed to elevate the long receiving antenna which was used at Signal Hill, Newfoundland. The signals which were received during this experiment were sent from a station installed at Poldhu and was an event of the greatest historical importance.



PHELPS' EXPERIMENTAL TELEVISOR

Unscrambling Television

By BOYD PHELPS

RECENTLY the radio listener has heard many peculiar sounds from his loud speaker, and, if he plays around on short waves, he probably is familiar with an unusual noise which may be identified as a television signal. To the untrained ear these transmissions all sound alike—a terrible racket; to the experienced television experimenter the sounds often give a fair idea of the picture, even to permit recognizing the "sound" of faces of the immediate laboratory staff. For the somewhat less experienced, a little practice with the speaker and televisor operating simultaneously will enable him to pick out important characteristics of the signal, as, for example, an abrupt change in tone quality when the picture contains two figures, as two individuals side by side.

The experimenter who intercepts a television program of unknown origin has before him the intensely interesting problem of deciphering these signals and determining the number of scanning holes and the speed of the disc, for this may be obtained from laboratory tests. In this connection this article relates the author's experience in unscrambling mysterious television signals which were heard regularly on Long Island.

The lowest frequency in a television signal cannot be classed as a musical tone; it is a rapid series of thumps coming at the rate of 7½, 10, 15 or 20 times per second. This represents the number of complete pictures per second. A picture rate below 15 generally causes a noticeable flicker to the eye, like moving pictures projected at a slower speed than normal.

THE SCAN FREQUENCY

THE audio tone which seems to be the loudest single frequency in a complex television signal represents the scan frequency which is the mathematical product obtained by multiplying the number of holes or scan lines by the number of complete pictures per second. This product is usually 360, 450, 480 or 720 cycles per second, or intermediate values. This pitch seems especially loud because it is in a sensitive range of the ordinary amplifier and speaker, and because it is pure, regular and continuous. It corresponds to a musical note near the middle of the piano key-board somewhat above middle C.

In television amplifiers, contrary to speech and music amplifiers, all audio tones below the scan frequency can be eliminated in many cases and quite good quality will remain. This feature is useful if a B-power unit is used to supply plate power for the amplifier, as a scarcely noticeable power-frequency hum in the speaker manifests itself on the picture as light and dark bands. When a power frequency of 60 cycles is used, four light bands appear if the disc is running 900 r.p.m. (15 pictures per second) and eight bands appear if 450 r.p.m. (7½ pictures per second) is the disc speed, for example, with 3XK and WRNY, respectively. If these bands creep slowly up or down while the picture is held correctly framed it is an indication that synchronizing by the direct mounting of the disc on a synchronous motor would not be feasible, as was discussed in last month's article by the writer. Therefore, if the amplifier has a sharp low-frequency cut-off above 120 cycles, the interference caused by the a.c. hum is eliminated. The only exception to this statement would be a case where the a.c. modulation varies the overall efficiency of the amplifier, for if the desired signal frequencies are choked off 60 times per second a high-pass filter will not help this. An example would be low-current filaments operated on a.c. much below their correct temperature where the emission varies rapidly with small changes in filament voltage. But a good amplifier underloaded should amplify weak or strong signals proportionately, whereas stray a.c. hum picked up in any stage, if passed to the next tube at high loss, does not assume great magnitude or appreciable nuisance in the television amplifier considered above. The writer has recently thrown together a three-stage transformer-coupled amplifier in which practically all the iron in the cores has been removed and the flat section of the curve moved up considerably, which seems promising although curves have not been run as yet.

We now come to the complex picture frequencies of a television signal which are the result of the detail of the image. If the picture were divided vertically into one light and one dark section we know the frequency would be 720 cycles in the case of the better forms of common television, therefore, it does not take much imagination to appreciate the fact that the details of a face—eyes, nose, moustache, etc.—may produce frequencies that will run well into the thousands of cycles For example, impulses crosswise of the picture, equivalent to the none-too-good detail represented by 48 vertical lines, at speed near the flicker point would be represented by a frequency of 48 x 48 x 15 which works out to be 34,560. Although decently recognizable faces can be produced without such high frequencies, the change from light to dark at the sharp contrast points, as the pupils of the eyes or edge of coat sleeve, is quite a ways from instantaneous, and in the received image the shaded gray area at these points may be several scan holes in width, although the photo-electric cell at the transmitter may be making its maximum change in a one-hole width of the picture. But, in photography, portraits usually have their sharp harshness removed by an intentional diffusion. Television limited to frequencies below 5000 cycles is, in the writer's opinion, far from hopeless. It is far easier to ruin a picture with improper adjustments of the amplifiers at the transmitter or receiver.

THE PROBLEM

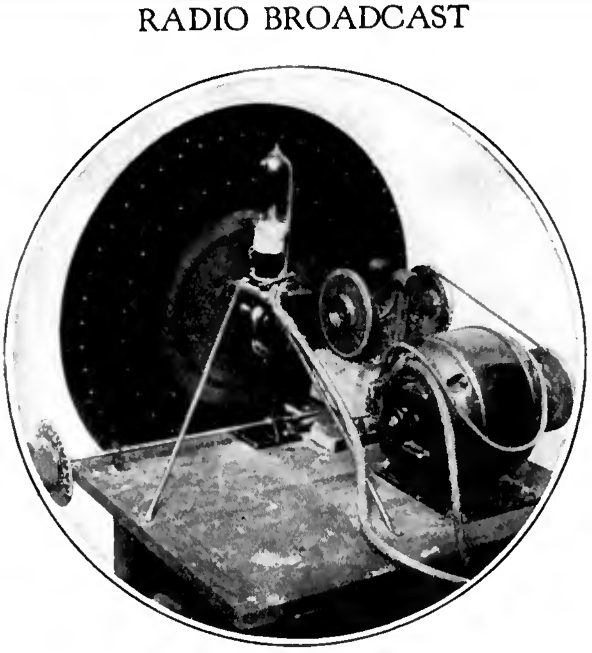
NOW we come to the problem of figuring out what kind of a disc the transmitting station is using by listening to it, and the writer has had some experiences along this line that may be of interest to recount. This form of "radio sleuthing" originated early in March, 1928, when an attempt was made to unscramble the signals sent by the Baird Laboratories in London to the *Berengaria* in mid-Atlantic. The details of this adventure were in the newspapers at the time and included such features as banging the characteristic notes on a piano and sending them over a telephone line to a piano tuner who was called out of bed to sound his tuning forks on the other end of the line to determine the absolute scan frequency. W2BUO, who assisted in this escapade, procured a fairly flat square brass disc of power-house flywheel proportions. In the haste to get the apparatus operating before the next nightly schedule, the corners were not even cut off. No further signals were transmitted, however, so it was never learned how accurately the number of holes and revolutions were calculated. A phonograph record was made of the signals as it is possible to preserve moving pictures this way.

Recently a near-by station was secretly sending short television schedules that have been shrouded in a similar deep mystery. Trial on all discs and speeds produced nothing intelligible, yet the sounds apparently were genuine and had the characteristic variations of a person moving around or the scene shifting. The characteristic scan frequency was quickly found to be B above middle C on the piano, which, according to international pitch scale, would be 488 cycles. The pitch of the piano in question is according to standards that pianos assume that have not been tuned since radio became popular—usually lower. However WRNY "tuned in" on G above middle C and their scan frequency is close to 360 cycles. (The keys now look like a log of Who's Who in Television.) Dust was blown off the old college physics book and the ratio of the two notes was found to be 4 to 5. The two musical notes on the piano still being good chords, both having lowered the same amount, the ratio was applied and a scan frequency of 450 determined.

Now, as the scan frequency is the product of the number of holes and the speed of rotation per second, and neither of these factors were known, the problem was still quite a way from complete solution. Some slide-rule computations reduced the unlimited possibilities to the following probabilities: 60 holes at $7\frac{1}{2}$ r. p. s., 50 holes at 9 r. p. s., 45 holes at 10 r. p. s. or 30 holes at 15 r. p. s. Any of these cases would give the characteristic 450-cycle scan-frequency note. It was assumed that even speeds were used with no "fractional" holes or trick arrangement of holes.

A NOVEL FREQUENCY COUNTER

THE next step was to measure the picture frequency which is strong in cases where an unmodulated series of scan lines exist, as for example, the margin above the head of an individual being scanned, or other irregularities appearing once in each complete picture. In the case of the unknown signals in question they were too fast to count—one can count to almost 12 in a second—so a device was invented for the purpose. The device consisted of a hand drill, a saucer and a bent nail. The gear ratio of the hand drill was such that the bent nail in the chuck made four taps on the saucer for every turn of the handle. The handle was turned at such speed as to have the taps on the saucer in step with the picture frequency, and the counting of the handle turns was easy. Thus, in a ten-second run a count of handle turns of $22\frac{1}{2}$, 25 or $37\frac{1}{2}$ would establish whether the picture frequency was 9, 10 or 15 per second or if not it would probably be a near-by value.



REAR VIEW OF TELEVISOR

ONE of the most ingenious experimenters in radio to-day is Boyd Phelps. His work represents in our mind a proper example of genuine "amateur" experimenting. This article, describing experiments in sorting out television signals in which every factor but transmission frequency was unknown, will be found worthy of the reader's attention—not only because the work represents an extraordinarily ingenious procedure but because it indicates very definitely the difficulties of achieving results of any account at all in television experimenting.

—THE EDITOR.

The second time the signals were heard this was tried and every trial turned out very close to $37\frac{1}{2}$ so it was a safe enough assumption that the transmitter was using 30 holes in a disc running 15 r. p. s. (900 r. p. m.) A vibrating reed was used, and a variable-speed 48-hole disc produced stationary specs of the image at 15 r. p. s.; all checked the bent nail observation closely.

Much has been written concerning the design of television discs so only the final data will be given here. A spiral inside an existing 48-hole spiral was laid out. In a 30-hole disc a maximum radius of slightly over 7" gives an image $1\frac{1}{2}$" wide at the top. A picture height of $1\frac{1}{2}$" was convenient as this gave exactly 20 scan lines per inch. These scan lines, while 0.05" wide in theory, were made with a round drill of larger size calculated on circle overlap such that inscribed squares would be edge to edge. The sides of the theoretical square being 0.05", the diagonal (also circle diameter) figured 0.0706" and the nearest drill size was No. 50 having a diameter of 0.0700."

THE RESULTS

IT WAS the morning of the third day when the disc was tried out and the interesting pictures watched with a thrill of one eavesdropping in on something unusual—like watching the antics of a comedian practicing in supposed solitude. This key-holing being absolutely a one-way affair added to the charm, due to security from detection. The question now arises, if I describe what I saw would I be violating my oath of secrecy sworn to on the back of my operator's license and the law not to divulge or publish the contents of any message not addressed to me or which I am not the authorized agent to forward? It was quite obviously not broadcast for public consumption, has had no advertising or publicity, and was preceded by a weak announcement, "Station 2x? conducting a test." The days of only a code operator being able to receive and divulge a radio message are over. Perhaps the oath of secrecy should be administered to the whole public and thereafter to all infants within 90 days of birth.

The pictures on these pages show the apparatus used in the experiments described in this article. The front view of the televisor reveals that the container was once a phonograph cabinet—pioneering now in television as it did in broadcasting at 9 ZT, when the writer sent its music to Minneapolis amateurs in 1921. Below the speed-control knob and shaft may be seen the bias resistor for the power tube. This resistor, which is common to the plate supply and the grid returns, is employed to regulate the brilliancy of the picture on the neon tube which is connected directly in series with the plate circuit of the 210-type power tube. The double-throw switch behind the bias resistor makes possible a change from ear to eye "entertainment."

An interesting feature of the televisor is the flivver speedometer which is mounted on the front panel. This instrument, having been taken apart and calibrated in r. p. m., is employed as a tachometer.

The second picture shows the mechanical arrangement of the scanning disc assembly. A synchronous motor providing uniform speed is belt connected to a countershaft having friction drive to the back face of the scanning disc. The knob to the left turns a threaded brass rod that moves the countershaft assembly radially to frame accurately the picture and compensate differences in scanning speeds of various transmitters. The pulleys have additional small flanges (not shown) which quickly take a shorter belt for slower speeds. The neon tube is shown opposite the 30-hole spiral described in this article, but it can be raised easily to the level of the 48-hole spiral. Many methods of speed control have been tried but this system has provided the best results.

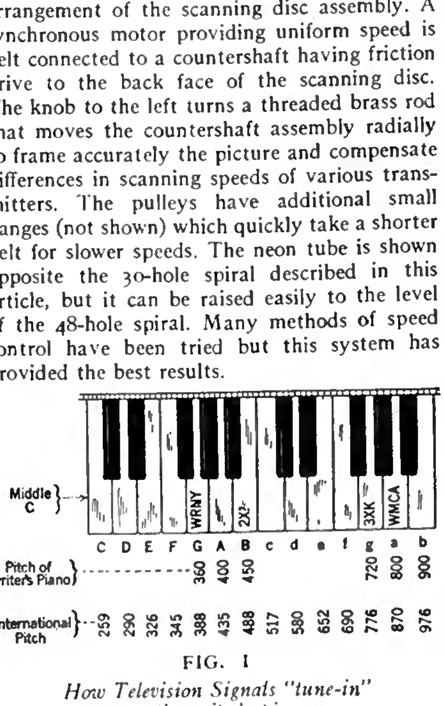
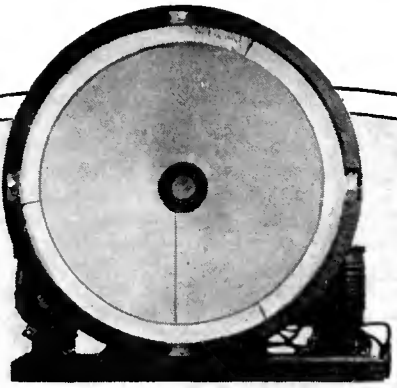
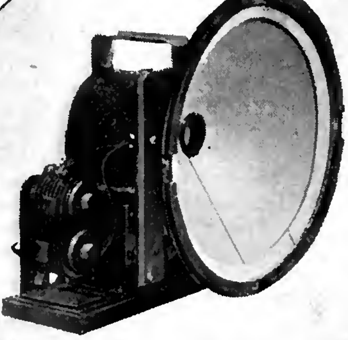
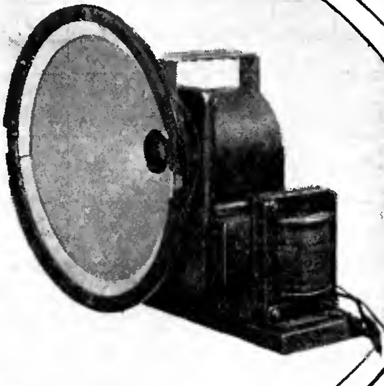


FIG. 1

How Television Signals "tune-in" on the writer's piano







All about the DYNAMIC *Loud Speaker*

By JOSEPH MORGAN

International Resestance Company

MANY months ago, in "Strays from the Laboratory," we predicted that the "dynamic" loud speaker would probably be predominant in the radio field during this season. That prediction has been amply borne out. Subsequent comment in "Strays" has compared the performance of these reproducers with other types and presented some information on their operation. This article, written by Joseph Morgan, an engineer in whom we have the highest confidence, does answer practically all of the questions which arise. A careful reading will enable those who are using this type of reproducer to make it better serve their needs and will clarify the minds of those who now feel they are pretty cloudy on the whole subject.

—THE EDITOR.

IT IS the purpose of this article to set forth clearly, simply, and without prejudice, the application, performance, method of use, advantages, and disadvantages of the modern dynamic loud speaker.

The arrival of a new and successful device upon the market is always attended by exaggerated claims and general misinformation as to its use and operation. This is not so much due to the desire of the manufacturer to further the sale of his product, as to the misguided enthusiasm of the radio fan. That such a condition should exist is deplorable, since the new device is often improperly employed and its good characteristics are discredited.

No new instrument is a panacea. Perfect design in a vacuum tube cannot compensate a defective rheostat. A perfect loud speaker cannot even slightly ignore the defects of an overloaded amplifier. In fact, the reverse is more nearly true—a poor loud speaker can, to a remarkable extent, overcome such defects!

Before considering the dynamic speaker in detail, the reader should have a knowledge of the general problems of loud speaker application and design, as well as the specific principle upon which the dynamic type is based. For this purpose the reader is referred to the article by the present writer, titled "All About Loud Speakers" which appeared in the August, 1928, RADIO BROADCAST.

The three most important properties to be considered in the discussion of the technical merits of a loud speaker are:

(1) The frequency-response characteristic
(2) The efficiency
(3) The load capacity

We will consider first the frequency-response characteristic. The dynamic type of loud speaker, using a free-edge paper cone, is essentially what is called an "inertia-controlled diaphragm" loud speaker. This means that throughout the important frequency range the electrical driving force is expended in accelerating the mass of the diaphragm. In other words, the moving structure, which consists of the voice coil and the sound-radiating paper cone, acts as a solid piston. If it were true that the dynamic loud speaker behaved solely in this manner throughout the entire audio-frequency range, the frequency-response curve would be very nearly a straight line with the response gradually falling off at the higher frequencies. However, there are a number of secondary factors which must be considered in the determination of the response of such a loud speaker.

We shall consider first the mechanical factors. Due to the fact that the moving coil must be supported more or less rigidly with respect to its concentric position in the air-gap of the magnetic field, two or more thin flat metal restraining springs are used, both to maintain the centering of the moving coil and to act as conductors of current to this coil. Further, the base of the cone is fastened to the metal supporting ring by means of a flexible annular ring or washer usually made of leather. These springs together with the leather ring, hold the moving structure quite rigidly with respect to radial movement, but permit very free axial motion.

The combination of paper cone, moving coil, and metal springs has its own natural frequency of vibration. Advantage is taken of this natural frequency to obtain a large response at the low-frequency end of the scale, where much energy is required to produce sufficiently intense sounds, due, in part, to the fact that much of the associated apparatus, such as amplifiers, have inadequate low-frequency characteristics. This natural frequency usually occurs somewhere between 20 and 70 cycles per second and varies not only with the make of the loud speaker but also from one loud speaker to another of the same make. In one well-known make of dynamic loud speaker tested by the writer, the resonant frequency in six loud speakers chosen at random varied from 40 to 65 cycles per second. If the resonant frequency were kept within the range mentioned it would have practically no influence upon the response of the loud speaker above 100 cycles per second.

THE CHANGE AT 3000 CYCLES

AT ABOUT 3000 cycles per second, the moving structure ceases to act as a solid piston and begins to behave as a conical diaphragm with a fixed outer edge. In that part of the sound spectrum in which the transition takes place from free-edge to fixed-edge action, large irregularities in response are likely to occur, and in the band of frequencies in the fixed-edge region the response is, in general, greater than in the free-edge region. This is due in part to the conical

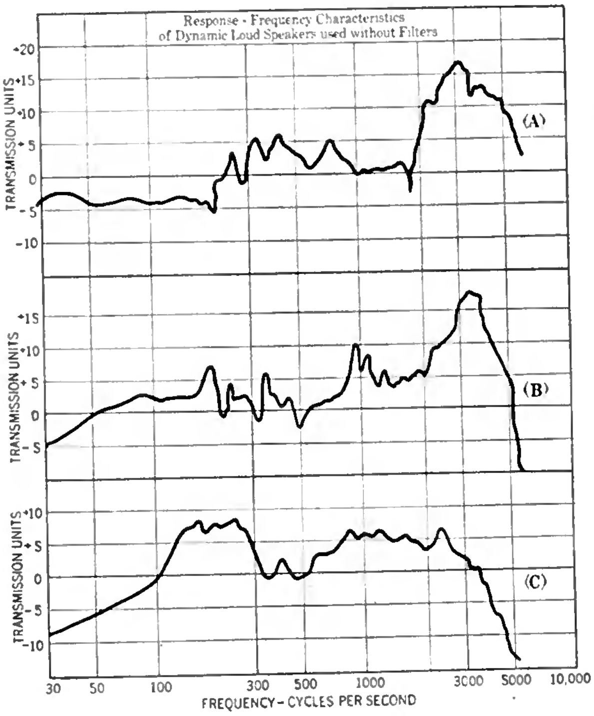


FIG. 1

shape of the diaphragm which acts as a horn for these higher frequencies.

The conical shape is chosen because it gives a maximum of rigidity with a minimum of weight. The angle of the cone varies in different instruments from approximately 75 degrees to 150 degrees. The maximum rigidity is obtained with a 90-degree angle at the apex. If the angle is increased beyond 90 degrees, less rigidity is obtained but a somewhat better frequency-response characteristic results. It is a difficult problem to obtain the best compromise.

The material and tension of the annular supports are very important. The ring must be stiff enough to hold the outer edge of the cone concentrically and to prevent the edge of the cone from whipping. At the same time it must not interfere with free axial motion.

The cone itself is usually made of stiff paper to obtain maximum strength with minimum weight. The paper must be carefully chosen so that it will not alter in texture, shape, or size with changes in atmospheric conditions such as temperature and humidity. In some makes of loud speakers, corrugated cones are used. It is claimed by some manufacturers of these loud speakers that a more even frequency-response characteristic results. However, after a number of tests, the writer has been unable to verify this statement.

A very important factor which influences the frequency characteristic of any loud speaker is the impedance of the voice coil. It is important to know the value of this impedance, its alteration with change in voice frequency, and the relative values of its resistance and reactance components. The ideal loud speaker would have a constant impedance of pure resistance. This ideal, while not realized in practice, is more closely approached in the dynamic type of loud speaker than in any other. The impedance increases with the higher frequencies, thus reducing the electrical input at these frequencies. Individual makes utilize voice coils having from one to as many as several thousand turns. In American practice the impedance of the moving coil, which usually is wound with 100 to 200 turns of fine wire, is of the order of magnitude of 10 ohms in the lower frequency range. There is on the market at least one loud speaker with a voice coil consisting of a single turn of thin copper ribbon, having an impedance of less than 0.001 ohm.

TRANSFORMER NEEDED

The very low impedance of these voice coils necessitates the use of a step-down transformer to feed into the voice coil, in order that the ratio of last-stage plate-circuit impedance to voice coil impedance shall be maintained at the proper value, usually 1:2. These transformers are usually built right into the loud-speaker housing, although there are obtainable on the market to-day specially constructed transformers to be used in place of those built into the loud speaker [See table on page 194 of this issue.—*Editor*]. Under certain conditions more efficient results can be obtained by the use of these special transformers.

In the case of the dynamic loud speaker, the method of mounting is very important, with respect to the reproduction of the lower frequencies. An entirely unmounted dynamic loud speaker radiates very little energy below 300 or 400 cycles. Therefore, in order to take advantage of the excellent low-frequency characteristic of this device, it is necessary to mount the loud speaker either in a suitable cabinet or baffleboard. If it is desired to reproduce frequencies down to about 100 cycles per second, the speaker may be mounted in a small inclosed cabinet with vent holes at the back. Sometimes annoying resonances are set up in these cabinets which cause the loud speaker to chatter at certain frequencies. Proper arrangement of the vent holes together with sound-absorbing padding inside of the cabinet will usually correct this trouble. However, if full advantage is to be taken of the low-frequency characteristic of the loud speaker it should be mounted in a large baffleboard or in a wall. In order successfully to radiate low tones, the distance from the front edge of the cone to the back edge by the shortest mechanical path through the air around the baffle should be at least one quarter the wavelength of the lowest note to be reproduced; 32 inches for 100 cycles, 110 inches for 30 cycles. An ideal method of mounting this type of loud speaker is to set it in a large wall above the level of the listener's head. Such a wall is in effect, an infinite baffle and will permit the speaker to radiate the lowest tones which it is capable of generating.

The tendency towards excessive response in the frequency range from 3000 to 5000 cycles has been mentioned before. In the reception of radio signals where the side bands are somewhat suppressed, due to too great selectivity, this excess actually improves the overall reproduction but in those cases in which there is no such cutting of the side bands, it is necessary for the best results to find some means of attenuating this excess high-frequency response.

For this purpose some manufacturers employ an equalizer-filter which tends to suppress this excessive response. This filter is usually connected across the input of the tube-to-coil transformer. They are called "band-suppression filters." In Fig. 1 are shown the frequency-response curves of three typical dynamic loud speakers without filters, designated as A, B, and

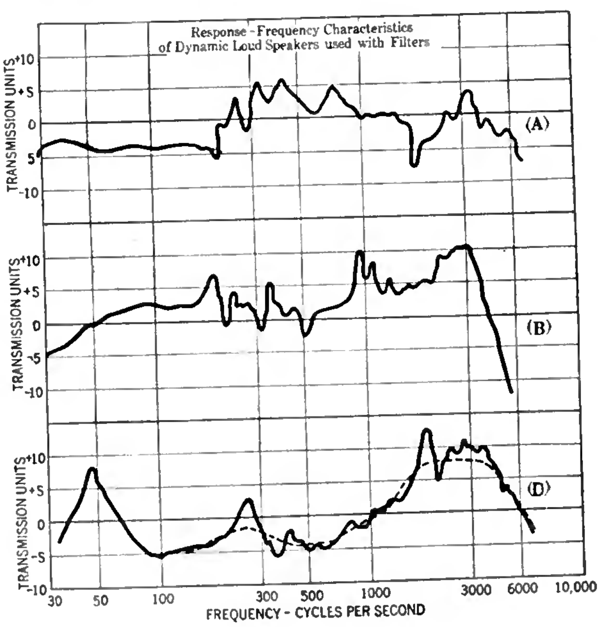


FIG. 2

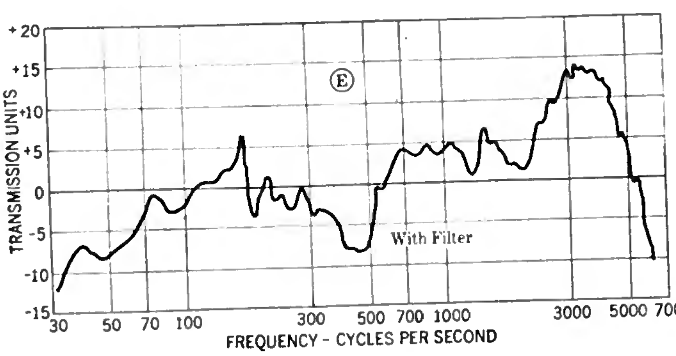


FIG. 3

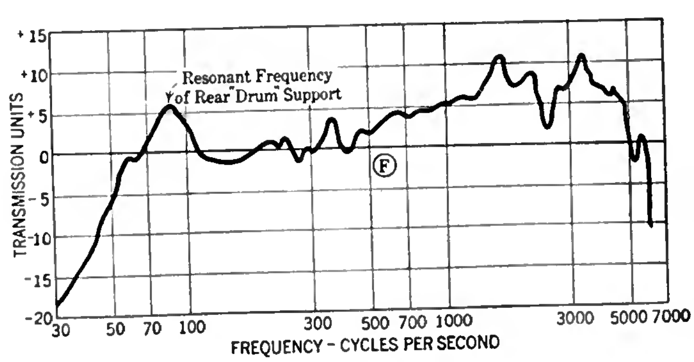


FIG. 4

C. It will be noted that A and B have markedly increased response at the higher frequencies, while C has not. In Fig. 2 are shown these same loud speakers, A and B, when the filters are used. The response of a fourth loud speaker, D, is also given. The frequency-response characteristics of two other dynamic loud speakers are shown in Figs. 3 and 4.

[In analyzing these response curves the many small irregularities can be neglected, since, in general, they will not be audible to the ear. A good idea of what we might term the "average" response curve of the loud speaker can be obtained by drawing a smooth curve as we have indicated in dotted lines on curve D of Fig. 2. Note that the curves are plotted in TU. With pure single-frequency tones the minimum change in response audible to the average ear is 2 TU, but

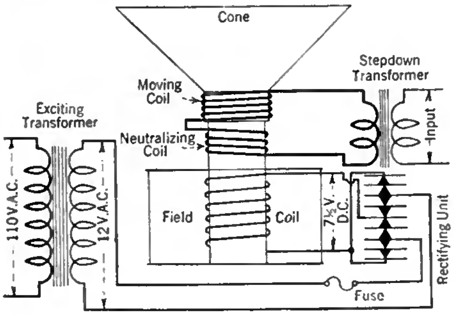


FIG. 5
Circuit of A.C. *Dynamic loud speaker*

when the tones are complexed as they are in speech or music a variation of 3 TU will not generally be audible to the untrained ear.—*Editor.*]

EFFICIENCY

THE second item to be considered is the question of efficiency. By efficiency is meant the ratio of the output power in sound to the input electrical power. It is well known that the efficiency of the average loud speaker is very low. In the better makes of horn and fixed-edge cone loud speakers, the efficiency rarely exceeds 1 per cent. In other words, 99 per cent. of the electrical output power of the amplifier is thrown away and only 1 per cent. converted into useful sound energy. In a good dynamic loud speaker, the efficiency is somewhat greater, and may be as high as 4 or 5 per cent. [In other words, for a given electrical input a good dynamic will turn out four or five times as much sound power as an ordinary cone, or conversely with about one-fifth the input the same output can be obtained from a good dynamic as from a cone.—*Editor.*] It is very important to have high efficiency since the higher the efficiency, the smaller the amplifier and associated apparatus necessary to produce a given volume of sound without distortion. In considering the efficiency of a dynamic loud speaker it is usual to neglect the power required to excite the electro-magnet, since this energy is readily obtained without the use of elaborate or expensive apparatus.

In order to obtain high efficiency it is first necessary to have a strong magnetic field. This is obtained by using large electro-magnets wound with many turns of wire. The limits to the intensity of the field which may be produced are the allowable heat developed in the field winding, the saturation of the magnetic circuit and the size of the air-gap across which this field must exist. There are three ways in common practice of exciting these fields. Choice among them is largely a matter of convenience, the final result being very much the same with all methods. The most common method employs a 6- to 12-volt storage battery for the excitation of the field. The second method utilizes the field as a choke coil in the filter system of the high-voltage d.c. power-supply device. This method is very economical since the energy dissipated in the field would otherwise go to waste. The third method, which is becoming more common, employs a transformer and rectifier so that 110 volts a.c. may be used as a source of field supply. The line voltage is stepped down by means of the transformer and is then rectified in order to give a pulsating direct current for the field. In some makes of loud speaker a compensating coil is used to reduce the hum which would otherwise result from this pulsating field current. If, however, the field magnets are thoroughly saturated, the hum may not be sufficient to cause trouble.

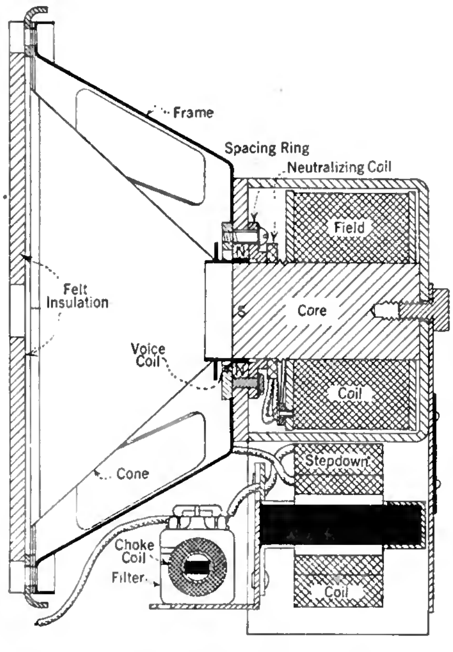


FIG. 6
Construction detail of a standard Dynamic loud speaker

In order to maintain a high field strength it is necessary to have as small an air-gap as possible. Since the voice coil moves *along,* rather than *across* the air-gap, it is necessary to have only sufficient space for clearance between the coil and the iron. This clearance is made as small as possible consistent with the free motion of the coil along the gap. Its value is usually about 0.005 inch.

Needless to say, the lighter the weight of the entire moving structure, the greater will be the efficiency of the loud speaker, since it is desirable to use as much of the electrical energy as possible to accelerate the air in front of the cone and as little as possible to accelerate the mass of the moving structure itself. The spring suspension

Mechanical and Electrical Data for Dynamic Speakers

NAME	CONE			VOICE COIL			TRANSFORMERS			MAGNETIC FIELD		
	Diameter	Thickness	Angle	Impedance	No. of Turns	Wire Size	Ratio	Primary	Secondary	Volts	Watts	Flux Density
A_1	8″	0.008″	90°	5.95 ohms at 100∼	105		$\frac{35}{1}$			6 d.c.	2.4	12000 lines/sq. cm.
A_2	8″	0.008″	90°	5.95 ohms at 100∼	105		$\frac{35}{1}$			110 d.c.	3.5	12000 lines/sq. cm.
A_3	8″	0.008″	90°	5.95 ohms at 100∼	105		$\frac{35}{1}$			110 a.c.	4.2	12000 lines/sq. cm.
B_1	6½″	0.008″	90°	6.4 ohms at 100∼ 6.7 ohms at 500∼ 26 ohms at 5000∼	100	33	$\frac{33}{1}$	4000 No. 35	120 No. 19	6–12 d.c.	3.9–15.6	
B_2	6½″	0.008″	90°	6.4 ohms at 100∼ 6.7 ohms at 500∼ 26 ohms at 5000∼	100	33	$\frac{33}{1}$	4000 No. 35	120 No. 19	100 to 200 d.c.	4–8	
C	9″		135°	less than 0.001 ohm	1		$\frac{4500}{1}$	4500	1	110 a.c.	10	14000 lines/sq. cm.
D_1	8″			13.5 ohms at 100∼	140	34	$\frac{20}{1}$	3600	180	6 d.c.	5.5	
D_2	8″			13.5 ohms at 100∼	140	34	$\frac{20}{1}$	3600	180	90 d.c.	4.2	
G	6½		110°	0.5 ohms at 100∼	29		$\frac{56}{1}$			6 d.c.	6	10,000 lines/sq. cm.

Note: Loud speakers A_1, A_2, and A_3, have characteristics which correspond to curves A of Figs. 1 and 2. The only difference between loud speakers identified by the same letter is in the design of the field winding.—THE EDITOR.

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previously referred to must be made light and flexible so as to expend a minimum of energy in the flexure of these springs.

The ohmic resistance of the voice coil should be kept low in order to reduce the heat loss in the copper to a minimum, for a given voice-coil current.

LOAD CAPACITY

THE third item is the load capacity of the loud speaker. This is limited by several factors. First, the tendency of the paper cone to buckle and rattle at the higher frequencies if too much energy is supplied to the speaker. Second, the tendency of the loud speaker to be thrown into violent motion at its low resonant-frequency point. The third limitation is that due to what is called "non-linear distortion." This means the introduction of frequencies into the sound radiated which were not present in the electrical input to the loud speaker. This may be due to a number of causes and this type of distortion distinctly limits the load capacity of the speaker, since such distortion increases greatly with the quantity of sound energy radiated. The major cause of this distortion is due to the inequality between the propelling and restraining forces acting on the moving structure. A well-constructed dynamic loud speaker, however, is capable of fairly large sound output without such distortion becoming apparent to the ear, and the writer has found that with most of the dynamic loud speakers on the market, the sound output capacity is limited by paper and spring rattles at the higher frequencies. The fourth limitation, which is seldom reached in the ordinary dynamic loud speaker, is that of the production of heat in the moving coil. In other words, if all three of the previous capacity limiting factors were absent, the capacity of the loud speaker would still be limited by the amount of heat which can be safely radiated from the voice coil.

In order to obtain a maximum of energy in a minimum of space with the greatest allowable temperature rise, one manufacturer uses a single-turn voice coil which permits a very small ratio of insulation to conductor thereby increasing the capacity of the loud speaker.

It will be seen from the above description that the design, construction, and application of the dynamic loud speaker is a problem involving many factors, consequently a great variation in the products of different manufacturers is to be expected. The writer has found this to be true, and has examined some which were excellent, some which were fair, and some which were very poor. It is not sufficient to have a good theoretical principle. The design, construction, and application based upon this principle determine the quality of the actual product.

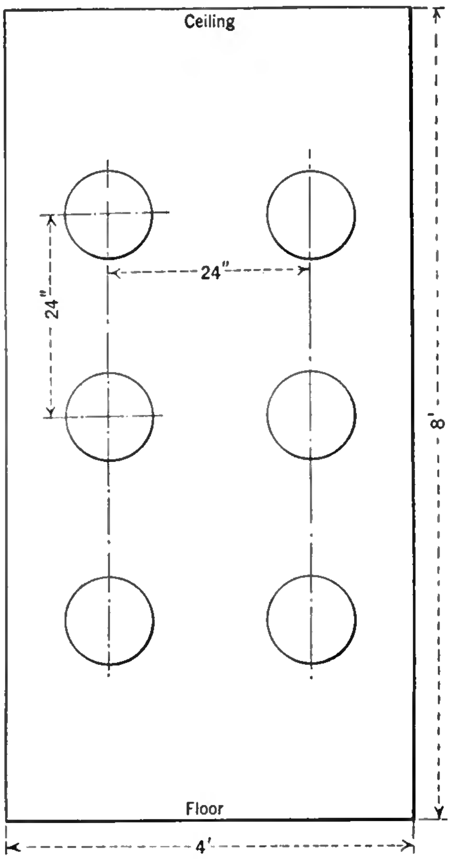

FIG. 7
Method of mounting six dynamic units on a large baffle

Many of the manufacturers issue complete specifications together with frequency-response curves, and much can be learned from these data. The reader is warned against believing that a loud speaker must be good because it is a dynamic loud speaker. It is also important to remind him that a loud speaker cannot be judged unless it is used in the proper manner, and with adequate associated apparatus. The larger the capacity of the amplifier, up to a reasonable limit, which feeds the loud speaker, the better will be the quality of the reproduction with a good loud speaker. If it is possible to use a well-designed amplifier with two 250-type tubes in push-pull in the last stage, an excellent result may be obtained. It is undoubtedly true that a sacrifice will be made if a smaller output is employed. This is particularly undesirable for the production of low tones which are so necessary for natural reproduction of speech and music.

MULTIPLE LOUD SPEAKERS

WHERE feasible, splendid results may be obtained by using two or more dynamic loud speakers in the same baffleboard. In one such design, built by the writer, six dynamic loud speakers of well-known make were placed in a single baffleboard as shown dimensionally in Fig. 7. These six loud speakers had their voice coils connected in series and were supplied by a special Amertran transformer feeding from two 250-type tubes in push-pull. At least four worth-while advantages are obtained by the use of multiple loud speakers. First, the inequalities of the individual frequency-response curves are smoothed out. Second, for a given sound energy radiated, each loud speaker supplies less load and therefore distorts less. Third, the sound comes from a large area instead of from a small one. This last factor greatly improves the naturalness and the sense of three dimensionality. Fourth, the radiation of the low-frequency and the high-frequency tones are markedly improved and a better tonal balance is obtained.

Book Reviews

PRACTICAL RADIO. By James A. Moyer and John F. Wostrel, Third Edition, 1928, McGraw-Hill Book Co., New York, 378 pages, $2.50.

James A. Moyer, S. B., A. M., one of the authors of *Practical Radio*, bears after his name on the title page the following list of affiliations: *Director of University Extension, Massachusetts Department of Education, Fellow of the American Association for the Advancement of Science; Fellow of the Royal Society of Arts; Mitglied des Vereines Deutscher Ingenieure; Membre Titulaire Association Internationale du Froid; Member of the Franklin Institute; American Society of Mechanical Engineers; Society of Automotive Engineers; Institute of Electrical Engineers, etc.*

Nevertheless, the book is not without merit. *Practical Radio* was first issued in 1924 and has been kept abreast of developments in subsequent editions. It is one of those non-mathematical, copiously illustrated and charted expositions written for experimenters, service men, boy scientists in the more advanced grades, and other fauna produced in quantities by the spread of broadcasting. All the emphasis, as one would expect, is on broadcast technology, especially in reception. This bias the authors reveal on page 2 with the bald statement: "The most important use of radio is for broadcasting the human voice." I certainly do not wish Messrs. Moyer and Wostrel any hard luck, but if they are ever on a vessel which catches fire 1000 miles from land I shall seize the opportunity to debate this opinion with them at greater length.

After a preliminary discussion on "What is Radio?" the book contains chapters on antennas, "radio electricity," crystal receiving sets and telephone receivers, vacuum-tube receivers, power sources for tubes, audio- and radio-frequency amplification, the selection, operation, and care of receiving apparatus (Chapter X), and radio transmission by telegraph and telephone. The inclusion of material is often haphazard; in Chapter X, for example, there is a discussion of the vagaries of distribution of field strength in cities, fading, etc. Following Chapter XII, on construction and testing of receiving instruments, the trend of the discussions is highly practical; the reader is told about machinists' drill gauges, panel templets, the testing of neutrodynes, and the characteristics of various types of battery eliminators. Chapter XV is devoted to "Common Troubles and their Remedies."

Clarity is a prime requisite in books of this type and *Practical Radio* succeeds in explaining lucidly, to the degree required by semi-technical readers, the numerous points which the development of broadcasting has raised. There are some loose statements, as when we are told, on page 51, that "The operation of the vacuum tube as used in radio sets was discovered by Edison," without any mention of Fleming and de Forest, and on page 195 where it is categorically set forth that in the Heising system of modulation "the two vacuum tubes (oscillator and modulator) should be the same type and as nearly electrically identical as possible." On the contrary, the modulator should be larger and of lower impedance. In practice this is accomplished by using a higher-powered tube as the modulator, or paralleling a number of tubes of the type used for the oscillator. Other such deviations from accuracy can be found in *Practical Radio* without the use of a microscope, in spite of the senior author's international feats in joinery, but to the students for whom this book has been written such details are inconsequential and the knowledge they want is certainly to be found within its covers.

CARL DREHER.

THE MARCH OF RADIO

NEWS AND INTERPRETATION OF CURRENT RADIO EVENTS

WGY's Attack on the Allocation Plan

When an irresponsible citizen of the broadcasting world sets his private interests above those of the listening public and takes legal measures threatening the security of our new broadcasting structure, the product of years of patient effort, we condemn the error of his ways and hope for his ignominious defeat at the hands of the courts. But, when so respected a citizen of the radio fraternity as WGY takes the first step which is likely to restore ether chaos, we lose hope that broadcasting will ever be sufficiently stabilized to get along without frequent reallocations, legal proceedings, and political pussyfooting.

WGY's cause is a just one. No station is better entitled to a clear channel because it serves a large audience and is the principal program reliance over an extended rural area. But it went about securing justice in a manner which was exactly 100 per cent. wrong, because it endangers the entire system of allocation based on engineering principles. WGY did not hesitate to enlist the aid of grotesque exaggeration of the facts, the ever-ready services of the halo-seeking politician, and even shamelessly sought to fix upon the Commission the obloquy of restricting service to the sick and injured in the hospitals. The consequences of its course portend such destruction that the propriety of WGY's claim to a cleared night and day channel has become a matter of minor importance.

At this writing, it is too early to determine whether the injunction will have as far-reaching and destructive an effect as that obtained by WJAZ two years ago, which brought chaos to broadcasting and stagnation to the radio industry. But it appears that only good fortune can prevent the complete upset of the allocation plan as a result of WGY's injunction, which converts a Fifth Zone cleared channel into one shared by the First and Fifth Zones, thereby upsetting the principle of cleared channels.

FACTS OF THE CASE

The case is one of such importance that its history is worthy of repetition. The Federal Radio Commission, under the Davis Amendment, is compelled to divide the channels of each character equally among the five zones. It decided to clear forty channels for high-power, night operation, allowing eight per zone. It is further required by the Davis Amendment that the facilities be divided among the states in each zone in proportion to their population. The eight cleared channels of the First Zone were, therefore, divided among the ten states in the Zone according to their respective populations.

The New York stations selected for clear channels were WEAF, WJZ, WABC and WHAM. Thus, three of the channels were assigned to the key stations of the three eastern networks, while the fourth was properly assigned to the western part of the state. The Commission's judgment in deciding upon WEAF, WJZ and WABC, each the key station of a different network, for three of New York's four channels can hardly be questioned. WGY might have challenged WHAM, but that station has excellent claims to a cleared channel. It is in an area somewhat more remote from New York than Schenectady and, therefore, less easily served by the three key stations in that city. Furthermore, Rochester is a source of musical talent of the highest grade.

WGY was assigned for daytime operation to a clear channel belonging to the Fifth (Western) Zone, occupied by KGO, which is operated, like WGY, by the General Electric Company. The Commission further gave special permission to WGY to operate in the East at night during any silent period on KGO's schedule. Because of a three-hour time difference, the earliest WGY is required to sign off, if no time concessions are made by KGO, is 8:17 P.M. and the latest 10:32 P.M. If KGO relinquishes all broadcasting between sunset and 7 P.M., this permits WGY to operate until 10 P.M. nightly. During four months of the year, this involves no sacrifice of time on the part of KGO because the sun sets after 7 P.M. on the coast during the months of May, June, July and August. For three months of the year, KGO's sacrifice is one hour or less in the early evening, for two months between one and one and a half hours, and for three months between one and a half and two hours, a part of which are afternoon silent periods.

MR. J. W. HORTON

After a twelve-year association with the Bell Telephone Laboratories, Mr. Horton has joined the General Radio staff in the capacity of Chief Engineer.

Operation until ten P.M. gives the maximum of service to the majority of WGY's listeners including hospital inmates and rural listeners. After ten P. M. also, late listeners may, except in midsummer, receive their programs from one or more of the 50,000- 30,000- and 15,000-watt stations within 150 miles of WGY, not to mention the numerous less powerful stations, some of which have chain affiliations. Furthermore, in summer, when local service is the only reliance of the listener, WGY could ultimately have obtained the permission of the Commission to continue still later operation simultaneously with KGO at night because, due to summer attenuation, heterodyning is unlikely at that season.

WGY has not been singled out as the only high-power station to operate on limited time. Three 50,000-watt stations, WFAA, WTIC and WBAP, are operating, or will operate, on half time only. WENR, the only 50,000-watt station in the Chicago area, is limited to two-sevenths time. These are assignments imposed by the limitations of the Davis Amendment and do not represent unfair discrimination by the Commission. Thirty-nine stations of 5000 watts power or more have been assigned part time.

IMPORTANCE OF WGY'S SERVICE

No one can fairly deny the magnificent service which WGY has rendered and its importance as a broadcasting station. Certainly it was entitled to go before the Commission and request one of the clear channels assigned to New York State. It did not, however, elect to take the orderly course, but went after a channel assigned to another zone, thus striking at the very heart of the principle of allocation. Anyone, not closely acquainted with the technicalities of allocation, would have gained the impression from press reports that WGY had been shut down entirely. Certainly, the letters from hospital inmates, copiously distributed to the press by WGY's publicity department, gave the impression that these sufferers believed they would hear no more of WGY after November 11. In pleading for the injunction which converted a clear Fifth-Zone channel into one heterodyned by a First-Zone station, Attorney General Jeremy R. Waldron of New Hampshire asked the Court of Appeals to grant the injunction "so that WGY listeners in our state will not be deprived of service after November 11."

WGY declined to comply with the Commission's procedure of challenging another station assigned a New York State channel on the ground that it had no quarrel with such stations. What WGY should have done, if it did not elect this course, would have been to strengthen the allocation plan, rather than to aim at its fundamental principles, by demanding additional clear channel for each zone. For example, were there fifty clear channels, allowing ten per zone, as recommended by the engineers' plan, the Commission automatically would have recognized WGY. The weight of its evidence could have been thrown in support of clearing more channels and giving better service.

Whether additional applications for injunction by other stations will follow the precedent established by WGY cannot be determined at this writing, but certainly the way has been paved for such action. We hope that, ultimately, WGY will secure its clear channel and that, in the process, the principle of allocations based on engineering considerations will not be even temporarily destroyed.

Commissioner Robinson Stands Firm

Commissioner Ira E. Robinson has been consistently out of sympathy with the other members of the Commission. He has firmly opposed the allocation plan, favoring a policy of delay in taking active steps to relieve the broadcasting situation. He inclines to the view that the listener is best served by

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many, low-power stations and fails to appreciate the improved service obtained by a more powerful signal. He has frequently expressed the belief that Congress expected the Commission to take several years to investigate the problems of broadcasting, which indeed it has already done, before it begins to function.

The progressive members of the Commission, however, over-ruled Commissioner Robinson's obstructive tactics and put through the allocation plan, after some compromise, in spite of him. When hearings over the plan began, Robinson issued a statement: "Having opposed and voted against the plan and the allocations made thereunder, I deem it unethical and improper to take part in the hearings of complaints against the same or the hearings for the modification of the same." He did not have the strength of conviction to resign from the Commission, but is evidently relying upon Congress to support him.

ANOTHER ROW

ANOTHER row with Commissioner Robinson was precipitated over the ruling regarding television and still pictures. He stated, after the ruling restricting still picture and television broadcasting to one hour a day and prohibiting it between six and eleven P.M. was adopted, that "the forwardness of manufacturers could well be curbed for the present. One induced by the order of the Commission to buy a television receiving set is likely to be so disappointed that he will not only damn the Commission but, at the same time, junk his newfangled contrivance for which he has paid the advertised price."

The radio industry is indeed fortunate that Commissioner Robinson was not in power at the time that broadcasting began in 1921 because broadcast receivers of that day were certainly worthy of the same condemnation. As a matter of fact, the crude results obtained with present-day television are well known and it is entirely unlikely that anyone will damn the Commission for the pioneering character of the art. The Commission has taken into full consideration the importance of protecting the listener from intrusion during entertainment hours by prohibiting picture transmissions between six and eleven P.M.

Conservatism is considered a characteristic of the English people, particularly of the Government itself. The British Broadcasting Corporation, however, which collects its income through the Government and takes no important action without its approval, has been progressive enough to inaugurate regular picture broadcasting.

It is no wonder that rumors of Commissioner Robinson's impending resignation frequently are heard from Washington. We believe, however, that these rumors are rather an expression of the hope of progressively minded people.

It is always desirable to have conservative influences present in any regulatory board or commission but, when the cause of conservatism is lack of knowledge of the subject, it is not always a helpful influence. Commissioner Robinson is thoroughly sincere and has the courage of his convictions in the face of preponderant opposition. His unfortunate situation demonstrates the hampering result of appointing novices to a job requiring experts.

The Regenerative Decision

THE Supreme Court of the United States has ruled that Dr. Lee deForest, and not Edwin H. Armstrong, is the original inventor of the oscillating vacuum-tube circuit. Considering that the Armstrong and Fessenden patents were the foundation of the Westinghouse Electric and Manuafcturing Company's membership in the five-power patent pool, it would appear that its present exalted position in the radio field is insecurely based. Anyone who examines the evidence placed before the Supreme Court, however, would discover a curious thing. They would find that Armstrong claimed to be the first to produce the device which we call the feed-back oscillator and was using it for receiving signals over thousands of miles as early as January, 1923. They would discover that deForest never claimed to have set up such a radio circuit until April, 1913, when he claimed he received signals over a distance of twenty miles. Nevertheless, by a technical legal process, he has been declared the inventor. The decision is based upon a strictly technical interpretation of the term "inventor" as the first to observe and record the invention or discovery. Apparently, Dr. de Forest stumbled accidentally upon the phenomenon of self-oscillations generated by the vacuum tube in the summer of 1912 while working on a wire telephone repeater. With the soft tube, with which he worked, it is indeed difficult to prevent the audio-frequency howling which he observed. Armstrong, at a later date, with the deliberate mental processes of a research engineer who knows what he is doing, evolved the theory and carried out the practice of building the first deliberately designed, radio-frequency oscillator. That he did his work later than deForest's accidental discovery is no discredit upon him and, despite the decision of the courts, he will always remain, in the minds of most engineers, the real contributor. For a technical legal reason, the court could not distinguish between audio-frequency and radio-frequency oscillation and, had this been possible, there seems little doubt that the decision would have proved favorable to Edwin H. Armstrong.

It must not be forgotten that this is only one of many discoveries which have been credited to Armstrong. Among these are the super-heterodyne circuit, the regenerative system, and the almost forgotten super-regenerative circuit. It is by no means proved that this latter will not ultimately be widely used in radio reception and we hope that Mr. Armstrong will devote himself again to his brilliant researches, rather than to fruitless patent litigation.

The decision in favor of deForest has no practical effect upon the licensing situation inasmuch as both deForest and Armstrong patents are covered by RCA licenses, although certain shop rights acquired by the Kolster Radio Corporation appear to be affirmed.

RADIO PICTURES TRANSMITTED IN THREE MINUTES

This picture of Kay Christiansen, chief engineer of the technical division of Danish Broadcasting, was transmitted in three minutes by a Danish radio picture transmitter.

With the Broadcasting Stations

THERE is considerable speculation as to the effect the election of Herbert Hoover will have upon the future status of radio regulation. According to the law, the Commission is automatically disbanded March 15 and thereafter becomes an appellate body with regulation residing directly in the hands of the Department of Commerce. Presumably, before that event takes place, the allocation plan will be fully established and the number of hearings will have fallen off. On the other hand, with Congress coming into session, such political pressure may be brought to bear upon the Commission that many of the stations will renew their protests and force the Commission back into its present routine of almost continuous sessions and hearings.

Mr. Hoover is thought to be sympathetic with Department of Commerce regulation, particularly after the work of the Commission has become effective, but there are so many political angles and aspects to the situation that anything may be expected. The terms of the Commissioners automatically end on March 15 and it may be hoped that thereafter the entire membership of the Commission will consist of radio men of the calibre of Caldwell and Lafount. Lawyers are necessary to the work of the Commission, but they are constituted by nature to bind themselves with the obstruction of red tape; energetic and effective tackling of problems in face of their inherent character is almost impossible. We owe whatever progress has been made by the Commission in its two-year tenure of office principally to the two members who are thoroughly acquainted with the radio phases of the problem and their ability to persuade the rest of the Commission to carry out allocations based on engineering rather than political considerations.

A CONFIDENTIAL survey of the effectiveness of commercial broadcasting has been prepared for the National Broadcasting Company. Most of the statistics released by stations show general census figures for the prosperity and business of their alleged service areas. Others, like the N. B. C. survey, go further and look into listener preferences as to the hours and frequency with which they use their radio receivers and the character of programs which they prefer. The great fundamental question, however, which interests the advertiser, is not the potential audience which he may have, but the actual sales or goodwill influence of his program. Surveys should consider the competitive situation which exists for the listener's attention. We are accustomed to thinking of audiences of millions for a particular program, but calculations, which take into account all the reasons why listeners may *not* be listening to a particular program, prove that audiences are considerably smaller than is generally estimated.

A further and more serious loss in the effectiveness of broadcasting is the remoteness of benefit to the sponsor who has presented an entertaining program. The art of capitalizing the broadcasting effort is the least developed phase of commercial broadcasting. As the ingenuity of the devices employed to bring actual consciousness of sponsorship relation to the program offered increases, it will place even greater valuations upon the possibilities of commercial broadcasting.

Another research of great interest has been prepared by the Dartnell Corporation of Chicago, entitled "The Use and Limitations of Radio Advertising." After quoting a number of authorities on the scope and suitability of broadcasting to various classes of business, it summarizes for the first time the actual appropriations expended by most leading commercial sponsors over a period of years and classifies them according to the character of each sponsor's business.

ONE of the principal test cases before the Commission at this time, which will determine its jurisdiction, is that pending in Chicago. WOK-WMBB has advertised its intention of going on the air in spite of the fact that the Commission has denied it a license. The moot question of property rights with a 20,000-watt transmitter, representing a considerable investment, is squarely the issue of the case. The District Court for the Northern District of Illinois denied an application for an injunction against the District Attorney who was seeking to enforce the Federal Radio Commission's assignment under the new allocation plan on WCRW. The Court held that WCRW had not exhausted the avenues provided in the Radio Act for a consideration of its case before applying for an injunction restraining the Commission. The Radio Act was held constitutional in this decision.

THE Federal Radio Commission issued regulations for synchronizing experiments which are helpful in that they lay a definite basis for such work in the future. They are rather stringent, requiring several months of test before the results can be applied under average broadcasting conditions. In fact, the safeguards which the Commission has placed on these experiments are so complex that they will discourage any but the most advanced laboratories from even undertaking such work. However, the public should be protected against experiments undertaken principally to secure publicity rather than scientific results and, if the regulations prove too burdensome to promote progress, the Commission will, doubtless, modify them slightly.

GENERAL Order No. 48, of the Commission permits stations, licensed to operate during daytime, only, on clear channels belonging to other zones, to take advantage of the silent evening hours of the major station. This is a wise regulation because many of the stations in the far west, assigned to cleared channels, begin operation at six or seven P. M. instead of directly at sunset, thereby leaving valuable hours available, under the new regulation, to the eastern stations assigned with them.

AN INTERESTING sidelight on the comparative values of broadcasting and newspaper advertising appeal, under very special conditions, is revealed in the remarks of Scott Howe Bowen at the National Association of Broadcasters convention in October. He stated: "The Democratic National Committee spent $35,000 in a series of newspaper advertisements and received in return less than $2000 in contributions. It later employed a network of National Broadcasting Company stations at a cost of $4000, which brought in $70,000 in contributions. Another experiment, through the Columbia network, involving an expenditure of $2000, brought in $50,000 in contributions."

A RADIO STATION IN THE WILDERNESS

This picture shows the forest camp at Red Lake, Ontario, Canada, which is one of the nine places in that district where short-wave radio stations have been installed to keep airplanes and forest rangers in the vicinity in touch with headquarters. The radio shack is in the building next to the tower, the latter being used to dry hose after a forest fire. The call letters of the station are VE9BD.

Commercial Radio Telegraphy and Telephony

THE latest addition to the international telephone service is the linking of the United States and Austria by the Bell System.

THE Mackay System is beginning the construction of radio-telegraph stations to inaugurate commercial and press service between San Francisco, Honolulu and Manila. This duplicates the existing network of the Radio Corporation of America and is another step in the intensive competition rapidly developing in American world-wide communication.

GENERAL Order No. 51 of the Commission requires discontinuance of the use of spark transmitters employing damped waves except in the case of ship stations. This is the formal embodiment of the final elimination of what was once a problem of great proportions, the interference created by commercial spark stations upon broadcast reception.

THE African Broadcasting Company, Ltd., which has practical control of broadcasting in the South African Union, appears at last to be established on a sound commercial basis, following its many vicissitudes of previous years. The company reports some three thousand new subscribers and a decrease in the number of listeners in Johannesburg who have, in the past, been evading the payment of license fees.

With the Radio Manufacturers

THE Kolster Radio Corporation announces successful experiments with a beam antenna, the angle of which may be changed to compensate fading effects.

Dr. Kolster also announces a small, direct-reading, radio compass for small vessels which can take bearings for distances up to approximately 25 miles. The over-all height of the instrument is only three and a half feet.

THE Radio Manufacturers' Association has apparently repudiated its agreement with the National Electrical Manufacturers' Association, which provided that R. M. A. would review NEMA standards and thus centralize standardization work in NEMA's hands. It has issued a 25-page leaflet of standards which differ in minor respects from the NEMA standards and are not as comprehensively or as satisfactorily compiled as the 150-page book which has heretofore been the sole standard authority of the industry. No explanation has been made by R. M. A. for its attempt to restore chaos in the standardization situation.

THE details of the new Radio-Albee Orpheum combination have been announced. A holding company, to be known as Radio-Keith-Orpheum with David Sarnoff as Chairman of the Board, has been formed and two classes of stock issued, 3,500,000 shares being Class A and 500,000 Class B, the latter being assigned to the Radio Corporation for a photofilm license. Dividends will be divided in the ratio of 1,100,000 shares to Keith-Orpheum, 500,000 to R. C. A. and 200,000 to F. B. O.

NEGOTIATIONS between Columbia Graphophone, Columbia Phonograph, Western Electric and Electric Research Products Corporation are said to be nearing completion. This makes a set-up quite similar to the R. C. A.'s association with Victor Talking Machine and requires only the addition of a film company to the Columbia group to round it out.

THE R. C. A. has incorporated two export subsidiaries, the R. C. A. of Argentina, Ltd. and the R. C. A. of Brazil.

THE bi-annual census of manufacturers shows a 32.3 per cent. gain in the value of radio B and C batteries manufactured in 1927 as compared with 1925. The figures for the two years were respectively approximately $25,000,000 and $33,000,000.

ATWATER KENT has broken ground for a new three-million-dollar factory which will double its output and make it the largest radio factory in the world.

—E. H. F.

A Few Radio Questions Answered

Nearly everyone wants to know the answer to some one question about radio. Many want to know the answer to specific questions, such as "What is wrong with my set, the tubes don't light?" Others want to know the answers to general questions: answers which should be obvious but are not. In this page the Laboratory Staff has attemped to answer a few of the questions that are asked it many, many times, and in this paragraph expresses the hope that readers who have other similar questions will not hesitate to send them in.

—The Editor

Why is the volume control placed in the r.f. amplifier?

It need not be; it may be connected in the antenna-ground circuit, in the r.f. amplifier, in the detector, or in the a.f. amplifier. It preferably should be connected in a circuit ahead of the detector, so that the signals may always be kept below the point where detector overloading begins. This is particularly important when a leak-condenser detector is used—because it has a low overloading limit. It is our guess that 99 per cent. of the sets now in use have this kind of detector. If the volume control is placed on the audio amplifier, that is, after the detector, distortion is liable to result on strong signals, even though the volume from the loud speaker is low. This is due to too strong signals being placed on the detector input.

I have a 171-type power tube. Is there any advantage in using a 171A-type tube?

The only advantage is in the improved economics of your radio system. The new tube will not deliver more volume, nor will it last longer, nor will it give better quality. It consumes half the A-battery current; hence, it is about twice as efficient, if you chose to call the efficiency of the tube the amount of audio-frequency output it will deliver per watt of power used up to heat the filament.

I dropped my audio transformer and now the quality seems "sour." What is wrong?

The chances are that your audio transformer had a high-permeability core made of one of the new alloys of iron, nickel, etc. It is a fact that the greatest care in manufacture is necessary not to lower the permeability of the core material by severe mechanical shocks. When the permeability is high, a relatively small core and relatively small amount of wire will produce a high-inductance winding. When a shock lowers the permeability, the inductance goes down, and the low frequencies fall out.

It is a standard physics class experiment to drop iron rods on a hard floor in such a direction that at the moment of contact the molecules can be oriented properly with respect to the earth's magnetic field. After a sufficient number of shocks, the iron bar will be found to be permanently magnetized. It is possible that your audio transformer has become permanently magnetized—which would have the same effect as sending too much d.c. current through it. It "saturates" easily.

How can I tell if my tubes need replacing?

According to certain publicity writers a new tube should be placed in each socket of a set least once a year—but don't you believe it. Just because you bought a tube a year ago to-day, is no reason why you should throw it in the wastebasket and invest in a new one provided, of course, a test proves it to be a good tube. Tubes do not run down in just that manner. The Laboratory has records of a number of Sylvania tubes which ran on a life test for 1500 hours without any change in their constants—except a minor improvement in some of the tubes—and were then taken off and used around the Laboratory for months afterwards. Some tubes last 1000 hours, others become anaemic at the end of a few hundred hours—for no reason that anyone can state. The tubes may have come from the same plant and exactly the same run—but something in their make-up gave them a short life.

If your set seems to have slowly given up its sensitiveness to weak signals, if it no longer gives out low notes, and if you can't get DX on a crisp cold December night when your next door neighbor gets PWX, you'd better have your tubes tested. When the quality seems bad, and the amplifier overloads easily, look to the 171-type power tube which is probably being run on a.c., and whose filament has been overloaded so that it no longer has sufficient electrons to handle low or loud notes. Any reputable dealer can test the tubes.

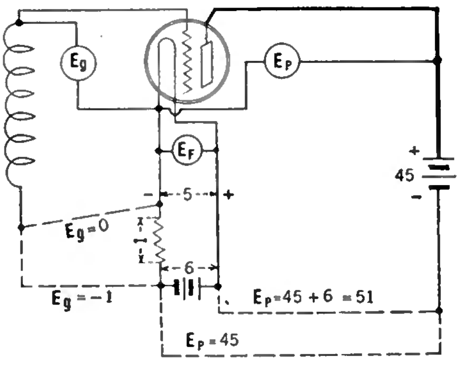


FIG. 1

Where should a filament rheostat be placed, in the positive or negative lead? Should the minus B wire be connected to minus or plus A wire?

Look at Fig. 1. Here the resistor, which may be variable or not, is connected in the negative filament lead. The bottom end of the coil attached to the grid is connected on the battery side of this resistance. There is a voltage drop across this resistance, which makes the end nearer the battery one volt more negative than the end near the tube. Since all tube voltages are measured with respect to the negative end of the filament, this voltage drop is applied to the grid. We can say, then, that the grid is one volt negative, meaning that it is actually one volt more negative than the negative end of the filament ($E_g = -1$). If the coil were attached to the filament end of the resistor, the grid would be at the same potential as the filament, and would be at zero bias ($E_g = 0$). It makes absolutely no difference in this case if the resistor is in the plus or minus lead.

When minus B is attached to minus A, the plate potential is the voltage of the B battery. When minus B is attached to plus A, the plate potential is the voltage of the B battery plus the voltage of the A battery, because plus A is above the voltage of minus A—which is connected to the negative filament lead—by the voltage of the A battery. Thus, if the B battery is 45 volts, and the A battery is 6 volts, and minus B is attached to plus A, the plate potential is 45 plus 6 or 51 volts. If the minus B is attached to minus A—and we prefer such a connection—the plate potential is the same as the B-battery voltage, namely, 45 volts. For years telephone circuits have connected minus B to plus A, but we don't see any good reason for it except tradition.

Can a high-mu tube such as the 240 be used as an r.f. amplifier?

Yes, and it will make a good one too. The trouble is that the amplification will go up a bit faster than the selectivity, so that the circuit seems to tune broadly. If a transformer is used to couple a high-mu tube to another amplifier tube or to a detector, the turns ratio must be greater when using a high-mu tube than when using a 201A-type tube. An explanation of this turns ratio business may be found in "Strays from the Laboratory" September and December.

What is a band-pass amplifier?

Strictly speaking it is an amplifier that admits, amplifies, and transmits only a certain band of frequencies, say from 50 to 60 kc., and refuses all other frequencies. Strictly speaking again, there is no such thing. All band-pass amplifiers admit a certain amount of currents of other frequencies, but this amount can be made quite small. A true band-pass amplifier characteristic would look like Fig. 2, and the amplifier would consist of a great many stages of filters, each composed of inductance and capacities.

A band-pass amplifier which does not have a sharp "cut-off" would look like Fig. 3, and a sharper one would look like Fig. 4. Both admit frequencies on either side of the desired 50–60 kc. band but in smaller amounts. Theoretically it is possible to build a band-pass amplifier with a flat top and steep sides. Whether or not an amplifier has such a characteristic in practice has not been determined in the Laboratory.

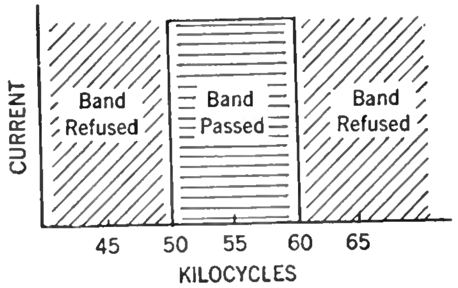


FIG. 2

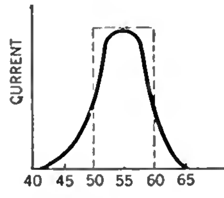


FIG. 3

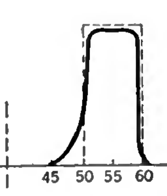
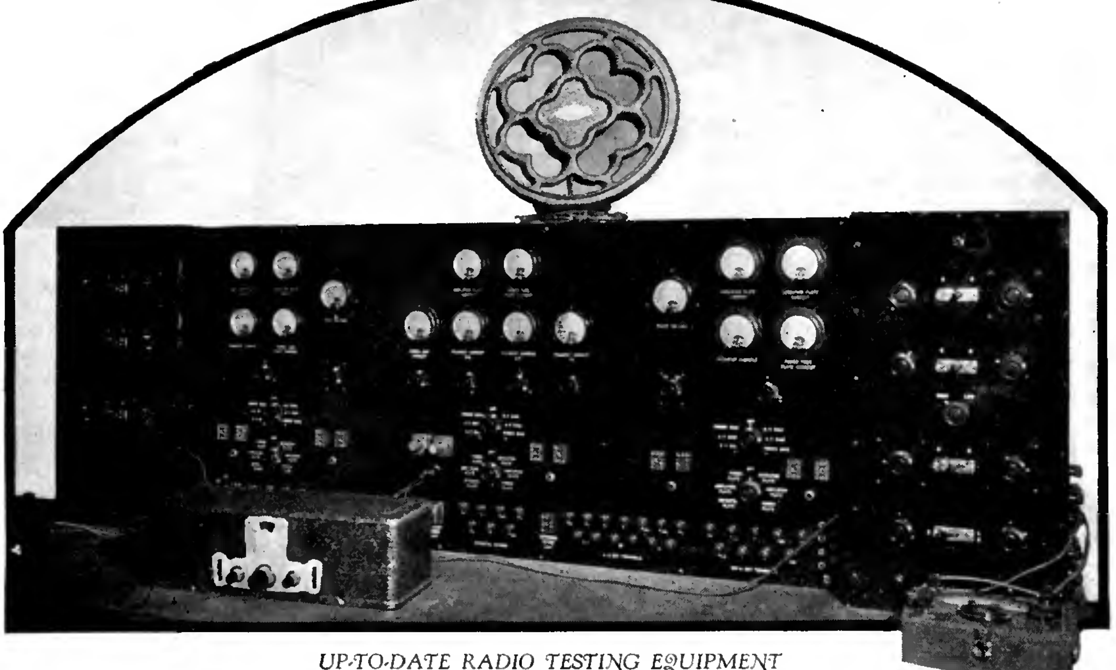


FIG. 4



UP-TO-DATE RADIO TESTING EQUIPMENT

Measuring a Receiver's Performance

By KENNETH W. JARVIS

IN ALMOST any Sunday newspaper radio supplement you may find something like the following: "Buy Now—a Guaranteed Jumpidyne—Coast to Coast Reception—Wonderful Tone Quality—Hair-Splitting Selectivity—Loud-Speaker Volume"—and so on for about two columns of variegated adjectives. On the next page you may read about another make, also "The Finest Receiver on Earth" with remarkable distance-getting ability and marvelous reproduction.

These picturesque descriptions are undoubtedly works of genius on the part of hard-struggling advertising managers, but do they help persuade a wavering prospect that his only hope of radio blessedness is to buy a Jumpidyne? It is rather doubtful. At best these masterpieces of word structure do nothing more than attract attention. True, attention is the first step in making a sale, but it's a long way to the dotted line.

Are such statements logical and proper in merchandising a radio product? Must the technical rating of our receivers be measured by the ingeniousness of the copy writers in coining new superlatives? Any radio engineer will answer these questions with a most emphatic "No," and will gladly repeat his answer if occasion demands. While not easy, performance characteristics of our receivers can be obtained and definitely expressed in numbers. Curves will be shown later illustrating this point.

There are several good reasons why the "performance characteristics" of radio receivers have not been used much to date. Such measurements are hard to take. Engineers could not agree as to what measurements were necessary nor how to make them. And, if made and published, the radio buying public would not know what it was all about. All of these objections are rapidly being answered; this prophesies the end of the set with nothing but adjectives to sell it. Measuring equipment is available. The Standardization Committee of the Institute of Radio Engineers have practically completed their work in the specification of Standard Tests. And the public is being educated by such articles as this. All of which is sufficient reason why our radio receivers should be sold to the public on their own merits.

HOW to measure the performance of a radio receiver has always been a subject of primary interest. Those inexperienc d in the field have never been able to see why some simple standards for receiver performance could not be set up to give information as definite and useful as that to be had from makers of automobiles. Radio engineers themselves—who ought to know—have been slow to agree on what the measurements should be and how they should be made. The author of this article, Mr. Jarvis, who is a member of the engineering staff of the Crosley Radio Corporation, discusses the problems of receiver measurement and tells something about how they are being solved.

—THE EDITOR.

SENSITIVITY MEASUREMENTS

PROBABLY the most important characteristic of a radio receiver is its sensitivity. This is the "mysterious" element that is responsible for distant reception. It's the influence that has made radio what it is to-day. Even the old timers still experience a thrill when tuning in a faint signal from across the Atlantic or Pacific. The sensitivity of a receiver is sort of a magic Arabian rug that takes you, via ear at least, to wherever you want to go. There is only one difference. The magic rug could go anywhere—the radio receiver will take you to the distance determined by its sensitivity.

How is this sensitivity measured? Engineers have agreed that the sensitivity of a set shall be determined by the amount of signal necessary to produce a standard output. (This "standard output" is arbitrarily agreed upon as a power of 50 milliwatts, which corresponds roughly to fair loud-speaker volume.) It is about half the output that can be obtained from a 112-type tube without distortion. The set to be measured is, therefore, connected to its proper A, B, and C voltages and an r.f. signal of certain characteristics (400 cycles at 30 per cent. modulation) impressed in the antenna circuit. The input voltage is varied until the standard output is reached, and then the input voltage is measured. Obviously, the more sensitive a receiver is, the *less* will be the voltage input. Thus, a set having a sensitivity of 40 microvolts per meter would be twice as sensitive as one having a sensitivity rating of 80 microvolts per meter. In reading the curves this point *must be remembered*. The *highest* curve is the *least* sensitive.

In Fig. 1 are shown three curves taken on three different receivers. These are marked A, B and C. Notice that the horizontal scale (frequency in kilocycles) is uniform while the vertical scale (sensitivity in microvolts per meter) is logarithmic. [The term "microvolts per meter" is determined in this manner: If one has a vertical antenna with an effective height of 10 meters—a meter is a little over three feet—and a distant transmitting station impresses a voltage across this antenna of 100 microvolts, the "field strength" at this point is said to be 10 microvolts per meter.—*The Editor*.] Obviously C is the best receiver throughout the entire broadcast band, while the curves of A and B cross and recross, giving A more sensitivity in the middle of the range with B having greater sensitivity at the

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extreme ends. With this data in front of you, which set would you buy? You should not decide until you know the value of the other factors, such as selectivity and fidelity. You must know the prices. And your judgment may be influenced by the appearance, ease of operation, dealer service facilities, etc. But to decide definitely, assume the prices for the various receivers are as follows: A-$95, B-$125, C-$100 (These are not the exact retail prices of these receivers, but are quite close. The exact figures are not given for obvious reasons. Neither does this price include fancy cabinets with which these receivers can be equipped.)

The sensitivity is roughly determined by the product of the radio-frequency amplification and the audio-frequency amplification.

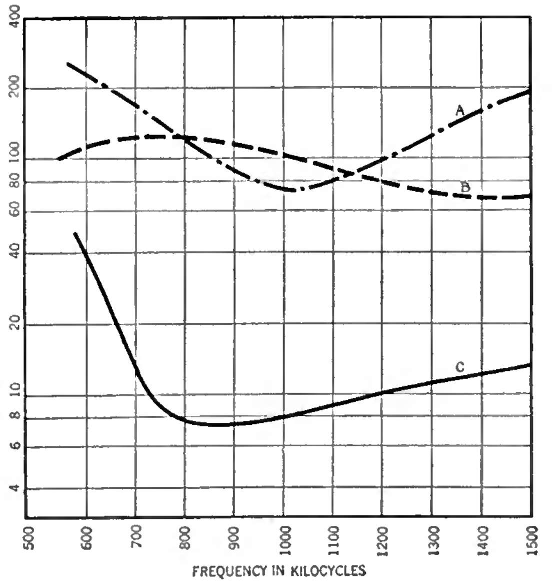


FIG. I. SENSITIVITY

DATA ON SELECTIVITY

THE selectivity of a radio receiver is the degree to which it rejects unwanted stations. It is measured by the strength of signal necessary to produce Interference Output. (This "Interference Output" is also arbitrarily agreed upon as a power of 50 microwatts, which corresponds roughly to a barely audible signal in the loud

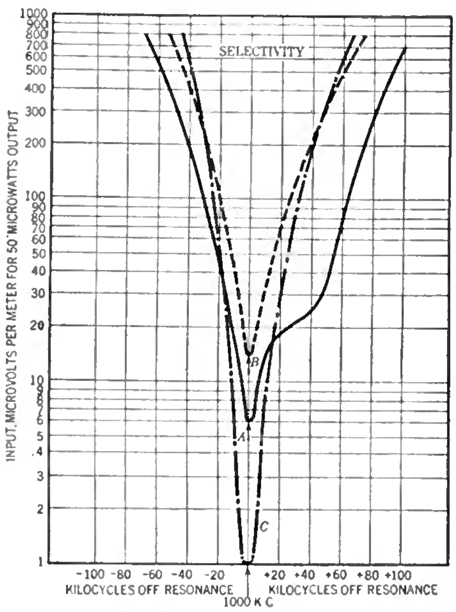


FIG. 2

speaker. It has one thousandth the power of the Standard output.) It is usually necessary to draw a complete curve to specify the selectivity. The selectivity curves for the three sets are shown in Fig. 2. All of the sets were tuned to resonance at 1000 kc. and the signal frequency was varied. Thus, in the case of set C, a station having a frequency of 1030 kilocycles would have to have a field strength of 80 microvolts to cause any noticeable interference to the listener. The shape of the curves in Fig. 2 is of more importance than their actual position. Their positions are determined by their relative sensitivities at this point. (Notice the order of sensitivity on Fig. 1 at 1000 kilocycles is C, A, B, just as is the order on Fig. 2.) The curve shapes of Fig. 2 are quite similar. The curve on receiver C is slightly sharper and this set, therefore, has the best selectivity. All of these sets are single-dial control. The queer shaped curve of A in Fig. 2 is due to the fact that one of the gang condensers did not track properly. Proper alignment of this condenser would have produced much better selectivity.

As sensitivity is the most important characteristic of a receiver, it was emphasized first. Then as more stations began crowding the ether, selectivity was the great cry. Low-loss coils and condensers had their day. As the army of listeners grew they became more critical, until to-day perhaps the biggest demand of a receiver is *fidelity* to the original. Quality and perfectly flat characteristics probably have been lied about so much that we are all rather skeptical. However, it is quite safe to say that the audio characteristics of a receiver (including the loud speakers—terrible sinners) are by far the weakest link in the chain of perfect reception. The selectivity of radio-frequency amplifiers "cuts the sidebands" and hurts the high-frequency reproduction. The detector arrangement is also the cause of considerable unwanted distortion.

In spite of many advertisements to the contrary, it is safe to say that an audio amplifier with a perfectly flat response curve from 30 to 10,000 cycles has never been built into a commercial set. Overloading in detector, amplifier or speaker is not only common, but customary. Quality and fidelity are sacrificed on the altar of volume. In self-defense some acoustic designing engineer may build such a set, and it probably will employ a 5-kilowatt tube!

REGARDING QUALITY OF REPRODUCTION

BUT before describing the fidelity of the receivers A, B and C, one point must be *emphasized*. The human ear is probably the least critical and least perceptive of all the sense organs. Certainly it will overlook an enormous amount of abuse camouflaged as music, and no receiver will sound half as bad, even to a trained ear, as the fidelity curve looks to the eye. In justice to the acoustic designing engineer, a fourth curve D, is added to the three of the receivers already discussed. Curve D is typical of radio sets constructed three years ago. These curves may be a little harder to understand. They are plotted in percentage response of that at 400 cycles. This means that if each receiver were adjusted to give the same sound output at 400 cycles, the other frequencies would sound as shown on the curves. A, B and C are all about alike at high frequencies. The decrease is due to the effects previously mentioned. At the low frequencies B gives the best fidelity (that's what the extra $25.00 pays for), with C and A following in order. The set producing D, in its day, was advertised as having "a marvelous audio system, having straight-line characteristics, and giving almost perfect quality." Obviously this amplifier would deliver an awful wallop at frequencies near 1000 cycles, but to term this "quality" was a sad (but still ethical) error.

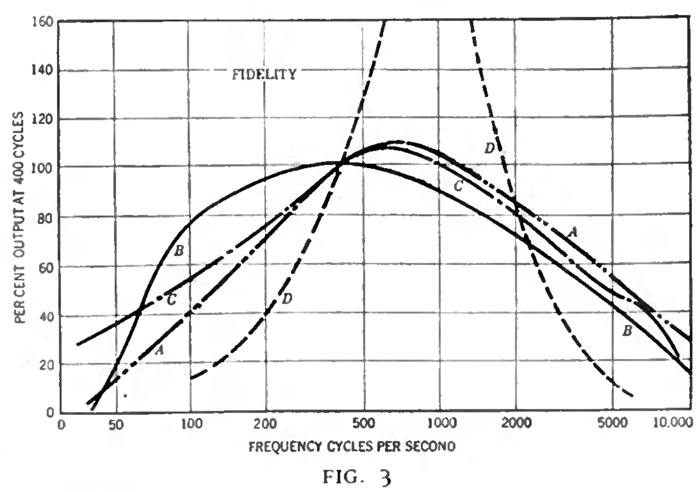


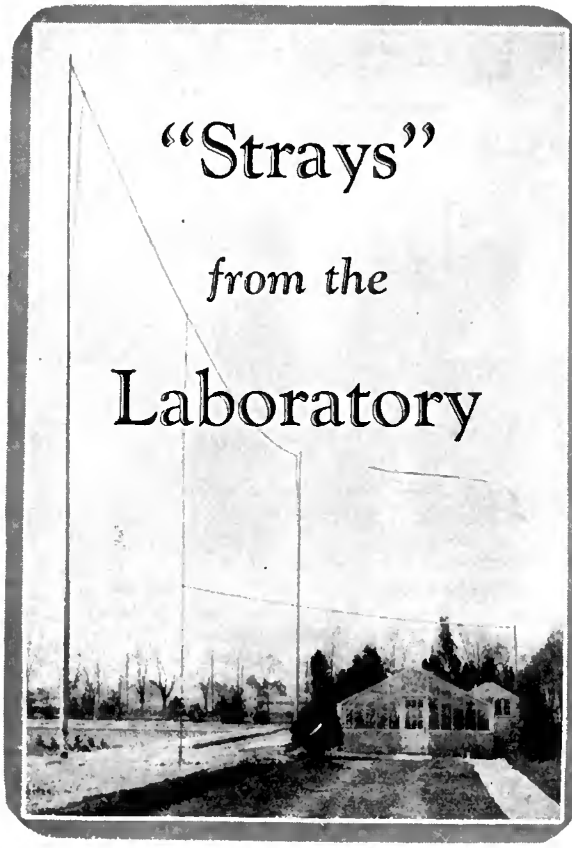
FIG. 3

CONCLUSIONS

WHAT does all this mean? It means that receiver performance (including many other factors not touched upon here) can be measured, it should be, and will be when the buying public demands accurate technical information regarding the product it is buying. In purchasing an automobile (radio) the buyer wants to know more than the number of cylinders (tubes). He wants to know its ease of handling (ease of operation), horse power (sensitivity), riding comfort (fidelity), safety (selectivity), oil and gas consumption (batteries or power supply). Those factors which his experience and judgment cannot evaluate (such as horsepower—"sensitivity") are rated by the manufacturer and given as part of the guarantee.

These measurements are difficult to make. The majority must be made at radio frequencies, where the slightest mistake means a big error. They must be made with small voltages and even smaller watts. (Millionths of a volt and thousand millionths of a watt). Receivers may vary in sensitivity, selectivity, fidelity and amplification enormously. There are sets run on a.c., d.c., generators, and batteries. There are super-heterodynes, neutrodynes, regenerators, stabilized receivers, and a host of other "dynes" and "flexes." Measuring apparatus must be sensitive, accurate, foolproof and rapid. Human equations must be eliminated, as prejudiced opinions should not be allowed to affect the results.

To what end is this being done by the larger manufacturers? That radio progress may not cease and that the customers may know exactly what they are buying some of the better-known manufacturers "engineer" their products, but many others merely build them out of coils, condensers, screws and cabinets.



"Strays" from the Laboratory

How Much Output Power is Needed

IN ATTEMPTING to state our point of view on the moving-coil loud speaker in November Radio Broadcast, we neglected one point of interest—it is brought to our attention by Zeh Bouck, who says. "There is one point in favor of the dynamic speaker which you failed to bring out, namely, its capability in the way of handling power.

"If volume in excess of that generally considered adequate for home reception is desired, a dynamic speaker is practically a necessity. It has been my experience that the best of cones suffer noticeably with even moderate usage and, after a few months of service, overload on relatively low volume—a fault that probably will never characterise a good moving-coil speaker."

Mr. Bouck is correct, of course. The ability to stand a lot of punishment in the form of power is one of the chief advantages of this type of loud speaker, of which the Jensen, Magnavox, Peerless, Rola, etc., are good examples. When using a 171A-type tube to provide the volume considered as necessary in most homes, the dynamic gives the impression of being able to handle this power without pin rattle or pole-pieces chattering on the low notes.

We are glad to note that Mr. Bouck recognizes there is a certain output of power beyond which it is not necessary to go for home reception. There are many people who refuse to recognize such a level; even if they use a 250-type power tube with full output, they want more. In the smallest apartments and in the midst of the most intimate conversation the radio is geared up to the limit. Many listeners seem to revel in a vast amount of sound, as others do in a riot of color. It is the amount of sound that attracts them, not the form or the sequence of the mixture of sounds. However, it is true that the complete benefit of a loud speaker which reproduces low notes is not secured unless the volume is rather high because it is only then that the low notes attain full perfection. But one cannot realise the full beauty of his automobile motor—if it is a good one—unless he goes about 75 miles per hour—but few of us find it necessary to extract the absolute limit of pleasure out of anything.

Many readers have asked what kind of amplifier we use. It is a single 171-type tube with something less than 180 volts on the plate and the reproducer is a standard moving-coil loud speaker in a three-foot baffleboard—and you never saw a more awkward object. We listen to symphony concerts, which we believe to be a good test of the volume range of present-day broadcasting, and manage to enjoy them without bothering the neighbors.

We understand Eveready (National Carbon Company) engineers made a series of tests a year or so ago in which many listeners, some of them musicians, voted on the volume level they desired while a receiver behind a screen was adjusted in output. The majority indicated a volume corresponding to the output of a 171A tube without knowing what the actual volume level was. There is also a feeling, we have heard, at the General Electric laboratories that a 171A is all that is needed for home reception.

Mr. Bouck states that cone speakers do not stand up under hard usage. We have never run into this difficulty, nor have we seen the similar trouble that some moving-coil speakers are said to have, namely, the disintegration of the paper cone or the leather or rubber circle that attaches it to the iron frame. Has any reader had an experience of this nature?

This Month the Following Subjects are Discussed in "Strays"

1. HOW MUCH POWER IS NEEDED
2. WHAT IS A DYNAMIC SPEAKER
3. OBTAINING C BIAS
4. THE TASK OF EDITING
5. EMPIRICAL RULES AND FORMULAS

What Is a Dynamic Speaker?

AFTER great deliberation the Aural Devices Committee of the Engineering Division of the R.M.A., of which Paul G. Andres is chairman, approves the following definition of a dynamic loud speaker.

"A Dynamic Speaker is one in which the portion of the conductor carrying the alternating signal current is a part of the moving system, the force producing the motion being due to the location of this conductor in a magnetic field."

This, in our estimation, is swell. And now the N.E.M.A. has a definition, and if the I.R.E. gets up a definition, and the Bureau of Standards gets up a definition, and they can all agree upon one which the National Better Business Bureau will not object to, we may be able to learn what a dynamic speaker is. By that time another craze in loud speakers will probably be on the horizon, and we can repeat the performance ad libitum.

Table I

	Type	If	Ip	μ	Rp	Gm	Ep	Eg
Te Ka Da Tubes	4A15	.13	2.6	14.6	10,000	1,480	90	— 3.0
	4N08	.068	3.7	10.0	9.000	1,100	90	— 1.5
	4H08	.068	2.3	13.0	13,000	1,000	90	— 1.5
	4L15	.125	4.6	6.0	6,600	1,000	135	—12.0
Seibt Tubes	H407	.16	4.0	17.0	18,000	900	135	— 1.5
	U410	.095	2.4	11.0	13,000	810	90	— 4.5
	L418	.12	11.0	6.0	5,600	1,070	135	— 9.0
	L419	.32	8.0	6.0	7,300	1,100	135	—13.5
	W404	.16	1.4	28.5	41,000	690	157.5	— 1.5

Some Interesting Formulas

ANY one wanting a pleasant hour or two of calculation and speculation may substitute values into the expression below for the turns ratio between secondary (tuned) and primary in the radio-frequency transformer coupling two tubes in a conventional r.f. amplifier. The values of turns ratio and maximum gain for the tube and its transformer are functions of the inductance and resistance of the secondary, and the plate resistance of the tube. Some constants of German tubes, measured in the Laboratory at the request of the manufacturer, are given in the accompanying table, and some coil data will be found on page 260 of September Radio Broadcast.

$$(\text{Turns ratio})^2 = N^2 = \frac{L\omega}{R} \times \frac{L\omega}{R_p} = \frac{L^2\omega^2}{RR_p} \quad \text{or}$$

$$N = \frac{L\omega}{\sqrt{RR_p}}$$

and when this turns ratio is used, the maximum possible voltage gain is

$$K = \tfrac{1}{2}N\mu = \tfrac{1}{2}\frac{\mu L\omega}{\sqrt{RR_p}}$$

It is particularly interesting to substitute into these equations the constants of the German Seibt tube W-404 which has an amplification factor of 28.5 and a plate resistance of 41,000 ohms.

Obtaining C Bias for a.f. amplifiers

AUDIO amplifiers continue to absorb the attention of Howard Rhodes, Technical Editor of Radio Broadcast. In December, we described some data taken on a two-stage transformer-coupled amplifier made up from Sangamo type-A transformers which proved that a well-designed amplifier does not necessarily give a better response to low frequencies when operated out of a low impedance.

Now let us consider the business of getting a C bias for an amplifier tube, not the last stage, by using the voltage drop across a resistor. What is the effect on the frequency characteristic of the amplifier of bypassing this resistor? The results of Mr. Rhodes' measurements are shown in the following table. Clearly there is a definite gain in bypassing the resistor—and this gain comes at the high frequencies, although many experimenters have advocated the use of a condenser because of improved low-frequency response. What is the cause?

At high frequencies the transformer can be looked upon as in Fig. 2 in which L, the primary inductance, is shunted by all the distributed and stray capacities, C, of the circuit. L_1 is the leakage inductance, R_p is the tube's plate resistance and R is the C-bias resistor. Now the leakage inductance and the capacity form a series-resonant circuit. The effect of L shunted across C is negligible, since it is a high-impedance shunted across a lower impedance. When the resistor, R, is not bypassed a considerable voltage is developed across it, due to the resonant current flowing through the resistance in this circuit. This voltage is introduced into the amplifier so that it is out of phase with the voltage from the signals on the grid of the tube. In other words it detracts from the amplification at this frequency.

When the resistor is properly bypassed, the voltage drop here is greatly reduced, and, of course, the out-of-phase voltage introduced into the amplifier is reduced, so normal gain is experienced.

Whether or not the resistor should be bypassed depends upon conditions. For example, there is usually a tendency for an amplifier to sing at the point where the capacity resonates with the leakage inductance. The tendency for the amplifier to sing, due to this resonance condition, then, is decreased when an out-of-phase voltage is introduced, due the C-bias resistor. Some amplifiers which do not sing when the bias resistor is not shunted, do sing when it is bypassed. In the case of the amplifier measured in the Laboratory, there was a gain of 6 TU at 6000 cycles—which went a long way toward making up the usual loss at this frequency, due to only ordinary side-band cutting in the r.f. amplifier.

Cycles	Without C TU	With C TU
60	-.5	+.5
100		0
2000	-1.0	0
4000	-2.5	0
6000	-6.0	-.7

The task of Editing Radio Copy

FEW writers for and readers of a magazine like RADIO BROADCAST realize the complexity of the tasks of its editorial and technical staff. Let us consider a how-to-make-it article, perhaps on a prominent kit from a well-known manufacturer. The kit comes to the Laboratory, is tested, accepted, or turned down. Then the article is looked over, diagrams are checked against lists of parts, the photographer is called in, and, after the result of his labor comes to the office, an "over-lay" is made, that is, the photograph is overlaid with a thin sheet of paper and the various condensers, resistance, coils, etc., are marked with letters and numbers which correspond with the list of parts and the circuit diagram. Here is where trouble begins. The set, the list of parts, the diagram, and the article which comes from the outside, from the kit manufacturer perhaps, seldom—may we say, never?—check. On the diagram a resistor may be marked as 50,000 ohms, in the list of parts it is 100,000 ohms, and in the article itself it may not be mentioned, or it may have a third value. Which is correct?

A recent article came to the office—late as usual—and still later came the receiver. The list of parts did not check either the diagram, or the receiver, although the manufacturer claimed we would have no trouble because the material was "just as he sent to his would-be purchasers." After exchanging several telegrams and long-distance phone calls, a list of parts, a diagram, and a photograph were assembled which checked —but unfortunately this list will not check anything the manufacturer sends out. What is the reader to do? Why cannot the manufacturer check his material before it gets into print?

We have a bulletin sent out by a well-known manufacturer, this time describing a B-power system which makes it possible to "get away with" smaller filter condensers. The diagram sent out with the bulletin gives one value of condenser; the circuit diagram gives another. Which is correct? Who knows?

We have another yarn from a publicity writer of a nationally known organization—we are going to turn it down—in which the list of parts gives several items which do not appear on the circuit diagram, and the diagram gives two items which do not appear on the list of parts.

The Technical Staff feels that its responsibility is to the reader. It will get up a list of parts which will work properly as evidenced by a test in the Laboratory—and if the manufacturer is foolish enough to send out material which not only conflicts with what we print but which contradicts his own printed matter, it is his own fault.

Incidentally, every receiver and power supply is tested in the Laboratory before it is described in the magazine—some of them several times, as well as many aggregations of apparatus whose descriptions never see the printed page of this magazine.

Empirical Rules and Formulas

THE CONFLICT between simplicity and accuracy rages in the soul of every technical man. Is there not some short cut to a mathematical or laboratory investigation that will give sufficient accuracy? What factor can we neglect in order to obtain the result sooner, and still not have the bridge we are designing fall down? It has been said that nearly any result may be obtained from a mathematical analysis of a given problem, providing the proper assumptions are made—and, as every physicist knows, many, many, problems cannot be solved completely at all. There are always some factors which must be neglected in favor of others.

In the hunt for simplified methods, certain empirical rules and formulas appear. Several have recently been published which are very interesting. One was in *Experimental Wireless* (England) September, 1928, and this was reprinted in *Lefax*, October, 1928. It related to a simple tube tester with which a service man could quickly determine the value of tubes. In the course of many measurements Marcus G. Scroggie, who developed the tube tester, discovered that the following expression would "work" with all modern tubes with a fair degree of accuracy.

$$R_p = \frac{0.6\ V}{I_p}$$

where R_p is the plate resistance of the tube
I_p is the plate current
V is the "lumped voltage" on the plate.

The lumped voltage is the effective voltage on the plate of the tube; that is, it is the sum of the voltages E_p (the voltage due to the plate battery) and E_g (the voltage due the grid). For example, if a tube has 90 volts on the plate, a C bias of 4.5 volts, and an amplification factor of 8, the lumped or effective voltage on the plate is

$$V = E_p + \mu E_g$$
$$= 90 + 8(-4.5) = 54$$

so that the effective voltage on the plate is 54 volts. Now, if the tube has a plate current of 2.5 milliamperes under these conditions, the plate resistance, R_p, can be obtained from Mr. Scroggie's formula. We have taken this formula and computed the figures below which give the measured and calculated R_p of several tubes and the discrepancy between them. The table follows:

Tube	Rp (meas)	Rp (calc)	%
199	15,500	14,500	—6.45
201A	11,000	12,900	+15.4
226	9,400	8,700	—7.45
112A	5,000	5,400	+8.0
171	2,000	1,750	—12.5
210	5,000	4,825	— 3.5
250	2,100	1,430	—32.0

Another set of empirical formulas appeared in October *Proceedings* I.R.E. and were developed in the Hazeltine Laboratories by Harold A. Wheeler. They relate to the inductance of three types of coils illustrated in Fig. 1. The inductance of the coils may be calculated with good accuracy by using the formulas on the diagrams.

For example, the formula for the multi-layer coil is accurate to within 1 per cent. if the three terms in the denominator are about equal, the formula for the solenoid inductance is accurate to 1.0 per cent. if the length of winding is greater than 0.8 times the diameter, and the formula for the single-layer spiral or helical coil is accurate to 1.0 per cent. if the dimension (c) is greater than 0.2 the dimension (a). All of the dimensions must be in inches to be used in these formulas. The inductance of such coils may be computed with one setting of this slide rule, and without consultation of complicated tables or correction factors.—KEITH HENNEY

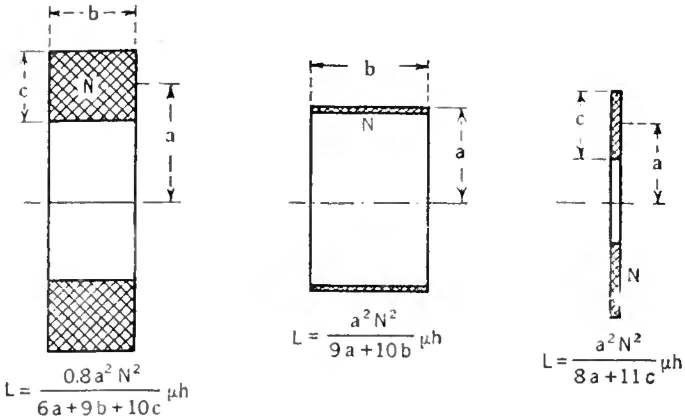


FIG. 1

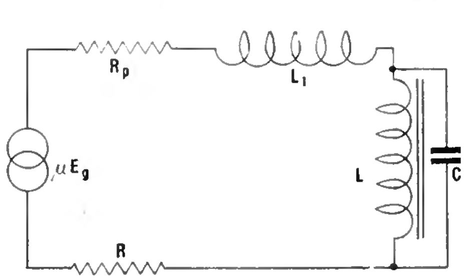


FIG. 2

A Simple A.C. Operated Tube Tester

By THE LABORATORY STAFF

THE following description of a simple tube tester will be interesting to service men and others who have occasion to doubt the efficiency of a tube. The tester determines the mutual conductance of the tube, that is, the amount of plate current variation with a given change in grid bias, but will not indicate whether the tube is microphonic, noisy, gassy or, suffering from other common ailments. The tester may be plugged into any a.c. socket, provided the voltage and frequency have the values for which the transformer is designed.

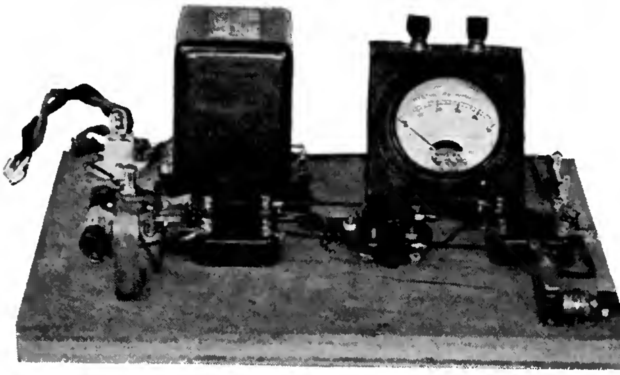
The circuit diagram shows a transformer which has all standard filament voltages, including 7.5 for power tubes. In the Laboratory it is seldom necessary to test tubes of this sort so a socket for them was not included in the set-up shown in Fig. 2. A resistor in the center-tap circuit (and the cathode of heater-type tube) provides a C bias for the tube. A switch short circuits part of this resistor in order to change the C bias and thus to change the plate current. The mutual conductance is the ratio between the corresponding plate current and grid voltage changes.

The circuit diagram and the picture show clearly how the parts of the tester are connected together. The list of apparatus includes only standard material, but any other similar units may be used, of course.

In operation, the tube is placed in the socket and the tester is plugged into a lamp socket. This lights the filament and puts a voltage on the plate. Current flowing in the plate circuit is read on the meter, M, and in returning to the center of the filament—or the heater—passes through the biasing resistors, R_1 and R_2, which are connected in series. The values of these resistors are known; in this case the total resistance is 4000 ohms. Then the resistor R_1 is shorted and the plate current increases because the bias on the tube is reduced. The difference between the two plate currents as read by the meter, divided by the difference between the two grid-bias potentials gives an estimate of the mutual conductance. The bias on the tube is calculated by multiplying the plate current by the biasing resistance in the circuit. As an example let us give the values obtained in the Laboratory when a 201A-type tube was tested. With a C-bias resistance of 4000 ohms (3500 plus 500) the plate current was 1 milliampere. When the 3500-ohm resistor was shorted the plate current increased to 3.1 milliamperes. The two biases were, then, $4000 \times 0.001 = 4$ volt and 500×0.0031 or 1.55 volts. The mutual conductance is

$$G_m = \frac{I_{p1} - I_{p2}}{E_{g2} - E_{g1}} = \frac{.0031 - .001}{4 - 1.55} = \frac{.0021}{2.45}$$

$$= 860 \text{ micromhos}$$



VIEW OF A.C. TUBE TESTER

THE tube tester described on this page may be used for checking the mutual conductance of any standard a.c. or d.c. tube. The tester is plugged into a 110-volt light socket and no batteries of any kind are required. Incidentally, the mutual conductance is the only important characteristic of a tube which it is necessary for a service man to check.

—THE EDITOR

ACCURACY OF TESTER

THE value of mutual conductance obtained by this tester is not very accurate because each change in grid-bias resistance changes the plate voltage as well as the plate current and the definition of G_m involves holding the plate voltage constant. In the Laboratory, however, several tubes were tested and the values of mutual conductances compared with values obtained on a bridge when the tube was operated at standard values of bias and plate voltage. The results outlined below show that the accuracy is all that is desired for practical purposes.

Tube type	No. tested	% accurate
226	4	93%
201A	5	78%
112A	3	90%
171A	3	89.5%

The meter used was a Model 301 Weston, 0-5 milliamperes. A shunt, R_3, is provided to reduce the sensitivity of the meter by a factor of three, so that its full-scale reading is 15 milliamperes. A switch removes this shunt when desired so that lower currents may be read more accurately. The switch has a spring in it so that the meter is always shunted until the operator deliberately removes the resistor, R_3. The value of the resistor varies with the meter, of course, but a rheostat may be placed across it and adjusted until any desired multiplying factor is secured. Then the wire of the rheostat used may be cut off and fixed in position. Between 3 and 4 ohms were required with the Weston meter.

A small flash lamp is connected as a fuse in series with the a.c. line to the plate of the tube to prevent an accident in case of a short circuit. Incidentally, the meter is in a very dangerous position in the circuit and it might be wise to place a short-circuiting strip of wire across its terminals. Of course, after the tester has been connected properly the strip should be removed. However, such a complication was not considered necessary in the Laboratory and the mortality of meters has been nil.

The operator will learn very quickly from experience the proper value of G_m for all standard types of tubes. Then, when tubes fall below this value they should be rejected or rejuvenated. He might, as an example, take a new tube, a very bad tube, and an old tube which still gives good signal strength. He can test them on this device and record their mutual conductances. Any tube which approaches the very bad tube should be rejuvenated or thrown away.

LIST OF PARTS

THE parts actually used in the construction of the tester are as follows:

T_1 One Silver-Marshall filament transformer, type 325;
R_1 One Ward-Leonard fixed resistor, 3500-ohm, type 507-56;
R_2 One Ward-Leonard fixed resistor, 500-ohm, type 507-17;
R_3 One Frost resistor, 4-ohm;
R_4 One General Radio center-tapped resistor; type 439;
Sw_1 One Frost filament switch;
Sw_2 One jack switch, S.P.D.T.;
One dial light and socket;
Two Frost sockets, UX-type;
One Benjamin socket, UY-type;
One wooden baseboard.

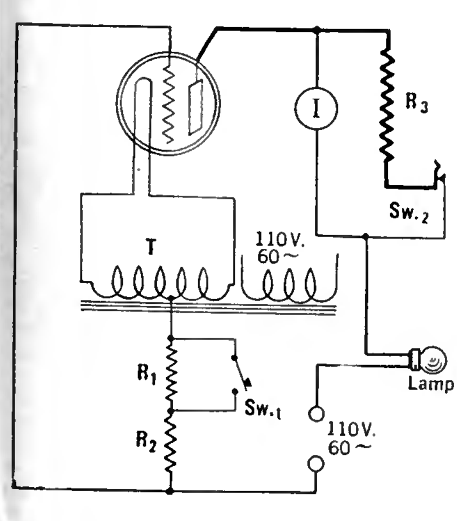


FIG. 1

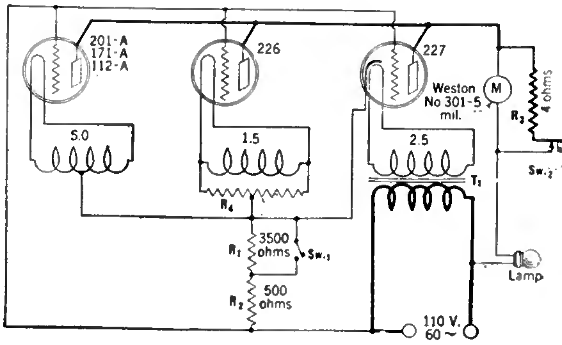


FIG. 2

Digitized by Microsoft®

The Isotone Screen-Grid "Super"

By DUDLEY WALFORD

THE ISOTONE IN A PHONOGRAPH-RADIO CABINET

This receiver was designed for use either as a radio set or a phonograph amplifier, and, when installed in a cabinet of the type illustrated, full advantage is taken of its dual entertainment value

ESSENTIALLY, there are very few different types of radio receivers, and of these the super-heterodyne is unique in that it is the only one in which the number of circuits which must be tuned to the frequency of the received signal is not made greater with an increase of amplification. In an ordinary tuned radio-frequency receiver, if we wish to obtain more gain, we have to provide additional tubes and tuned circuits, and in operating the receiver it is necessary that these circuits always be adjusted to resonance with the wavelength of the particular station we desire to receive. In a super-heterodyne most of the amplification takes place in the intermediate-frequency amplifier which always operates at the same frequency and therefore, does not have to be adjusted when receiving signals of different frequencies. This is one of the major advantages of the super-heterodyne receiver, and one of the most important parts in such a receiver is the intermediate-frequency amplifier, for upon its characteristics depend the sensitivity and selectivity of the set.

Accurate matching during manufacture of the transformers in an intermediate-frequency amplifier is not very difficult if the intermediate-frequency is low, say 30 to 60 kc. On the other hand, the disadvantage of using a low intermediate frequency in an ordinary super-heterodyne is due to the phenomenon of so-called "repeat points" by which it becomes possible to tune in most local stations at many points on the dial. A super-heterodyne can be made essentially "one spot" by the use of a high intermediate frequency, but at such frequencies the effect of tube capacities, etc., becomes important and accurate matching of the intermediate-frequency transformers during manufacture is not always possible. When using a high intermediate frequency it is of advantage, therefore, to so arrange the transformers that they may be manually adjusted to the point of maximum sensitivity after the receiver has been completely constructed. Such transformers are used in the H. F. L. Isotone receiver described in this article. The following paragraphs will discuss in more detail the technical characteristics of this set.

Fundamentally, the Isotone is a standard screen-grid super-heterodyne utilizing nine tubes. There is an additional tube which is used when the instrument is employed for phonograph reproduction. The ten tubes of the set are distributed in the following manner: one 201A-type first-detector tube, one 201A-type oscillator tube, three 222-type intermediate-frequency tubes, one 112A-type second-detector tube, one 112A-type phonograph-amplifier tube, one 112A-type first-stage a.f. tube, and two 171A-type push-pull a.f. tubes.

The set itself is composed of four main units, namely, the front tuning unit, the screen-grid intermediate-frequency amplifier, the audio-frequency amplifier, and the control box. The wiring and testing of these four units is done at the factory; each piece of each individual unit undergoes several tests and then the entire unit is tested.

THE H. F. L. Isotone described in this article is very different from the standard design of super-heterodyne kit. Whereas the usual set of this type requires many long tedious hours for its construction, the ten-tube Isotone may be completely assembled and placed in operation in less than one hour! This is made possible by the use of wired units which the set-builder fastens to the chassis and wires into the circuit. The design of the set is such that it is almost impossible to make a mistake, and the necessary circuit adjustments are easily accomplished. The Isotone is also efficient when used as a phonograph amplifier.

—THE EDITOR.

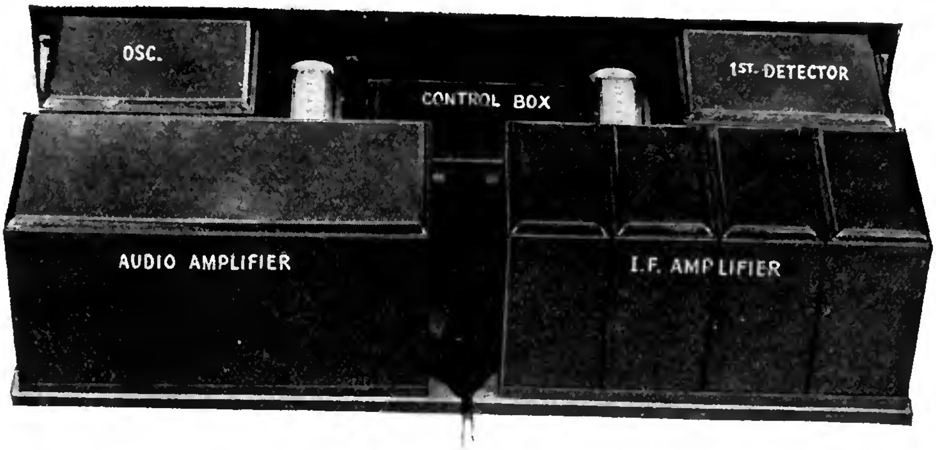
One of the main features of the receiver which is not apparent from the schematic diagram is the operating frequency of the intermediate-frequency amplifier which is 475 kilocycles. Most set-constructors are by this time aware of the fact that such a frequency allows the receiver to be tuned as a "one-spot" instrument and does away with many of the annoying repeat points on the dial. When such a high frequency is used, it is absolutely necessary, as mentioned previously, that the intermediate-frequency transformers be furnished with a means of compensating the various tube capacities and the capacities of the wiring in the receiver.

The tuning of each transformer in this set is accomplished by two condensers—one of these, a small mica condenser, C_1, having a fixed value of 0.0001 mfd., is connected permanently across the secondary of each intermediate-transformer, T_1, T_2, T_3 and T_4, and the other, a small variable condenser, C_2, having a variable capacity of 0.000025 mfd., is connected in shunt with the fixed condenser, C_1. This system of manually tuning the four transformers allows one to adjust the intermediate-frequency amplifier easily to the point of maximum sensitivity and selectivity.

In the shield compartments of the intermediate-frequency amplifier are the four transformers, their associate tubes, sockets, resistors, tuning condensers and twelve 0.5-mfd. by-pass condensers. The twelve by-pass condensers are of extreme importance in the proper operation of the amplifier. While their use increases the cost, the results seem to justify the expenditure, for the operation of the amplifier is perfectly stable, and oscillations cannot be produced under any normal operating condition.

Immediately to the right of the screen-grid amplifier we see the completely shielded audio section of the Isotone. This consists of four transformers, four sockets, a by-pass condenser, a series resistor and the necessary input and output tip jacks. The first transformer, T_5, in the amplifier section is in the output circuit of the phonograph pick-up unit; it has a turns ratio of 1 to 1. When the set is being used as a radio receiver, this transformer and its associate tube is switched entirely out of the circuit by the automatic control switch, S.

By referring to the schematic diagram, it will be seen that the plate voltage to the phonograph tube, and also to the second-detector tube, is supplied through the resistor, R_1, connected between B-plus terminal of the first audio-frequency transformer and the 135-volt supply lead. This resistor is bypassed by a 1-mfd. condenser. The audio-frequency transformer, T_6, has a ratio of 5 to 1, and the input transformer, T_7, to the push-pull circuit has a ratio of 2 to 1. The schematic diagram shows that the output of the loud speaker is taken from opposite ends of the high-impedance choke, L_1.



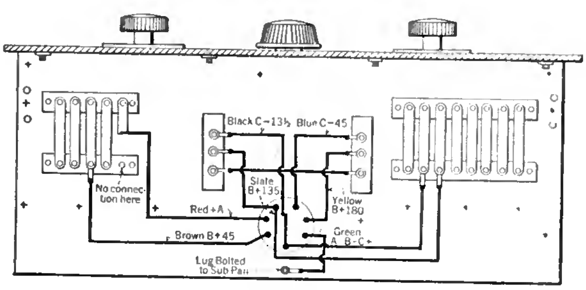
VIEW OF COMPLETED RECEIVER

This picture of the Isotone shows the set with shields in place. It may be noted that the receiver consists of five units which are mounted on a steel chassis

THE TUNING UNIT

THE long unit immediately in front of the two amplifiers contains the tuning circuits. This unit consists of the antenna-tuning stage at the left, the oscillator at the right, and in the center are located the control resistors and the automatic ballasting switch. The antenna-tuning circuit is equipped with detachable leads to the coil, L_2—a highly desirable feature inasmuch as it permits the operation of the set on either a loop or an outside antenna. Ordinarily the instrument is set up for loop operation, but the operator may employ an outside antenna by simply plugging the three flexible connections from the coil into three tip jacks in the antenna compartment. The antenna may then be connected directly to the antenna binding post. This circuit is tuned by the condenser, C_3, having a capacity of 0.000475 mfd., and the inductance of the coil L_2 is such that the dial reading of C_3 will coincide with those of the oscillator tuning dial, C_4, when the two dials are properly matched by means of a small midget condenser, C_5, in the oscillator circuit. These two dials may then be operated with readings almost exactly the same over 85 per cent. of the dial. The oscillator circuit is tuned by a condenser, C_4, having a capacity of 0.00025 mfd. The r.f. heterodyne voltage is transferred from this circuit to that of the antenna circuit through the pick-up coil, L_3, which is connected to the center-tap terminal of the loop antenna (or L_2 if an antenna is used).

The controlling devices for the receiver are located in the small metal compartment situated between the two drum dials in the center of the front tuning unit. This metal compartment houses a special wire-wound potentiometer, R_2, having a value of 25,000 ohms and serving as a voltage divider in the screen-grid circuits. This control allows any potential from 0 to 67½ volts to be placed upon the screen grids of the tubes. The other variable control is a 500,000-ohm volume-control potentiometer, R_3, which is connected across the secondary of the first audio-frequency transformer.



PICTURE WIRING DIAGRAM

The design of the Isotone is such that its construction may be accomplished in less than one hour. The simplicity of wiring is indicated in this diagram which shows all connections which it is necessary for the set-builder to make in order to complete the circuits of the five individually wired units

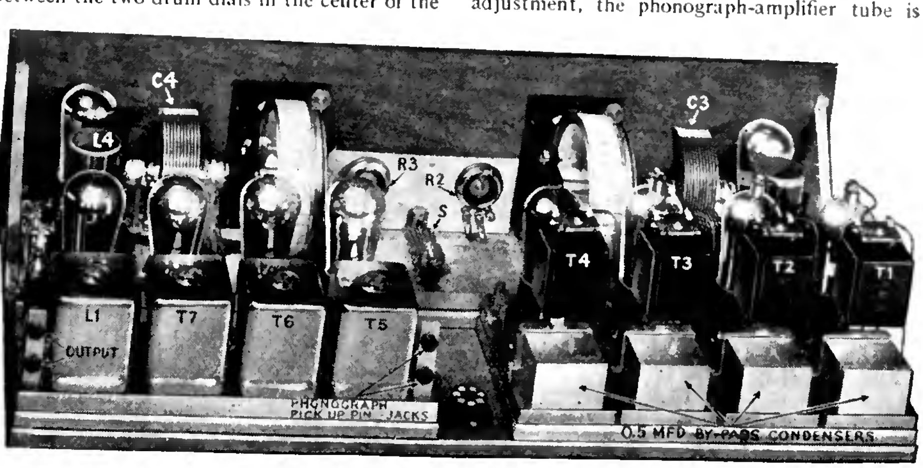
The switch, S, in the center handles several operations. In one position it automatically connects all of the circuits required to make the Isotone operate as a radio receiver. With this adjustment, the phonograph-amplifier tube is disconnected from the circuit. In the reverse position the Isotone operates as a phonograph amplifier; the switch connects only the last four tubes of the instrument, or the audio amplifier, and at the same time disconnects the remaining six tubes in the radio section of the set.

One of the interesting features of the controlling system is the 6.6-ohm resistor, R_4, which is automatically connected across the filament-supply circuit when the audio amplifier is being used for phonograph work. The extreme desirability of this arrangement is appreciated when it is realized that this ballast resistor has a load characteristic which corresponds with that of the six tubes which are disconnected when the set is being used for phonograph reproduction. This permits the use of an A-power unit and the voltage supplied to the tube remains steady at all times, regardless of the position of the control switch. If it were not for this ballast resistor, the filament voltage would jump suddenly upward when the six tubes were disconnected, and the remaining four tubes in the audio amplifier would be subjected to a filament potential considerably above their rating.

ASSEMBLY AND WIRING

THE assembly of an Isotone receiver is such a simple procedure that even a novice set-builder would not experience difficulty with the task. The main steel base plate is supplied with all necessary holes punched in the proper positions. The assembly operation is started by simply placing the three main units down on the base plate and securing them in position by means of a few nuts and bolts. Slots have been cut in the base plate and the terminal strips of the individual units protrude down through the slots.

The positions of the terminal strips are such that when the three units are mounted in their respective positions, practically all of the connections can be made by means of metal connecting strips which are furnished with the kit. Therefore, it is only necessary for the constructor to slip the thirteen metal connecting strips down over their respective bolts and tighten them on by means of nuts. The wiring is then completed by running the power connections from the cable receptacle to the proper points on the terminal strips. There are ten wires to be connected in all. The above describes all of the connections which it is necessary for the assembly of the receiver. There is ½" of space between the bottoms of the individual unit base pans and the top of the



VIEW OF SET WITH SHIELDS REMOVED

The arrangement of apparatus on the chassis of this receiver is shown clearly in the above picture. The symbols used for the purpose of identifying parts correspond with those used in the text, list of parts, and schematic diagram main foundation base plate. All of the wiring in the receiver (with the exception of the external power leads), is placed within this ½" of space.

Originally the H. F. L. Isotone was designed as a battery-operated receiver. The engineers realized that, while electric operation was highly desirable, a satisfactory receiver would have to be built around direct current tubes. Tubes of the a.c. type, and particularly those of the a.c. screen-grid type, are not considered by the writer to be conductive to the best possible results.

Therefore, in designing the Isotone particular attention was paid to stability, ease of operation, and economy in operaion. When a receiver was realized on a direct-current basis which furnished these desirable factors, it was decided that the practical way of electrifying such a set would be by a dry power-supply unit furnishing all A, B and C voltages.

THE POWER UNIT

This power unit, which was designed especially for use with the Isotone receiver, supplies all necessary grid, filament, and plate potentials. The A current is obtained from a dry rectifier unit, and a 280-type tube is employed to provide the B voltages

POWER SUPPLY UNIT

THE Model 5 ABC power supply was designed as a special current-supply device for the H. F. L. Isotone. The A voltage is furnished by an Elkon dry rectifier unit operating in conjunction with large filter chokes. The power supply also furnished plate potentials of 50, 135 and 180 volts for the plate circuits of the various tubes. In addition to these voltages there is also a connection marked "90 volts" which has an individual variable resistor as its controlling device. From this terminal any voltage from 0 to 180 volts may be obtained. Thus, the unit will deliver a set of voltages which will operate practically any receiver in existence to-day.

Regarding the performance of the receiver. In an actual test in the City of Chicago on October 22nd, 1928, the Isotone brought in station PWX, Havana, Cuba, with full loudspeaker volume for a period of one hour starting at nine p. m. Central Standard Daylight-Saving Time. The temperature at this time was around fifty degrees, and it is estimated that at this same hour over twenty seven local stations were operating.

LIST OF PARTS

THE Isotone receiver is sold only in semi-completed form as described in this article; that is the various units are supplied completely assembled and wired. However, it may be well to list the actual parts of the H. F. L. kit just as they come to the set-builder:

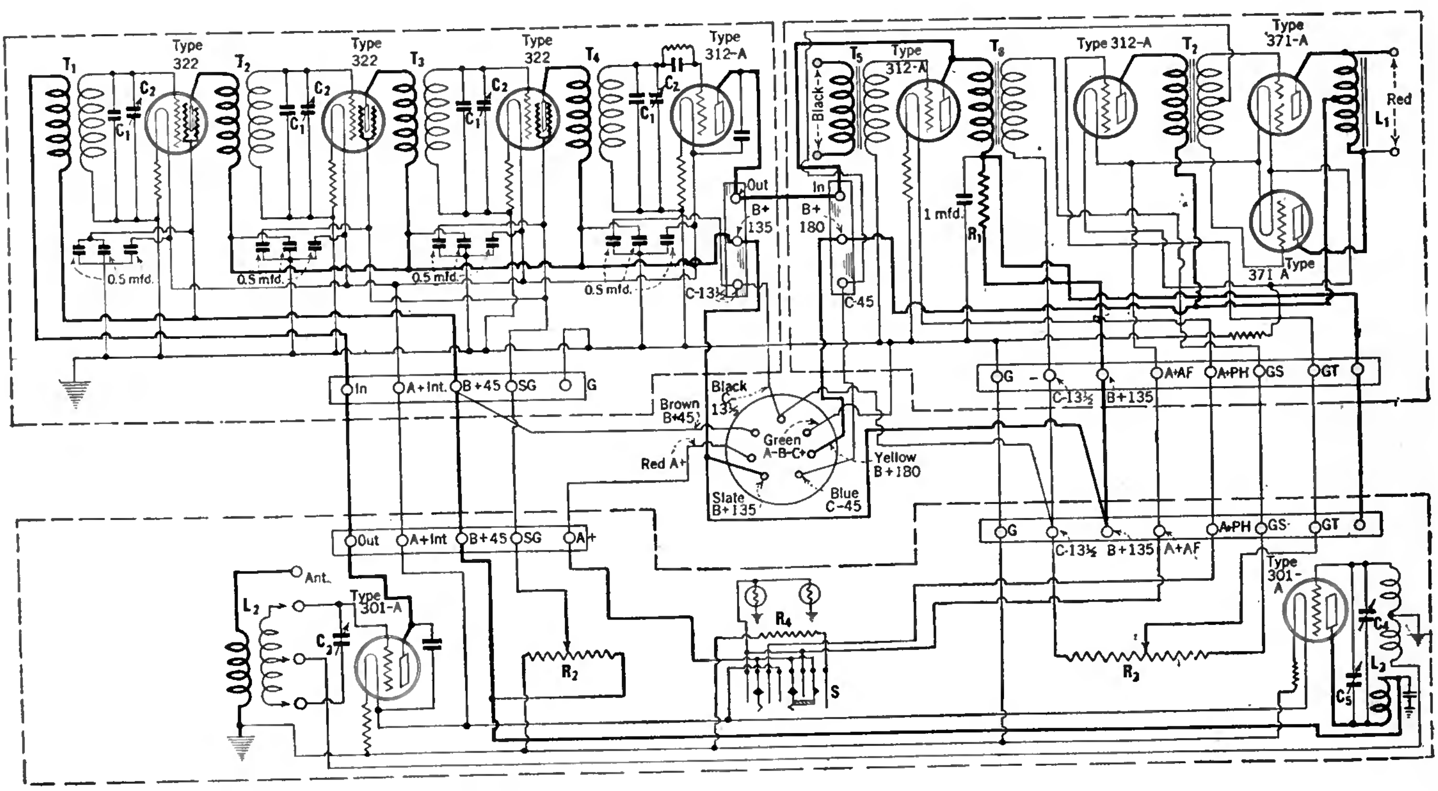
One assembled and wired tuning unit;
One assembled and wired screen-grid amplifier;
One assembled and wired audio amplifier;
Eight shield cans with tops;
One base assembly plate;
One drilled and engraved front panel;
One seven-wire cable and socket;
Two gold escutcheons with knobs (attached);
Two dial lights (inside of drums);
Two large walnut switch knobs;
One small walnut switch knob;
Two steel panel supporting brackets;
Twelve plated connecting strips;
Fifty-five 6–32 hexagon brass nuts;
Fourteen ⅜-inch hexagon spacer studs;
Fourteen ¾ by 6–32 inch R.H. machine screws;
Six ¼ by 6–32 inch F.H. black machine screws;
Four ⅜ by 6–32 inch R.H. machine screws;
Eleven tinned copper lugs;
Six feet push-back wire.

Assuming A.C. operation, the constructor will require the following accessories;

Three 222-type tubes;
Three 112A-type tubes;
Two 171A-type tubes;
Two 201A-type tubes;
One Model 5 ABC power supply;
One 280-type tube (for the power supply);
One Pacent phonograph pick-up unit (optional);
One loop antenna.

For D.C. operation the following batteries will be required:

One 6-volt storage battery (120-ampere hour);
Two 22½-volt C batteries;
Four 45-volt heavy-duty B batteries.



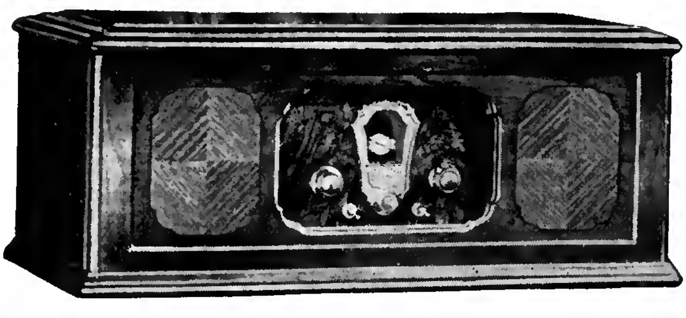
COMPLETE SCHEMATIC DIAGRAM OF RECEIVER

Although the five basic units of the Isotone receiver are supplied completely wired by the manufacturer, this diagram shows the circuit of the entire set. The peculiar arrangement of the diagram will be found a great aid to the set-builder when constructing the set, as it follows closely the mechanical arrangement of the parts. The dotted lines of the diagram enclose the shielded circuits

No. 15. January, 1929.

Radio Broadcast's Service Data Sheets

The Bremer-Tully 8-20 Radio Receiver



THE Bremer-Tully model 8-20 receiver consists of four stages of radio-frequency amplification followed by a detector and a two-stage audio amplifier.

TECHNICAL DISCUSSION

1. Tuning System

There are four main tuned circuits in the receiver, consisting of L_1C_1, L_2C_2, L_3C_3 and L_4C_4. The fifth tuned circuit, L_5C_4, is in a sense a wave trap; it is not connected between the grid and filament of the first r. f. tube as the first tuned circuit generally is, but instead is coupled to the small primary coil L_6 which is connected between the grid and filament of the first r.f. tube. It should be noted that the leads from the neutralizing condensers to the grid circuits are not connected directly to the grid of the tube, but instead are connected to a tap on the secondary coils at a point a few turns from the grid end of the coil, the designers of the receiver having determined that with such a connection the receiver is neutralized more easily over the entire broadcast band. Type 226 tubes are used in all the r. f. stages, with about 100 volts of plate potential.

2. Detector and audio system.

A leak-condenser-type detector is used, the grid leak resistor, R_1, having a resistance of 3 megohms and the grid condenser, C_{11}, having a capacity of 0.00025 mfd. The detector tube is a 227-type with about 45 volts on the plate, and its output contains a 0.006-mfd. condenser, C_{12}, to bypass the r. f. currents directly to the cathode. The r. f. choke, L_7, also helps to keep the r. f. currents out of the a. f. amplifier where they might cause distortion. The choke coil, L_7, connects, through the phonograph jack, J, to the first audio transformer, T_1.

3. Volume control.

The resistor R_4 is the volume control, and it will be noted that it is actually connected across the grid-filament circuit of the first r. f. tube and also in series with the plate circuit of the second r.f. tube. When the movable contact on the volume control is at the position of maximum volume (2) all the resistance is connected between the grid and filament of the first tube and there is zero resistance in the plate circuit. As the arm is moved toward the other end (1), the resistance connected between the grid and filament of the first tube is gradually reduced and at the same time the resistance in the plate circuit is proportionally increased.

4. Filament circuits.

Filament current for the various tubes in the receiver is supplied by several filament windings on the power transformer located in the power-supply device, the 226s being supplied with 1.5 volts, the 227s with 2.5 volts and the power tubes with 7.5 volts. Across secondaries S_1 and S_2 are placed center-tapped 8-ohm resistors, it being necessary to connect all the grid and plate returns to a center point of the filament circuit to prevent hum. Similarly a 15-ohm resistance is connected across the 2.5-volt filament winding, S_4, supplying the 227-type tubes and a 40-ohm resistance across the 7.5-volt filament winding, S_5, which supplies the 210-type tubes.

5. Plate circuits.

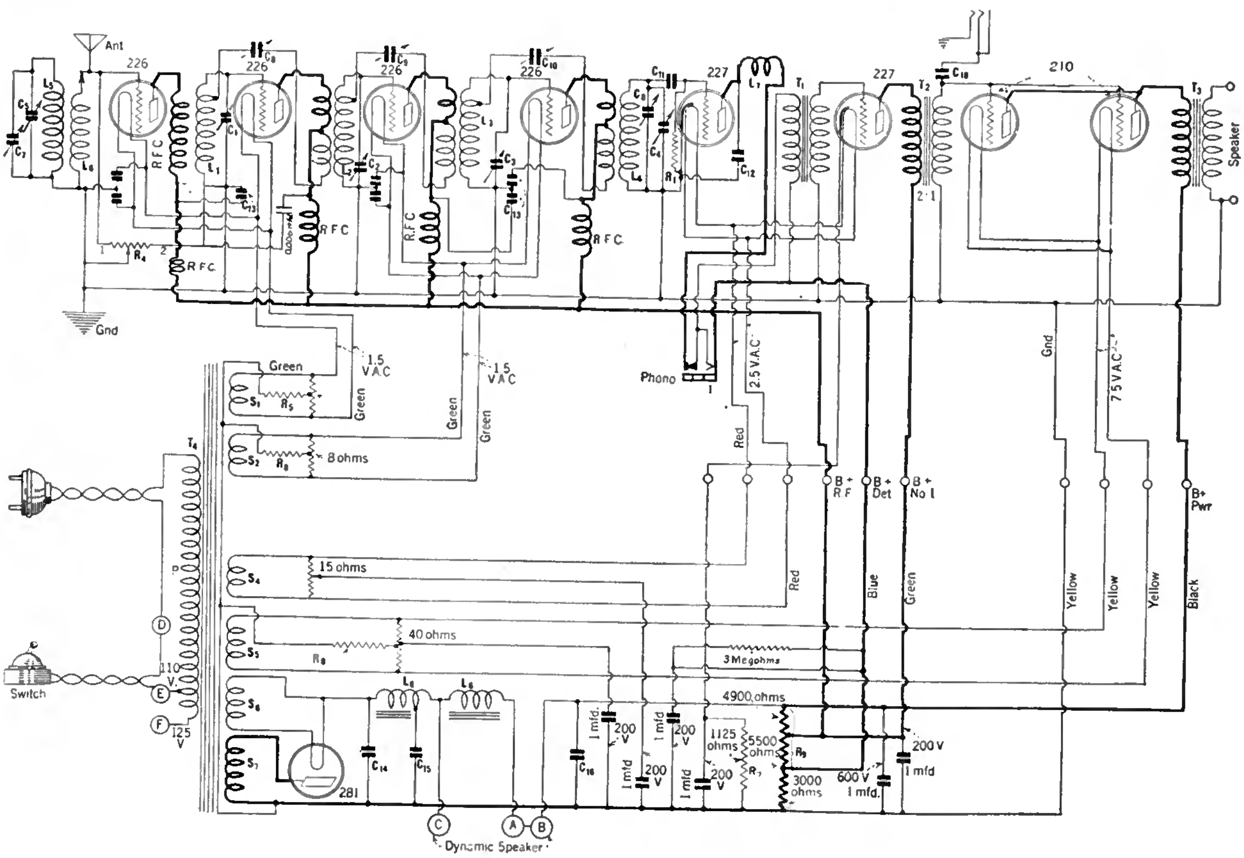
The plate circuit of each r. f. tube contains an r. f. choke, marked R.F.C. on the diagram, to prevent any of the r. f. currents passing into the plate-supply device. The by-pass condensers, C_{13}, are connected from each r. f. choke to ground. All of the r. f. tubes are supplied with the same plate potential, and the other plate leads connected between the receiver and the power supply furnish voltage to the detector and audio amplifier tubes.

6. Grid Circuits.

All tubes in the receiver are biased by connecting resistors of the correct value between the center points of the filament circuits and negative B. Grid bias for the first two r. f. tubes is obtained by the voltage drop across a 770-ohm resistor, R_5. The drop across this resistance is about 6 volts. A similar resistance, R_6, supplies grid bias to the third and fourth r. f. tubes. Grid bias for the first audio tube is furnished by the 1125-ohm resistance, R_7, and grid bias to the power tube is obtained from the resistance, R_8, which has a value of 770 ohms.

7. Power supply.

The power-supply transformer, T_4, contains a primary winding, P, tapped for line voltages of 110 and 125, and six secondary windings. A 281-type half-wave rectifier is used. The filter system consists of the two choke coils, L_8 and L_9, and the 2-mfd. filter condensers, C_{14}, C_{16}, and C_{16}. C_{14} has a voltage rating of 800 volts, and C_{15}, and C_{16} each have a rating of 600 volts. The filter circuit is ordinarily closed by terminals A and B in the power supply. If, however, a dynamic loud speaker is to be used, and the field of this speaker is to act as one of the filter choke coils, then the connecting link between A and B is removed and the terminals from the field winding of the loud speaker are connected to terminals B and C. The output of the filter system is fed directly to the plate of the 210-type tube. After reduction by the resistor, R_9, the voltage is correct for application to the plates of the r. f. detector and first audio tubes. One-mfd., 200-volt, by-pass condensers are connected as indicated on the diagram between negative B wire and various points in the circuit. They prevent coupling which might cause distortion. The power to the receiver is completely controlled by the switch connected in the primary of the power transformer.



CIRCUIT DIAGRAM OF RECEIVER AND POWER UNIT

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No. 16. January, 1929.

Radio Broadcast's Service Data Sheets

The Freshman Model Q Receiver

MODEL Q

THE model Q Freshman receiver is unusual in that it employs a 222-type screen-grid tube in the r.f. amplifier. The 222-type tube used is one designed for d.c. operation, but in this receiver it is operated on alternating current. The single screen-grid stage of radio-frequency amplication is followed by the usual 227 heater-type a.c. detector, the first audio stage with a 226-type tube, and a 171A-type power tube.

TECHNICAL DISCUSSION

1. Tuning system.
This receiver contains only two tuned circuits, L_1C_1 and L_2C_2, and both of the tuning condensers are ganged to a single control. A small midget condenser, C_3, with a maximum capacity of 50 mmfd., is connected in series with the antenna. The two tuning controls, i.e., the main dial controlling C_1 and C_2, and the vernier adjuster controlling C_3, are interdependent and a slight change in one necessitates a change in the other. It should be noted that the plate of the detector tube connects through a fixed condenser, C_4, to the lower end of the inductance, L_2. The r.f. currents in the plate circuit must, therefore, pass through C_4 to the lower end of L_2 and hence through C_5, with a capacity of 0.02 mfd., to ground. These currents in the plate circuit of the detector which flowing through the condenser C_5, connected in the grid circuit of the detector, thereby impress on the grid circuit of this tube a small voltage and causes regeneration which increases the gain of the receiver.

2. Detector and audio system.
The grid-rectification detector in this receiver, using a grid leak, R_1, with a value of 2 or 3 megohms, and a grid condenser, C_4, with a value of 0.00025 mfd., is followed by a two-stage transformer-coupled amplifier with a 226-type tube in the first a.f. stage and a 171A-type tube in the power stage. C_5 with a capacity of 0.02 mfd. is part of the regenerative system mentioned in the preceding section.

3. Volume control.
The volume control consists of a variable resistance, R_2, connected between antenna and ground, and in this position it serves to regulate the amount of energy supplied to the first r.f. amplifier.

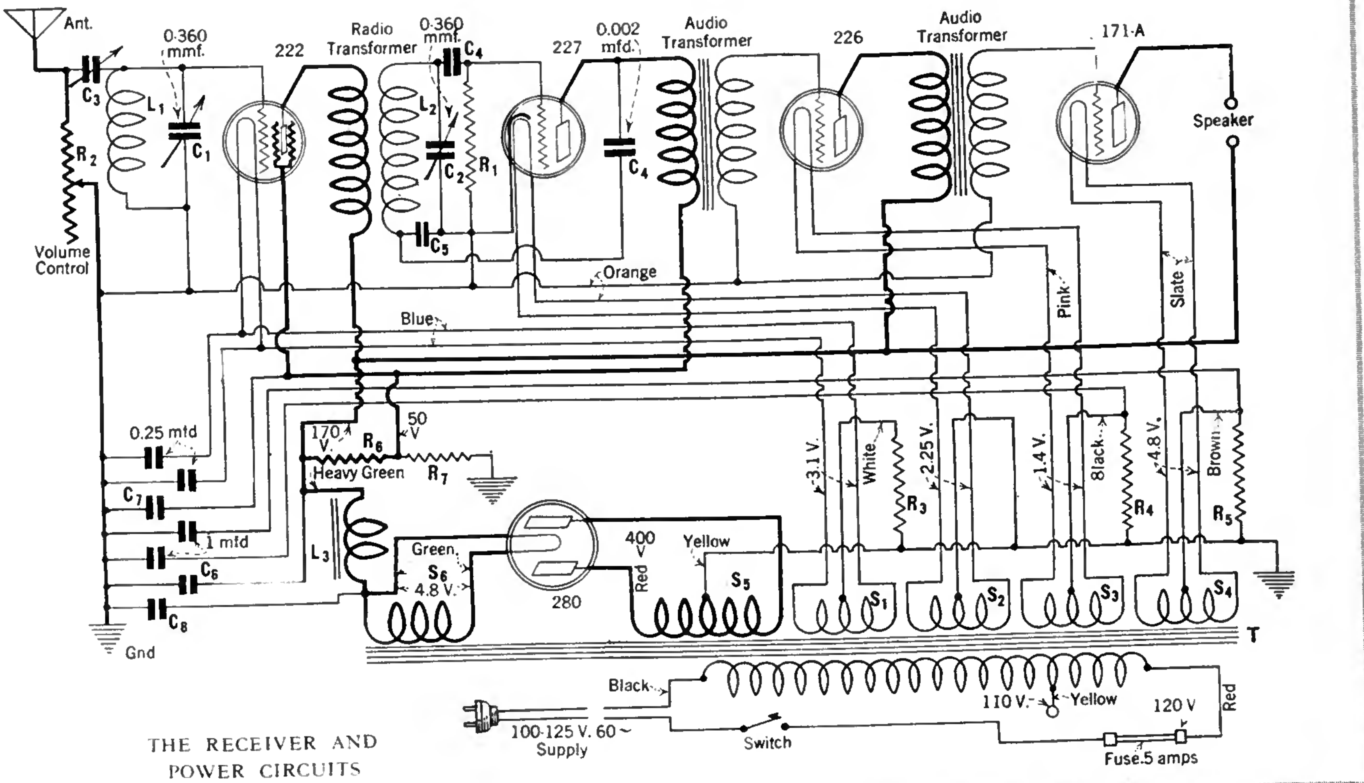
4. Filament circuits.
Since four different types of tubes are used in this receiver it is necessary that the power-supply transformer contain four separate filament windings. A 3.1-volt winding, S_1, supplies the 222-type r.f. amplifier, a 2.25-volt winding, S_2, supplies the 227-type detector tube, a 1.4-volt windings, S_3, supplies the 226-type audio amplifier and a 4.8-volt winding, S_4, supplies the 171A-type power tube. It is interesting to note that all of these voltages are somewhat lower than the rated filament voltages of the tubes they supply. These low voltages are used because it has been found that the various tubes will give satisfactory emission with these potentials and that their life will be greatly increased.

5. Plate circuits.
The plate of the 222-type tube is supplied with 170 volts, the detector with 50 volts, and the first audio and second audio tubes with 170 volts. The screen-grid of the r.f. tube is supplied with 50 volts. It will be noted that the 170 volts with which the plates of the r.f. tube and first audio tube are supplied is considerably above the maximum value specified by the standard tube manufacturers. The reason for the use of these high voltages is probably that the hum in the output of the receiver is less than with rated voltages, due to the fact that with high plate voltages high values of grid bias can be used and as a result the modulating effect on the grid circuits of any a.c. hum voltages is proportionately less. All the plate circuits are bypassed to ground with fixed condensers.

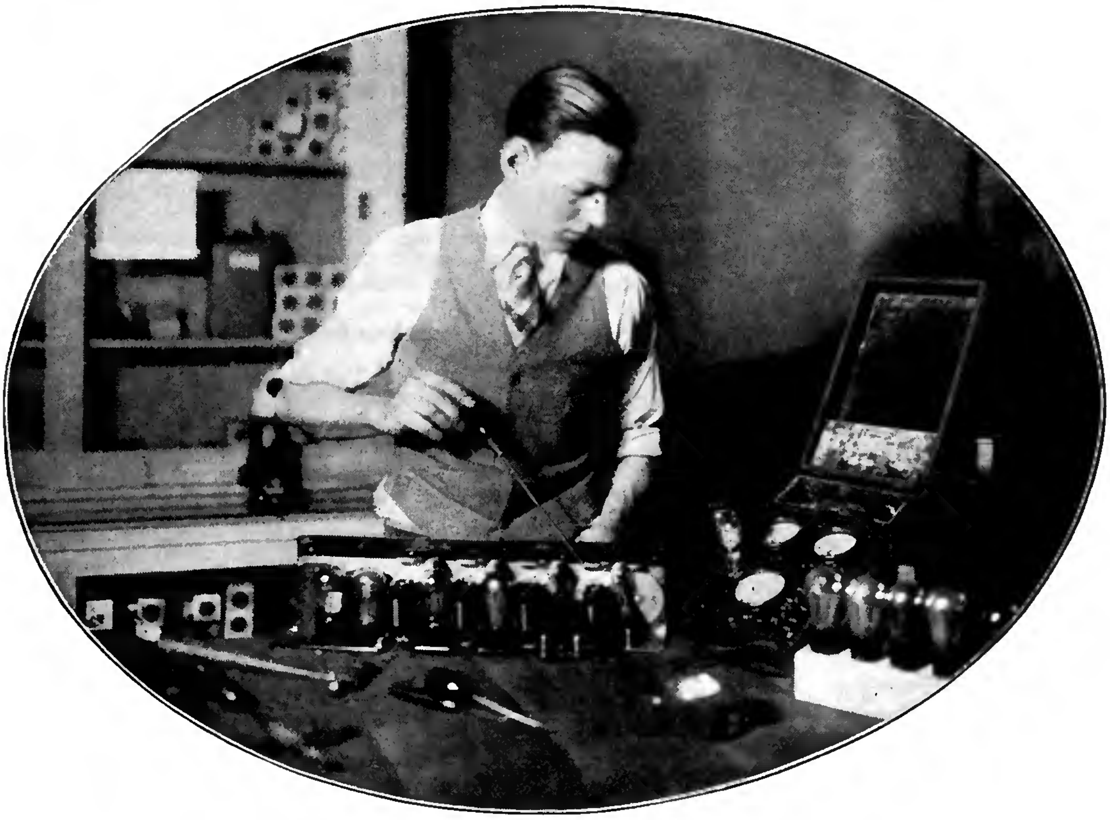
6. Grid circuits.
Grid bias for the various tubes is obtained from resistors connected in series with the center taps of the various filament windings on the power transformer. The 3.1-volt winding supplying the 222-type tube has in series with its center tap a fixed resistance, R_3, which supplies a negative potential of approximately 2.5. volts to the control grid of the r.f. tube, There is no bias on the grid of the detector tube except that due to grid current flowing through the grid leak, R_1. The 226-type audio amplifier tube obtains grid bias from the 1800-ohm resistor, R_4; the voltage drop across this resistance places a negative bias of about 10 volts on the grid of this tube. Negative bias on the grid of the power tube is approximately 35 volts and is obtained from the voltage drop across the resistance, R_5.

7. Power supply.
A 280-type full-wave rectifier is used in the power supply, this tube being supplied with 400 volts from the secondary winding, S_6, and 4.8 volts on the filament from S_5. The output of the tube feeds into the filter system consisting of a single choke coil, L_3, and the two condensers, C_8 with a capacity of 2 mfd., and C_6 with a capacity of 4 mfd. C_8 has a rating of 2000 volts and C_6 has a rating of 1000 volts. It should be noted that condensers of a far higher voltage rating than is actually applied to them are used in order to insure long life without danger of break down. The output of the filter circuit supplies the plates of all of the tubes except the detector, and by use of the voltage dividing resistors, R_6 and R_7, the maximum output potential is reduced to 50 volts for the plate of the detector tube and the screen grid of the 222-type tube. R_6 has a value of 12,500 ohms and R_7 is a 10,000-ohm resistor.

Note: As this issue goes to press we are informed that the Freshman Model Q receiver has been superseded by the model 3Q. The new receiver employs an additional tuned circuit—THE EDITOR.



THE RECEIVER AND POWER CIRCUITS



SERVICING A RADIO RECEIVER

Servicing Home-Made Radio Receivers

By B. B. ALCORN

The third installment of a series of articles discussing the problems of a radio service man

IN THE repair of radio receivers the service man is confronted with two different types of problems; one manner of trouble is to be expected in the modern factory-built set, but it is impossible to anticipate the sort of defect which may be discovered in a home-assembled outfit. Fortunately, however, the man who "rolls his own" is not easily discouraged—he does not surrender to the extent of requesting the aid of a service man until he has exhausted his ideas as well as those of his friends.

In the October article of this series there were listed, in the order of their importance, the causes of trouble experienced in the servicing of factory-made receivers. These disorders as well as others are encountered in home-made sets. However, very frequently when called upon to service sets of this type the poor results will be found to be caused by (1) the use of an incorrect, inefficient, or tricky circuit, (2) carelessness in wiring or assembling of parts, (3) the use of poorly selected apparatus, (4) improper arrangement of apparatus and wiring, and (5) all sorts of peculiar conditions which are the result of lack of knowledge on the part of the novice set-builder.

From the remarks given in the above paragraph it may be appreciated that in some cases, in order to make the set operate properly, it is only possible to salvage the apparatus and rebuild. However, the usual radio fan is not supercritical when regarding his own work; as a result a simple repair which will cause the set to operate—even if the performance is poor—is often considered entirely satisfactory. I might add that the inexpensive repair almost invariably is preferred, as the set-builder objects when it is necessary for him to pay for work he should be able to do himself.

Home-made sets may be divided into three distinct classes, namely, the completely home-made set, the home-assembled kit set, and the home-modernized factory-built receiver. The first type usually presents the greatest problem to the service man, the kit sets often can be repaired without too much difficulty, and those which fall in the last class may or may not be reconditioned, depending upon their design, but frequently they should have been junked years ago.

AN UNUSUAL SHORT CIRCUIT

WHILE on the subject of home-constructed radio receivers, a few experiences with sets of this type may be of interest. A set which recently was given to us for repair typifies the unusual conditions which frequently are found. This particular set was made by a very careful workman; every connection was carefully soldered, the circuit was correctly wired, the best available parts were used throughout, and the construction was beyond criticism, except for one detail. An examination of the receiver showed that each by-pass condenser—they were of the moulded-bakelite type—was mounted to the base panel with a machine screw passing through a hole drilled in the center of the condenser. Of course, drilling the holes through the condensers caused a short circuit in each case, thus making the receiver entirely inoperative. The builder of the receiver, admitting that his knowledge of radio was limited, explained that in constructing the set he tried to improve the mechanical design which was described in a newspaper radio supplement.

Another interesting experience with a home-constructed set proved very baffling for some time. The builder of this set had had considerable experience in building receivers for himself and his friends, and he had been very successful in most cases. However, the set in question proved to be his Waterloo. On the surface the construction of this set appeared to be perfect, but an electrical test showed many shorts throughout the circuit. The wiring was checked from beginning to end and it was found to be correct in every particular; nevertheless, shorts were existant in all parts of the circuit. Finally it was discovered that the front and base panels of the set were made of "self-shielding" material (these panels present the appearance of bakelite, but are imbedded with a wire mesh) which was as effective in short circuiting the various parts as an uninsulated metal chassis would have been. After insulating the apparatus and wiring from the wire mesh in the panels the set performed perfectly.

A third experience concerns a home-constructed "Hi-Q 28" kit set which was wired for operation with a.c. tubes. The set was carefully

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constructed by a man who had had considerable radio experience, but it refused to function. No error was found in the wiring diagram which was studied carefully, and an electrical test failed to disclose the trouble. However, it was discovered that with the antenna connected to the grid of the detector tube, the set would pick-up signals, but with the shields in place and the antenna connected with the antenna post the set was "dead." After considerable checking it was found that a 0.00025-mfd. by-pass condenser had accidentally been connected in shunt with the secondary of the detector r.f. transformer, thus causing the detector circuit to tune to a much higher wavelength than the preceeding r.f. stage which was tuned by a condenser on the same shaft as the detector condenser. As soon as this condenser was removed from the circuit the receiver provided excellent results.

The troubles located in home-reconstructed commercial receivers usually are as foolish as those found in other home-made sets. We were recently called upon to repair an old four-tube Garod reflex receiver, this set having performed satisfactorily until the owner decided to improve the quality of reproduction by substituting new a.f. transformers. However, after the new transformers had been installed the volume was much lower than it had been originally. An examination of wiring disclosed the fact that the first transformer was connected backwards, i.e., the secondary winding was connected in the plate circuit.

The next incident, which concerns a Radiola 17, is more amusing than instructive. The set had an open grid suppressor and it was brought to the shop for repair, but when the cabinet was opened it was found that around each tube was a piece of friction tape which held in place a large square of tin foil. After the grid suppressor had been replaced the set, minus the tin foil decorations, was returned to the owner, and out of curiosity we asked his reason for placing the tin foil on the tubes. He explained that when the set started to lose volume he thought that the tubes were at fault. After noting that the "silver plating" on the inside of some tubes was heavier than on others, he decided to repair the "weak" tubes with tin foil.

The novice experimenter who builds receivers is not the only radio fan who causes trouble for the service man. On the other hand there is the ambitious radio fan who adds accessories and other "gadgets" to his factory-built receiver, as in many cases this is also the cause of poor results. This fact calls to mind a short of a peculiar nature occurring in an Atwater Kent model 20 receiver, and in this particular instance the trouble was very difficult to locate.

The owner of the receiver purchased a Philco B-supply unit and for several days he was very much pleased with the results. Then, one evening he returned the power unit to the dealer and stated that it would not deliver current, and, as no amount of argument would convince him that the power unit was in perfect condition, he was given a Bosch power pack in exchange. The next morning the Bosch unit was returned and the customer requested that a service man examine his receiver. The man who tackled the job found a very unusual condition; both power units would work satisfactorily if, when changing the connections from the batteries to the power unit, the tubes were not turned off, but if the tubes were turned off and on the power unit would not operate the receiver. Further examination disclosed a short circuit in the B + 135-volt lead of the set, and it was discovered that a by-pass condenser had blown out. When new condenser was installed in the set perfect results were obtained.

The Atwater Kent model 20 receiver is not the only set in which by-pass condensers are apt to become shorted upon the addition of a B-power unit, as the trouble is experienced frequently with many old-type receivers. In this connection the writer would suggest replacing the by-pass condensers of old sets with new condensers, which are capable of withstanding a higher voltage, before installing a B-supply device.

While on the subject of B-supply devices a short of a peculiar nature which was encountered in the power circuit of a Freshman Equaphase a.c. receiver might be of interest. In this particular case the receiver behaved in a very strange manner; in the middle of a musical selection the volume would increase to terrific proportions and then die away to a whisper the next moment. After considerable checking it was found that the trouble was caused by an uninsulated wire which short circuited the detector resistance of the voltage-divider strip. However, it was discovered that, as a result of the short circuit, considerable current passed through the wire, thus producing sufficient heat to cause the wire to expand and open the shorted resistor. Of course, when the wire cooled it contracted again and shorted the resistor, and then the cycle was repeated. This short circuit proved very difficult to locate as the wire in question was fastened to the cover of the power unit and nothing out of the ordinary could be noted when the apparatus was examined. However, the set tester described last month proved its values as it detected the variations in plate voltage.

NO SERVICE man—and his number is legion—can hope to succeed completely unless he has the best of radio backgrounds. He must know, almost instinctively why things go wrong and where to look for the trouble. The service man can learn only little if he attempts to remember—merely—how a certain trouble was cured; he must go back to fundamentals. These articles by Mr. Alcorn, himself a practising service man, are designed not so much to tell service men how to cure specific troubles, but more to discuss common troubles and their remedies. This, we hope, will help to show those who are eager to learn something about what that knowledge must be and how they must apply it. —THE EDITOR.

MANIFESTATIONS OF SHORTS

IN B-supply devices and the power packs of receivers shorted filter condensers and choke coils make their presence noted by an increased a.c. hum in the loud speaker. Incidentally the only remedy for such trouble is to replace the defective parts. Also, the writer wishes to state that all radio service men would appreciate it if less insulating material were used in the manufacture of these units, as the time employed in digging out the defective parts certainly could be employed more profitably.

Another shorted condenser which develops quite frequently in Radiola models 17 and 18 receivers occurs in a part of the circuit where one would not be apt to look for trouble. The circuit diagram of Radiola 17—it was incorrectly labelled as the 18—was given in the first article of this series (Page 26 November RADIO BROADCAST). The small condensers designated by the letters G are the ones which have been found defective in a number of instances, G_3 being the unit which generally is found at fault. This short is very difficult to locate the first time it is encountered, as the set seems to be operating properly except that signals cannot be picked up. In the repair of the receiver the condenser may be omitted from the circuit if another is not available, as little or no difference will be noted in the results.

Short circuits in accessories, such as loud speakers, lightning arrestors, extension cords, etc., should receive some mention at this time as devices of this type are the cause of considerable trouble and it seldom occurs to the service man to look for shorts in these parts of the circuit. This is especially true of the loud speaker, and for this reason it is advisable to connect a pair of phones to the output of the set before making further tests. Often it will be found that the windings of the loud speaker have become shorted or burnt out, or the cords have become defective.

TWO INTERESTING OPEN CIRCUITS

THERE recently have come to our attention two open-circuit troubles which are considered of particular interest, because in each case the set-checking device failed to detect the defect. The first instance concerns a Radiola 17 receiver, and when the complaint was received the cause was diagnosed as an opened grid suppressor. However, an electrical test showed the circuit to be in good condition, even though the set lacked volume on all stations, including powerful local broadcasters. In this case the problem was solved by the old method of attaching the antenna to the grid of each of the various r.f. tubes. As soon as the antenna wire was touched to the grid of the second tube signals were received with greatly improved volume, thus indicating that the trouble must be located in the first r.f. circuit. Finally it was discovered that an open circuit existed in the volume control which is in the antenna circuit of the receiver.

The second open-circuit difficulty was experienced with a Crosley Bandbox receiver, and it was suspected that the trouble would be found in the external power-supply unit. The set did not provide sufficient volume, but the set-checking device indicated that the receiving circuit was satisfactory, and the output voltages of the power-supply unit were found to be correct with a d.c. voltmeter. As a last resort the battery-voltmeter continuity test was given the set and an open was found in one of the r.f. choke coils. We have never been able to determine why this defect did not show up in the test with the set-checking device, but it did not and we were forced to spend more time in looking for the trouble than was profitable. In addition, it was necessary to rewind the choke coil as none of this type was available at the time.

Another thing which should be remembered in connection with Crosley Bandbox receivers is that the external power unit is not of the dry type; it employs a Merschon filter condenser which is of electrolytic construction. Because of this fact the power unit should never be installed on its side, as the electrolyte is apt to seep through the cork and cause corrosion. The writer knows of several cases where this mistake has been made and in one instance a beautiful mahogany bookcase was badly discolored. Incidentally, it is never good policy to install power units on their side when a filament-type tube is used as a rectifier. In the instructions which are supplied with each tube the manufacturer recommends that the tube be operated in a vertical position if maximum life is desired. When the tubes are operated in a horizontal position the filament is apt to sag and cause trouble.

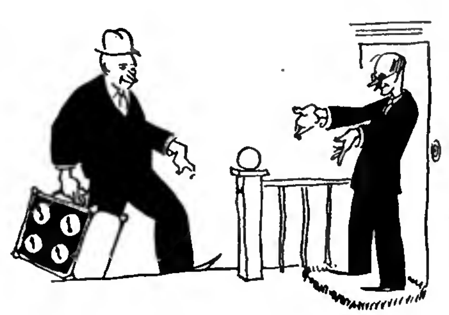
The Service Man's Corner

THE many practising radio service men who see RADIO BROADCAST regularly have praised highly the articles for and by service men which are now a regular feature of this magazine. Those of our readers working in this field seem to like "The Service Man's Corner" especially. "Although I feel confident to face almost any kind of service problem," writes one reader, "I enjoyed reading the first 'Service Man's Corner' and am looking forward to future issues. All of us need to keep in touch with what other workers are doing and I feel I can always learn something from reports of other's experiences."

Even though some of the suggestions appearing in these pages may seem self-apparent and too simple to deserve mention, it is possible that the point covered is so obvious that many readers have never thought of it.

A.C. Hum: Some service men tell us that where they have replaced a.c. tubes in an "electric" set an unusual amount of hum developed. The answer is apparently in the fact that some a.c. tubes or circuits vary slightly in some characteristic and adjusting the resistor responsible for balancing out the hum will cure the trouble. In other words, the resistor in question should have the tap adjusted in the exact center, but in the case of some tubes, the lowest resulting hum in operation results when the resistor is adjusted slightly off-center, the exact point being a matter of experiment. Many commercial receivers now are equipped with variable "center-tapped" resistors, which makes the solution of this trouble simple. In servicing less modern sets, it may be wise where possible to replace the fixed center-tapped resistor with a variable unit.

Getting the "lows": It is curious how a condenser across the loud-speaker leads helps to bring out these lower notes that everybody is yelping for. Try different values until the customer yelps out loud. [This stunt will be effective on low frequencies, but will cut off most of the highs.—*Editor.*] There is another suggestion I wish to make at this time: have a routine in checking a receiver and don't vary from it. I spent several days learning that a voltage-divider system was "open" in the detector supply before I relearned the value of an invariable routine. The groping was unproductive, but the trouble was almost at once apparent when the set was checked systematically. We never seem to learn: I blew three tubes a few days ago, and repeated that performance the next day. And yet it's so easy to remove tubes while working on a set!



[What test routine do readers prefer? The best contributions will be printed.—*Editor.*]

H. J. GODDARD, Ellendale, N. D.

R.T.F. Set Trouble: In servicing an Atwater Kent, the following trouble presented itself. The set worked on local stations but the signal strength was weak. Having eliminated the batteries, tubes, antenna, and loud speaker for faults, the set itself was inspected. It was a one-

THIS page marks the second appearance of our department exclusively for the practising service man. It is unique, we feel, because for the most part it is written by the service man himself. These pages will be a forum where the service man can discuss his problems, get his pet idea into print, and see now and then a hint which will be useful in his daily work. Contributions which should preferably be short, to the point, and typewritten are solicited and will be paid for if used. Address your articles to the editor, "Service Man's Corner."

—THE EDITOR.

dial, three-condenser set. The puzzling thing was that all continuity tests showed the set to be ok. By placing my finger on the stator plates of the first condenser the signals faded out completely; the same result was found in touching the third condenser. On the center condenser the signals remained the same. Moving the second condenser caused little change.

Grasping the center or second r.f. coil, and forcing it slightly from side to side, the set worked ok at times. The continuity test showed no open circuits. By moving each wire connected to this coil a bad connection was located where the lead was soldered to the coil. The connection was slightly corroded. The condition was this: even though this connection passed 22 volts in the continuity test, the corroded joint would not pass r.f. current because of its high resistance. After the connection was cleaned and resoldered the set worked satisfactorily. Such a condition might not occur in a new set, but this possibility is well to remember when working on receivers which have been in use for some time.

—THOMAS GLOSE, Allentown, Pa.

Filament voltage on the CX-350: A service man writes us that he "is having trouble with a new cx350 tube arcing across between the elements and wonders if the trouble is general with others." He continues, "I am using the drop across a 1500-ohm resistor for grid bias and the tube draws 50 mils. On loud signals, there is an arc inside the tube and the milliammeter in the plate circuit deflects toward the high end of the scale. I have had three tubes and they all do the same thing."

Roger M. Wise, chief engineer of E. T. Cunningham, has cast some light on the probable cause of the trouble. He says: "In using the cx-350 we find that the important precaution of operating the filament at approximately the rated voltage is often overlooked. We investigated recently a complaint of flash-over in an amplifier in which two of these tubes were being used. When tested in our laboratory, the tubes in question operated normally at rated maximum plate voltage, but when placed in the amplifier giving the trouble, one of the tubes arced. A check on the operating conditions showed that while the plate voltage in this amplifier was only 375 volts, the filament voltage was 6.0. As soon as the filament potential was raised to the rated figure, 7.5 volts, the tube operated satisfactorily."

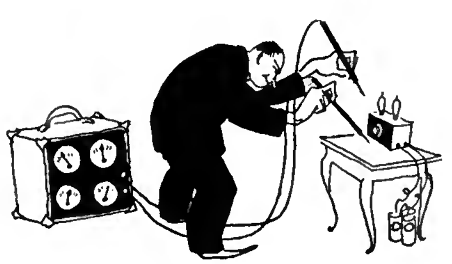
Items of Interest

SOME manufacturers tell us that the demand for power amplifiers for public address work in its various possible applications is one of the year's most astounding developments in radio accessories. The service man and professional set-builder who is interested in this work ought to have—in addition to the catalogs of the various makers—the *General Radio Experimenter* vol. 3 no. 4 for September, 1928, for the article "Notes on Group Address System," by C. T. Burke. Silver-Marshall's *The Radiobuilder*, vol. 1, no. 6, dated October 9, 1928, describes in interesting detail the new S-M rack-and-panel "P. A." amplifiers. Jenkins & Adair, of Chicago have just issued Bulletin No 7 on a microphone mixing panel which should be useful in more pretentious public address systems.

¶ The Weston Electrical Instrument Corporation have just released descriptions and prices on testing apparatus for the service man. Their publications describe Model 537 a.c.-d.c. set tester, Model 533 Counter Tube Checker (which is a.c.-operated) and circulars Y and X describing portable a.c. and d.c. testing instruments respectively.

¶ What list of equipment do service men feel is the minimum for field work? Most service men feel rather strongly on this point and we should like to have lists submitted. The results will be tabulated and be published in this department.

¶ Practising service men, especially those who are working out of a radio store, will find the excellent loose-leaf tube data book issued by E. T. Cunningham, 370 Seventh Avenue, New York, of constant value. These sheets, supplied in a binder give the following data: name of receiver, manufacturer's name, model number, a chart showing location of tubes, socket number and what part in the circuit each tube plays. Space is provided on each sheet for notes, and remarks containing useful data on the set in question. We are advised that Cunningham will supply service men with the book, on request.



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Sound Motion Pictures

Volume Control in the "Talkies"

SOME years ago an eminent progressive, being asked in a locality noted for repeated industrial warfare what he thought of law and order, answered to the effect that he thought it would be all right, but he had never seen any. Exaggeration often points the way to truth. The truth about volume control in the sound-movie field is that in most theatres there isn't any. This is probably the most serious defect in the technique of audible photoplay reproduction at the present time. The theatres, in this matter of gain adjustment, are now at the stage in which broadcasting was in 1923, but the effect is worse, because the combination of sound reproduction with pictorial action presents more difficult problems than sound reproduction alone.

The principal faults may be summarized as follows:

(1) General level of speech reproduction too high.

(2) Failure of volume to follow the action or to maintain a natural proportionality.

(3) Abrupt jumps from one musical selection to another as scenes change.

(4) Inability to adapt sound reproduction to audience reaction in special cases.

Under the first count of the indictment, I may say that I attend a good many sound-picture showings in various cities and different sizes of theatres, and very rarely encounter inadequate volume of either speech or musical accompaniment. Excessive loudness of synchronized musical accompaniment I hear sometimes, but not often enough to write an article about it. Unnaturally loud speech reproduction, however, is rampant. This generally excessive level of speech reproduction is caused by failure on the part of the recording experts, projectionists, theatre managers, and other functionaries to appreciate the simple fact that speech is usually not as loud as music. So, in changing from orchestral accompaniment to speech, during a picture, they ought to drop the level, perhaps 10 TU. But in most pictures which have talking portions alternating with music nobody does anything about this. The result is that even in the top gallery the speech is absurdly loud. The setting should be such that in this location conversational speech from the sound movie machine is loud enough to be comfortably understandable. In a house with good acoustics this will not be much louder than speech of the same sort from an actor on the stage. Even when this rule is followed the speech may be too loud in the front of the orchestra, but it will not be as bad as when the level is excessive up above.

TOO MUCH VOLUME

THIS chronic tendency to oversupply volume leads to a number of corollary defects. One is a distortional change in voices. An actor playing a love scene, for example, and talking to a girl at close range, naturally speaks in a low voice. His low voice is not the same, in distribution of overtones, fundamental pitch, and other characteristics as if he were talking loudly. The recording operator, perhaps, brings up the gain control to get above the noise level of his equipment. Then in the theatre some more amplification is piled on, and the voice issues from the projectors a few million times louder than at the beginning. The ear recognizes the fact that something adventitious has happened to the man's voice. Quiet speech sounds natural only when it is reproduced at a relatively low intensity. Furthermore, dramatic contrast is lost when even moderately loud sounds are reproduced heavily. If you deafen the audience with the amorous murmuring of the lovers, what more can you do when they begin to shout at each other, or when the hero pulls a machine gun out of his trousers and shoots one of his fellow gangsters? If you are working at plus 10 for sounds of low volume, and you emit 100 times as much energy for a louder sound, the effect on the ear goes up to plus 30, an increase of 200 per cent. as far as the ear is concerned. But if you are already working at plus 40 the same ratio of increase only brings you up to plus 60, an increase of 50 per cent. to the ear. The audiences, even though they don't know much about logarithms, have ears which act logarithmically.

THIS is the first of a series of articles dealing with sound motion pictures. RADIO BROADCAST *was first and alone in its field to provide intelligent and authoritative articles on the engineering aspects of broadcasting and we are happy to be first now with authoritative articles on sound movies. The latter field is so close to broadcast engineering that it is proving of absorbing interest to almost everyone in radio. Pages in this magazine will regularly be devoted to this subject.* —THE EDITOR.

Part of what has been said also has a bearing on the second point listed above. Fundamentally, the failure to correlate volume with the action of the play is a fault in recording. Skillful gain variation in the theatre can make up for defects in recording, but what we frequently get is mediocre recording to begin with, aggravated by bungling in reproduction. One of the faults frequently mentioned by critics of talking pictures is that when characters go backstage after a close-up there is no corresponding diminution in the level of their speech. This is something which should be taken care of in recording, but usually isn't. The close-up is one shot and the movement backstage very likely another. By the time the recording engineers are taking the latter they have forgotten the initial volume, but the audience, getting the two close together, notices the incongruity. The remedy lies in recognition of such defects, more utilization of instruments, and standardization of technique. Similarly when an actor turns away from the audience there is not the change in his voice which one would expect. The reason usually is that a second microphone was used to pick him up when he turned away, and the recording expert neglected to bring down the gain control somewhat on his transmitter to take care of its direction with respect to the future audience.

Some of the troubles discussed above involve refinements in technique and training of skilled personnel, which cannot he accomplished overnight, but such scandalous defects as abrupt changes in musical selections are inexcusable. As long as audiences tolerate such barbarities it seems there will be producers and exhibitors foolish enough to perpetrate them. In the meantime other producers will refine their technique and sell the product to the more far-sighted theatre proprietors, and when the public becomes critical the latter will get the business and the former will be left wondering why their seats are empty. As yet, unfortunately, the public has not become discriminating, and one sees audiences sitting through synchronized pictures in which, as the scenes change, one musical selection is abruptly broken off and another starts with full volume in the middle of a bar. These are the subtle operations of the cutting rooms on sound film. As originally scored, the picture has appropriate musical selections fitted to the various scenes, with suitable transitions and pauses as scenes change. Further changes being decided on, pieces are chopped out of the reel. This may improve the picture (sometimes the more that is cut out the better the picture becomes) but unfortunately the sound track goes with the picture, and with it the artistic transitions arranged by the musical director. Of course these portions might be re-orchestrated, but the productions have to appear on schedule, and some of the producers are willing to send the stuff out as long as they think there is a chance that the audiences will not get up, throw the chairs at the screen, and lynch the house manager

AUDIENCE REACTIONS

ANOTHER difficulty, for which the producers cannot be held responsible, lies in the uncertainty of audience reactions. In one instance which I witnessed the victim was the illustrious Martinelli, singing *Va Prononcer Ma Mort*, from *La Juive*, one of Vitaphone's operatic shorts. The tenor appeared in street clothes on the screen after being divested of his costume and Hittite nose. A small audience on a warm Sunday afternoon applauded only moderately and when the shade of Martinelli implacably offered two or three bows and synchronized smirks after they were silent, naturally they laughed. In this case the projectionist was caught flat-footed. He should have doused the grateful artist as soon as the audience indicated that it could bear to let him go back to the rewinder. Too few bows are always better than too many. A much harder problem is encountered in connection with loud laughter from audiences during comedies. In a stage comedy when the audience laughs loud enough to drown out the succeeding dialogue the actors pause and wait for the roars to die down. In vaudeville they can laugh with the audience.

(Concluded on Page 200)

No. 131 **Radio Broadcast's Home Study Sheets** January, 1929

Calibrating a Radio Wavemeter

A RADIO laboratory, regardless of how small it may be, cannot get along without a wavemeter or frequency meter. Such a meter generally consists of a coil, a condenser, and a dial. If it is part of an oscillating tube circuit, so much the better. It can, then, be used as a source of signals from which a receiver may be adjusted to a desired frequency. A good frequency meter can be made from coils such as the General Radio Company Series 277 which have the dimensions shown in Table 1. When attached to a tube, as shown in Fig. 1, with or without a grid current meter, a very useful frequency standard may be had. The problem is to calibrate it. Calibrating such a meter is a very interesting and instructive experiment.

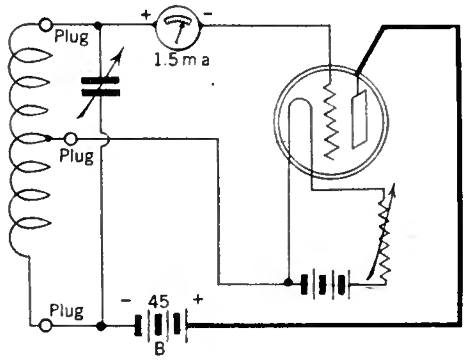

FIG. 1

LIST OF APPARATUS

1. An oscillating wavemeter as in Fig. 1.
2. An oscillating detector tube, tuned to some known frequency in the broadcast band. (See Fig. 2.)
3. An audio amplifier connected to the output of the oscillating detector.
4. A pair of headphones connected to the output of the amplifier.

TABLE 1

Coil	Turns	Size Wire	Diam.	Length of Winding	Inductance
277-A	15	21	2 11/16"	1 3/8"	0.014 mh
277-B	30	21	2 11/16"	1 1/2"	0.055 mh
277-C	60	21	2 11/16"	1 5/8"	0.217 mh
277-E	90	27	2 11/16"	1 3/8"	0.495 mh

PROCEDURE

Connect up the wavemeter and the oscillating detector and place within a foot or two of each other (See Figs. 1 and 2). Connect the detector loosely to an antenna and pick up a known broadcast station. By means of a vernier condenser, or a fine adjustment on the tuning condenser, tune the detector to "zero beat" with the broadcasting station. Move away the antenna coupling coil slowly and see if the beat note—which should be as near zero as is possible to hear in a quiet room with one stage of audio—changes. If so, adjust the tuning again until no sound is heard. The broadcasting station and the local generating receiver are tuned to the same frequency. In the Laboratory a 610 kc. station was used.

Now use the broadcast-band coil for the wavemeter, and make its tube oscillate. Couple the wavemeter and the detector inductances fairly closely together, perhaps by winding a turn of wire about each and connecting the turns together. Turn the wavemeter dial slowly, and mark down on a piece of paper when beat notes are heard in the telephones. A very loud note will be heard when the two circuits are in exact resonance (it may be necessary to decrease the coupling to get the exact dial setting), and another loud note will be heard when the wavemeter is tuned to the double frequency—or half the wavelength—in our case at 610 and 1220 kc. Between these points several other much weaker "squeaks" may be heard. Put them down but mark the strong ones with an asterisk. Then use a smaller wavemeter coil and repeat. Put down the squeaks again marking the loudest. At least two loud notes should be heard, the second and the fourth harmonic, in our case, the 1220 and 2440 kc. points. Repeat for as many coils as are to be calibrated.

If the coils are wound so that each smaller coil has half as many turns as the preceding one, the beats will occur at the same place on the dial. That is, if we pick-up 610 kc. at 85 degrees on one coil, we ought to look for 1220 kc. at about 85 degrees on the next smaller coil, and so on.

Now prepare a table like that in Table 2, in which the numbers along the top are secured by multiplying the detector frequency by whole numbers, say from 1 to 5, and in which the vertical columns represent the upper figures divided by whole numbers. Thus in our table, the detector frequency is 610 kc. Twice this gives 1220 kc., three times 1830 kc., etc. Reading down, one half gives 305, one third gives 205, etc. Then from this table make a list of the various frequencies that may be looked for in our calibration, viz., 610, 763, 813, 915, 1016, etc.

TABLE 2

	1	2	3	4	5	6
1	610	1220	1830	2440	3050	3660
2	305	610	915	1220	1525	1830
3	202.5	406	610	813	1016	1220
4	152.5	305	457	610	763	915

What actually happens as we tune the wavemeter is as follows. We are listening in the oscillating detector circuit. It is generating not only a 610 kc. current but multiples of this frequency as well, harmonics they are called. These additional frequencies are much weaker than the fundamental, 610 kc. When we tune the wavemeter to 1220 kc., its fundamental (1220 kc.) beats with the second harmonic of the detector (1220 kc.) and so we get a squeak. It is also possible for the second harmonic of some frequency to beat with the third of another, producing a beat frequency of 610 kc. For example, a beat occurs when the wavemeter is tuned to 763 kc., that is because 763 kc. is the fifth harmonic of 152.5 kc., and 610 kc. is the fourth harmonic of 152.5 kc. (see Table 2).

We now have data showing points on the wavemeter dial where we heard beat notes, and a list of frequencies at which beat notes should occur. How can we identify and properly label the points?

Let us consider the broadcast-band coil, which in the Laboratory is tuned by placing the condenser across only half the coil so only a small part of the band is covered. We set down the figures as in Table 3, and subtract the dial settings as in Column 2. We heard strong beats at 10.2 and 85 degrees on the dial. We guess that these are respectively the 1220 kc. and the 610 kc. points. Now we note that from 10.2 to the next point is 24 degrees, and that from this point to the next at 47 is a difference of 13 degrees. If we consider 13 degrees as a unit, we see that there are 6 units between 1220 kc. and 610 kc. that is about 100 kc. per unit. So we put down 1220 kc. as the 10.2 degree point, subtract 200 kc. for the next and get 1020, (which is two units distant), subtract one unit or 100 kc. for the next and get 920 kc., and so on. Now we look at our table of expected beat notes and find that 1220, 1016, 915, 813 and 610 are to be expected. We can then attach these frequencies to the above points. We can get the frequencies of the other coil points in exactly the same way.

If we wish we may use another method of computing roughly what the beat frequencies are, and then check them against our table of expected beats as before. We note that between 10.2 and 85 degrees—a difference of 75 degrees approximately—a difference of 610 kc. exists, or a difference of about 8 kc. per degree. Then the difference between 10.2 and 34 should give 23.8 × 8 kc. or about 190 kc., that is from 1220 to 1220 - 190 or 1030 kc. Actually our table shows the frequency to be 1016 kc.

TABLE 3

Dial degrees	Diff.	Units Diff.	f Approx.	f Exact
10.2*			1220	1220
34.0	23.8	2	1020	1016
47.0	13.0	1	920	915
60.0	13.0	1	820	813
85.0*	25.0	2	610	610

*Indicates points on dial where loudest beat notes are received.

PROCEDURE

Either set up the apparatus and calibrate it as suggested, or complete the data in Table 2. Plot the frequencies against dial setting. Transfer these frequencies to meters and make a calibration of wavelengths in meters against dial setting. Make a table similar to Table 2 but calculate the beats in terms of wavelength in meters. Calculate the inductance of the coil (Home Study Sheet No. 2 July 1928) and from it calculate the condenser capacities at various settings and plot. As a check on the above data, pick up another broadcast station whose frequency is known and repeat the calibration. See how nearly the calculated points and calibration curve check each other.

PROBLEMS

1. Do you know why an oscillating vacuum tube produces harmonics?
2. If the nearest approach to the actual "zero beat" you can attain is 100 cycles at 1000 kc. what percentage accurate is your calibration? Why cannot frequencies below about 100 cycles be heard in the receivers?
3. Remembering that wavelength in meters is proportional to the square root of L times C, what is the ratio of capacity when the wavemeter is set at the second and then the third harmonic? That is, suppose the capacity setting of the wavemeter for the second harmonic is C degrees. What will it be for the third? Do you see a way to check your calibration by this method?

Note: Readers may send the answers to these questions to the Editor to be checked.

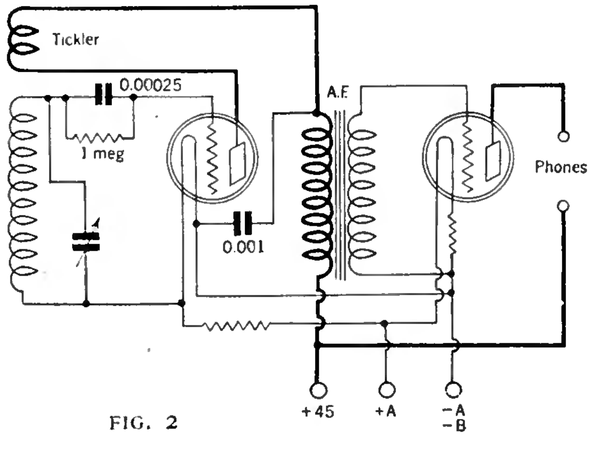

FIG. 2

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No. 14 **Radio Broadcast's Home Study Sheets** January, 1929

Plotting Power Tube Characteristics

EVERY radio experimenter knows the value of the characteristic curves of a vacuum tube. Home Study Sheets Nos. 5 and 6 (September RADIO BROADCAST) tell how these characteristic curves may be made and how one can obtain from them the important tube constants. This Sheet tells us more about the power tube in one's audio amplifier.

No electrical apparatus is really necessary for this experiment. Some plotting paper, a rule, and perhaps a French curve will suffice. All of the data may be obtained from a single set of figures which show the plate current of a tube as the plate voltage is changed, the grid being maintained at zero bias. If, however, the experimenter desires to take data on one of his tubes and to carry out the result of the experiment, it is much better. All that is necessary is the E_p-I_p curve for a single value of grid bias (0).

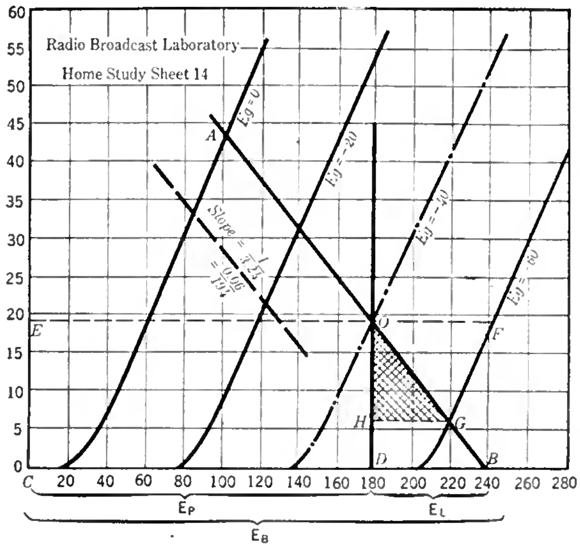

FIG. 1

DISCUSSION

The effective voltage, E, on the plate of a tube which does not have high-resistance load in its plate circuit is given by $E = E_p + \mu E_g$ which states in mathematical language that the voltage on the plate of the tube is equal to the sum of the voltage due the plate battery and whatever grid voltage there is multiplied by the mu of the tube. When the grid bias (E_g) is negative the effective plate voltage is less than E_p. That is, the plate current which flows when a 100-volt plate battery and a negative C bias of 20 volts are employed is less than the plate current which flows when the C bias is zero. How much less is it? We could tell if we had available the single curve mentioned above and shown in Fig. 1 ($E_g = 0$).

For example, let us take the $E_g = 0$ curve of Fig. 1 which represents the plate current of a tube, similar to the 171, at zero grid bias. Now suppose we want to plot the curve for $E_g = -20$. We assume various voltages and substitute in the formula for the effective voltage (This is called the "lumped voltage" in England). The mu of the tube is 2.8, and suppose we assume $E_p = 100$,

$$E = E_p + 2.8\,(-20) = 100 - 56 = 44$$

and looking at our curve we note that when $E_p = 44$, $E_g = 0$, and the plate current is 8 mA. Therefore when $E_p = 100$ and $E_g = -20$, $I_p = 8$. This is one point for the new curve. Now assuming $E_p = 120$, $E = 120 - 56 = 64$ and the plate current is 20 mA. This system is continued until sufficient points are marked down to enable us to draw a line through them. This line will be parallel to the zero-grid voltage line. Then assume another grid bias, of say, —40 volts and plot that curve. Finally we have a family of curves like that in Fig. 1.

Now the slope of this line represents the reciprocal of the plate resistance of the tube, that is, the slope $= 1/R_p$, and a little calculation will show that R_p for this particular tube = 1620 ohms.

Engineers have shown that the maximum undistorted power output from a tube will be attained when the load resistance, into which the tube works is twice the plate resistance of the tube, in this case 3240 ohms. Under these conditions the plate current, goes up and down in accordance with the input a.c. grid voltages. How much does it vary, what is the a.c. power lost on the tube, what is the a.c. power in the load resistance, etc? We can find these various values in the following manner.

1. We draw the line AOB which goes through the intersection of the 180-volt line with the $E_g = -40$-volt line and has a slope equal to the reciprocal of the load resistance in ohms.

$$\text{That is, the slope of AOB} = \frac{\text{I (amperes)}}{\text{E (volts)}} = \frac{1}{3240} \text{ or } \frac{\text{I (milliamperes)}}{\text{E (volts)}} = \frac{1}{3.24}$$

and if we take 60 mA. as the vertical side of a triangle ,we get the horizontal side from $\frac{1}{3.24} = \frac{60}{E}$

whence E = 194 and connecting the 60 mA. point on the vertical axis with the 194 volt point on the horizontal axis we draw a line. Then the line through 0 is to be drawn parallel to this line.

Now with such a "family" of curves and the "load line," AOB, we can tell many things about what happens when the grid is excited with an a.c. voltage. Suppose the input grid voltage has a maximum value of 20 volts. The grid bias is minus 40, the plate current is 19 mA., the voltage actually on the plate is 180, and the voltage lost across the load resistance is 60 (240 — 180). In other words E_p = CD and E_l = DB. If the tube is so biased that no plate current flows, the entire battery voltage is applied to the tube, that is 180 + 60 or 240 volts. To apply 180 volts to the tube through a load resistance of 3240 ohms when 19 mA. flows, the plate battery must be 240 volts or CB.

Now when the grid swings from minus 60 (— 40 from the C bias and — 20 from the maximum negative input a.c. voltage) the current drops to 6 mA., and when the grid becomes minus 20 (— 40 from the bias battery and plus 20 from the a.c. input) the plate current increases to 31.5 mA. The voltage variations across the load under these grid-voltage variations are from 20 to 100 volts or a total voltage swing of 80 volts and the voltage variations across the tube are from 220 to 140 volts.

In other words, the plate current swings up and down this load line about its average value of 19.0 mA. and has a maximum value 31.5 mA. and a minimum value of 6mA.

The d.c. power used up in the plate of the tube is $E_p \times I_p$ or the area of the rectangle EODC and is equal numerically to 180 × .019 = 3.42 watts. Similarly the power used up in the load is $I_p \times E_L$ or the area of the rectangle OFBD and numerically is equal to 60 × .019 = 1.14 watts. These powers are being used in heating the plate and the load resistance, regardless of whether there is any a.c. voltage on the grid or not. Their sum, 4.56 watts must come from the B battery.

When an a.c. voltage is applied to the grid, a.c. power appears in the load resistance. The product of the r.m.s. values of current through and voltage across the load will give the power in the load. The maximum value of the a.c. voltage, e, across the load is H_g or 40 volts and the maximum value of current, i, is OH or 1.3 mA. Since the r.m.s. value may be obtained by dividing the maximum value by $\sqrt{2}$ we may get the power in the load as

$$\frac{e \times i}{\sqrt{2} \times \sqrt{2}} = \frac{e \times i}{2} = \frac{H_g \times OH}{2} = \frac{40 \times .013}{2} = 260 \text{ m.w.}$$

This represents the area of the triangle OGH.

Since the d.c. power supplied from the plate battery is constant, the a.c. power in the load must be added to the d.c. power used up there, and must be subtracted from the power wasted on the plate of the tube. When the grid is excited by an incoming signal, less power is used up in the tube, and the plate of a large power tube will actually run cooler when signals are applied to it.

PROCEDURE

Using the data in Table 1, plot the "family" of E_p-I_p curves. Assume mu = 8, calculate (1) the plate resistance, R_p, (2) the proper load resistance, R_o, for maximum undistorted power output, (3) the load line, AOB, assuming a plate voltage actually on the tube of 135 and a grid bias of minus 9 volts. Calculate the d.c. power lost in the tube, and in the load, and the a.c. power in the load when the grid swings a maximum of 6.5 volts, that is from the $E_g = -2.5$-volt line to the $E_g = -15.5$-volt line. Draw in the rectangles representing the d.c. powers, and the triangle representing the a.c. power in the load. Calculate the total power supplied from the B battery, and, assuming the efficiency of the tube and circuit is the ratio between a.c. power in the load and the total d.c. power supplied from the battery, calculate the efficiency of the system. (Efficiency $= \frac{\text{a.c. power in load}}{\text{d.c. power from battery}} \times 100\%$)

TABLE I

Ep	Eg = 0	2.5	5.0	7.5	9.0	11.5
40	3					
60	6	3				
80	11	6	3			
100	16	11	6			
120		16	11			
140			16			

I_p (m.a.)

PROBLEMS

1. The power output of a tube is equal to

$$\text{power output} = \left(\frac{\mu E_g}{R_p + R_o}\right)^2 \times R_o$$

where E_g is the input r.m.s. voltage. Calculate the power output of the tube whose characteristics you have plotted. Compare this value with the value secured from the graphical method.

2. Do you know why the area of the triangle is the a.c. power in the load?

3. Using the above formula calculate the power output if $R_o = R_p$ and the efficiency of the system using the values of E_p, mu, etc., used in the experiment.

4. Using the above formula, plot a curve showing the power output from a 171 tube as the input a.c. r.m.s. voltage is increased from zero to 37 volts.

5. Does more power come from the B battery when the grid of the tube is excited?

6. Does the output voltage of a B power unit change when the tube is supply a.c. power—or is the output voltage constant regardless of whether the tube is amplifying signals or not?

Note: Readers may send the answers to these questions to the Editor to be checked.

AS THE BROADCASTER SEES IT

BY CARL DREHER

Photographic Data For Broadcasters

H. B. MARVIN, during the discussion on his paper, "A System of Motion Pictures with Sound,"* said, "The latter (variable area type of sound record on film) requires a sound track which has a high degree of contrast and that is all. We aim at an exposure which will give us a density of 1.3 and develop to a gamma of 1, but these are not critical. The variable density system requires fairly close control of exposure and development in order to eliminate distortion. . . ."

It is as necessary for broadcast engineers who are transferring their allegiance to sound motion pictures to learn something about the photographic end of the business as it is for the movie people to acquire some familiarity with audio-frequency technique. While almost everyone knows something about photographic contrast, development, etc., a more scientific understanding of such terms is required by the professional. A useful work in this field is *Photography as a Scientific Implement*, written collectively by a group of authors, published by Blackie and Son, Ltd., in England, and distributed in the United States by the D. Van Nostrand Company. Chapter IV, on "The Theory of Photographic Processes and Methods," by S. E. Sheppard, is referred to in the present discussion of photographic exposure and development, which is not intended as more than an introduction and basis for further study.

We may begin with a few definitions. The *opacity* of a photographic image is defined as the ratio of the incident normal light to the emergent light. The *transparency* is the reciprocal of the opacity. It follows that opacity may theoretically be anything from one to infinity while transparency varies between zero and unity, the latter corresponding to perfect transparency. The Briggs logarithm of the opacity is called the *density*. The electrical engineer will note the analogy to transmission of energy along telephone lines. The ratio of the electrical energy impressed on a line to the energy received at the other terminal is analogous to the opacity of a photographic image in the field of optics, and the TU method of reckoning transmission loss and gain corresponds to photographic density, which is likewise a logarithmic function (See RADIO BROADCAST for September and October, 1926, pages 405 to 408 and 506 to 509, respectively, for a discussion of telephonic gain and the standard transmission unit).

Transactions, Society of Motion Picture Engineers, XII, No. 33, p. 86, 1928.

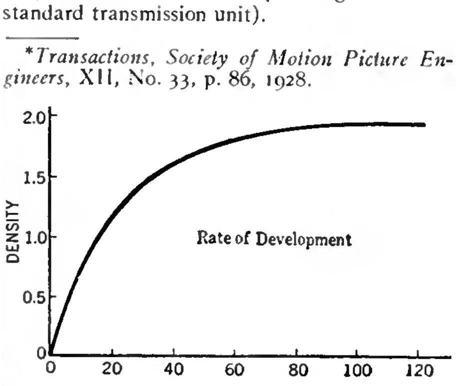

FIG. 3

It may be shown experimentally that, approximately,

$$D = pM$$

where D is the density, p is a constant, and M is the mass of metallic silver per unit area on a negative. The photographic process is essentially the transformation of silver from the ionic to the metallic state. The above terminology and relationship were worked out by the photometric physicists Hurter and Driffield, and they also introduced the characteristic curve of a plate or film shown below as Fig. 1, in which densities are plotted as ordinates against $\log_{10}E$, E being the *exposure*, which is the intensity of the light to which the plate was exposed multiplied by the time of exposure.

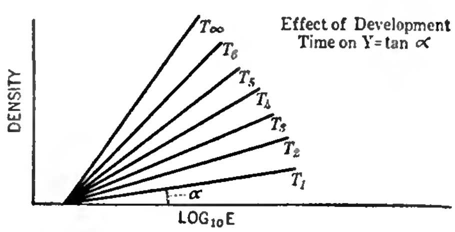

FIG. 2

This photographic characteristic curve which, it will be noted, is similar in shape to the static plate current-grid voltage graph of a vacuum tube, shows the relationship between two logarithmic functions: that of the opacity of a negative and the degree of exposure to light which produced the opacity. The region convex to the X-axis at the left is known as the *region of under-exposure*; the middle part, which is sensibly a straight line, is called the *region of correct exposure*; the portion to the right where the curve bends and becomes concave to the X-axis is the *region of over-exposure*. In the middle, where the curve is straight, the slope or tangent of the angle which the straight line makes with the X-axis is called the *development factor* (*gamma*). It is a convenient measure of the photometric contrast of the negative in question, and is also known as the *contrast factor*. Mathematically the straight line portion of the curve is represented by the equation

$$D = \gamma\,(\log_{10}E - \log_{10}i)$$

where D is the density, γ (gamma) the development factor of the negative, E the exposure (intensity of light x time) and i is a constant corresponding to the value of the exposure where the extended straight line cuts the X-axis. If E is held constant, therefore, it follows that $D = k\gamma$, that is, the density equals a constant times gamma.

However, there is more to the idea of gamma than the relation of density to exposure. The chemical development also plays a part, and in general the value of gamma increases with the time of development up to a limit of extreme contrast, called gamma infinity (γ_∞). Fig. 2 shows a family of curves illustrating the variation of gamma with the time of development T, up to the maximum T_∞. For each time of development there is a definite value of gamma corresponding to the slope of the line, and a definite linear variation of density with degree of exposure. All the curves intersect at the point $\log_{10}i$ on the horizontal axis.

The value of gamma, while it increases with time of development, does so at a decreasing rate (since less and less silver remains to be acted on) and ultimately reaches a limit which is largely fixed by the constitution of the plate in question. If plates which have been given a series of exposures increasing in geometrical proportion are subjected to different development times and the resulting densities are measured, a graph of density against time of development has the saturation form shown in Fig. 3. The decreasing slope is what would be expected. It is the same picture as that of a temperature-time variation in a heat run on a transformer, or many other chemical and electrical processes.

The meaning of Marvin's statement as cited above should now be clear. It indicates that in the process of sound recording by the variable area method the exposure is regulated so that the density, as plotted in Fig. 1, would be about 1.3 (corresponding to an opacity of almost 20) and subsequent development is timed so that, in Fig. 2, the appropriate curve would be one making an angle of 45 degrees with the horizontal axis and therefore having a tangent of 1.0. Of course, as far as regulation of exposure goes, the time is fixed by the constant movement of the film at the rate of 90 feet per minute, but the result desired may be secured by properly setting the intensity of the recording light, which is constant in the variable area system of recording. In the variable density system, since the recording is accomplished by audio-frequency variations in the intensity of the light source, it is difficult to avoid wave form distortion caused by movement above or below the straight portion of the characteristic of Fig. 1.

To some of the boys who are more given to reading *Liberty* than poring over technical treatises, the above discussion may seem unduly theoretical. If it seems so, it is merely because they are not at home in the field of photography, which, being older than radio, has a more extensive literature and at least as involved a technique. The discussion, as a matter of fact, is most elementary and less technical, probably, than much of the broadcast material which has appeared in this department in past years. The trouble is that it involves penetration of a new field to those of us who come from the radio side of the business. An understanding of it is indispensable to anyone who wants to approach such

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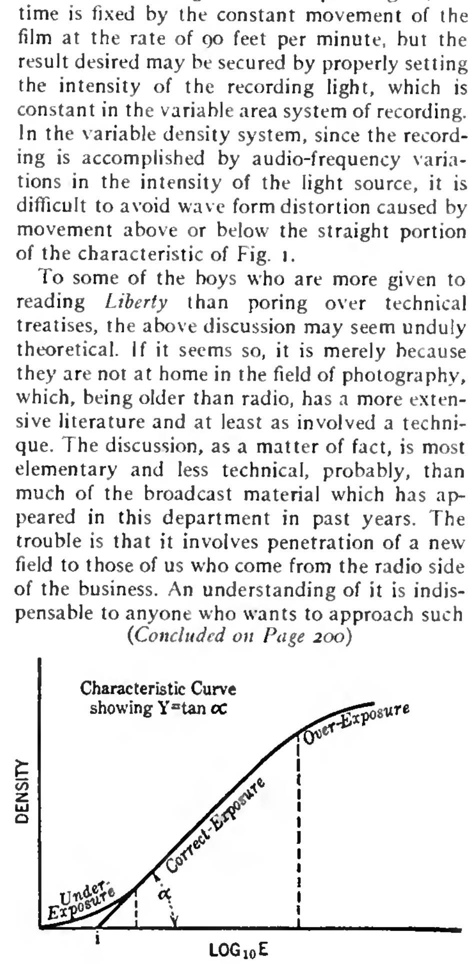

FIG. 1

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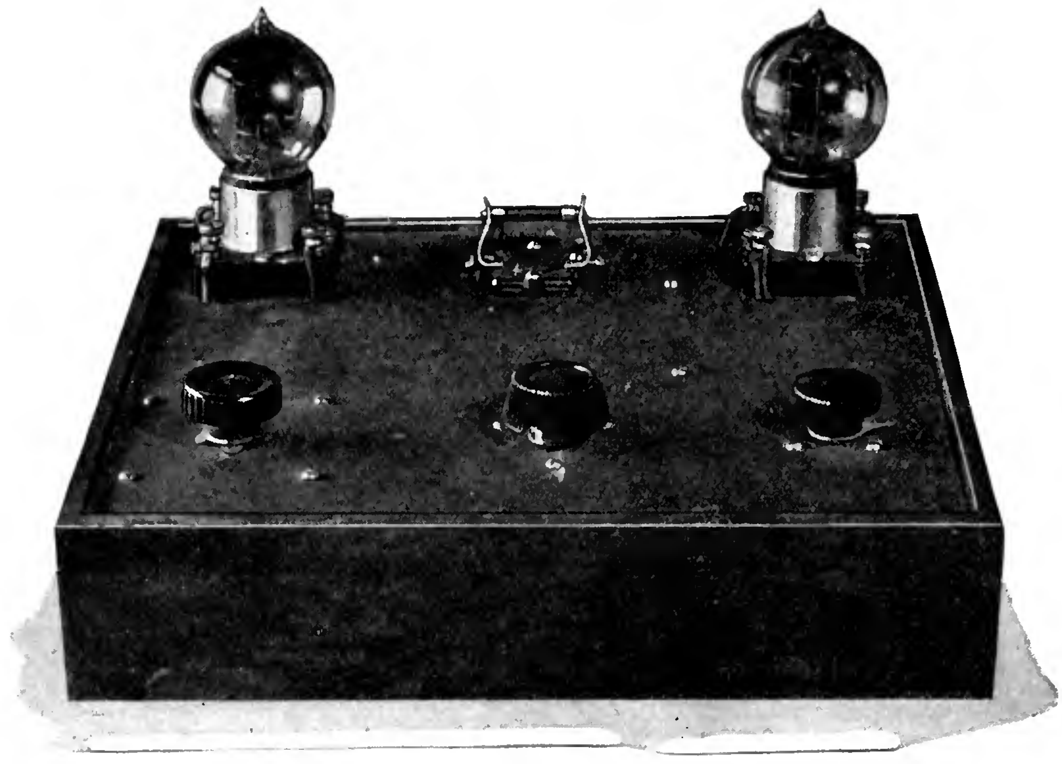

GENERAL VIEW OF HOME-MADE AUDIO OSCILLATOR

An Inexpensive Audio Oscillator

By EDWARD STANKO

ONE of the greatest problems that confronts the average experimenter is the lack of adequate apparatus for conducting the tests that are so vitally important to the final outcome of the experiment. In nearly all cases the cost of the apparatus involved in making an experiment which leads to an authoritative answer places it beyond the reach of the individual. It was with the idea of solving this problem that the writer spent considerable time in designing the inexpensive audio-frequency oscillator presented in this article.

The various experiments and measurements to which an oscillator of this type may be put to use are not only quite varied, but at the same time quite useful. In connection with measuring the frequency characteristics of audio-frequency amplifiers, this oscillator has proved itself indispensable. Amateur or commercial radio stations may use it in place of the usual buzzer to modulate the carrier. In the broadcasting field, the oscillator may be used for lining up telephone circuits which connect the broadcasting station with remote apparatus. Many other uses may suggest themselves to the experimenter, such as determining the frequency characteristic of an audio-frequency transformer, filter coil, loud speaker, etc.

THE CONSTRUCTION OF THE UNIT

THE oscillator which is described here is made up of two component parts, the oscillator proper and the one-stage amplifier. For practical purposes it is desirable to have this stage of amplification built in the same housing, and combined with the oscillator to make one complete unit.

In constructing this oscillator, it is first necessary to obtain a Ford ignition coil (or some similar spark coil), such as used on the model T car. A photograph of this unit is shown at the left in Fig. 1. The wooden housing, which the ignition unit is molded in, is carefully removed with a screwdriver. While the process of dismantling the unit is in progress, an electric soldering iron should be kept handy for unsoldering all of the connections on the inside of the housing. When the entire housing has been removed, place the ignition unit in a moderately warm oven. After it has been given a thorough warming, remove the unit from the oven and cut off with a knife all of the surplus insulating compound in which the coils and condenser are imbedded. Remove the paper condenser and lay aside. It will be used later. Dig around in the insulating compound until the primary winding of the coil is located. The primary winding can be easily distinguished from the secondary by noting the size of the wire. The primary is larger in diameter than the secondary. When this winding is found, the wire is pulled out endwise until all of the wire is removed from the iron core. Care should be taken not to damage the secondary winding while the primary is being removed.

THE oscillator which Mr. Stanko describes uses apparatus that nearly every experimenter has, or can obtain. It will generate audio frequencies from about 60 to 5000 cycles, which is sufficient range to conduct any and all tests on present-day audio apparatus. In the Laboratory, a similar oscillator has been in use for several years; we used a push-pull output transformer instead of a Ford coil, but the results are the same. The values of capacity indicated as C_1 in the circuit diagram must be determined experimentally. The larger the capacity the lower the generated frequency. The Laboratory Staff will be glad to learn of other apparatus of similar nature that experimenters have developed.

—THE EDITOR.

When the ignition unit is completely dismantled, as shown in the center in Fig. 1, it will be necessary to locate the secondary leads. The two outside leads will not be hard to find as they are at the extreme ends of the two secondary coils. The difficult problem is to locate the connection that connects the two secondary coils in series. This connection is usually found between the secondary coils imbedded in the insulating compound. Progress at this stage must be very slow, as considerable pains should be taken not to damage any of the windings or leads. When this connection is located, cut the connection at the center. Flexible wires are now soldered to all of the leads that extend from the two coils.

The unit is now ready for reassembly. The simplest and easiest way of assembling these parts is to get a tin can that will accommodate the two secondary coils and the iron core. Place the coils in the can, one on top of another, slip in the iron core and center it with respect to the secondaries with small wooden wedges. Pour the can full of hot paraffin and let it cool. When the paraffin has hardened, warm the can over a gas flame or immerse it in a bucket of hot water. After warming the can for a few minutes, turn it upside down and the unit will slide out in the shape of the mold. A simple and effective mounting can be made by getting a copper or brass strip, one inch wide and six inches long, and bend to shape as shown in Fig. 3. Twenty or twenty-two gauge strip will do nicely. As a safeguard it might be well to mention that if the copper strip is wrapped with rubber or friction tape the chances of short-circuiting any of the oscillator connections will be greatly reduced. The assembly should look like the right-hand view in Fig. 1. at this stage of the construction.

When using the oscillator for making certain measurements, the input to the system under test must be maintained at some constant value. As the output of the oscillator varies with the frequency generated, it is obvious that there must be some means for controlling the power output of the oscillator. Not only must we have some means of controlling the gain of the oscillator, but the gain control must be of a type that will permit the output of the oscillator to be varied without changing its frequency.

After experimenting with several types of gain controls, the constant-impedance type was chosen. This control, R_2 in Fig. 4, is composed of two 600-ohm Federal potentiometers mounted back to back on a piece of thin bakelite. The method of mounting them is shown on Fig. 2 A single shaft is used to rotate both of the potentiometers. If the wiring diagram of the constant-impedance control is traced out, it will be found that as the resistance is increased in one of the potentiometers, the resistance is decreased in the other, thereby keeping the impedance, which is the sum of these resistances, at the same value at any position of the control. Two grid condensers, C_2, are employed in this circuit, a 0.005-mfd. capacity for frequencies below 500 cycles per second, and a 0.00025-mfd. capacity for frequencies above 500 cycles. A grid leak of two megohms seems to be about right. The paper condenser from the Ford coil, C_3, is used in the primary circuit of the audio transformer to keep d.c. out of it.

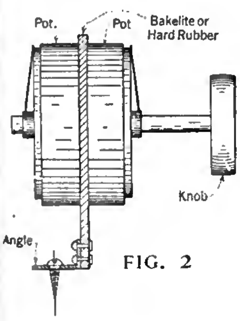

FIG. 2

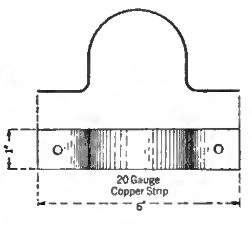

FIG. 3

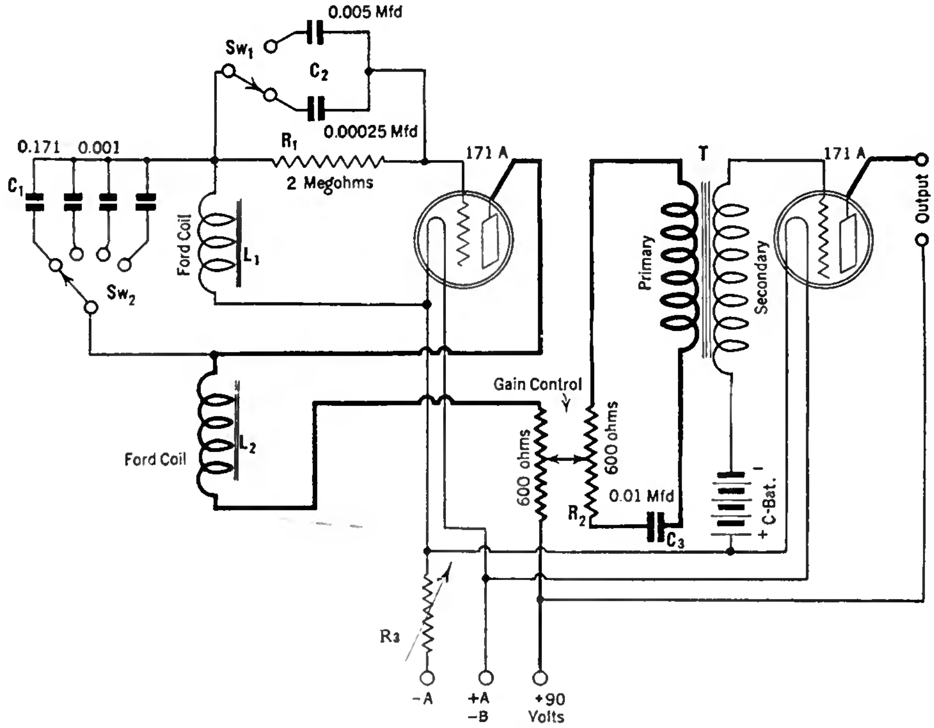

FIG. 4

This is the complete circuit diagram of the home-made audio oscillator described in this article. Note that the two 600-ohm potentiometers, R_2, are mounted on the same shaft

PRELIMINARY TESTS

When the oscillator and amplifier have been wired up as shown in Fig. 4, the unit should be given a preliminary test. Connect batteries, light tubes, place a loud speaker or pair of headphones across the output, then move, switch, Sw_1, so that the 0.00025-mfd. condenser is connected in the grid circuit. Set switch Sw_2 on an open point, that is, so there is no capacity across L_1. The oscillator should immediately go into oscillation, generating a frequency around five- or six-thousand cycles per second. If the oscillator fails to work, check up on the wiring, particularly at the coil connections. If one of the coils is reversed, the oscillator will refuse to work and one or the other of the coils must have its connection reversed. When the oscillator is working properly a frequency of about 1000 cycles can be tried. To do this leave the grid condenser on the 0.00025-mfd. tap. Move switch Sw_2 so that the 0.0001-mfd. fixed condenser is shunted across L_1. If everything is working properly with this arrangement, a frequency around 1000 cycles should now be heard. Throw switch Sw_1 so the 0.005-mfd. condenser is connected in the grid circuit. Move switch Sw_2 so that the 0.171-mfd. condenser is across L_1. The oscillator should be now generating a low-pitched frequency around 100 cycles. If the oscillator refuses to work at this low frequency, use a larger grid condenser. However, it has been found that if the grid condenser was kept at the smallest possible capacity that would keep the circuit oscillating, the harmonics were considerably reduced. No attempt is made to give the exact numerical figures for the fixed condensers used across L_1, as the condensers manufactured by some concerns vary to such a degree that it would be entirely out of the question to attempt to build an oscillator from directions given that would be accurate enough for calibration purposes without first comparing the generated frequency with some known standard. However, capacities for several frequencies are mentioned.

The oscillator will generate audio frequencies from 60 cycles up to six-or seven-thousand cycles per second, depending upon the capacity of the

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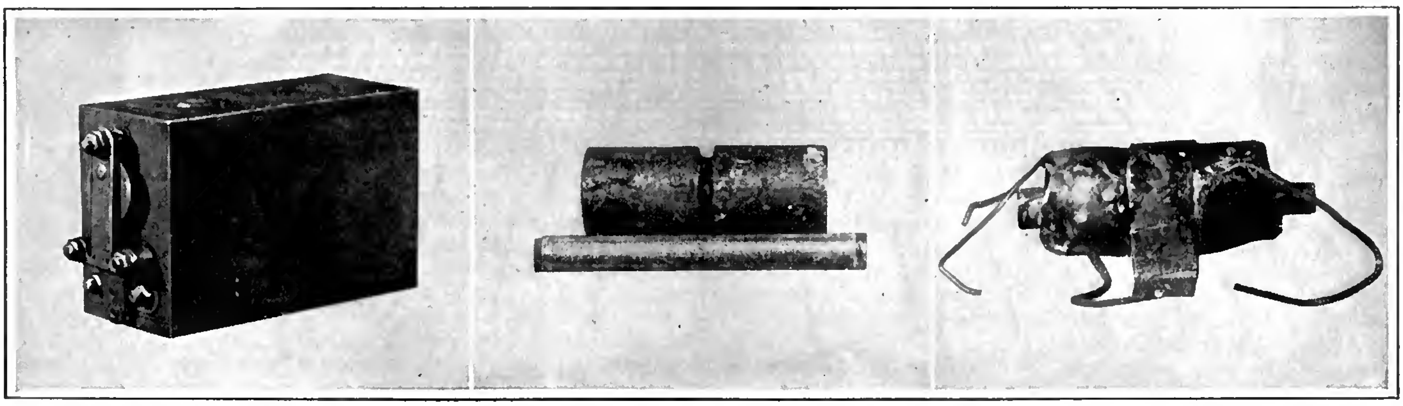

FIG. 1. METHOD OF REBUILDING FORD SPARK COIL FOR USE IN AN AUDIO OSCILLATOR

The picture on the left shows the spark coil in its original case, the picture in the center shows the secondary coils and core which have been removed from the spark coil, and the illustration on the right shows the secondary coils and core mounted for use in the oscillator

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A Chart for Making DX Measurements

By JAMES B. FRIAUF, Ph. D.

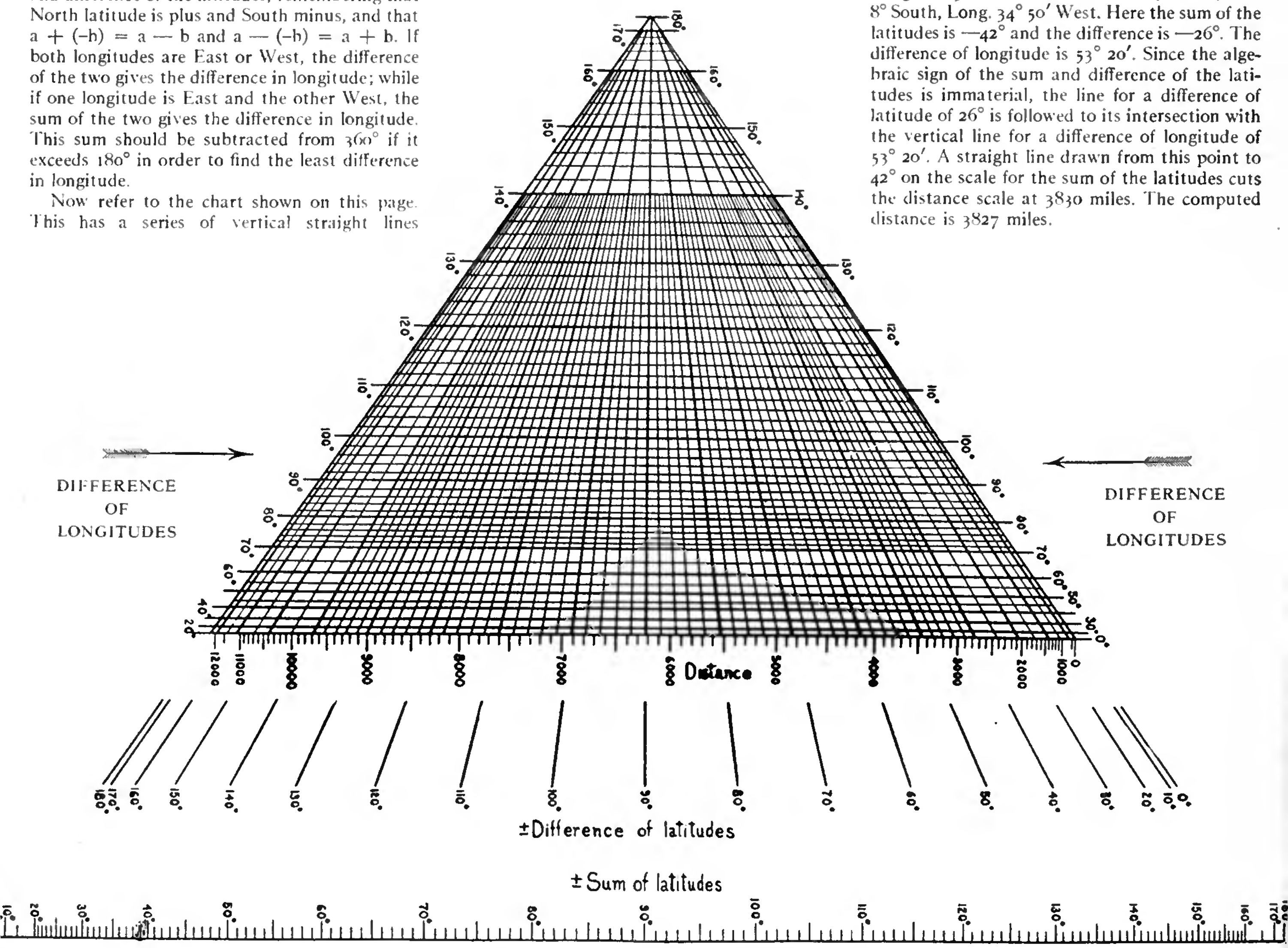
DUE to the use of short waves for broadcasting purposes it is possible for the broadcast listener to hear stations from distant continents as well as from the far corners of his own continent. In many such cases the DX enthusiast wishes to know the distance to the station which he has heard. This distance cannot be obtained directly from a map when the sending and receiving stations are widely separated, but can be computed by one of the formulas of spherical trigonometry when the latitudes and longitudes of the two stations are known. The computation is somewhat long and tedious, however, and the result obtained may be seriously in error unless the work is carefully done. For this reason the chart which accompanies this article has been prepared for the purpose of making the computation graphically. The use of this chart requires no knowledge of trigonometry, and the result is obtained in very much less time than is required to compute the distance.

The chart is for determining the distance between any two stations of known latitude and longitude. Hence, the first step in the use of the chart is to find the latitude and longitude of each station. This may be taken from a map with sufficient accuracy. Then find the algebraic sum and difference of the latitudes, remembering that North latitude is plus and South minus, and that $a + (-b) = a - b$ and $a - (-b) = a + b$. If both longitudes are East or West, the difference of the two gives the difference in longitude; while if one longitude is East and the other West, the sum of the two gives the difference in longitude. This sum should be subtracted from 360° if it exceeds 180° in order to find the least difference in longitude.

Now refer to the chart shown on this page. This has a series of vertical straight lines for the difference in longitude, and a series of straight lines radiating from a point at the left of the chart for the difference of the latitudes of the two stations. Find the line corresponding to the difference of the latitudes. These lines are marked at 10° intervals on their extensions into the space between the distance scale and the scale for the sum of the latitudes, and are marked "± Difference of latitudes". The same line is to be used whether the algebraic sign of the difference of latitude is plus or minus. Follow this line to its intersection with the vertical line corresponding to the difference of longitude. From the intersection of these two lines, pass a straight line to the sum of the latitudes on the scale marked "± Sum of latitudes," and here again the algebraic sign is immaterial. This straight line intersects the scale marked "Distance" at the distance, in land miles, between the two stations. It is advisable not to draw the straight line with a pencil since this would confuse the chart for future use, but to use a stretched thread or a piece of transparent celluloid with a straight line scratched on it.

A few examples will help to make this clear. Suppose that it is desired to find the distance from New York, Lat. $40^\circ 40'$ North, Long. 74° West, to Melbourne, Australia, Lat. $37^\circ 50'$ South, Long. 145° East. The sum of the latitudes is $40^\circ 40' + (-37^\circ 50') = 2^\circ 50'$; the difference of the latitudes is $40^\circ 40' - (-37^\circ 50') = 78^\circ 30'$. Since one longitude is East and the other West, the sum of the two should be taken, and since this sum, 219°, exceeds 180° it should be subtracted from 360° to give 141°. This is the difference in longitude between New York and Melbourne measured the short way around. The line for a difference of latitude of $78^\circ 30'$ is not drawn on the chart but would be one quarter of the way from the 78° line to the 80° line. Follow this to its intersection with the line for a difference of longitude of 141° which would be half way between the lines for 140° and 142°. From this point pass a straight line to the sum of the latitudes, $2^\circ 50'$, which is close to the lower end of the scale for the sum of the latitudes. This line cuts the distance scale at 10,350 miles which is the distance from New York to Melbourne. The distance computed from the formula is 10,360 miles.

A second example is furnished by the distance from Cape Town, South Africa, Lat. 34° South, Long. $18^\circ 30'$ East, to Pernambuco, Brazil, Lat. 8° South, Long. $34^\circ 50'$ West. Here the sum of the latitudes is -42° and the difference is -26°. The difference of longitude is $53^\circ 20'$. Since the algebraic sign of the sum and difference of the latitudes is immaterial, the line for a difference of latitude of 26° is followed to its intersection with the vertical line for a difference of longitude of $53^\circ 20'$. A straight line drawn from this point to 42° on the scale for the sum of the latitudes cuts the distance scale at 3830 miles. The computed distance is 3827 miles.



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Armchair Chats on Short-Wave Subjects

By ROBERT S. KRUSE

This month's subjects include "Push-Pull Vs. Back-to-Back Circuits" and "Short-Wave Reception Troubles"

THE writer now understands perfectly the feelings of an actor who is pushed suddenly on the stage and told to "fill" until some delay back stage can he "unscrambled." Luck is certainly with him if he has practiced something that is not included in the regular performance of the show.

This is a complicated way of explaining that the article describing a short-wave receiver, which had been scheduled tentatively for this issue, has been held over because of some changes on the part of a manufacturer who suddenly made it impossible to obtain certain apparatus which had been selected for use in the final version of the set. Of course, it would have been possible to substitute other parts but the time available prior to publication was insufficient to permit checking thoroughly the sensitivity and selectivity of the revised receiver. Therefore, as a matter of policy the receiver will not be presented, as it is considered unwise to describe a set before it has been tested, even if one feels sure of the results. As a result it is a case of "Better late than—early," and the receiver will retire for the present in favor of the assorted comments on short-wave subjects which form the basis of this month's article.

Push-Pull Vs. Back-to-Back

SEVERAL correspondents simultaneously have requested a brief and simple explanation of the differences between "back-to-back" and "push-pull" circuits. Unfortunately this is not a subject which lends itself to brief treatment, but in the following paragraphs an endeavor will be made to cover the more important aspects of the two transmitting systems.

Although the term usually is applied to audio-frequency amplifiers, the "push-pull" system is also used in many radio-frequency amplifiers and oscillators. On the other hand, because it is employed only in oscillators, the "back-to-back" system belongs exclusively to the transmitting fraternity. Both circuits always require the use of at least two tubes, but there are several important differences in the ways the tubes are connected. In order to appreciate fully the features of the two systems it is necessary to study carefully the circuit diagram of each. For the purpose of this comparison four versions of the old standby oscillator circuit devised by R. V. L. Hartley have been selected (see Fig. 1).

In diagram A of Fig. 1 we have a standard shunt-feed one-tube Hartley oscillator with a dotted line separating the tuned circuit, L_1C_1, from the tube and its plate supply, stopping condenser, and grid leak. The terminology employed is standard, R. F. C. being the r.f. choke coil, C_p the stopping condenser, and C_g and R_g the grid condenser and leak, respectively. Of course, it is understood that C_p and C_g both have capacities larger than the capacities of the tube; therefore, they do not affect the tuning, but serve only to keep the d.c. plate supply out of the r.f. tuning system to the left of the dotted line.

In diagram B of Fig. 1 is the schematic circuit of a shunt-feed Hartley oscillator with two tubes connected in parallel. It should be noted that in this diagram there is no fundamental difference in the circuit; in fact, the apparatus to the left of the dotted line has not been changed, nor have any additional feed chokes been added. It would even be possible to connect the grids of the two tubes directly together and use a single grid leak and condenser. However, smoother operation usually is obtained with the arrangement shown.

THE BACK-TO-BACK SYSTEM

THE diagram of a Hartley oscillator with two tubes connected "back-to-back" is given in diagram C of Fig. 1. This circuit appears very similar to diagram B but its operation differs in an important manner, even though the tuning system to the left of the dotted line has not been changed. Whereas in diagram B the two tubes operate simultaneously, an analysis shows that in diagram C they operate alternately, due to the fact that each tube operates only when its plate is positive. A comparison of the two circuits will quickly show the difference between them; in circuit B the plates of both tubes are supplied with current which flows through the choke coil, R. F. C., but in circuit C the currents for tubes Nos. 1 and 2 pass through separate choke coils, R. F. $C._1$ and R. F. $C._2$, which are connected to the two high-voltage terminals, M and N, of the power transformer, T_r, the center-tap terminal of which is connected to the filaments of the two tubes. Therefore, when M is positive tube No. 1 operates, but at this instant N is negative and tube No. 2 is inoperative.

THE PUSH-PULL ARRANGEMENT

THE circuit arrangement in diagram D of Fig. 1 shows an oscillator with two tubes connected in "push-pull". This arrangement has features which are similar to both B and C, but the operation of the system is quite different from either of the former circuits. Neglecting the dotted lines of the diagram and tracing the connections, it will be noted that the plate power, which is supplied to the center-tap connection of the coil L_1, flows in both directions through the coil to the plates of the two tubes. Therefore, the two plates are at the same potential as far as the power supply is concerned, but the r.f. voltage between them is obviously the entire voltage across the tuned circuit L_1C_1. Accordingly, we may say that in diagram C (back-to-back) the plates are at opposite sides of the *plate-supply cycle*, while in diagram D (push-pull) the plates are on opposite sides of the *radio-frequency cycle*. Conversely, the plates of the tubes in the back-to-back system are connected together through two large condensers and, therefore, have no *r.f. voltage* between then, while the plates of the tubes in the push-pull system are connected together by wire and have no *low-frequency voltage* between them.

In the above paragraph, we believe, the important differences between "back-to-back" and "push-pull" oscillator circuits have been clearly explained. However, some readers may be interested in the relative merits of the two systems. We shall, therefore, devote some space to this subject.

An important feature of the back-to-back system is that by careful adjustment of the various condensers, choke coils, etc., it is possible to obtain a r.f. output with a low modulation, i.e., a good tone. From the viewpoint of the reader this may prove a very unexpected conclusion, but let us study the action of the tubes. Inasmuch as the tubes are supplied with pure a.c. one would expect that tube No. 1 would oscillate briefly for 60 periods each second —if 60-cycle current is used—and that tube No. 2 would go through the same performance while No. 1 is resting, i.e., each tube would operate for $\frac{1}{120}$ of a second, or during one half of each cycle (see diagram A of Fig. 2). If this were true the r.f. output of the transmitter would be similar to the curve in diagram B of Fig. 2. In practice, however, this is not exactly what takes place in the tuned circuit, L_1C_1, of Fig. 1C. On the other hand, by careful adjustment it is possible to make each tube oscillate for more than one-half cycle, and, since this is true, it is evident that the r.f. output may be much smoother than indicated in diagram B of Fig. 2, as the train of oscillations of one tube

The Japanese Schoolboy's "Q" Signals

AT THE late International Radio Conference at Washington, D. C., many curious things were said and done, but a special height of foolish sublimity was attained in the new list of "Q" signals and their definitions.

It is not known just why anyone felt that it was necessary to tinker with the old list, but one can say with some certainty just who was retained to write the definitions of the abbreviations. It was positively *Hashimura Togo, Wallace Irwin's Japanese schoolboy. The inspired ability to choose the wrong word, the faultless gift for reversed word order, the special genius for associating ideas that have no connection —all are present.*

Hashimura has exceeded his Saturday Evening Post *performances in some ways, perhaps because the opportunity was so good. The "Q" Signals are so called because they all begin with that uncommon letter, and since the meaning of each is purely arbitrary Hashimura had free rein. Thus, he was able to use the abbreviation "QSF?" to mean "Is my automatic transmission good?" and to make the corresponding statement read "QSF" "Your automatic transmission fades out," Of course, only God and Hashimura know what conceivable connection there may be between fading and quality of keying.*

Again he was able to go through the list of questions, carefully removing the word "Shall" from each and replacing it by "Must" to secure the desired Asiatic flavor.

Again he was able—but why go further? Who let this silly set of definitions escape without proof reading of a capable sort?

—R. S. K.

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overlaps that of the other tube. Diagram C of Fig. 2 is an oscillogram of one tube operating for a period of more than one-half cycle.

PUSH–PULL FEATURES

THE outstanding feature of the push-pull radio-frequency arrangement is less manifest than that of the back-to-back device. European writers consistently inform us that they are able to produce oscillations of a higher frequency and better stability with such circuits than with single tubes. I am quite unable to find similar results in either regard, nor do I see any theoretical basis for the belief. It is, of course, quite possible that the use of series feed via a center-tap connection may result in smoother tuning over a range of frequencies, because one avoids the troublesome natural frequencies and varying reactance of the feed choke. However, this is beside the case since the push-pull (or balanced) circuits have no monopoly over this method of feeding. The push-pull circuits can be shunt fed as suggested by the dotted lines in diagram D of Fig. 1, and, on the other hand, single-tube circuits can be fed without chokes by using a neutral connection of the tuning system as the feed point. For example, in Fig. 3 we have the one-tube Hoffman version of the Colpitts circuit in which one avoids both plate chokes and grid-leak losses. Incidentally, this circuit escapes the tiresome tendency of the push-pull systems to generate two frequencies near each other but unfortunately not quite the same.

Short-wave Tuner and Adapter Troubles

THERE appears to be considerable confusion and uncertainty among the purchasers of short-wave tuners and "adapters" for short-wave reception. On the one hand perfectly excellent apparatus is being accused unfairly, while on the other hand good results are vainly being sought with equipment that is quite incapable of decent work and which is unfairly giving the short waves a bad name. Perhaps it will be well to go over the possibilities and difficulties.

First of all, what has one a right to expect?

Assuming that one has a well-made set in good order, there is still no certainty as to the results which will be obtained. While the reception between 200 and 550 meters changes greatly between day and night this change is as nothing compared to the corresponding change on some of the short waves. Very roughly, wavelengths between 13 and 55 meters may be thought of as the "daylight waves" which work better by day than by night, but always over rather long distances. At shorter ranges they are rather unreliable and often very weak. The waves above 55 meters have the more normal ability to go further by night than by day, although between 30 and 60 meters lie waves which not infrequently do good daytime work. On dark days even 80-meter waves come through rather well. The summertime shifts the best working wavelengths toward the shorter end of the spectrum, simply because there is more daylight. In all cases one may expect rather rapid changes during sunset or sunrise at either transmitter or receiver.

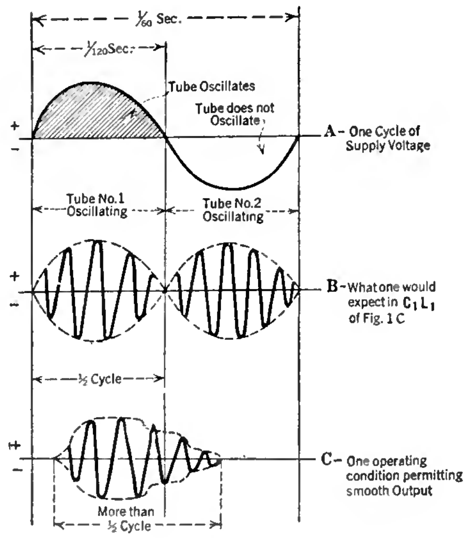

FIG. 2

With this rough set of rules as a guide one may begin to listen. However, at this point a very distressing difficulty may develop, namely, a "soupy" or "growly" audio quality that is entirely worthless as entertainment and often quite unintelligible. Such things happen in the 200–550 meter region at times, but not often or on all stations. But on short wavelengths every available station may be affected for an hour, a day, or a week, and in some locations the effect seems permanent! If the latter is the case, and one is sure that the tuner is not at fault, the short-wave idea had best be dropped. Usually, however, the effect is present only a portion of the time, and even then is seldom as prohibitive as the strong static which often mars reception on standard wavelengths.

Assuming now that we have managed to find signals and that they are decently free from the "audio-frequency fading" just mentioned, we may next proceed to determine the usefulness of the various available signals. On short waves it will be found that the strength of a signal has even less relation to the station's distance and power than is the case between 200 and 550 meters. Thus, at my own location the English station 5SW is somewhat stronger than WGY's various short-wave transmitters, though the latter are but 100 miles away and materially more powerful. Also, the English station fades far less. Usually it is the fading which determines the usefulness of a short-wave signal; if it is very bad one is subjected to such extreme changes of volume that all the pleasure is eliminated, especially as the effect usually carries with it the so-called "selective fading" which produces weird and unpleasant shifts of quality.

All this sounds as if the short-wave game were a most unreliable one and of no real value. This is by no means the case. If one will but accept its vagaries, and avoid them intelligently, when that is possible, one may hear quite an array of things with a short-wave receiver that would otherwise not "come in" at all. No inconsiderable part of this matter will arrive in good order and with steadiness as is shown by the occasional rebroadcasting of material received from another continent on a short-wave channel. Such work is usually done with a powerful initial signal. While it is true that a weak transmitter does occasionally put a strong signal into a remote region one still must not take seriously the claims of a broadcasting station which "broadcasts to the entire civilized world" with a 50- or 250-watt set.

Having agreed that the short-wave game is more of a sport and less of a utility than the standard waves, we arrive near the truth. Silver-Marshall's phrase, "The thrill bands" is correct. There is no thrill in the routine reception of a reliable station—but there is a possibility of a

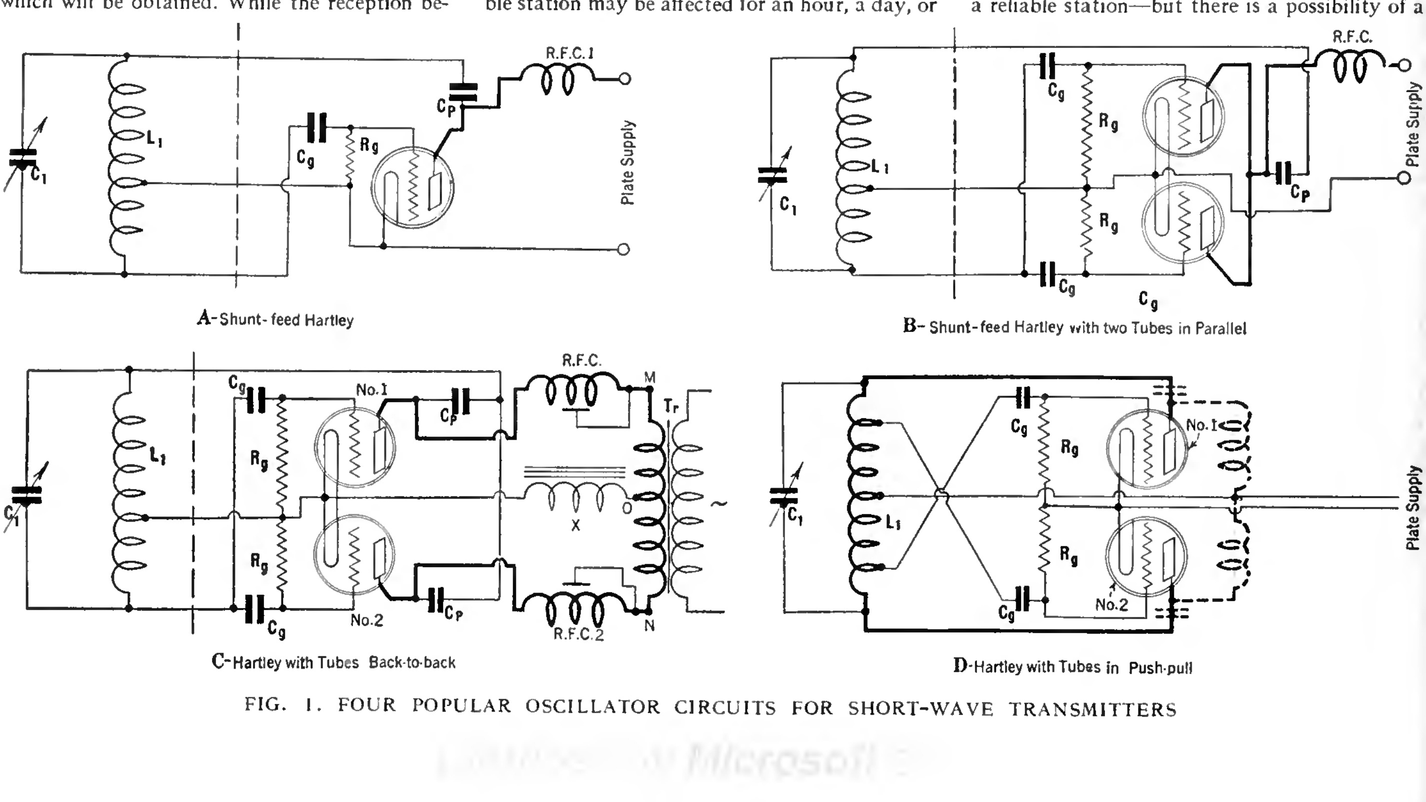

FIG. 1. FOUR POPULAR OSCILLATOR CIRCUITS FOR SHORT-WAVE TRANSMITTERS

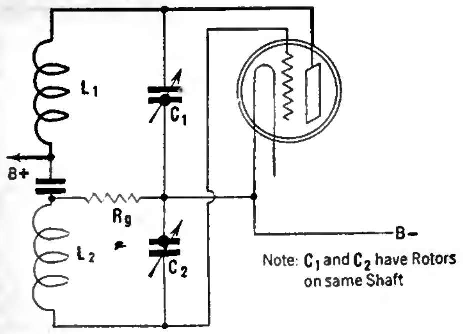

FIG. 3

thrill in fishing about among the short waves, uncertain of what one may land.

TROUBLESHOOTING—IN ADVANCE

IT MUST be repeated that there exists excellent short-wave equipment. Roughly it divides into three classes which can be thought of as (A) complete receivers, (B) short-wave tuners designed for use in connection with the audio amplifier of a broadcast receiver, and (C) short-wave adapters designed to autodyne or heterodyne the short-wave into an existing r.f. or i.f. amplifier, which may then handle it in the usual way. Since good and bad examples of each exist, one arrives at rather bewildering conclusions, making it hard to choose correctly, especially as the price does not seem to have a direct relation to the efficiency of the device. Fortunately, it is possible to lay down some rules that will be of help.

In types A and B we usually have a detector with a regeneration control. The coils may be of the plug-in type or a single coil may be used in the set. Before purchasing the set see if the regeneration control will cause the detector to oscillate over the entire tuning range of *each* coil. It is not serious if the oscillations fail below 15 meters or at the extreme ends (5 scale division or so) of other coils, provided there is enough overlap between coils so that this does not leave "blank" waves. Perhaps the best rule is to object if the set will not oscillate over the entire wavelength range without howling. The usual means of obtaining correct action should, of course, be tried. These include the use of a somewhat higher detector plate voltage and the use of several values of grid leaks between 1.5 and 8 megohms. If a means of loosening the antenna coupling is provided that also may be tried, and, if the tube is under suspicion, it may be changed. A reversed A battery will also cause trouble. If the set oscillates try the various coils in their sockets to make sure that a dependable contact exists. Finally, the tuning control and regeneration knob must operate smoothly, for, if there is any slipping or binding whatever, the tuner will be a constant aggravation. When the tuner is connected up it should be possible to operate both tuning and regeneration controls without a noticeable noise in the headset or loud speaker. One expects this from a standard-wave receiver as a matter of course, yet little attention seems to be paid to it by the makers of some of our short-wave jobs.

Type C may be simply a detector oscillating feebly and tuned to shift the beat-frequency wave into some existing broadcast amplifying system of a normal receiver. It is somewhat harder to locate faulty action in such devices, since one cannot detect the action as easily by listening. Close observation will make it possible, however, since one can hear the usual "rushing" sound whenever the oscillator or autodyne is working properly into the broadcast receiver. The most frequent failure of these devices seems to be a tendency to squeal, occasioned by the over-anxiety of the designer to insure oscillation on all wavelengths. Generally this can be cured by reducing the plate voltage of the oscillator or autodyne tube. Where it is not convenient to use a lower battery voltage one may connect into the lead from the battery a high-resistance rheostat (500,000-ohm) shunted by a 0.1-mfd paper condenser.

TROUBLESHOOTING—AFTERWARD

SUPPOSING that one already owns the set, and finds that it must be made to work, several dodges are useful. First let us assume that there is difficulty in securing even oscillation—which means that one is also unable to secure smooth regeneration. If the coils are wound like Fig. 4A the difficulty probably lies right there, and rewinding the tickler with small wire, and bunching it as in 4B, will probably help materially. The number of turns can be determined by trial. Too many turns causes squealing, too few turns results in silence or feeble action. A fair rule is to start with $\frac{2}{3}$ as many turns on the tickler as on the secondary. After a rough adjustment has been made try changing the grid leak and plate voltage in an attempt to secure smoother action, always making sure that each coil of the set continues to work. Generally it is the smallest coil that causes trouble. Having obtained fairly smooth action one may find that, when a signal is tuned in, the regeneration control cannot be adjusted without having to retune; this is often true in circuits of the type shown in diagrams C and D of Fig. 4. However, this tuning effect of the regeneration-control condenser, C_2, can be reduced by moving the tickler coil, T, to the filament end of the grid coil, S, as in Fig. 4E, or if that is not convenient the control can be changed to the resistance type shown in Fig. 4F. In diagram F the condenser C_2 can be set for approximately the correct action and thereafter R is used with little or no tuning effect. Unless one wishes to lose the calibration ("logging") C_2 must then be left alone. R must be noiseless in operation, and, so far as I have been able to determine, the Frost resistor is the only one which meets this requirement for any length of time. Wire-wound or step-by-step devices are hopeless, as are the compression types.

The drive for C_2 (if used) may be through a plain dial, and in no case should a high-ratio "vernier" dial be used. The drive for C_1 should be the smoothest available. I have never found anything as beautiful in operation as the old-type National dial. Lest it be thought that undue emphasis is given the subject of dials one must consider that most short-wave tuners attempt to go from about 15 to 200 meters with perhaps 4 coils. In effect this means that one must cover about 20,000 kc. in going across the scale 4 times, as against some 1000 kc. for the scale of the usual broadcast receiver. With 5 times as cramped a scale, smooth operation is imperative.

As regards the type C devices which heterodyne the signal into an existing i.f. system, the combinations here become so numerous that one can hardly lay down general rules. However, a hint may be of value. If the short-wave heterodyne oscillator seems unwilling to work smoothly try converting the system into the circuit of 4F by connecting the primary of the first i.f. transformer to the points marked "output." The antenna may be connected to the grid end of the coil S (not to the grid but to the tuning condenser stator) through a small capacity of about 15 mmfd. (.000015 mfd.). A still better method might be to wind a single-turn primary around the lower end of the form on which S is wound. In either case there may be "dead spots, and" this always suggests overclose antenna coupling or a bad choke coil. The former is remedied by reducing down the capacity of a "vernier" condenser in the antenna — even where the primary is used! The latter is a matter of cut and try.

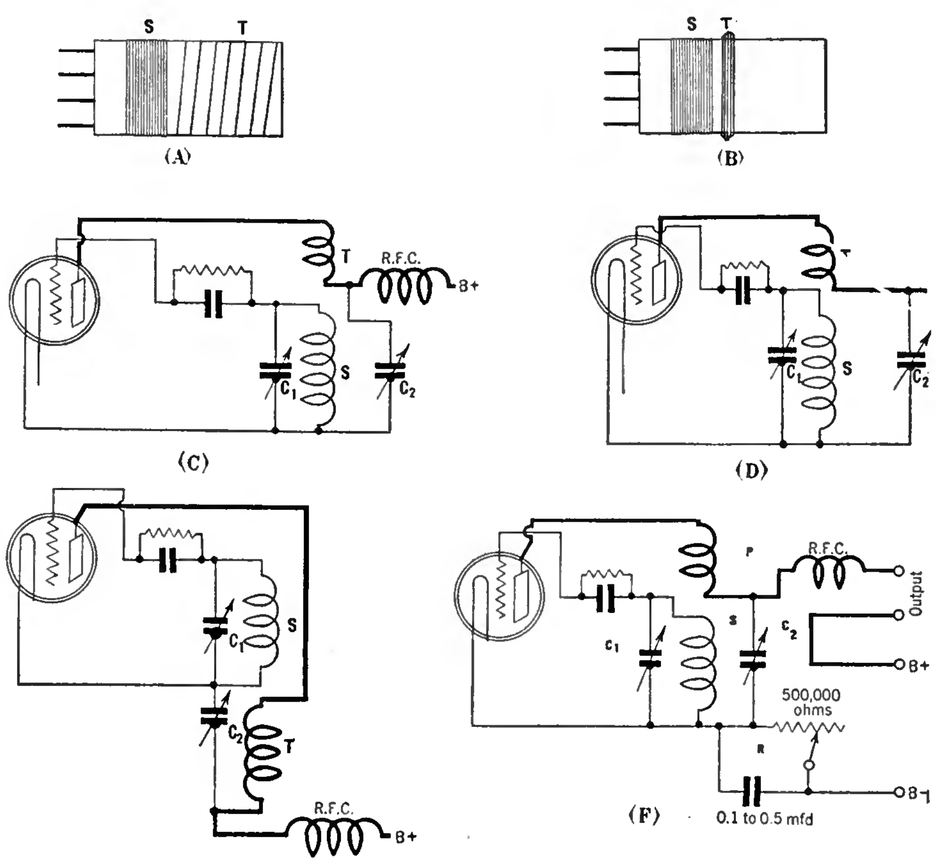

FIG. 4. SHORT-WAVE RECEIVING CIRCUITS

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"Our Readers Suggest—"

THIS department of RADIO BROADCAST *is utilized each month for the presentation of miscellaneous short radio articles which are received from readers. These abbreviated manuscripts describe "kinks," radio short cuts and economies that the experimenter runs across from time to time and that can be made clear in a concise exposition. Although some of these notes have been submitted by engineers and professional writers, the editors particularly solicit contributions from the average reader. All material accepted, including photographs, will be paid for on publication at our usual rates with extra consideration for particularly meritorious ideas.*

—THE EDITOR.

A Simple Wave Trap

WHEN WLW opened up with full fifty kilowatts at Mason, about twenty miles from Cincinnati, I experienced a bit of interference from this station. Rummaging around the collection of used parts generally found in the enthusiast's shop, I speedily assembled the essentials of a simple wave-trap, and had it operating satisfactorily an hour after WLW came in the air.

While there is nothing new in the trap idea, or in the design advocated by the writer, the economy of the arrangement will recommend itself to many readers, particularly in these days of consistently increasing power.

The essential parts are a variable condenser, a standard r.f. coil to match the condenser (if coverage of the full wavelength range is desired), a panel, and a dial.

The primary and secondary connections to the coil should be definitely located. The primary winding generally can be identified by the initialing P and B+, and the secondary by G and F. If no stamping is apparent, as may be the case on some r.f. transformers, the secondary winding has more turns than the primary coil.

The condenser should be mounted on a small panel, about five inches square, and the coil mounted to the condenser frame. The secondary winding is then connected across the variable condenser. This completes the wave-trap, illustrated in Fig. 2.

The primary winding is connected in series with the antenna lead to the receiving set, the connections being indicated in Fig. 1.

D. H. BOYD, Cincinnati, Ohio.

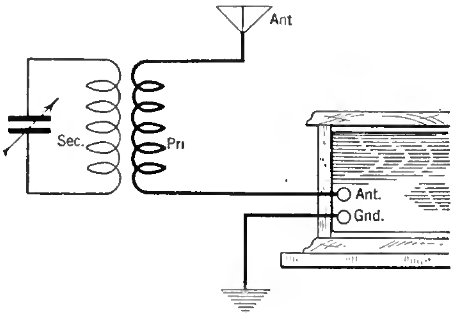

FIG. 1

The wave-trap circuit. The primary coil of the r. f. transformer is connected in series with the antenna lead.

STAFF COMMENT

The method of operation is simple. First, the receiver is tuned to the station *it is desired to eliminate*. The wave-trap is then adjusted until this station is weakest. Leaving the wave-trap at this setting, the desired station is now tuned in—generally with little or no interference from the first transmitter. If there is insufficient trapping action, five to ten additional turns of wire should be wound on the primary coil, in the direction of the original winding. Of course, the extra turns should be included in the antenna circuit.

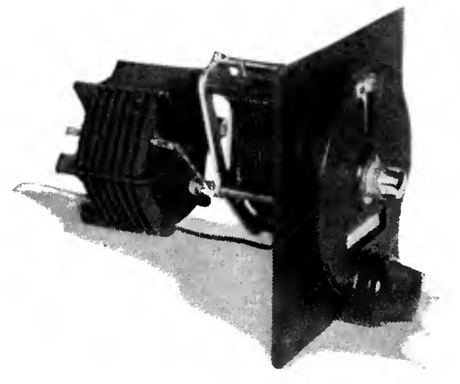

FIG. 2

A simple wave-trap made with a standard radio-frequency transformer and variable condenser.

A Source of Accurate Meters

EVERY experimenter needs meters to determine accurately the values of the current and voltage with which he is working. However, with reliable meters costing from $7.00 to $20.00 a piece, this important item is often necessarily neglected.

Accurate d.c. meters may easily be made from zero-center moving-coil ammeters readily obtainable at any automobile junk yard for fifty cents. Older models of high-priced cars were equipped with moving-coil instruments, such as Weston models 301 and 267. These meters have a 50-millivolt movement, and require from 10 to 20 milliamperes for full-scale deflection.

The shunt should first be removed from the meter, and the needle swung to the extreme left by moving both the zero adjuster and the corresponding adjustment found at the under side of the movement. The meter may then be calibrated as a low-reading milliammeter. By using shunts of proper values, milliammeters or ammeters of any range may be had.

The small operating current required by these meters readily permits their use as voltmeters having a sensitivity of from 50 to 100 ohms per volt by merely connecting the proper resistance in series.

EARL H. MILLER, Bellefonte, Pa.

R.F. Choke Coil

AN EFFICIENT radio-frequency choke coil of the plug-in type may be made from a burned-out filament ballast. The ballast tube should be wound with about 250 turns of number 34 silk-covered wire. The wire may be wound in a haphazard fashion and the ends soldered to the caps of the ballast plug.

This choke will be effective over the entire broadcast range and down to about 100 meters. For shorter wavelengths a 150-turn coil would be better.

ALLAN HAMILTON, Houston, Texas.

More Output Ideas

PUSH-PULL amplifiers generally are provided with an output transformer to which the loud speaker is connected. In some cases better results may be obtained by connecting the loud speaker directly to the primary through two 2-mfd. condensers, as suggested in the diagram Fig. 3. Posts 1 and 4 are used for any single loud speaker, while a very satisfactory combination of cone and horn loud speakers can be effected by connecting one reproducer to posts 1 and 2 and the other to posts 3 and 4.

H. M. THOMPSON, Vancouver, B. C.

A Band Selector for the Universal Receiver

I HAVE always been a booster of the RADIO BROADCAST Universal circuit, my only possible criticism of the arrangement being the lack of selectivity when operated in congested broadcast localities.

However, by utilizing the familiar link circuit, as suggested in Fig. 5, the selectivity was improved to an entirely satisfactory degree with a negligible loss of volume.

The following describes the coils indicated on the diagram:

Coil A, 10 turns wire on a 2¾ inch diameter tube;

Coil B, 48 turns of wire spaced ¼ inch from coil A;

Coils C and D each have 10 turns of wire on 2½-inch tubing;

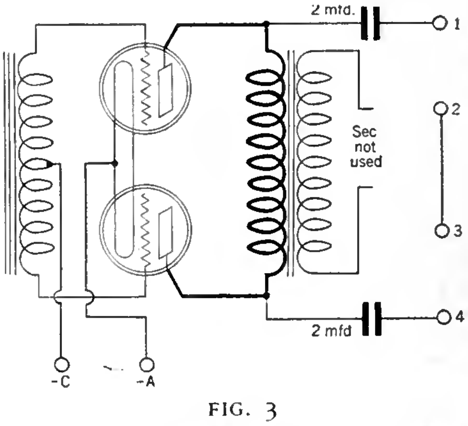

FIG. 3

An output arrangement that is occasionally superior to the transformer circuit, and which provides for one or two loud speakers.

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Coil E is wound on a $2\frac{3}{4}$-inch tube with 48 turns of wire.

Coils C and D slip inside of coils B and E, respectively, permitting any desired variation of coupling.

The condensers tuning these coils may be ganged.

H. T. Gallaher, Rock Island, Ill.

STAFF COMMENT

The arrangement suggested by our correspondent functions in many respects as a band filter —a system of station discrimination that characterizes the best of modern receivers. The arrangement suggested in Fig. 5 can be applied to practically any receiving circuit, it particularly recommends itself for use with the receivers having only one stage of tuned radio-frequency amplification.

Frequency Compensation on Moving-Coil Speakers

MOVING-COIL speakers, when used with some types of audio amplifiers, have a tendency to over-accentuate the bass notes. The deep rumbling tone is a characteristic to which many people take exception when hearing this type of speaker for the first time. The cause is apparently due to a slight peak on the low tones in most of the present-day audio transformers, originally intended to make up for the losses suffered in the usual magnetic speaker.

I have found that a very simple filter can be inserted easily in the input stage to eliminate this effect. The secondary of an old audio transformer, with core removed, is connected across the primary of the first transformer through a variable high resistance of about 100,000 ohms. Any desired balance may be had by simply adjusting this resistance.

George H. Miller, Buffalo, N. Y.

STAFF COMMENT

The apparent preponderance of low notes when first using a properly baffled moving-coil speaker, is often a psychological contrast with the deficiencies of other loud speakers. The genuine cases of over-emphasis of low frequencies with which this department has had experience, were resonant effects, several moving-coil speakers having decided resonant peaks in the neighborhood of fifty cycles.

Over-reproduction of low notes, if the reader is convinced that such exists, can be corrected by moving the speaker slightly away from the baffleboard. By varying this distance, any degree of low-frequency response can be obtained.

This department editor's experience with moving-coil speakers has been more or less confined to high-frequency emphasis when the loud speaker is operated from a push-pull amplifier, employing the proper output transformer in the amplifier rather than that in the loud speaker. This substitution eliminates the high-frequency compensation circuit included in many speakers to flatten out the hump above five-thousand cycles. These high frequencies are, therefore, over-reproduced, with an unpleasant fringe on certain types of broadcasting, noticeably on tenor and baritone soloists.

This effect generally can be compensated by shunting a 0.00025-mfd. fixed condenser across the secondary of the first audio-frequency transformer.

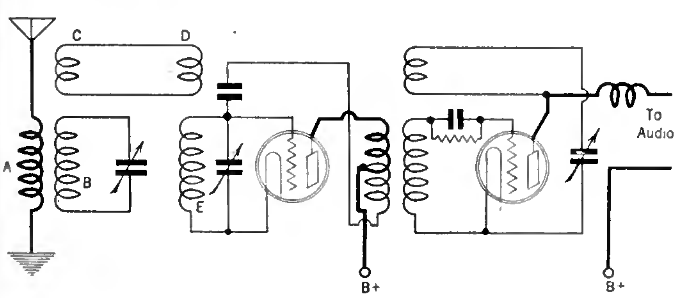

FIG. 5

This "link" circuit, when used with the R. B. Universal receiver, will add selectivity to the set. Its design is such that it functions somewhat as a band selector.

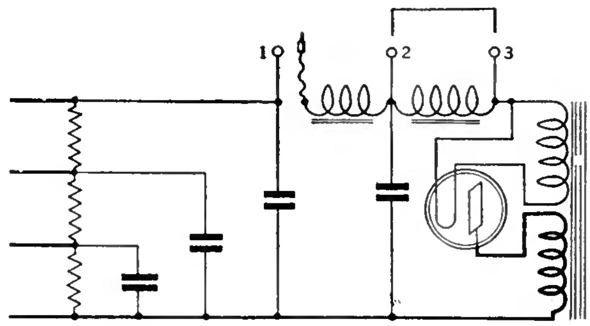

FIG. 6

Prearranging the power-supply circuit for the possible use of a moving-coil speaker with a high-voltage field-excitation coil.

Razor-Blade Condenser

THE fixed condenser described below is highly efficient and is constructed with rigid-metal air-spaced vanes. It costs but a few cents to make, as old safety-razor blades of the "Gillette" type are utilized.

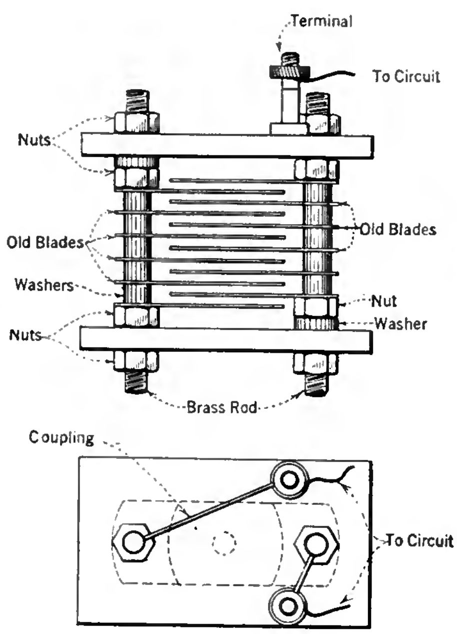

FIG. 4

A home-made razor-blade condenser. This air-dielectric condenser is excellent as an antenna series capacitor in short-wave transmitting circuits.

The materials needed for constructing the condenser will be found in the cellar or workshop of any radio enthusiast. The necessary parts include: two pieces of ebonite, each 3" by 2" by $\frac{1}{4}$"; two threaded rods, $\frac{3}{16}$" in diameter, and about $3\frac{1}{2}$" long; eight nuts to fit the rods; two terminals; twelve "Gillette" razor blades; and twelve metal washers. Washers are placed between the blades to separate them properly.

In assembling the condenser, the two rods are bolted to the piece forming the base, a washer being added to one of them. The blades and spacing washers are then assembled alternately on the rods to interleave without touching, adding a washer to the other rod to level the top when all the blades have been added. The two top nuts are then screwed down tight, and the top ebonite plate, with terminals mounted, is bolted in place. The connections are made as suggested in the diagram, Fig. 4. A test should be made to determine that the vanes are not "shorting" and the condenser is then ready for use.

The condenser will have a capacity of about 0.0001 mfd., and it will prove as satisfactory as the best condenser of this type on the market. By increasing the number of blades, one may, of course, increase the capacity.

Edward Piranian, Philadelphia, Pa.

STAFF COMMENT

This ingenious condenser recommends itself particularly as an antenna series capacitor in short-wave transmitting circuits.

Novel Power-Supply Device

BEING called upon very recently to design and build an amplifier and power supply for use with a power tube and an ordinary magnetic speaker, but also having in mind the possibility of later using the device with a moving-coil speaker requiring a field supply of 110 volts d.c., I designed the arrangement illustrated in Fig. 6. Each terminal of the choke except the last was brought out to a binding post. A flexible lead with a phone tip soldered to the end was attached to the last terminal. The three binding posts were mounted on a bakelite strip.

When an ordinary magnetic speaker is to be used the flexible tip from the choke is connected to binding post 1. This places the choke in operation and the speaker is attached in the usual way. When a moving-coil speaker is to be used, however, the flexible lead is disconnected from binding post 1 and the field winding of the moving-coil speaker is connected to binding posts 1 and 2. A jumper made of bus wire is connected between binding posts 2 to 3; this cuts out the first section of the choke while the second section is replaced by the winding of the moving-coil speaker.

Karl F. Oerlein, Philadelphia, Pa.

STAFF COMMENT

Such an arrangement has much to commend it. It is generally unsatisfactory to connect the field-winding terminals of the moving-coil loud speaker in series with the filter system of the power supply, since the additional resistance of the field winding may cause a considerable decrease in output voltage.

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New Apparatus and Its Applications

Transformers Now Available for Linking Dynamic Loud Speakers With Push-Pull Amplifiers

AGAIN this month a change is made in the method of presenting new apparatus in these pages. Parts submitted by different manufacturers usually are treated as separate items, but in this issue several dynamic-speaker output transformers of the push-pull type are described in one article. In this way it is possible to give a more lengthy discussion of the applications of these devices, as space is not wasted in duplicating descriptions. A second article under this heading describes a dual push-pull public-address amplifier. A complete list of parts is specified in the text, and much valuable data is given on the design of amplifiers of this type.

THE story is told of a man and woman who, while riding through California, expressed great curiosity regarding some immense fields of French artichokes, with which they were unfamiliar. It was explained to them what these vegetables were, what a toothsome dish they provided, and the suggestion made that they try them. To which the gentleman replied with utmost finality, "Oh, no! We never eat strange foods." An antipathy towards "strange foods" is fortunately not a characteristic of radio enthusiasts to whom new things are a staff of life.

The newest "strange food" to which many of us have probably devoted considerable thought during the past few months is concerned with moving-coil loud speakers—how good they are, how to operate them, and so forth. This article is devoted to one particular angle of the subject, the reason for the use of a coupling transformer between the moving coil of the loud speaker and the plate circuit of the power tube.

The coupling transformer, T, in a moving-coil loud speaker is connected in the circuit as indicated in Fig. 1, and it has one major purpose in life—to "match" the impedance of the moving coil to the plate resistance of the power tube. It is true that the transformer will also serve to keep the d.c. plate current of the tube out of the moving coil, but this purpose is secondary in comparison with that previously mentioned. Now, since the purpose of the transformer is to match the tube to the moving coil, it would seem to follow that manufacturers would have to put into the moving-coil loud speaker a coupling transformer that can only be used with a tube of a definite plate resistance—unless it is possible to design the transformer so that it will be satisfactory for use with all types of tubes. Let us see if we cannot answer this question very briefly.

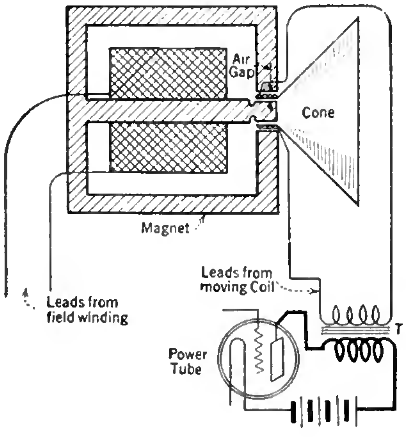


FIG. 1

It is not our purpose in this article to enter into a discussion of transformer characteristics. From such a discussion we would finally reach the following conclusions: (a) that a properly constructed coupling transformer designed to work out of an impedance of 5000 ohms, corresponding to a 112A- or 210-type tube, will also work satisfactorily out of 2000 ohms, corresponding to a 171A- or 250-type tube, and

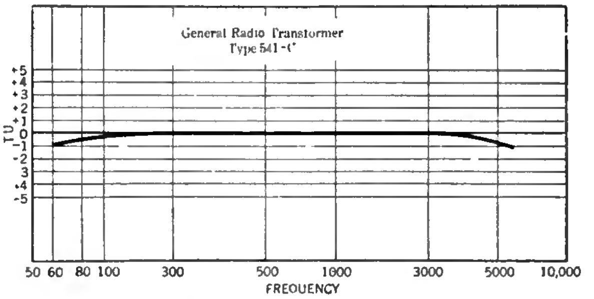


FIG. 2 CHARACTERISTICS OF GENERAL RADIO TRANSFORMER

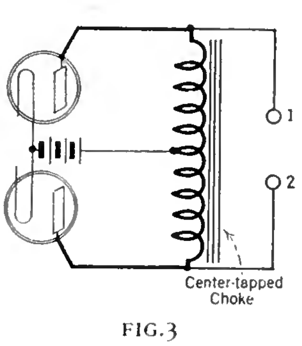


FIG. 3

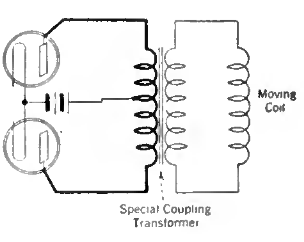


FIG. 4

(b) that a transformer designed to work out of an impedance of 2000 ohms, corresponding to a 171A- or 250-type tube, *will not operate* satisfactorily out of a 112A- or 210-type tube, because with such a transformer the two latter types of tubes would operate with a load impedance in their plate circuit of less than twice the plate resistance of the tube and, for this reason, the plate current-grid voltage characteristic of the tube will be curved and distortion will result.

For these reasons we find that the coupling transformers which always are built into a moving-coil loud speaker are designed according to (a), and the transformer will, therefore, work satisfactorily out of a 112A-, 171A-, 210-, or 250-type tube.

In some cases, however, we may want to operate a moving-coil loud speaker out of a push-pull stage. When this is to be done, two possibilities are open to us—we can either remove the transformer supplied with the loud speaker and substitute one designed for use between the moving coil of such a loud speaker and a push-pull stage, or we can just connect the output terminals of the present push-pull transformer in the set to the input terminals of the coupling transformer incorporated in the loud speaker. If we use the former arrangement the resultant circuit will look like Fig. 4, and if we use the latter arrangement the circuit will look like Fig. 5.

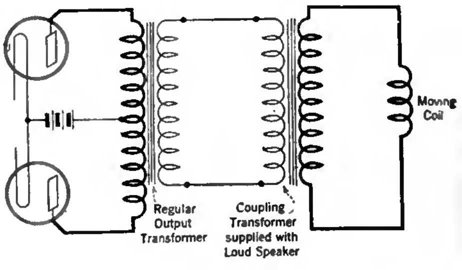


FIG. 5

Whether the arrangement of Fig. 4 or Fig. 5 is used depends upon various circumstances which are listed below:

(a) If the present output push-pull transformer in the receiver is a *good* one designed for use with ordinary cones with a nominal impedance of about 2000 or 4000 ohms, then the circuit of Fig. 5 may be used with satisfactory results. The power loss due to the use of two transformers will only be about 2 TU—a negligible loss.

(b) If the present push-pull output transformer in the set is thought to have a poor frequency characteristic it will be best to remove it and use the circuit arrangement Fig. 4.

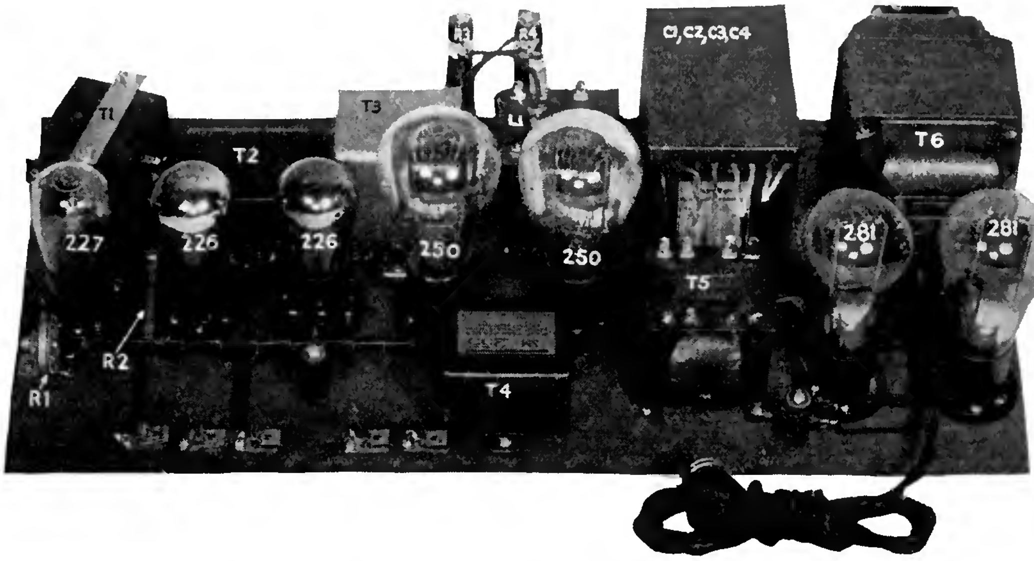
(c) If a choke output circuit, Fig. 3, is used in the output of the push-pull tube then the circuit of Fig. 5 may be used (i.e. terminals 1 and 2 of Fig. 3 may be connected to the leads from coupling transformer supplied with the loud speaker) if 171A tubes are used in the push-pull amplifier, provided that each of the choke coils have an inductance of not less than 30 henries.

(d) If a choke output circuit is usedwith 210-type tubes then the chokes and the coupling transformer in the loud speaker should be removed, and a special transformer substituted and arranged in the circuit as per Fig. 4.

There are listed in the following table a number of special transformers, designed to replace the coupling transformer of a dynamic speaker:

Manufacturer	Type	Type tube for use with Single	Push-Pull
Amertran Sales Co.	300		210 or 112A
	362		171A
Dongan Electric Company	2112	171A	
	1189	250	
	1192		171A or 210
	1183		250
Ferranti, Inc.	OP-2	112A or 171A	
	OP-4C		All types
General Radio Co.	585-O	All types	
	541-C		All types
Sangamo Electric Co.	GX-210		112A or 210
	HX-171		171A or 250
Thordarson Electric Mfg. Co.	T-2902	171A or 250	
	T-2903		171A or 250
	T-2629		112A or 210

New Dual Push-Pull Public-Address Amplifier Provides 15 Watts of Power



GENERAL VIEW OF PUBLIC ADDRESS AMPLIFIER

The amplifier pictured above employs three transformer-coupled stages and has an undistorted output of 15 watts. The unit, which is completely a.c. operated, was designed for use in large theatres

THE item of new apparatus described in this article is a three-stage light-socket-operated audio amplifier possessing ample amplification to boost the output of a radio set's detector tube, a microphone, or a magnetic phonograph pick-up unit up to a volume level sufficient for a large theatre or an outdoor crowd. The gain-frequency characteristics of the amplifier are such that an effect of naturalness for human voice or music will be conveyed to every listener.

This amplifier has little application in the average home radio outfit. Its real appeal, rather, is to those experimenters and professional set-builders who have found that there is much real demand for public-address amplification that cannot be adequately met by ordinary equipment designed primarily for home use. To such individuals, this amplifier offers the possibility of sale or rental to moving-picture theatres, skating rinks, schools, race tracks, and conventions, not to mention other uses. The fine possibilities of such sales can be grasped when one considers that a skating rink or theatre can avoid the considerable expense of even a small orchestra with a pair of phonograph turn-tables and record pick-up units, a supply of good records, one to four loud speakers, and this amplifier. Whereas the smaller theatre or rink could only afford a a small mediocre orchestra at most, the amplifier installation brings out music played by the orchestras of Paul Whiteman, Vincent Lopez, the New York Philharmonic, the Boston Symphony, etc., with all of its original color, tone and volume, yet the total cost need not be more than three- to five-hundred dollars! To the movie exhibitor, the radio fan, and the wide-awake professional set-builder, no more need be said.

POWER REQUIRED

IN DESIGNING this amplifier, much experimental work was done to determine the approximate power needed for various classes of coverage. In 1000- to 2000-seat theatres, for instance, five to seven watts, taken from one UX250 tube, was found sufficient in most cases to give realistic reproduction. As the desire of many exhibitors was to produce greater than natural volume, more power was found necessary for such "volume hounds." Conclusions reached experimentally indicated that for such conditions an undistorted power of fifteen watts would give coverate of theatres seating up to 2000 or 3000 people, under conditions of maximum absorption and with all seats occupied. Outdoor tests indicated that this same power would give natural understandable speech and music at volume sufficient for crowds of 10,000 to 15,000 people. From a gain-frequency standpoint, it was found that an accentuation of bass frequencies was desirable, particularly as phonograph records and radio programs are generally lacking in the lower bass registers. Practical experience indicates that if the amplifier accentuated frequencies between 60 and 200 cycles (lower notes being used infrequently in music and speech), the most pleasing effect would be obtained.

With this information at hand, a power output stage was first developed, after which suitable input stages were designed to insure the operation of the output stage at its full capacity with the lowest input voltage to be anticipated in practise. Adjustment of the transformer characteristics was made to obtain the desired gain-frequency curve. The power-handling capacity of the input stages was made so great that no overloading would occur in them, even though the output stage were operated at well over its maximum capacity. The whole amplifier was then adapted for full a.c. operation.

The requirement that 15 watts of undistorted power be available from the output stage automatically eliminated the possibility of using tubes smaller than the 250 type, and since the maximum output of one tube is 4.65 watts, a push-pull circuit with two 250-type tubes seemed to be a good starting point. From tests it was determined that, with a load impedance equal to four times the R_p of one tube, the requirements set down could be satisfied with a plate potential of 450 volts, and a grid voltage of 80, maximum safe values for *selected* 250-type tubes. An undistorted output of 15.75 watts was obtained from the two 250-type tubes in push-pull with a specially developed output coupling impedance.

The results of some gain measurements are shown in Fig. 1. It will be noticed that 10 watts may be developed without any appreciable decrease in gain (which would indicate distortion). The curve of Fig. 1 varies only 2 TU between 1 and 15.75 watts output and, as 2 TU is the

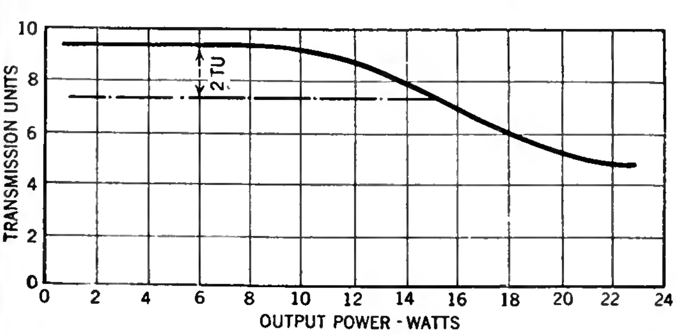


FIG. 1. OUTPUT CHARACTERISTICS

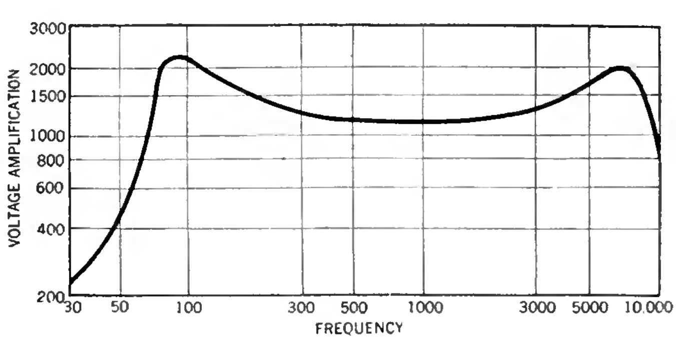


FIG. 2 FREQUENCY CHARACTERISTICS

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minimum sound variation perceptible to the average ear in a musical selection, a 2 TU variation may be taken as a very conservative limit on allowable distortion. Distortion becomes more serious at 18 to 22 watts, although the average person will not be disagreeably affected even at such an overload. While Fig. 1 is the power output curve for the final push-pull stage selected, it was actually taken on the whole amplifier, so that it is also a measure of such overloading as might occur in preceding stages.

ANALYSIS OF AMPLIFIER

AN ANALYSIS indicated that the signal voltage applied to each 250 tube at the 14.35-watt point on the curve of Fig. 3 was 90 volts. (The advantage of the push-pull stage is here well demonstrated—the grids were actually 10 volts positive over the 80-volt bias, yet distortion which would have been serious with such an overload on one tube has not become perceptible to most ears with the push-pull stage.) With 90 volts required at the 250 grids, and allowing conservatively for a 0.2 volt-signal at the input of the amplifier the voltage gain needed to develop 90 volts from a 0.2 volt-signal would be $90 \div 0.2 = 450$ times. This is a conservative figure, since the averge detector tube will turn out 0.3- to 0.4-signal volts, and average pick-up unit will deliver as much as 1 to 2 volts. Further measurements indicated that the standard Clough system transformers (described in July, 1928, RADIO BROCADAST), and one 226-type tube would give a gain of 120.5, obviously insufficient to operate the push-pull stage to capacity. At this point, one 226-type tube was found to be unable to operate the push-pull stage to capacity without overloading. A 171A-type tube preceding the push-pull stage was tried with considerable success, as well as two 226-type tubes in push-pull. The latter were found most desirable, due to the simplification of filtration and isolation that the push-pull stage permitted, as well as its greater undistorted output.

Suitable transformers of the Clough type were then designed to feed from one standard amplifier tube into a push-pull stage, and to feed from one push-pull stage into a second push-pull stage. These transformers were provided with a low-frequency cut-off below a hump ranging from 65 to 200 cycles and with a flat curve up to about 8000 cycles. (Incidentally, they will be welcomed by the many fans who have written to the designer asking for just such transformers.) An amplifier was then set up and measured, using one 4.3:1-ratio transformer feeding into a 227-type tube, one 1.75:1 push-pull input transformer feeding into two 226-type tubes in push-pull, and one 1.75:1 interstage push-pull transformer feeding from the 226-type tubes to the 250-type tubes. The output of the 250-type tubes was fed, through the specially designed adjustable output impedance previously mentioned, into several different speakers, and measurements were made. Fig. 2 shows the result in the form of an overall gain-frequency characteristic from input to power tube grids. The desirable bass hump is present, and above 3000 cycles common coupling through the power supply produced a second hump which was left in the amplifier to compensate the side-band cutting in radio reception. Many observers liked the effect produced by the rise at high frequencies but if the writer's dislike of this effect is shared by others, a needle-scratch filter across a record pick-up, or a 0.00015-mfd. condenser across the input transformer secondary, will flatten it out effectively. This hump would not appear in battery operation, and its effect consequently must not be exaggerated by the reader who has previously been shown only curves taken on battery-operated amplifiers, which curves would not show regeneration almost sure to develop where standard power-supply units were substituted for batteries. The curve of Fig. 2 is not a "hand-picked" laboratory product—it is a true measure of performance at signal voltages developing actual operating output powers in actual loud speakers.

A.C. OPERATION

ADAPTING a high-gain amplifier giving good response at 60 cycles to a.c. operation was no easy task. Fortunately, two push-pull stages simplified the process, but the high overall gain made special precautions necessary for the input stage. The B supply for the push-pull output stage was found to need no filtering, while a resistance-capacity filter in the B wire was adequate for the intermediate push-pull stage. Filament balances were non-critical on both-push-pull stages. Such good fortune did not hold for the input stage. A very high inductance choke, in an unusual resistance-inductance-capacity filter proved necessary for B and C supply, and in addition the input transformer had to be oriented to minimize induction from the power-supply transformer which was 18″ away. In the final models a.c. hum was reduced (when using airchrome-, dynamic- or cone-type loud speakers) to a point where it was not objectionable for home use.

Final models, operated with one dynamic speaker placed at an open window on a crowded boulevard, provided understandable speech and good music over traffic noise a city block away. Twelve air-column speakers distributed about three floors gave such effective coverage of 30,000 square feet of factory floor space that one could not hear conversation at normal speaking volume.

The assembly of the amplifier is well illustrated in the accompanying picture and the physical layout will be found to follow very closely the general arrangement of the schematic wiring diagram in that the amplifier progresses from left to right with the power-supply apparatus at the extreme right of the wooden baseboard. The 255 transformer is not screwed directly down to the baseboard, but should be wired into circuit loosely so that it can be adjusted for the minimum-hum position in actual operating tests. After its proper position has been determined (and outlined upon the baseboard with a pencil), it is clamped down by means of the steel tie-bar and two of the short-threaded brass rods with their nuts, the holes for them in the baseboard being counterbored.

The wiring of the amplifier is comparatively simple and is accomplished by using the flexible hook-up wire cut to proper lengths with insulation pushed back and ends soldered to proper soldering lugs or fastened directly under tube socket terminal screws. Amplifier grid and plate leads should be isolated as far as possible from each other and from other wiring, and can be made quite short due to the layout of parts. All filament and power wiring should preferably be run in a common cable as far as possible, which may be laced with waxed shoemaker's thread after testing. The two loud speaker connections to the S-M 248 universal output choke should be terminated in battery clips so that they may be moved about to the different groups of soldering lugs on the choke in preliminary tests.

LIST OF APPARATUS

THE following is a complete list of the apparatus employed in the construction of the power amplifier described in this article:

C_1, C_2, C_3, C_4 Potter condenser bank, type 673;
L_1 One S-M Universal output choke, type 248;
R_1 One Carter potentiometer, type AP-15;
R_2 One Yaxley resistor, 2000-ohm, type 72000;
R_5, R_6 Two Frost tapped resistors, type FT-64;
R_3, R_4 Two S-M resistors, type 659;
R_7, R_8 Two Polymet resistors, 750-ohm;
S_1 One S-M tube socket, type 512;
S_2 to S_7 Six S-M tube sockets, type 511;
T_1, T_4 Two S-M a. f. transformers, type 255;
T_2 One S-M push-pull transformer, type 257;
T_3 One S-M push-pull transformer, interstage-type, type 227;
T_5 One S-M filament transformer, type 247;
T_6 One S-M power transformer, type 328;
One phone cord and plug, five-foot;
One roll of S-M hook-up wire, type 818;
Five Fahnestock clips;
One S-M wooden chassis, 21-$\frac{7}{16}$″ x $\frac{5}{16}$″ x $\frac{1}{2}$″.

The total cost of the apparatus is $93.36.

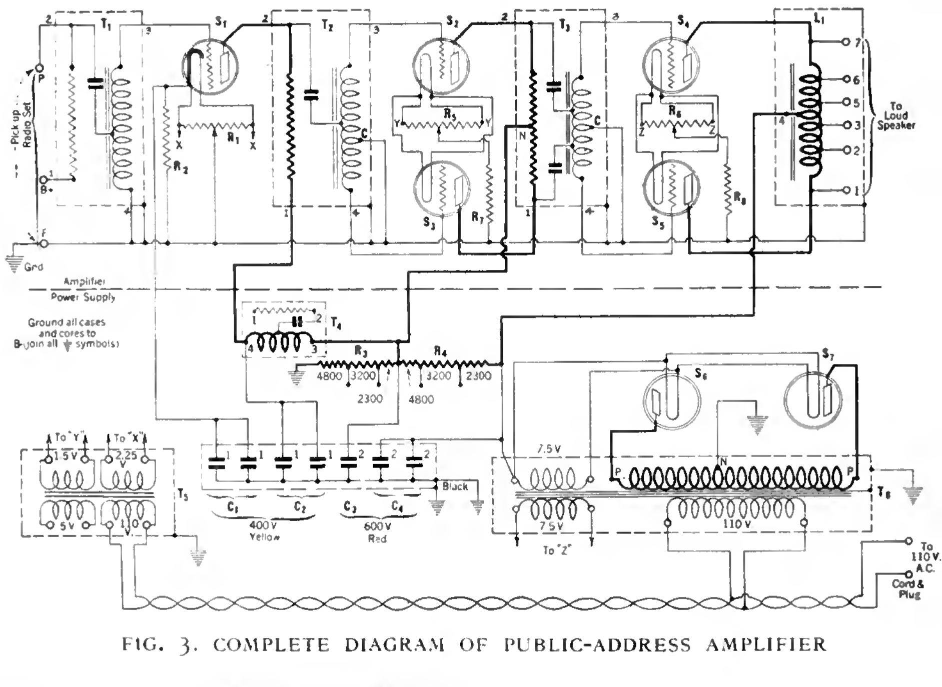
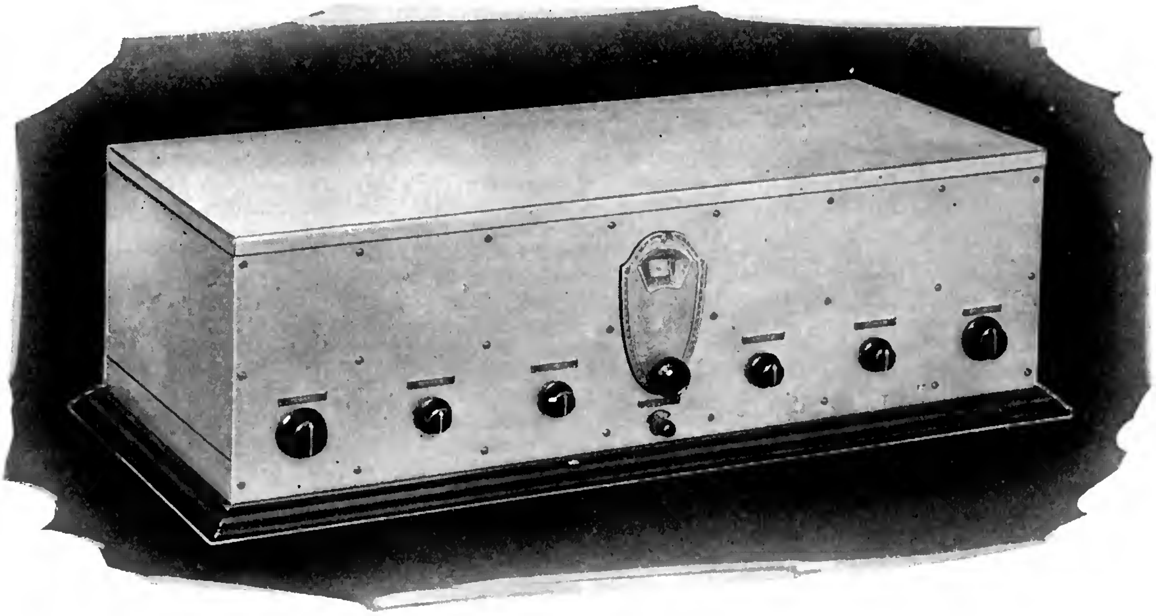


FIG. 3. COMPLETE DIAGRAM OF PUBLIC-ADDRESS AMPLIFIER



A RECEIVER OF MODERN DESIGN FOR THE DX FAN

More Data on the Sargent-Rayment

By HOWARD BARCLAY

AT THE time the article entitled "The Sargent-Rayment Seven Receiver" was prepared for October, 1928, RADIO BROADCAST, the writer, as a result of testing a model receiver attendant upon the preparation of his article, had become firmly convinced that this receiver was an unusual example of a fine kit, and that, in short, it would be heard from in no uncertain terms once a number had been built. Circumstances have since proven that the silent prophet is not always unhonored in his own country. Believing that the comments of some experienced experimenters who have built and tested the set may be of interest, as well as a bit of additional engineering data and a few timely operating suggestions, this, the writer's second article upon the Sargent-Rayment Seven Receiver, has been prepared.

Extended experience with western conditions on the part of the designers of this receiver had effectively convinced them of the necessity of a far more selective set than would in all probability ever be developed in the East, due to the peculiarities of western reception conditions. In consequence, it would seem that if the Sargent-Rayment receiver were capable of giving a good account of itself on the West Coast, it would certainly be able to do so in any other location in the United States. Such is actually the case. As an example of results obtained from a typical Sargent-Rayment set, a report received from Lloyd Breck, 110 Pacific Avenue, Piedmont, California, is most interesting. In the course of two evenings' tuning, Mr. Breck was able to tune in a total of 116 stations upon the receiver he had built. Out of the total of 116 stations, 44 were located in the East, and Mr. Breck's log included CYJ and CYA of Mexico City, KFQD of Anchorage, Alaska, KHGU of Honolulu, Hawaii, and PWX of Havana, Cuba. The log is interesting, for there are only approximately 100 transmission channels in the broadcast band, and the reception of 116 stations meant that several transmission channels were heard from twice!

Turning from Mr. Breck's results, the comments of F. Edwin Schmitt, of New York City, upon the performance of a Sargent-Rayment located at White Plains, New York are interesting as coming from the opposite coast. Mr. Schmitt reports that between the hours of 8:00 and 12:00 P. M. on an evening late in October, one station in Portland, Oregon, one in Seattle, Washington, one in San Diego, California, three in Los Angeles, one in Denver, one in Fort Worth and many closer by were heard with excellent volume on the loud speaker through the barrage of stations located in and about New York City. These comments, together with reports of average logging of from 50 to 100 stations in an evening from many different builders, indicate that the receiver is evidently adequately selective for present-day conditions.

THE Sargent-Rayment receiver was first described in our October, 1928, issue. This article gives additional operating notes and other comments which are sure to interest those who have built the set and probably will be of interest to those who may now be planning to build one.

—THE EDITOR.

REGARDING COIL DESIGN

IN FIGS. 2 and 3 are some interesting amplification curves made upon several typical r.f. stages tested in the development of the Sargent-Rayment receiver. In order to determine the most satisfactory type of coil for the general type of mechanical assembly which seemed desirable, a family of coils, each of approximately the same inductance, were constructed and placed in a single stage compartment for measurement. It was observed that with constant coupling maintained for each coil, the amplification obtained increased with decreases in coil size, due to a reduction in shielding absorption. The most satisfactory coil of the various types tested consisted of 72 turns of No. 25 enamelled wire wound upon a bakelite tube $2\frac{1}{2}''$ in diameter, threaded 32 turns to the inch. When measured unshielded, this coil actually was inferior to a larger type which, also wound upon a $2\frac{1}{2}''$ tube, consisted of 80 turns of No. 20 enamelled wire, threaded 20 turns per inch. This larger coil, being affected to a much more marked degree by the presence of the shielding than was the smaller coil, actually delivered lower amplification in practise. This is indicated by the curves, Fig. 2, showing the amplification obtained with four different values of screen-grid voltage when using the larger coil with a primary consisting of 35 turns of No. 34 d.c.c. wire slipped into the secondary at the filament end of the latter. Amplification with 45 volts on the screen grid ranges from 17.to 26.5 between 550 and 1450 kilocycles, with selectivity varying 3.9 to 1.21 for the different frequencies.

The curve of Fig. 3 taken upon the smaller coil with a 25-turn primary shows a considerable improvement in amplification over the larger coil, and a very appreciable improvement in selectivity as indicated by the selectivity figures appearing in the curve. (These selectivity figures represent the ratio of amplification of the desired signal to the amplification of another signal 10 kilocycles off resonance, and to the engineer the merit of the stage represented in Fig. 3 will be appreciated as being quite high.)

HOW SENSITIVITY IS OBTAINED

TO THE average reader, the values of amplification per stage shown in Fig. 3 may seem quite low, but it must be borne in mind that in designing the Sargent-Rayment receiver

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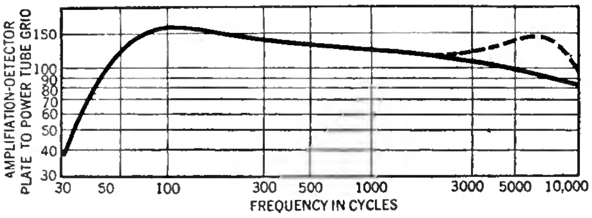

FIG. I

the thought was to employ as many stages of suitable r.f. amplification as were needed to give the desired degree of amplification, rather than to obtain the highest possible amplification per stage. This decision made, the designers were left free to concentrate upon the problem of selectivity rather than amplification in each stage. The wisdom of this policy is indicated by the fact that the selectivity of each r.f. stage is practically that of the tuned secondary circuit alone without the deleterious effects of coupling a preceding amplifier tube into this circuit through a primary large enough to obtain the highest possible value of amplification which always halves the selectivity factor. Lest, however, the casual reader should be inclined to regard the amplification of the Sargent-Rayment receiver as being of a very low order, it is interesting to compare the r.f. amplification of typical six-tube, one-dial receivers averaging about 1000 times between antenna and detector grid with the r.f. gain of the Sargent-Rayment, neglecting entirely its tuned antenna input circuit with its large potential amplifying possibilities. The r.f. gain of the Sargent-Rayment, operating in a perfectly stable manner has a value adequate to allow the receiver to go down to the lowest noise level; this is equivalent to many times the gain given by many of the receivers of the type mentioned above.

An over-all amplification curve for the two-stage audio amplifier employed in the Sargent-Rayment is shown in Fig. 1, this curve being

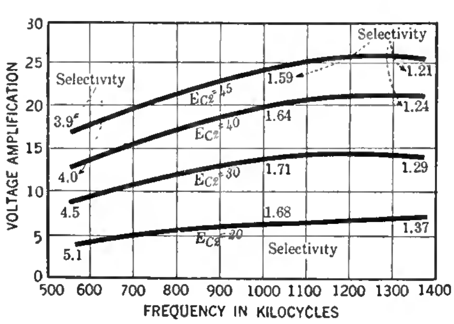

FIG. 2

made with 112A-type tubes in the detector and first audio positions, and a 171A-type tube in the second audio position, with recommended operating voltages. It is, however, quite feasible to employ a 210- or 250-type power tube in the output stage of the receiver through the use of a high-voltage power-supply unit. The standard S-M 675ABC kit is especially suitable for this purpose providing, as it does, 7.5 volts for filament lighting through an adapter plug inserted between the power tube and the second audio socket, together with B voltage and C bias for the entire receiver including a 210- or 250-type power tube. With this combination and the substitution of the 1-mfd. 600-volt condenser, as specified in the circuit diagram on page 355 of October, 1928, RADIO BROADCAST, the Sargent-Rayment receiver provides an unusually fine combination of tone quality, sensitivity, and selectivity.

ANTI-MOTORBOATING FILTER

UNFORTUNATELY, the set is not without its one drawback, though this drawback is in itself the accompaniment of the extremely high amplification developed by the receiver. When used with standard B-power units, there occasionally develops a tendency for the receiver to "motorboat," particularly at one setting of the volume control regulating the screen-grid voltage to the r.f. tubes. Messrs. Sargent and Rayment have recommended a non-motorboating filter which they have termed a "stabilizer." It consists of a small choke coil, similar to the S-M 251 output transformer, connected in the 45-volt screen-grid lead and a 50,000-ohm resistor connected in the positive B lead to the detector plate. Each of these circuits is then bypassed back to the receiver chassis, a 4-mfd. condenser being used for the screen-grid bias and a 1-mfd. for the detector-plate lead. The circuit is shown in Fig. 4.

INCREASING THE SENSITIVITY

AN EXAMINATION of the receiver circuit diagram (October RADIO BROADCAST) indicates that the input from antenna to first r.f. tube is through a rejector type of wave filter which, in its general characteristics, is essentially similar to that of the tuned r.f. stages. The thought has occurred to some builders that through shifting the screen-grid connection of the left-hand screen-grid tube from the antenna connection (2) of the coil L_1 to the free end of the tuned secondary coil (3) of the wave filter, an increase in amplification may be obtained. Whether or not this is necessary is for individual decision, for the performance of the receiver is perfectly stable with the recommended connection, and the amplification is high enough to go down to the most favorable low-noise level. The change in connection to utilize the rejector circuit as a tuned r.f. stage will usually tend to make the receiver oscillate, with oscillation controlled by the volume knob. The effect, however, of the regeneration introduced through this change is to reduce the effective repeater amplification, so that only a very slight actual gain in sensitivity results. Nevertheless, under extremely favorable conditions, as, for instance, early in the morning when listening for Japanese or Australian stations, this connection has sufficient merit to justify its trial, at least, for it will result in some boost of a very weak signal.

As stated above the writer is of the opinion that the receiver possesses ample sensitivity, as well as selectivity, in its present form. This view is more or less substantiated by letters from many experimenters who have built the receiver. Two of these communications are particularly interesting and excerpts are printed below. The first is from Frank McDonell, president of Rossiter, Tyler and McDonell, a well-known engineering and service organization located in New York. After testing the Sargent-Rayment receiver in a steel-frame building in the heart of the lower New York business district, Mr. McDonell write as follows:

"You will be interested in a word of comment on the Sargent-Rayment receiver. I want to put myself on record right now as saying that it is without question the best receiving set of any type or description that we have ever demonstrated. During the evening demonstrations, we were able to tune-in at will almost anything in the country that we desired, getting such stations as Fort Worth, Atlantic City, Atlanta, Ga., and literally hosts of others, with as much volume as any ordinary receiving set receives WEAF in this locality. Incidentally, our receiving conditions here are most abominable."

FIVE JAPANESE STATIONS HEARD

TURNING again to the opposite Coast for confirmation of such performance, the report of Kenneth G. Ormiston, the technical editor of *Radio Doings*, a Los Angeles publication, is interesting. Mr. Ormiston commented as follows:

"We are impressed with the very obvious sensitivity of the Sargent-Rayment receiver, due to its ability to reach the noise level with the sensitivity control but half on. The volume of WGN, when he signed off, inspired us to set the

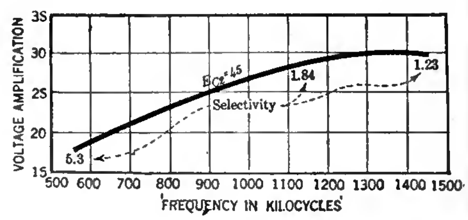

FIG. 3

alarm clock for 4 A. M., and, when we turned the set on at that hour, five of the "Japs" and 4QG in Brisbane were received with good volume. Also, WFAA, WMMJ, KMA and some Easterners were heard on the air with their early morning programs.

"In all, we were very well satisfied with the performance of the receiver. Not alone satisfied, but considerably surprised! No repeats or harmonics, very fine tone quality, on both local and DX, and its ease of operation are factors which are bound to make the set popular with those fans who believe that d.c. tubes, operated from either batteries or a socket-power unit, give peak performance."

Apparently Mr. Ormiston started the ball rolling, for immediately after receiving word of his reception, reports came in from many different West-Coast builders of reception of Japanese and Australian stations, not to mention a large number of eastern American stations. In particular, E. W. Gardner of Del Monte, California, reports the reception of six Japanese broadcast stations.

Considering the fact that the comments quoted from and referred to herewith are but a very few of the large number of favorable reports which have been received from builders, it may be assumed that the Sargent-Rayment receiver provides an unusual degree of selectivity and amplification (as we write this, a Chicago experimenter reports reception of what were apparently Japanese programs upon the wavelength of JOAK on November 6.)

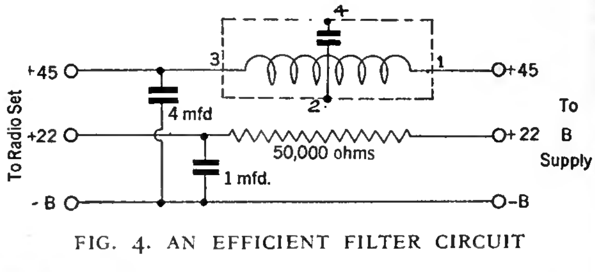

FIG. 4. AN EFFICIENT FILTER CIRCUIT

Manufacturers' Booklets

A Varied List of Books Pertaining to Radio and Allied Subjects Obtainable Free With the Accompanying Coupon

READERS may obtain any of the booklets listed below by using the coupon printed on this page. Order by number only.

1. FILAMENT CONTROL—Problems of filament supply, voltage regulation, and effect on various circuits. 1928 revised booklet, with circuit diagrams of popular kits. RADIALL COMPANY.

5. CARBORUNDUM IN RADIO—A book giving pertinent data on the crystal as used for detection, with hook-ups, and a section giving information on the use of resistors. THE CARBORUNDUM COMPANY.

12. DISTORTION AND WHAT CAUSES IT—Hook-ups of resistance-coupled amplifiers with standard circuits. ALLEN-BRADLEY COMPANY.

15. B-ELIMINATOR AND POWER AMPLIFIER—Instructions for assembly and operation using Raytheon tube. GENERAL RADIO COMPANY.

15a. B-ELIMINATOR AND POWER AMPLIFIER—Instructions for assembly and operation using an R. C. A. rectifier. GENERAL RADIO COMPANY.

17. BAKELITE—A description of various uses of bakelite in radio, its manufacture, and its properties. BAKELITE CORPORATION

22. A PRIMER OF ELECTRICITY—Fundamentals of electricity with special reference to the application of dry cells to radio and other uses. Constructional data on buzzers, automatic switches, alarms, etc. NATIONAL CARBON COMPANY.

23. AUTOMATIC RELAY CONNECTIONS—A data sheet showing how a relay may be used to control A and B circuits. YAXLEY MANUFACTURING COMPANY.

30. TUBE CHARACTERISTICS—A data sheet giving constants of tubes. C. E. MANUFACTURING COMPANY.

32. METERS FOR RADIO—A catalogue of meters used in radio, with diagrams. BURTON-ROGERS COMPANY.

33. SWITCHBOARD AND PORTABLE METERS—A booklet giving dimensions, specifications, and shunts used with various meters. BURTON-ROGERS COMPANY.

37. WHY RADIO IS BETTER WITH BATTERY POWER—Advice on what dry cell battery to use: their application to radio, with wiring diagrams. NATIONAL CARBON COMPANY.

46. AUDIO-FREQUENCY CHOKES—A pamphlet showing positions in the circuit where audio-frequency chokes may be used. SAMSON ELECTRIC COMPANY.

47. RADIO-FREQUENCY CHOKES—Circuit diagrams illustrating the use of chokes to keep out radio-frequency currents from definite points. SAMSON ELECTRIC COMPANY.

48. TRANSFORMER AND IMPEDANCE DATA—Tables giving the mechanical and electrical characteristics of transformers and impedances, together with a short description of their use in the circuit. SAMSON ELECTRIC COMPANY.

53. TUBE REACTIVATOR—Information on the care of vacuum tubes, with notes on how and when they should be reactivated. THE STERLING MANUFACTURING COMPANY.

56. VARIABLE CONDENSERS—A bulletin giving an analysis of various condensers together with their characteristics. GENERAL RADIO COMPANY.

57. FILTER DATA—Facts about the filtering of direct current supplied by means of motor-generator outfits used with transmitters. ELECTRIC SPECIALTY COMPANY.

58. HOW TO SELECT A RECEIVER—A common-sense booklet describing what a radio set is, and what you should expect from it, in language that anyone can understand. DAY-FAN ELECTRIC COMPANY.

67. WEATHER FOR RADIO—A very interesting booklet on the relationship between weather and radio reception, with maps and data on forecasting the probable results. TAYLOR INSTRUMENT COMPANIES.

69. VACUUM TUBES—A booklet giving the characteristics of the various tube types with a short description of where they may be used in the circuit; list of American and Canadian broadcast stations. RADIO CORPORATION OF AMERICA.

72. PLATE SUPPLY SYSTEMS. Technical information on audio and power systems. Bulletins dealing with two-stage transformer amplifier systems, two-stage push-pull, three-stage push-pull, parallel push-pull, and other audio amplifier, plate, and filament supply systems. AMERICAN TRANSFORMER COMPANY.

73. RADIO SIMPLIFIED—A non-technical booklet giving pertinent data on various radio subjects. Of especial interest to the beginner and set owner. CROSLEY RADIO CORPORATION.

76. RADIO INSTRUMENTS—A description of various meters used in radio and electrical circuits together with a short discussion of their uses. JEWELL ELECTRICAL INSTRUMENT COMPANY.

78. ELECTRICAL TROUBLES—A pamphlet describing the use of electrical testing instruments in automotive work combined with a description of the cadmium test for storage batteries. Of interest to the owner of storage batteries. BURTON ROGERS COMPANY.

81. BETTER TUNING—A booklet giving much general information on the subject of radio reception with specific illustrations. Primarily for the non-technical home constructor. BREMER-TULLY MANUFACTURING COMPANY.

84. FIVE-TUBE EQUAMATIC—Panel layout, circuit diagrams, and instructions for building a five-tube receiver, together with data on the operation of tuned radio-frequency transformers of special design. KARAS ELECTRIC COMPANY.

88. SUPER-HETERODYNE CONSTRUCTION—A booklet giving full instructions, together with a blue print and necessary data, for building an eight-tube receiver. THE GEORGE W. WALKER COMPANY.

89. SHORT-WAVE TRANSMITTING EQUIPMENT. Data and wiring diagrams on construction of all popular short-wave transmitters, operating instructions, keying, antennas; information and wiring diagrams on receiving apparatus; data on variety of apparatus used in high-frequency work. RADIO ENGINEERING LABORATORIES.

90. IMPEDANCE AMPLIFICATION—The theory and practice of a special type of dual-impedance audio amplification are given. ALDEN MANUFACTURING COMPANY.

ON THIS page are listed radio manufacturer's booklets which may prove of interest to readers of RADIO BROADCAST. The list is revised each month and a constant effort is made to keep it as accurate as possible. In all cases the booklets listed have been selected because of the valuable information which they contain. Among the new booklets of interest to service men are the following: 135, 139, 140, 145, 146, 152, and 154.

95. Resistance Data—Successive bulletins regarding the use of resistors in various parts of the radio circuit. INTERNATIONAL RESISTANCE COMPANY.

98. COPPER SHIELDING—A booklet giving information on the use of shielding in radio receivers, with notes and diagrams showing how it may be applied practically. Of special interest to the home constructor. THE COPPER AND BRASS RESEARCH ASSOCIATION.

99. RADIO CONVENIENCE OUTLETS—A folder giving diagrams and specifications for installing loud speakers in various locations at some distance from the receiving set, also antenna, ground and battery connections. YAXLEY MANUFACTURING COMPANY.

101. USING CHOKES—A folder with circuit diagrams of the more popular circuits showing where choke coils may be placed to produce better results. SAMSON ELECTRIC COMPANY.

102. RADIO POWER BULLETINS—Circuit diagrams, theory constants, and trouble-shooting hints for units employing the BH or B rectifier tubes. RAYTHEON MANUFACTURING COMPANY.

104. OSCILLATION CONTROL WITH THE "PHASATROL"—Circuit diagrams, details for connection in circuit, and specific operating suggestions for using the "Phasatrol" as a balancing device to control oscillation. ELECTRAD, INCORPORATED.

105. RECEIVING AND TRANSMITTING CIRCUITS. Construction booklet with data on 25 receivers and transmitters together with discussion of low losses in receiver tuning circuits. AERO PRODUCTS COMPANY.

108. VACUUM TUBES—Operating characteristics of an a.c. tube with curves and circuit diagram for connection in converting various receivers to a.c. operation with a four-prong a.c. tube. ARCTURUS RADIO COMPANY.

112. HEAVY-DUTY RESISTORS—Circuit calculations and data on receiving and transmitting resistances for a variety of uses, diagrams for popular power supply circuits, d.c. resistors for battery charging use. WARD LEONARD ELECTRIC COMPANY.

In sending the coupon below, make sure that your name and address are included and are plainly written. Also make sure that the listing of booklets from which you choose is that of the latest issue of the magazine, as Radio Broadcast cannot guarantee the delivery of booklets not listed in its current issue.

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113. CONE LOUD SPEAKERS—Technical and practical information on electro-dynamic and permanent magnet type cone loud speakers. THE MAGNAVOX COMPANY.

114. TUBE ADAPTERS—Concise information concerning simplified methods of including various power tubes in existing receivers. ALDEN MANUFACTURING COMPANY.

115. WHAT SET SHALL I BUILD?—Descriptive matter, with illustrations, of fourteen popular receivers for the home constructor. HERBERT H. FROST, INCORPORATED.

118. RADIO INSTRUMENTS. CIRCULAR "J"—A descriptive manual on the use of measuring instruments for every radio circuit requirement. A complete listing of models for transmitters, receivers, set servicing, and power unit control. WESTON ELECTRICAL INSTRUMENT CORPORATION.

120. THE RESEARCH WORKER—A monthly bulletin of interest to the engineer and home builder. Each issue contains special articles on radio design and construction with special emphasis on resistors and condensers. AEROVOX WIRELESS CORPORATION.

121. FILTER CONDENSERS—Some practical points on the manufacture and use of filter condensers. The difference between inductive and non-inductive condensers. POLYMET MFG. CORP.

123. B SUPPLY DEVICES—Circuit diagrams, characteristics, and list of parts for nationally known power supply units. ELECTRAD, INC.

124. POWER AMPLIFIER AND B SUPPLY—A booklet giving several circuit arrangements and constructional information and a combined B supply and push-pull audio amplifier, the latter using 210 type tubes. THORDARSON ELECTRIC MFG. CO.

125. A. C. TUBE OPERATION—A small but complete booklet describing a method of filament supply for a.c. tubes. THORDARSON ELECTRIC MFG. CO.

126. MICROMETRIC RESISTANCE—How to use resistances for: Sensitivity control; oscillation control; volume control; regeneration control; tone control; detector plate voltage control: resistance and impedance coupling: loud speaker control, etc. CLAROSTAT MFG. CO.

129. TONE—Some model audio hook-ups, with an explanation of the proper use of transformers and chokes. SANGAMO ELECTRIC CO.

130. SCREEN-GRID AUDIO AMPLIFICATION—Diagrams and constructional details for remodeling old audio amplifiers for operation with screen-grid tubes. THORDARSON ELECTRIC MFG. CO.

131. THE MERSHON CONDENSER—An illustrated booklet giving the theory and uses of the electrolytic condenser. AMRAD CORPORATION.

132. THE NATIONAL SCREEN-GRID SHORT-WAVE RECEIVER—Constructional and operating data, with diagrams and photographs. JAMES MILLEN.

133. THE NATIONAL SHIELD-GRID FIVE—A circuit diagram with constructional and operating notes on this receiver. JAMES MILLEN.

134. REMLER SERVICE BULLETINS—A regular service for the professional set builder, giving constructional data, and hints on marketing. GRAY & DANIELSON MFG. CO.

135. THE RADIOBUILDER—A periodic bulletin giving advance information, constructional and operating data on S-M products. SILVER-MARSHALL, INC.

136. SILVER MARSHALL DATA SHEETS—These data sheets cover all problems of construction and operation on Silver-Marshall products. SILVER-MARSHALL, INC.

139. POWER UNIT DESIGN—Periodical data sheets on power unit problems, design, and construction. RAYTHEON MFG. CO.

140. POWER UNIT PROBLEMS—Resistance problems in power units, with informative tables and circuit diagrams. ELECTRAD, INC.

141. AUDIO AND POWER UNITS—Illustrated descriptions of power amplifiers and power supplies, with circuit diagrams. THORDARSON ELECTRIC MFG. CO.

142. USE OF VOLUME AND VOLTAGE CONTROLS. A complete booklet with data on useful apparatus and circuits for application in receiving, power, amateur transmitter, and phonograph pick-up circuits. CENTRAL RADIO LABORATORIES.

143. RADIO THEORY. Simplified explanation of radio phenomena with especial reference to the vacuum tube, with data on various tubes. DE FOREST RADIO COMPANY.

144. LOW FILAMENT VOLTAGE A. C. TUBES. Data on characteristics and operation of four types of a.c. tubes. ARCTURUS RADIO COMPANY.

145. AUDIO UNITS. Circuits and data on transformers and impedances for use in audio-amplifier circuits, plate and output impedances and special apparatus for use with dynamic speakers. SANGAMO ELECTRIC COMPANY.

146. RECEIVER CIRCUIT DATA. Circuits for using resistances in receivers, and in power units with descriptions of other apparatus. H. H. FROST, INC.

147. SUPER-HETERODYNE CONSTRUCTION. Construction and operation of a nine-tube screen-grid super-heterodyne. SET BUILDERS' SUPPLY COMPANY.

148. SHORT-WAVE RECEIVER. Constructional and operation data on a four-tube short-wave receiver. KARAS ELECTRIC COMPANY.

149. FIVE-TUBE SCREEN-GRID RECEIVER. Blueprint with full constructional details for building a broadcast receiver using two screen-grid tubes. KARAS ELECTRIC COMPANY.

150. FIVE-TUBE A.C. RECEIVER. Blueprint for constructing a five-tube a.c. receiver employing the "equamatic system." KARAS ELECTRIC COMPANY.

151. THE SECRET OF THE SUPER. Constructional and operation data on the Lincoln 8-80 One-Spot Super. LINCOLN RADIO CORPORATION.

152. POWER SUPPLY ESSENTIALS. Circuits and data on power-supply devices, and descriptions of power apparatus. POLYMET MANUFACTURING COMPANY.

153. WHAT THE EVEREADY FIDELITY CURVE MEANS TO RADIO RECEPTION. An analysis of the frequency range of musical instruments and the human voice which shows how these tones are reproduced by a receiver with an audio range of 60 to 5000 cycles. NATIONAL CARBON COMPANY.

154. AMPLIFIER AND POWER SUPPLY CONSTRUCTION MANUAL. A booklet giving descriptions, circuit diagrams, and lists of parts of several popular amplifier and power supply circuits. ACME WIRE COMPANY.

Sound Motion Pictures

(*Continued from Page 182*)

But in the talking movies how is the director to know, when the action is recorded, what the audiences are going to do? His spacing is a matter of guesswork. He can, of course, have an audience present and try it on them, but, as every actor knows, different audiences do different things.

To return to volume control, however—what is the remedy for some of these defects? My answer is no better than that of anybody else, but I will venture a few suggestions. One consists in disagreement with the dogma that volume control is all taken care of in recording and, after the initial gain setting is made in the projection room, the faders should be left alone. This is good theory, but it doesn't always work in the present state of the recording art.

Part of the trouble is that the recording engineers, especially when they are working with discs, always have to worry about the ground noise. Their tendency is to bring up the gain on low portions and to iron out the record to one level. When the changes are not too rapid this could be fixed in projection. A wider range in volume can be secured there without excessive background disturbance, since lowering the reproducing gain brings down the ground noise with the signal. And, in general, accurate control of volume in recording, particularly in rush production, awaits future developments in instruments and technique. In short, while the best answer would be to record so well that projection could take place without any change in gain, with the present technique of recording skillful gain adjustment in the theatre could do a lot of good.

The projectionist, clearly, cannot be relied on for this. For one thing, he has too many other things to do. Secondly, he is not listening in the house, but in a more or less noisy and uncomfortable projection room. Thirdly, he is seldom fitted by temperament for an audio monitoring job.

A POSSIBLE SOLUTION

ONE solution is to use automatic, electrical, or mechanical means of some sort to vary the amplification in the theatre within certain limits. This adds to the complications, but it is a possible future development.

In the meantime the best answer may be a limited gain control manipulated from a point in the house by someone who has nothing else to watch. This man may be a theatre musician, whose judgment is likely to be good on such matters as proper volume of speech and music. He will operate a remote gain control permitting a latitude of, say, 15 or 20 TU. The setting in the booth will be such that the house gain control can be brought up to the maximum without causing overloading or any such difficulties. The operator of the house control will preview the film several times with the house manager or someone in authority. In this way he will be able to arrange a cue sheet, which can readily be memorized after the first few trials, enabling him to turn out a much smoother performance than under present conditions in most theatres. For example, if there is an abrupt change in selections, he will at least be able to fade down to low volume during the shift. He will be able to drop an appropriate number of units for dialogue, bring up the gain once more for heavy musical accompaniments, tone down pianissimos which have been recorded with too much amplitude, and in general graduate the performance. I suspect that such a man, judiciously chosen, would more than earn his salary, and that his presence would help, in some measure, to preserve the life of the goose which is laying the golden eggs.—CARL DREHER

An Inexpensive Audio Oscillator

(*Continued from Page 187*)

condensers used in connection with the circuit. The greater the capacity across L_1, the lower the frequency. It is suggested that the oscillator be calibrated from either tuning forks or a reliable frequency standard. If only the middle part of the audio-frequency scale is desired, the oscillator can be calibrated from a piano keyboard by striking a key that corresponds to the frequency generated by the oscillator.

An audio-frequency transformer with a fairly good characteristic between 60 and 6,000 cycles should be used in connection with the oscillator, otherwise the higher frequencies will be cut off or will come through so weak that additional amplification will be necessary to step up the voltage of the oscillator.

The question of harmonics will probably be brought up by the readers of this article; it is admitted that the percentage of harmonics with this type of oscillator is rather high. However, the results obtained with the oscillator are sufficiently good for most experimental purposes.

WHAT PARTS TO USE

THE picture of the oscillator on page 186 shows Western Electric tubes; any type of tube may be used instead of the ones shown; a power-type tube is suggested, such as the 112 or 171A, depending on how much power is desired. The C bias of the amplifier tube should be carefully adjusted so that no distortion may take place in this part of the circuit. The normal bias for the 171 with 90 volts on the plate is about 16.5 volts.

In the following list of parts, the writer has indicated few trade names; the reason is that any well-constructed apparatus will work as well as any other. The only special part in the list below is the Ford coil, and even here the name Ford indicates nothing more than that such a coil may be used—any similar spark coil will do as well.

The complete list of apparatus follows:

C_1—Several small fixed condensers of various capacities.
C_2—Two fixed mica condensers, 0.00025– and 0.005–mfd.;
C_3—One paper condenser from Ford unit (about 0.01 mfd.);
L_1 L_2—One Ford ignition coil used on Model T cars;
R_1—One grid leak, 2 megohms;
R_2—Two Federal potentiometers, 600-ohm;
R_3—One rheostat, 6-ohm;
Sw_1, Sw_2—Two small multipoint switches (Carter, Frost, Yaxley, etc.)
T_1 One audio transformer of good characteristics.

To place this oscillator in operation, the following will be needed:

Two power tubes, 112A– or 171A– type;
One storage battery, 6-volt;
B batteries or equivalent power supply, 90-volt;
One C battery, 16.5–volt.

As the Broadcaster Sees It

(*Continued from Page 185*)

intensely practical problems as the frequent conflict between optimum development for the picture and optimum development for sound, comparisons between different systems of recording, and other problems which are being widely discussed and some of which will be considered in this department. The movie people, of course, have the same difficulty in the other direction.

At present a lot of skillful bluffers from both camps are getting by and drawing their imposing salaries. This will not last. One dark morning the deflation of experts will begin, and the ex-property men and fourth-rate broadcast operators will be propelled back into the rear ranks. As a practical criterion at the present juncture, I should say that no one should be allowed to qualify as an engineer in sound movie work who cannot understand all the articles on broadcast and audio-frequency technique in the *Proceedings of the Institute of Radio Engineers* and the *Journal of the American Institute of Electrical Engineers*, as well as the papers on sound movies in the *Transactions of the Society of Motion Picture Engineers*. That is a reasonable minimum; of course if he can follow some of the optical material in the latter publication, and the electrical and radio-frequency discussions in the former two, he is better qualified to hold the position and is of much greater value to his employers.

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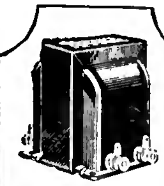

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Transformer Specialists Since 1895
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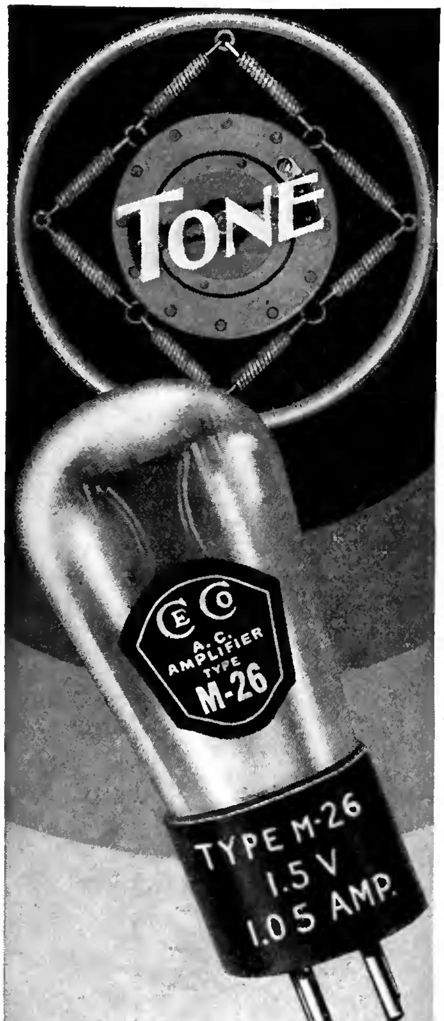

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Radio Tubes

The *Radio Broadcast* LABORATORY INFORMATION SHEETS

THE aim of the Radio Broadcast Laboratory Information Sheets is to present in a convenient form, concise and accurate information in the field of radio and closely allied sciences. It is not the purpose of the Sheets to include only new information, but to present practical data, whether new or old, that may be of value to the experimenter, set builder or service man. In order to make the Sheets easier to refer to, they are arranged so that they may be cut from the magazine and preserved, either in a blank book or on 4" x 6" filing cards. The cards should be arranged in numerical order.

Since they began, in June, 1926, the popularity of the Information Sheets has increased so greatly that it has been decided to reprint the first one hundred and ninety of them (June, 1926–May, 1928) in a single substantially bound volume. This volume, "Radio Broadcast's Data Sheets" may now be bought on the newsstands, or from the Circulation Department, Doubleday, Doran & Company, Inc., Garden City, New York, for $1.00. Inside each volume is a credit coupon which is worth $1.00 toward the subscription price of this magazine. In other words, a year's subscription to Radio Broadcast, accompanied by this $1.00 credit coupon, gives you Radio Broadcast for one year for $3.00, instead of the usual subscription price of $4.00.

—The Editor.

No. 249 Radio Broadcast Laboratory Information Sheet **January, 1929**

A Resistance-Coupled Amplifier

PARTS REQUIRED

ON LABORATORY Sheet No. 250 is published the circuit diagram of a resistance-coupled amplifier illustrating the use of filter circuits in the plate and grid leads. As explained in Sheet No. 243, lack of proper filter circuits will cause distortion due to common coupling in the plate supply. It will frequently be worth while to incorporate such filter circuits in existing resistance-coupled amplifiers, especially if the amplifier exhibits a tendency to "motorboat" or distort.

In operating a resistance-coupled amplifier it is especially important that overloading be prevented by keeping the volume down to the point where none of the tubes draw grid current, and it is up to the user of the amplifier to operate it so that grid current does not flow.

In constructing the amplifier illustrated on the next sheet the following parts will be required:

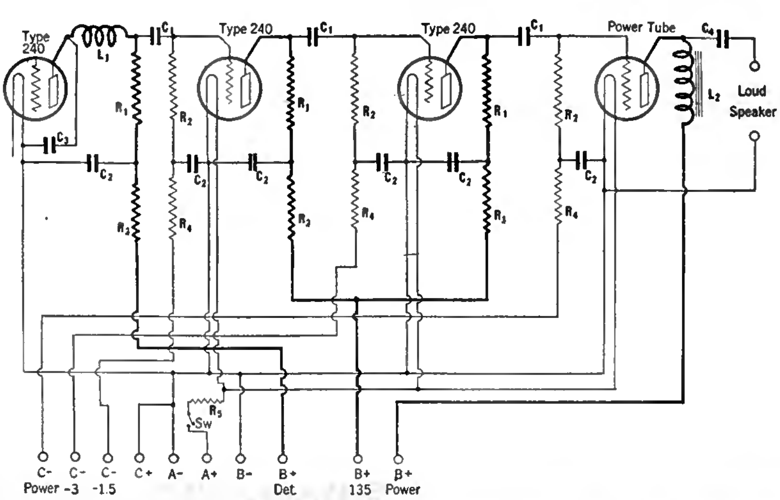
R_1—Three plate-coupling resistors, 250,000-ohm;
R_2—Three grid resistors, 2-megohm;
R_3—Three plate-circuit filtering resistors, 25,000-ohm;
R_4—Three grid-circuit filtering resistors, 50,000-ohm;
R_5—Filament rheostat, 6-ohm;
C_1—Three coupling condensers, 0.01-mfd.;
C_2—Six by-pass condensers, 1-mfd.;
C_3—One by-pass condenser, 0.0002-mfd.;
C_4—Output condenser, 4-mfd.;
L_1—R.F. choke coil;
L_2—Output choke coil, 30-henries;
Sw—Filament switch.

The detector and the first two of the audio amplifiers may be 240-type tubes and the power tube may be any type, depending upon the personal preference of the builder. The voltages applied to the B-plus power terminal and the C-minus power-terminal will, of course, depend upon the type of power amplifier; it is recommended that a 171A-type power tube be used.

The simplest and most satisfactory construction to follow in building a resistance-coupled amplifier is to mount the tube sockets and the resistor mounts for the grid- and plate-coupling resistors all in a line. With this arrangement the grid and plate leads between the tubes and the coupling resistors are very short.

No. 250 Radio Broadcast Laboratory Information Sheet **January, 1929**

A Resistance-Coupled Amplifier



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I will show you too how to start a spare time or full time Radio Business of Your Own *without capital*

Radio's amazing growth is making many big jobs. The world-wide use of receiving sets and the lack of trained men to sell, install and service them has opened many splendid chances for spare time and full time businesses.

Ever so often a new business is started in this country. We have seen how the growth of the automobile industry, electricity and others made men rich. Now Radio is doing the same thing. Its growth has already made many men rich and will make more wealthy in the future. Surely you are not going to pass up this wonderful chance for success.

More Trained Radio Men Needed

A famous Radio expert says there are four good jobs for every man trained to hold them. Radio has grown so fast that it simply has not got the number of trained men it needs. Every year there are hundreds of fine jobs among its many branches such as broadcasting stations, Radio factories, jobbers, dealers, on board ship, commercial land stations, and many others. Many of the six to ten million receiving sets now in use are only 25% to 40% efficient. This has made your big chance for a spare time or full time business of your own selling, installing, repairing sets.

So Many Opportunities You Can Make Extra Money While Learning

Many of our students make $10, $20, $30 a week extra while learning. I'll show you the plans and ideas that have proved successful for them—show you how to begin making extra money shortly after you enroll. G. W. Page, 1807-21st Ave., S., Nashville, Tenn., made $935 in his spare time while taking my course.

I Give You Practical Radio Experience With My Course

My course is not just theory. My method gives you practical Radio experience—you learn the "how" and "why" of practically every type of Radio set made. This gives you confidence to tackle any Radio problems and shows up in your pay envelope too.

You can build 100 circuits with the Six Big Outfits of Radio parts I give you. The pictures here show only three of them. My book explains my method of giving practical training at home. Get your copy!

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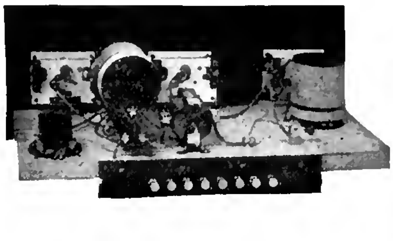

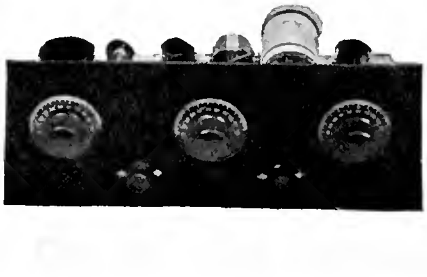

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Safeguard Your
A. C. Installation

SATISFACTORY and economical operation of A. C. receivers is contingent upon maintaining close regulation of operating voltages, by means of suitable A. C. measuring instruments. This is necessary because of the wide fluctuation in the potential of secondary lines furnishing current to house lighting circuits.

Set manufacturers, dealers and electric light and power companies everywhere are cooperating to the end that voltage regulation, both on supply lines and in connection with voltage control equipment of the receivers themselves, may be effected for the better operating service of all set owners. For this reason, as well as for other testing requirements outlined in the following, all purchasers of A. C. receivers are urged to provide themselves with an instrument such as is shown in the illustration—known as the Weston Model 528 A. C. Voltmeter, range 150/8/4 volts.

When you find that there is an excessive in-put voltage, it follows that there is too high a voltage on the filament which shortens the operating life of the rectifying tubes. The Model 528 Voltmeter therefore checks the line supply voltage at all times and indicates when adjustments should be made to manually operated line voltage regulators between the power supply and the power transformer.

This voltmeter also indicates when the line voltage is over-rated, thus enabling the operator to make an adjustment in the set for the higher line voltage so that normal life can be obtained from his tubes.

The Model 528 is also made as Ammeters which are especially useful in checking the total load of the A. C. Set—in conformity with set manufacturers' instructions. The determination of A. C. filament flow in A. C. tube filament circuits is easily obtained by means of this instrument.

Write for your copy of Circular J fully describing the Weston Radio Line.

Weston Electrical Instrument Corporation

604 Frelinghuysen Ave.,
Newark, N. J.

WESTON RADIO INSTRUMENTS

No. 251 RADIO BROADCAST Laboratory Information Sheet January, 1929

Moving-Coil Loud Speakers

DESIGN OF THE COUPLING TRANSFORMERS

WHEN an engineer designs a moving-coil loud speaker, he also has to design the input transformer which is used to couple the loud speaker and receiver. The impedance ratio of this transformer will depend upon the impedance of the moving-coil system and upon the plate resistance of the power tube in the receiver. Since the engineer doesn't know what type of power tube the buyer of the loud speaker is going to use, upon what facts does he base his decision regarding the impedance ratio of the transformer which is finally incorporated in the loud speaker?

The fact has been mentioned many times in these data sheets that the maximum undistorted output is obtained from a tube when the load into which it works is equal to twice the plate resistance of the tube. A curve was also given on Laboratory Sheet No. 237 showing how the power output changed with variations in load impedance and this curve indicated quite clearly that a large percentage of the maximum amount of undistorted power was still available in the load, even though the load resistance was 5 or 6 times greater than the plate resistance of the tube. Suppose the engineer designed the coupling transformer so that looking into the primary the impedance is 4000 ohms. The plate resistance of a 171A-type tube is 2000 ohms and if this tube were used the maximum undistorted power output would be obtained (since 4000 ohms is twice the plate resistance of a 171A). If, however, this loud speaker were to be used with a 112A- or 210-type tube, both of which have a plate resistance of about 5000 ohms, then only 40 per cent. of the maximum available power would appear across the loud-speaker circuit. Also, when a high plate resistance tube is used with a low-impedance load the tube characteristic is curved (see Laboratory Sheet No. 124) and this produces distortion. Evidently then, if such a design were decided upon, the power loss would be somewhat greater than half when using a 112A- or 210-type tube and also distortion would be produced due to curvature of the tube's characteristic.

If the transformer were designed so that from the primary the impedance was 10,000 ohms then the maximum amount of undistorted power would be obtained from a 112A- or 210-type tube, since they are both 5000-ohm tubes. On the other hand, if a 171A-type tube with a 2000-ohm plate resistance were used with this transformer we still would obtain 70 per cent. of the maximum power, and, since the plate load, 10,000 ohms, is much greater than the tube resistance, 2000 ohms, distortion would not be introduced due to curvature of the characteristic. This design of the transformer is obviously the correct one.

No. 252 RADIO BROADCAST Laboratory Information Sheet January, 1929

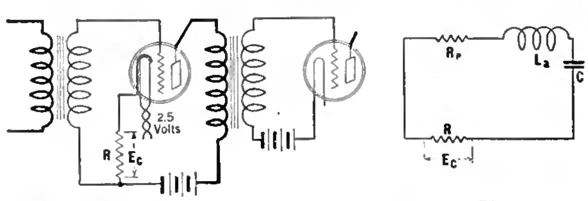
Audio Amplifiers

IMPORTANCE OF BY-PASS CONDENSERS

IN SKETCH A on this sheet we illustrate the circuit of a single-stage audio amplifier. Resistor R, being connected in series with the cathode of the tube, functions to supply C bias to the grid of the tube. Should the resistance, R, be bypassed with a condenser?

If this circuit were casually analyzed one would be inclined to answer this question negatively, since this resistance is in series with the primary of the audio transformer, T, and the impedance of this circuit is very high. Consequently the a.c. currents around through the plate circuit and through the resistance ought to be very small. If, however, we draw out the equivalent circuit, as we have done in sketch B, a different condition is seen to exist. This equivalent circuit represents what the tube and transformer look like at high audio frequencies, L_a being the leakage inductance in the transformer and C the distributed capacity reflected into the primary. R is the grid resistor and R_p the plate resistance of the tube. At high frequencies this is a series resonant circuit and the currents are, therefore, quite large. For this reason a comparatively large voltage may be developed across the resistor R which supplies the C-bias voltage, E_c, to the grid of the tube. This voltage, E_c, should obviously be only a d.c. voltage, but, since the circuit is a series resonant one, considerable a.c. voltage will be developed across the resistance and be impressed back on the grid of the tube. This voltage impressed back on the grid will be out of phase with the original voltage and it will, therefore, reduce the amplification at high frequencies.

These facts were checked on an amplifier in the Laboratory a short while ago and proved to be true. The low-frequency response of the amplifier was unaffected by the condenser across the C-bias resistor. At high frequencies, however, there was a very considerable loss in gain unless a by-pass condenser of 1 or 2 mfd. was placed across the resistance. It is therefore recommended that home constructors always make certain that all the C-bias resistors are properly bypassed.



(A) (B)

No. 253 RADIO BROADCAST Laboratory Information Sheet January, 1929

Shielding

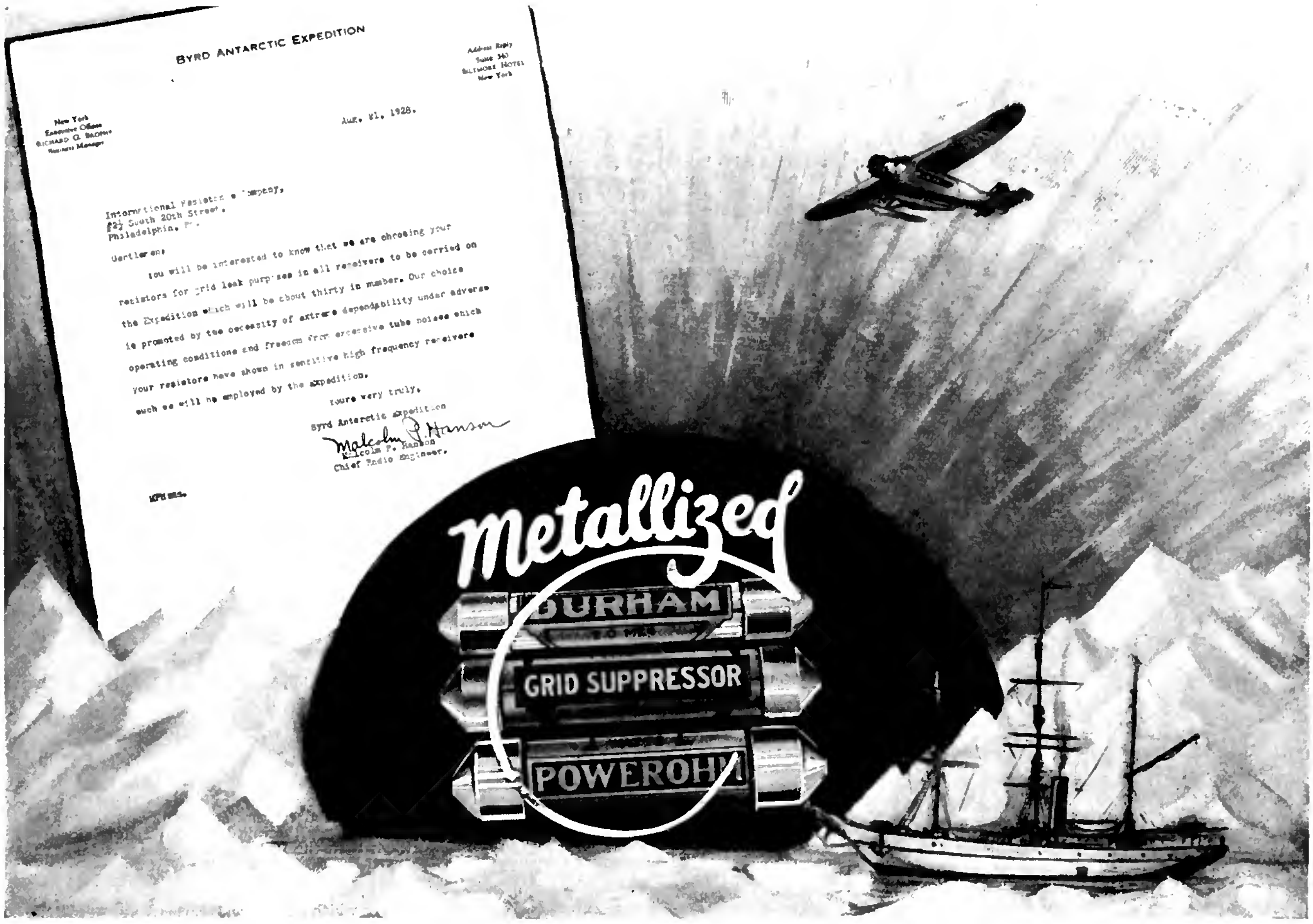
SUGGESTIONS REGARDING ITS USE

SHIELDING is used in radio receivers for two purposes. First, it prevents direct pick-up, by the coils in a receiver, of signals from powerful local stations, for, when such pick-up exists, the receiver is likely to be non-selective. Second, the use of shielding prevents electrostatic and electromagnetic coupling between the various parts of the circuit, particularly the various inductance coils. Electrostatic coupling is readily prevented, thin sheets of shielding material between the apparatus to be shielded generally being sufficient. Electromagnetic coupling is more difficult to prevent. The prevention of such coupling necessitates the use of very complete shielding, the joints must be tight and a material with a low electrical resistance must be used.

The shielding in a receiver should be used for only one purpose—shielding. It should not be used to conduct currents, for example, between a coil and a condenser. If this is done the usefulness of the shielding frequently will be destroyed due to the fact that these currents flowing through the shielding material constitute circuits which can readily produce coupling to adjacent conductors.

All the shielding in a receiver should be grounded and connected also to negative-B, negative-A, and plus-C wires. Except for the fact that the shield may be used for the A-minus conductor, the wiring of the set should be done as though the shielding were not present. In other words, the fact that some condenser, for example, one of the tuning condensers, is connected to the shield should not cause us to connect one end of a tuning coil to the shield and thereby complete the circuit through the shielding material. Instead a lead should be run from the tuning coil to the tuning condenser so that the currents in this circuit will pass through this lead and not through the shielding.

The coils in a receiver should preferably be located about central within the shielding compartment, since in this position the increase in resistance of the coil due to the shield will be a minimum. If these simple rules are followed in constructing a shielded receiver, many difficulties will be prevented.



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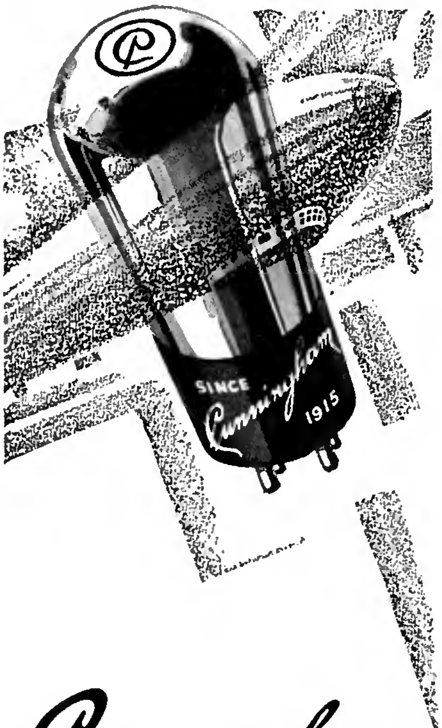

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No. 254 RADIO BROADCAST Laboratory Information Sheet January, 1929

A. C. Tubes

EFFECT OF FILAMENT VOLTAGE

IT IS becoming increasingly common to find manufacturers designing the filament windings on power transformers to supply voltages somewhat less than those rated for use with 226- and 227-type a.c. tubes. One parts manufacturer is marketing a filament transformer designed to supply 2.25 volts to the filament of a 227-type tube, although the rated voltage of this tube is 2.5 volts. A study of the circuit diagrams of manufactured receivers published in RADIO BROADCAST will bring to light other cases where a.c. tubes are supplied with somewhat lower than rated voltage.

The life of a vacuum tube depends very much upon the filament voltage with which it is supplied, and frequently a very small increase in voltage above the rated value will cause a considerable shortening in the life of the tube. With a.c. tubes this problem has assumed especial importance, for these tubes are subjected to variations in filament voltage in accordance with any fluctuations of the line voltage. If the line voltage becomes somewhat higher than that value at which the set is designed to operate, the various tubes receive excessive filament voltage and their life is shortened to a marked extent. It is for this reason that manufacturers have designed the power transformer to deliver somewhat lower than rated voltage to the tubes so that even if the line voltage rises above normal the tube filaments will not be overloaded.

A.C. tubes, types 226 and 227, will give entirely satisfactory operation at less than the rated voltage. The table on this sheet, obtained from figures in the *Cunningham Tube Data Book*, gives the characteristics of the 226-type tube with a filament voltage of 1.3 volts and 1.5 volts, the latter value being that at which the tube is rated. The slight increase in plate resistance and decrease in mutual conductance which results when the tube is operated at 1.3 volts is not sufficient to affect its operating characteristics. The 227-type tube saturates at about 1.9 volts on the filament and, therefore, it also may be operated at somewhat less than its rated voltage with satisfactory results.

TUBE	FILAMENT VOLTAGE	PLATE IMPEDANCE	MUTUAL CONDUCTANCE	AMPLIFICATION FACTOR
226	1.3	10,000	750	8.3
226	1.5	9,000	830	8.3

No. 255 RADIO BROADCAST Laboratory Information Sheet January, 1929

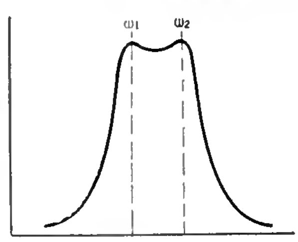
Band-Pass Circuits

WIDTH OF BAND

BAND-PASS filters, as used in radio receivers, consist of an arrangement of coils and condensers which produce a resonance curve of a form approximating that illustrated in the drawing on this sheet. It is possible to design a circuit to have a band-pass characteristic by the use of two separate tuned circuits, each tuned to exactly the same frequency and coupled. The coupling may be produced by condensers, by a separate coil, or by simply placing the coils of the tuned circuits in such relation that there is some coupling between them. One of the most important characteristics of a band-pass circuit is the distance between the two peaks in the curve, marked ω_1 and ω_2.

J. H. Morecroft in *Principles of Radio Communication* gives some formulas for coupled circuits. If two circuits are coupled inductively, then the width in kilocycles of the band between ω_1 and ω_2 is equal to the resonant frequency of either circuit alone multiplied by the percentage coefficient of coupling, k, between them. For example, we might take two coils and two condensers, arrange them in the form of two tuned circuits adjusted, say, to 1000 kilocycles. When there is 1 per cent. coupling between them then the width of the band will be equal to

band with $=\omega_1 \times k$
$=1000 \times 0.01$
$=10$ kc.



The width of the band is, therefore, 10 kilocycles. It should be noted that the band width is directly a function of ω_1 (or ω_2 since they are both tuned to the same frequency). Therefore, if the percentage coupling remains constant then the width of the band at 500 kc. is 5 kilocycles and at 1500 kc. is 15 kilocycles. The fact that the width of the band varies over the broadcast band in a ratio of 3 to 1 (5 kc. to 15 kc.) is a disadvantage, it being desirable, of course, that the width of the band should be constant over the entire broadcast range. If the circuits were capacitatively coupled the characteristic would be opposite to that when inductive coupling is used, i.e., at 1500 kc. the band width would be 5 kc., at 1000 kc. the width would be 10 kc., and at 500 kc. the band width would be 15 kc.

No. 256 RADIO BROADCAST Laboratory Information Sheet January, 1929

Power Output

HOW MUCH IS REQUIRED?

HOW much available power in the output tube of a radio receiver does one need for ordinary home reception when using a standard loud speaker? This is a question about which one can find many diverse opinions. In Laboratory Sheet No. 245 we quoted George Crom to the effect that the usual loud speaker requires an input of 1 to 1.5 watts for a volume of reception slightly above normal. In the *Cunningham Tube Data Book* (which costs $2.50 and which we recommend that you purchase, if possible) we read, "For home reception, with a speaker of average sensitivity, a tube capable of supplying at least 100 milliwatts (0.1 watt) maximum undistorted power output is recommended. The use of a tube giving lower output is almost certain to result in distortion appreciable to the listener. It is very desirable to have additional reserve power available, up to approximately 500 milliwatts, if the "B" power required can be conveniently supplied. Under such conditions the quality will not suffer if the volume is turned a little above normal, as may be required in a large room or for dancing, or if the loud speaker is somewhat low in sensitivity."

The average of George Crom's figure is 1.25 watts and Cunningham recommends 0.500 watt. The mean of these two is 875 milliwatts, 0.875 watt. If the table of Laboratory Sheet No. 246 is referred to it will be found that the smallest power tube giving approximately this output is the 171A which is capable of supplying a maximum of 700 milliwatts to the loud speaker.

It, therefore, seems fair to state that any installation using a power tube or combination of tubes in the output such that the available power is about 0.7 watt, that this amount of power will be sufficient to permit loud-speaker reproduction at fair volume without overloading.

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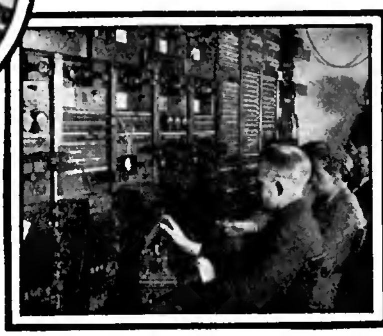

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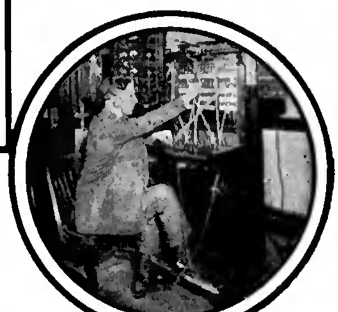

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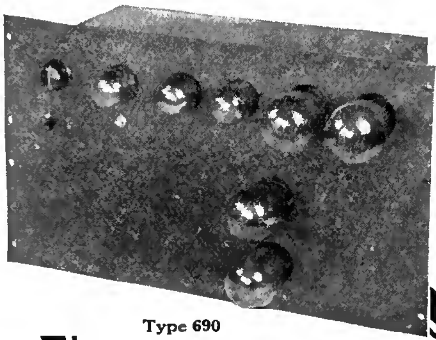


Type 690

EVER since the revolutionary improvement in tone quality created by the Clough audio system when first demonstrated to the trade last June, the S-M laboratories have been working day and night to make this discovery available for the largest theatres, auditoriums, football stadiums, and such assemblages at a low cost.

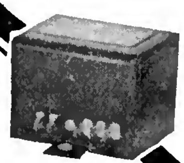
As the culmination of these labors, S-M takes the greatest pride in announcing the 690 Super-Power Amplifier. Three stages—*two* of them push-pull—microphone, radio, or single or double record input—two 250 type tubes in the last push-pull stage giving 15,000 to 16,000 milliwatts output, with uniformly high tone quality down to 50 cycles such as only S-M Clough Audio Transformers can produce—the same quality that is drawing crowds into S-M-equipped movie theatres throughout the United States.

With such a unit available completely wired at $245 list price, less tubes—knowing as you do the tremendous present demand for sound amplifiers of the highest grade—can you as a setbuilder or service man afford to neglect the installation opportunities which this new S-M amplifier offers you?

For the Smaller Theatre, or the Home—

The new 2-stage S-M 678PD Phonograph Amplifier is priced so low that, while particularly adapted for dance halls and small theaters, it is ideal for the home also. Used with any 110 volt D.C. dynamic speaker, it takes input from any magnetic phonograph pickup, or from the detector tube of a broadcast or short-wave receiver, and, by means of its S-M Clough-system audio transformers, supplies to the speaker *undistorted* the full power output of its 250-type tube. Tubes required are: 1—226, 1—280, 1—250 type. All input power is taken from the 110 volt A.C. house-lighting mains. Price (less tubes), WIRED, $73.00; complete KIT, $65.00.

These New S-M Transformers Make It Possible



Type 257

Built on the Clough System, with curves flat from below 50 cycles to well above 5000—these transformers give to "push-pull" a new and really startling significance. And their prices, like their quality, are unbeatable!

257 Push-Pull Input Transformer, to operate from one amplifier tube into two 171A, 210, or 250 tubes. Price, $7.00

227 Push-Pull Interstage Transformer, to feed from two 112A, 226, or 227 tubes into two 112A, 226, 227 or 171A, 210 or 250 tubes....................................$8.00

258 Tapped Output Impedance, to feed from two 171A tubes into any standard speakers..................$5.00

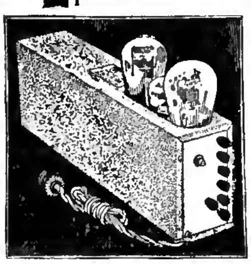
248 Universal Output Choke, to feed out of two 210 or 250 tubes into one to six or more standard speakers; provided with several impedance-matching taps. It will handle over 20 watts without core saturation.

Open-mounted..$7.00

228 (248 in case like 227)...........$8.00

Type 227

Get 250 Tone Quality in Your Present Receiver



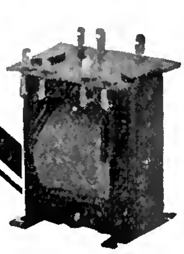
Type 678D

Or you can get 250-tube power *right in your present set* by inserting a 250 tube (with an adapter) in the last socket of the set, and using the S-M 675ABC Power Supply. Presto!—the 675 supplies all ABC power to the new power tube (without a single change to the set) and replaces all B batteries or other B eliminators as well. (It will also supply A and C power to A.C. tubes).

Add a 675 to your set and you have all the advantages of the fine, full sonorous tone the super-power tubes bring—tone you find only in $300.00 to $500.00 factory-built sets—yet you can add it to your set for $54.00 plus two tubes!

The 675ABC power supply is priced at only $54.00 for the kit, or $58.00 fully wired with adapter.

Remember—S-M guarantees these push-pull transformers to have a finer frequency characteristic than any and all competitive types—bar none.



Type 248

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....No. 5. 720 Screen Grid Six Receiver
....No. 6. 740 "Coast-to-Coast" Screen Grid Four
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....No. 8. Sargent-Rayment Seven
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SM

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"Just to say that I have one of your 720 Screen-Grid Six's with 670B power unit . . . Picked up Japan, 1:00 A. M.—came in strong—four stations in Chicago and everything up and down the coast . . . "
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"Think of the thrill of getting your dinner concert from KFI on a 6-tube receiver away up here in Northern Wisconsin . . . At the end of the dial twisting session I had 28 stations over 1000 miles away, from 21 states and 3 provinces of Canada, and WKAQ, Porto Rico . . . "
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"I am writing to tell you about the results I am getting from the 720 Screen-Grid Six. I have brought in stations from New York to Japan with good volume on the speaker and the tone quality is very natural . . . The following are some of the stations I have received: JOIK, Sapporo, Japan, WHAM, Rochester, N. Y. . . . I had two other Japanese and some other foreign stations, but I haven't the call letters yet. WLW, WGN, KWKH come in good almost every night."
—Alonzo Henderson, Mossy Rock, Washington.

"I am having great success with the 720 and 740 sets. Only today, I received 3 orders for 720s and one for a 730. In all my experience of building kits for fans, I have never had the feeling of really giving value till I took up your line. I think it is the best that money can buy in its class and my long list of satisfied customers surely is the proof that their sets are wonderful."
—Howard Brett, New York City.

"Last night picked up Halifax, Nova Scotia with such volume that I had to turn the volume control half off. We then proceeded to pick distance to the satisfaction of the prospect . . . I got his order then and there."
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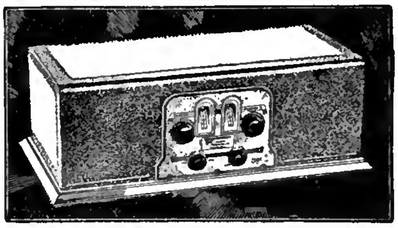
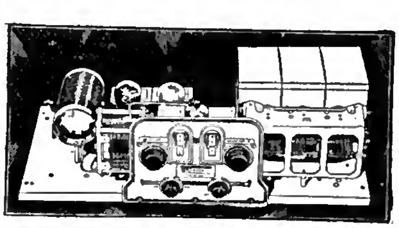
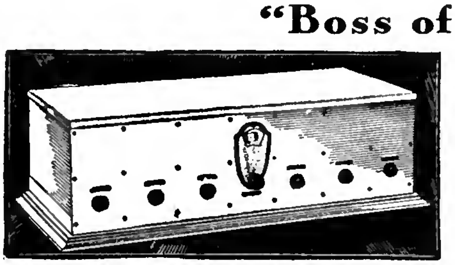
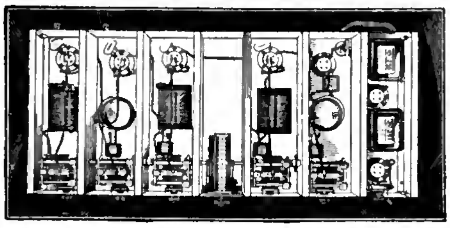
The plain cold facts are simple. The Silver-Marshall 720 is a six-tube t.r.f. set using three screen-grid tubes, a detector, and two stages of S-M Clough audio amplification. It's an all-metal, shielded assembly, just like the finest ready-made sets, with its own attractive two tone brown metal shielding cabinet, its antique brass escutcheon plate with two dials, volume knob, and a small selectivity knob. Yet this set with its three stages of screen grid r.f. amplification, and its audio system that money can't buy in a ready-made set, costs you but $72.50 for the S-M packed kit, or $102.00 for an S-M custom-built wired receiver, complete with cabinet.





"Boss of the Air"—





The Sargent-Rayment Seven is the first and only set to offer four stages of screen-grid tuned r.f. amplification, and the unsurpassed tone quality of the S-M Clough audio system—the first and only set to give one-dial control, yet at the same time individual stage trimmers that mean the last drop of sensitivity when you want it. And its seven tubes, with 171, 210, or 250 power tube, give fine tone or hair-splitting selectivity, super-distance or local programs with thrilling quality. Shipped from stock: KIT $130.00—or FACTORY-WIRED $175.00. Both complete with handsome satin aluminum shielding cabinet.

Doubt It?—Read These:

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Samuel H. Trude, Judge

"I am very much pleased with the custom-built 710 Sargent-Rayment receiver. . . which I have been using in connection with a cone-type loud speaker at the South Shore Country Club, Chicago.

"This is a remarkably good receiver for all kinds of radio reception. I have found that distant broadcasting stations can be tuned in on all wave channels over the entire broadcasting band—one and only one at a time with the single tuning drum."
—Samuel H. Trude

"It may interest you to know that the first station I tuned in was KOA (1500 miles away) and that last Saturday morning from 3 to 4 A.M. we listened to three stations in Japan—JOAK, JOGK, and JOAH."
—Walter A. Reeves, Seattle, Wash.

"Some time ago I bought a 710 Sargent-Rayment set from Mr. Toolan of Lansing, Michigan. . . It has marvelous tone, volume, sensitiveness, and selectivity. I am right across the street from WTAM and can tune them out. . .in a few points."
—J. W. Carvey, Cleveland, Ohio.

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