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June 8th, 1929 **15 Cents**

RADIO WORLD

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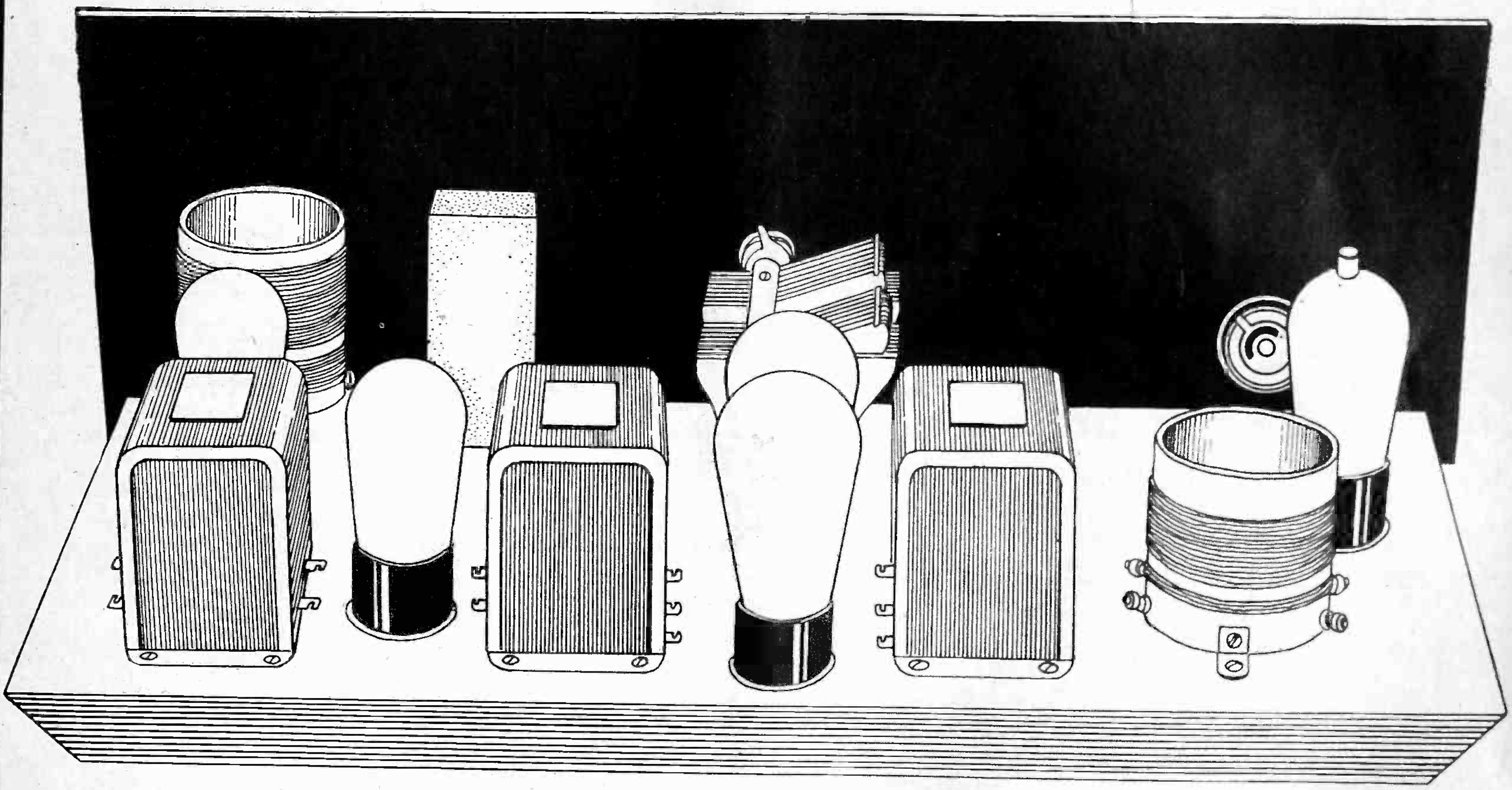
The First and Only National Radio Weekly

376th Consecutive Issue—Eighth Year

AC PUSH-PULL DIAMOND

CONTROL OF VOLUME AND SENSITIVITY

NEW DECIBEL MEASUREMENTS



The AC Screen Grid Diamond of the Air, shown for use with a separate B supply. See article on page 3.

POWER AMPLIFIER IN OPERATION

BETTER RECEPTION LOOMS

ANALYSIS OF IMPEDANCE COUPLING

MB-29 SCREEN GRID TUNER

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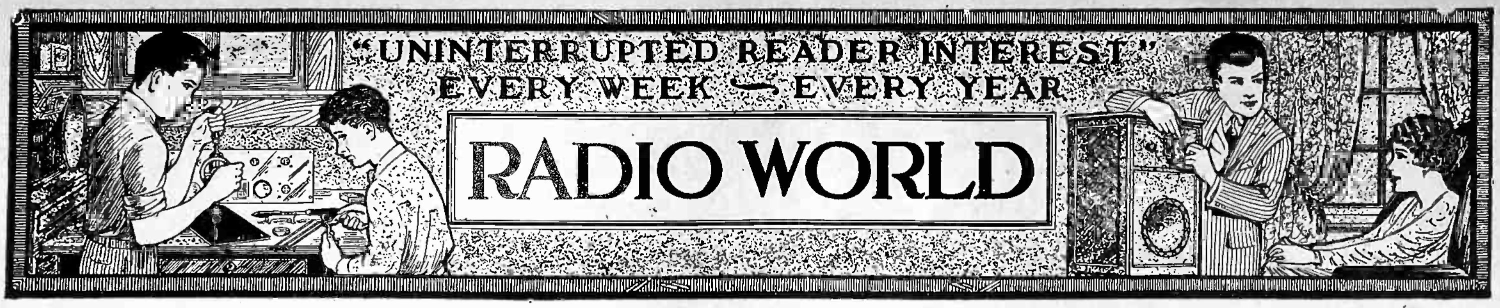

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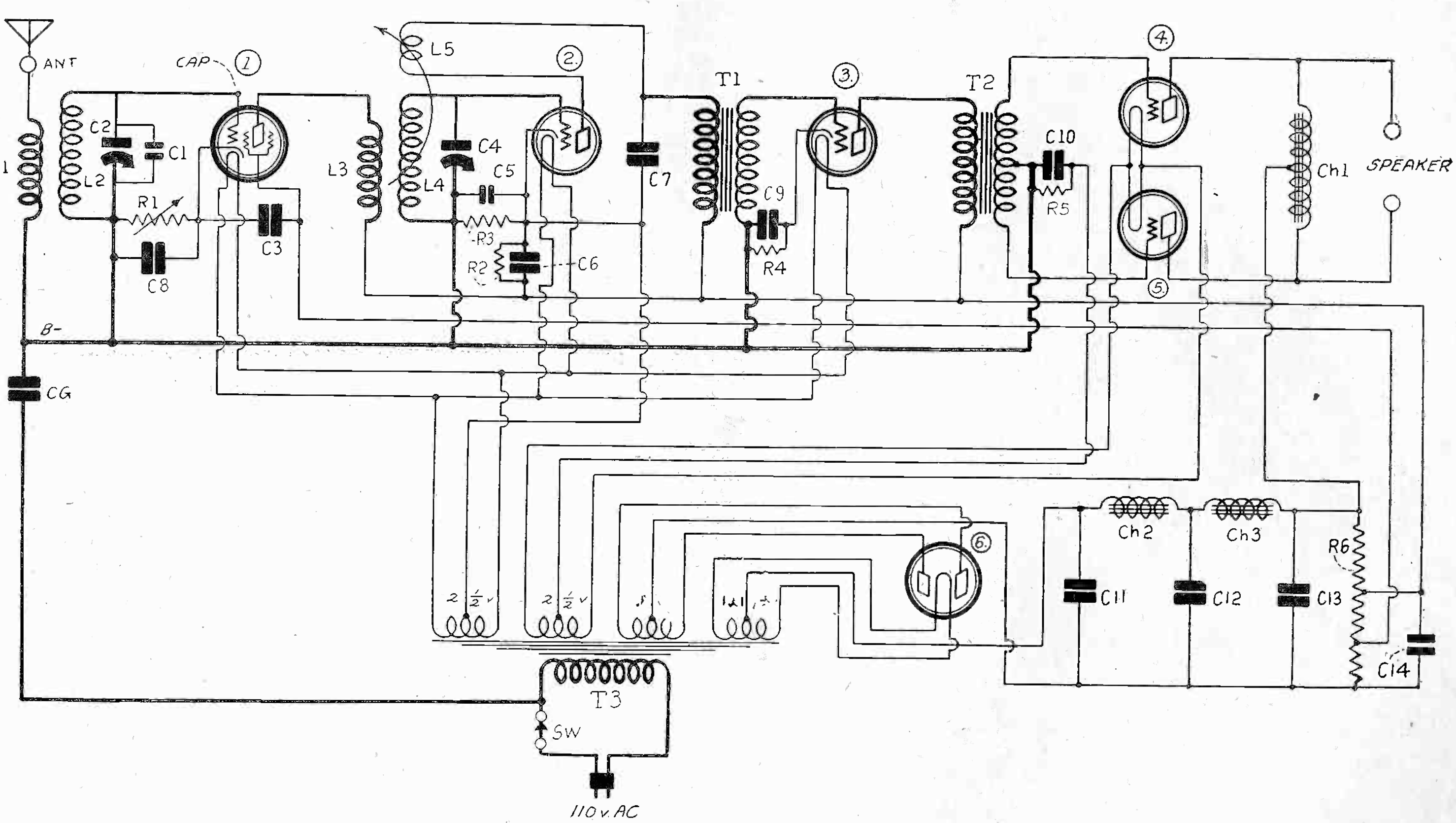
The Push-Pull Diamond

AC Model with Power Detector and with 245s in Output

By Herman Bernard
Managing Editor



TWO 245 TUBES IN PUSH-PULL CONSTITUTE THE OUTPUT OF THE 5-TUBE AC DIAMOND OF THE AIR.

TWO 245s have become the most popular pair for push-pull. The Diamond of the Air is shown in a five-tube AC model so as to embody this push-pull output. The design in Fig. 1 is for a complete table model on a 12x20" baseboard or metal subpanel.

If you have a B supply that provides 300 volts maximum you may construct the receiver (include the filament transformer), and obtain the B voltages from your present supply. The front cover illustration shows such a model.

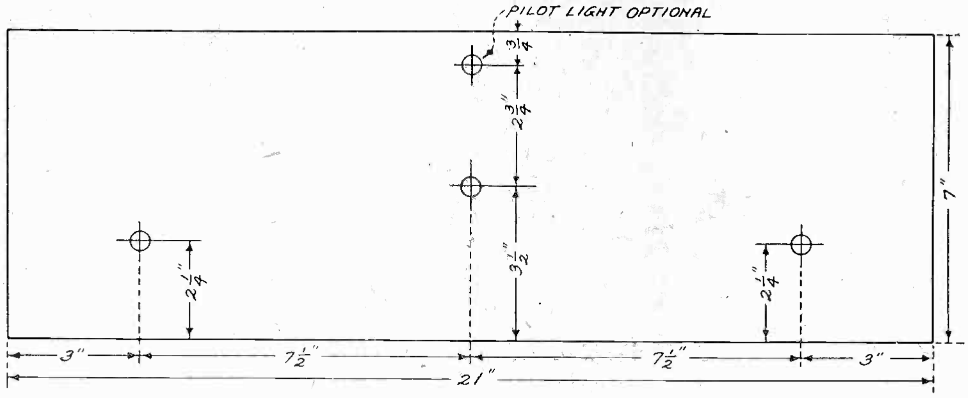
The inclusion of push-pull is not for increasing the volume, as this remains

LIST OF PARTS

L1, L2—One antenna coil (Cat. AC5).
L3, L4, L5—One screen grid three-circuit tuner (Cat. SGT5).
C1—One Hammarlund equalizer, 70 mmfd.
C2, C4—One Hammarlund 2 gang condenser, each section .0005 mfd. (Cat. MLD23).
CG, C3, C5, C6, C8, C9—Six Aerovox .02 mfd. fixed condensers.
C7—One Aerovox .0005 mfd. fixed condenser.
C10—One Aerovox 4 mfd. bypass condenser.
C11, C12, C13, C14—Mershon 8-18-18-8.
R1—One Electrad Royalty variable resistor, 5,000 ohms, with 110 volt AC switch.
R2, R3—One 20,000 ohm Electrad resistor type B (with 3 terminals).
R4—One 1,000 ohm Electrad resistance strip.
R5—One 800 ohm Electrad resistor type B.
R —One Aerovox Pyrohm, type A.
T1—One National A100 audio transformer.
T2—One National push-pull input transformer.
T3—One power transformer (Guaranty Radio Goods Co.).
Ch1—One push-pull output choke (Guaranty Radio Goods Co.).
Ch2, Ch3—One Silver-Marshall Unichoke 331.
Ant., Speaker—Three binding posts.
(1)—One 224 tube; (2), (3), two 227 tubes; (4), (5), two 245 tubes; (6), one 280 tube.
One 7x21" front panel.
One 12x20" baseboard with three UY sockets and three UX sockets; or one metal subpanel with sockets affixed.
One flat type dial.
Two knobs.
One roll Corwico Braidite.
One pilot light, with bracket (optional).

Pointers on Push-Pull

Biasing Analyzed, Impedance Output Explained



DIMENSIONS FOR THE 7 X 21" FRONT PANEL USED FOR THE PUSH-PULL DIAMOND OF THE AIR. THE VOLUME CONTROL R1 AND SWITCH SW, CONSISTING OF A SINGLE COMPOSITE INSTRUMENT, ARE MOUNTED AT LEFT. THE TUNING CONDENSER IS AT CENTER, 3½" UP. THE PILOT LIGHT, IF USED, IS ABOVE THE CONDENSER. AT RIGHT THE THREE CIRCUIT TUNER IS MOUNTED UPSIDE DOWN, THAT IS, WITH TICKLER COIL TOWARD THE SUBPANEL. THREE HOLES EQUIDISTANT AT BOTTOM MAY BE USED FOR ANCHORAGE TO THE SUBPANEL.

(*Continued from preceding page*)
about the same, but for improving the quality, since push-pull tends to reduce or eliminate extraneous noises by stifling the even order of harmonics.

Power Detection

The tuner is approximately the same as heretofore, except that the volume control is put in the grid biasing circuit of the 224 RF tube, and the power detector's effectiveness is heightened by passing some extra plate current through a lower biasing resistor. The bleeder and the biaser are one resistor, with three terminals, so that one extreme terminal goes to B plus 180 volts, the next one to the cathode and the other extreme terminal to B minus. The third slider is placed near the B minus end. An Electrad wire-wound resistor, type B, 20,000 ohms, is used, and about 2,000 ohms are used for bias and 18,000 ohms for bleeding.

Then the current drawn by the bleeder is passed through the biasing part of the resistor, avoiding the necessity of high reduction of precious plate current in the detector by use of a high value of biasing resistor, which would have to be on the order of 50,000 ohms otherwise.

No ground need be provided externally, as the filament transformer (or, in the case of the complete table model, the power transformer) has a self-grounding effect, and in addition the B minus lead is grounded to the one side of the AC line through a .02 mfd. fixed condenser, CG. The grounding effect through this condenser may not be material unless the plug is inserted in the convenience outlet in the right way. Reverse the plug to determine which connection provides louder signals, then adopt this connection permanently.

Output Impedance

The remaining novelty of the circuit is the push-pull output impedance. This is used instead of an output transformer, because it is more nearly suitable to various types of speakers, whether dynamic or magnetic. The speaker is connected to the two plates, and no current should flow through the speaker, because the flow is through the impedance in opposite directions from its center-tap. The direct current being equal and opposite, it flows only through a circuit embodying half of the impedance, while none flows across the extreme terminals to which the speaker is connected.

Since magnetic speakers have a relatively high impedance, this output is suitable indeed for them. Also, dynamic speakers have output transformers built in, and these have a high impedance primary but a low impedance secondary, therefore the output serves this purpose well, also.

The biasing resistor in the last stage should be half the resistance of one used for a single-sided output because the plate current passed through it is twice as great. A value of 800 ohms fully takes care of the maximum required bias. But it must be a resistor easily capable of carrying 64 milliamperes. A 5-watt resistor provides an ample margin of safety.

The B Voltages

The B voltages are about 300 maximum, 180 for all plates save the last, and about 75 volts for the screen grid of the 224 tube. This screen grid voltage may be reduced if oscillation trouble arises.

Not all of the 300 volts is effective on the plate of the push-pull output tubes, on account of the effect that the voltage drop in the biasing resistor has on the regulation. As a separate biasing resistor is used for the last stage, the reduction in voltage from the total is not absolute, but relative. However, the voltage actually obtained is never more than a little more than the 250 volts recommended, and any slight excess is tolerable, and is taken care of automatically, by biasing for the higher voltage, since the current is increased through the biasing resistor.

Large capacity condensers of the electrolytic type are used in the B supply. The capacities are, from left to right, 8 mfd., 18 mfd. and 18 mfd., with another 8 mfd. going from the 180-volt tap to B minus. The mica condenser from screen grid to cathode of the 224 tube takes care of the bypassing for the screen grid current. On the other hand, the plate current of three tubes is obtained from the 180-volt post, hence the second 8 mfd. condenser is connected there. The four condensers are in one small copper can. The smaller capacity (8 and 8) are farther from the periphery than the 18 and 18.

Filament Windings

The filament windings are three: 2½ volts upper, which will stand 9 amperes and to which the tuner tubes and first audio are connected; 5 volts at center for the filament of the 280 rectifier, and 2½ volts, bottom, for the two 245 tubes used in push-pull stage. All windings are center tapped. The top winding's center may be connected to B minus (not shown), to maintain the heater negative in respect to the cathode, and thus prevent the heater from acting as a fifth element.

A separate winding is used for the push-pull tubes' filaments, although the voltage is 2½ also, because a common winding would make the heaters of the three preceding tubes positive in respect to the cathodes, to the extent of the negative bias on the last push-pull pair. Thus the heater might become an electron-attracter, and function as a sort of adventitious plate, which would be objectionable. Hum and instability might arise, also, particularly in respect to the screen grid tube, short life would result.

Absence of Shielding

No shielding is used in the tuner, because only one screen grid stage is incorporated, and the amplification obtained from the tube is maintained within workable limits.

The primary of the three-circuit tuner, nevertheless, has a fairly large number of turns, thus offering a higher impedance than the primary of tuners used with general purpose tubes. It is not possible to obtain the results of high sensitivity unless this primary impedance is larger than the ordinary.

The antenna coil has a small primary, to maintain high selectivity. On a 2½" diameter tubing, 2½" high, wind 6 to 8 turns for L1, and 48 turns for L2, separating the windings by ¼". For L3 wind 24 turns, leave ¼", then for L4 wind 48 turns. The diameter is again 2½", but the coil form may be a little higher, around 3". All wire is No. 24 single or double silk covered. The tickler L5 consists of 30 turns on a 1¾" diameter, using No. 24 wire or smaller, half the number of turns being placed to one side, half to the other, so that the rotor shaft may penetrate the tickler coil far enough to hold it, and not be obstructed by any of the turns.

Equalized Tuning

The circuits may not tune exactly alike unless a trimmer is placed across the first tuning condenser. Tune in a low wavelength station, say, around 250 meters, with the trimmer set at minimum capacity. This little condenser is of the book type and is adjustable by a screwdriver, but you'd better use a wooden dowel fashioned at the end in screwdriver style, to avoid capacity effects obtained from a metal screwdriver making the adjustment difficult. Turn the trimmer until the station comes in loudest. A slight readjustment of the tuning dial may be necessary. If so, try the trimmer again, always striving for maximum volume. When that it attained, the circuit is set permanently, and resonance will result throughout.

[Other illustrations on front cover]

(*Part II next week, issue of June 15th*)

Sensitivity and Volume

How Both May Be Well Controlled at the Same Time

By Bruce Deeming

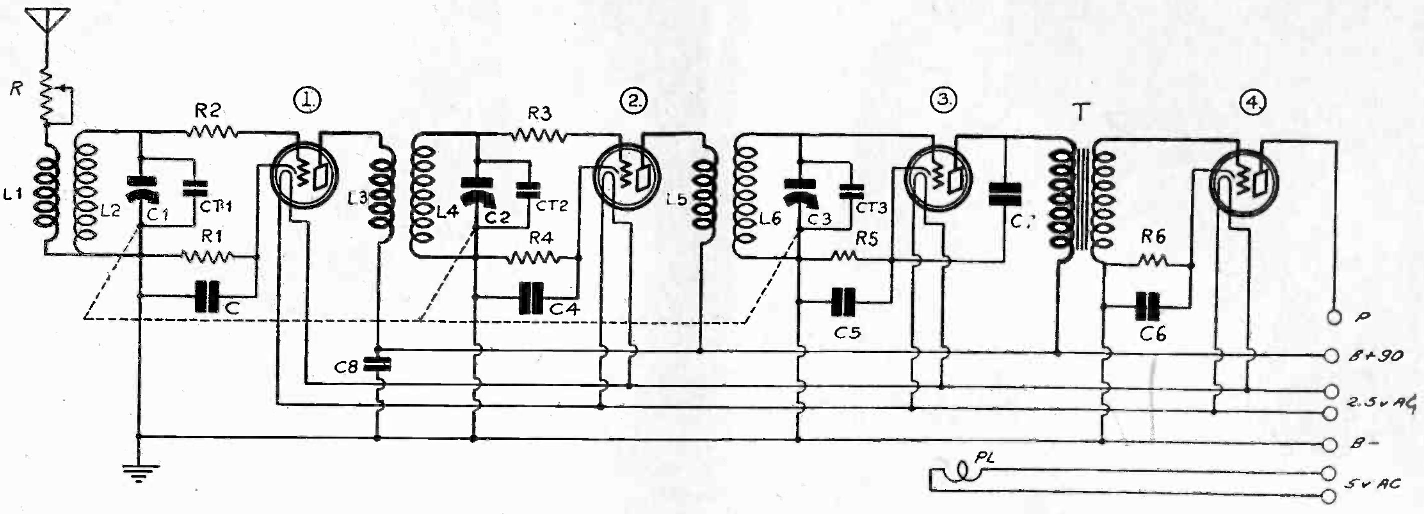


FIG. 1
RECEIVERS CONTAINING HEATER TYPE TUBES CAN BEST BE CONTROLLED AS TO SENSITIVITY AND VOLUME BY MEANS OF VARIABLE GRID BIAS RESISTORS, PLACED IN THE POSITIONS R1 AND R4. THIS IS A LITTLE BETTER THAN THE AERIAL RESISTOR METHOD SHOWN AS R.

STABILIZATION of radio frequency amplifiers and control of sensitivity are two questions which are continually in the mind of radio fans. These questions do no longer present a problem in battery sets, for the filament current in the radio frequency tubes can be changed over any desired range with instantaneous response.

When heater type tubes are used they are problems because the filament current cannot be changed readily, and if it is changed the response is not immediate. For example, suppose the volume is too great so that it becomes necessary to reduce it, that is, to reduce the sensitivity of the received. The filament current is reduced by a certain amount. It makes no difference by what means it is reduced —reduction in the primary voltage supplying the heating transformer, or reducing the secondary voltage by means of a resistor. Whatever be the method used, the response is slow. It may take three-quarters of a minute before any change is noticed.

Overshooting the Mark

The amount by which the filament current is changed is pure guess. When a certain change has been made, say downward, the volume will gradually reduce. When a stable state has been reached, the volume may be entirely too low. The guess was a poor one. So it becomes necessary to increase the volume. There is another wait and then the volume may be too loud. Even if the correct guess is made the second time, the signal strength may have changed during the process of adjustment, so that it becomes necessary to start all over again.

Changing the filament current in a set embodying heater tubes is obviously not a satisfactory method of controlling the volume.

One method of controlling the volume, one which responds instantly, is to use a variable resistor in the antenna circuit, as illustrated in Fig. 1. R is a variable resistor which can be changed over a range of from 0 to 5,000 ohms. If the required sensitivity range of the receiver is not wide, this method is quite satisfactory, and it is convenient.

Insufficient Range

But if the set is very sensitive when adjusted to maximum sensitivity, this method is not quite sufficient. Even when all the resistance is inserted in the antenna circuit there remains a good deal of pick-up. Some of this is through the antenna and some through the coils in the set. A more effective method of controlling the volume is necessary when the radio frequency amplification is high.

In nearly all AC sets the grid bias is provided by means of a bias resistor, often a separate resistor for each tube. Fig. 1 illustrates this case. In this circuit there are four bias resistors R1, R4, R5 and R6. The first two of these, R1 and R4, are in the grid circuits of the radio frequency amplifiers, and for that reason they can be manipulated without effecting the quality of the output.

As is well known, the amplification of the tube depends on the value of the grid bias. If the bias is increased the amplification decreases, if the bias is decreased, up to a certain point, the amplification increases.

Now the bias given to a tube by a resistor is directly proportional to the value of the resistance, the current through it remaining constant. Hence the sensitivity of the receiver can be changed by merely increasing the value of the bias resistor. The effect is instantaneous no matter what the type of tube that is used.

Decrease in Plate Current

But the current through the resistor does not remain constant. It decreases as the resistance is increased. It would seem that this would defeat the purpose of the increase of the resistor, but that is not so. As the bias is increased by the resistor method, the plate voltage decreases in direct proportion. Hence the need for a high bias is lessened. The two effects work together so that the effect on the sensitivity is about the same as if the grid bias actually increased in proporion to the resistance value.

This method of controlling the sensitivity of a receiver, and hence its amplification and output volume, is one of the best yet devised, at least for circuits incorporating heater type tubes.

While it should not be necessary to vary more than one of the grid bias resistors, in some instances it may be desirable to vary both R1 and R4. The sensitivity can be varied over a much wider range if both are made variable.

R1 and R4 may even be combined into one resistor in some instances. This is possible when the plate voltage applied to the two tubes involved is the same, as it is in the circuit represented by Fig. 1. When this is done the maximum value of the resistor should be one half as great as the value of a resistor used for a single tube. A suitable value for the resistor for one tube is 20,000 ohms and for one used for two tubes 10,000 ohms.

By-pass Condensers Indispensable

The by-pass condensers C and C4 across the grid bias resistors are indispensable, for without them the maximum sensitivity of the receiver will be very low and there will be feedback from one tube to the preceding.

By-pass condensers C5 and C6 in the detector and audio stages are even more important, for if they are not used there will not only be a reduction in the amplification but also frequency distortion, the bass notes being suppressed. And these condensers must be as large as practical. Condensers of 1 mfd. will help but condensers of 4 mfd. will be much more effective. The radio frequency condensers C and C4 need not be so large, values larger than .1 mfd. being unnecessary.

Stabilizers Employed

In radio frequency amplifiers designed for high gain, or high sensitivity, there is usually oscillation on the higher frequencies in the broadcast band. To stop this oscillation without at the same time reducing the sensitivity greatly, grid resistors R2 and R3 are inserted in the leads to the grids. The value of these required in any circuit is not a definite quantity, depending on the tubes as well as on the circuit associated with them. About 900 ohms has been found to be a good average value.

New Decibel System

Relative Amplification Values Measured Logarithmetically

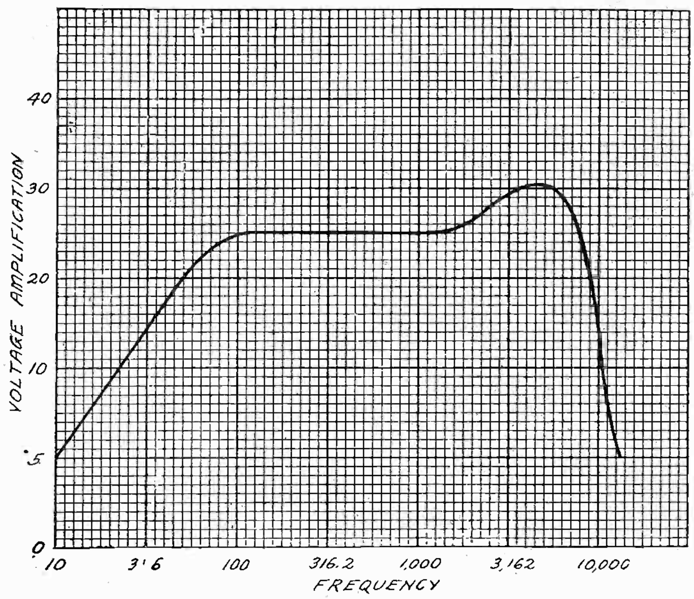


FIG. 1
A TYPICAL RESPONSE CURVE OF A STAGE OF TRANSFORMER-COUPLED AMPLIFICATION WITH FREQUENCIES LAID OUT ON THE FAMILIAR LOGARITHMIC BASIS.

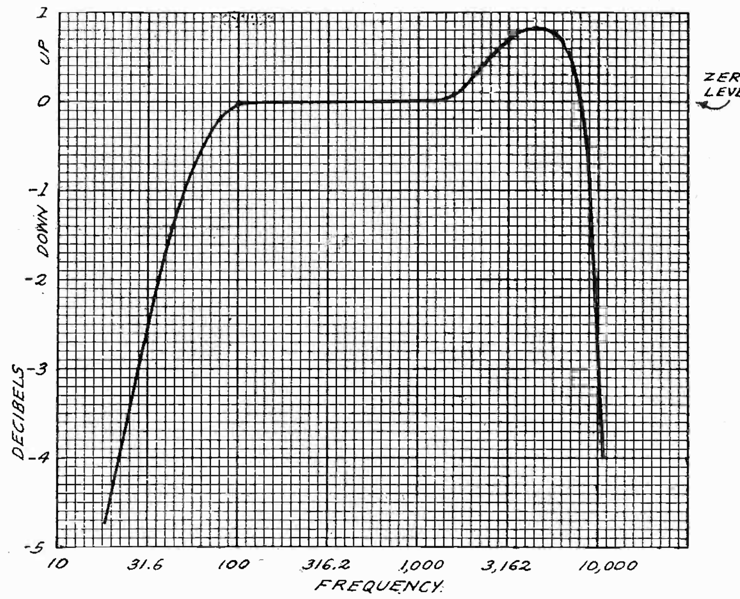


FIG. 2
THE SAME RESPONSE CURVE ON THE SAME FREQUENCY BASIS BUT PLOTTED VERTICALLY ACCORDING TO THE NUMBER OF DECIBELS UP OR DOWN, COMPARED WITH THE AMPLIFICATION AT 400 CYCLES.

IN plotting response curves it has been customary to plot either frequency or octaves against the amplification. The resulting curves are familiar to most readers of radio articles. Fig. 1 gives the typical form of such a curve. In this the ordinates give the amplification and the abscissas the frequency in octaves, or a scale which amounts to the same thing as octaves. The gradual slope of this curve from 10 cycles to 100, the level region between 100 cycles to a little over 1,000, the rise to a maximum at about 5,000 cycles, and the sudden drop beyond that point are familiar characteristics of amplifiers containing audio transformers.

Plotting in Terms of Decibels

In recent articles the term decibel has appeared as a measure of relative amplification. This is not yet universally known, nor are the amplification curves plotted on this basis familiar.

The term decibel, named in honor of Alexander Graham Bell, the inventor of the telephone, has been adopted the world over in place of the unit formerly known as the transmission unit. It is defined in terms of the common logarithm of the ratio between two similar quantities which it is desired to compare. Stated mathematically, if D expresses the number of decibels by which two quantities V0 and V1 differ, then D = 10 log (V_0/V_1), the common logarithm being understood. If V0 is larger than V1, D is positive, and conversely, if V1 is larger than V0, D is negative.

One of the quantities compared, for example, V0, is taken as the zero level, which means simply the basis of comparison. When D is negative, V1 is "down" with respect to V0, or the zero level, and when D is positive, V1 is "up" with respect to the zero level. The amount by which V1 is "up" or "down" is expressed by the number of decibels.

Decibel Measures Ratio Only

The decibel tells nothing about the absolute values of the quantities involved, only relative values. Two quantities measured in kilovolts may differ by the same number of decibels as two quantities measured in microvolts. Often the absolute values of the quantities are of little importance, but the relative values may be of prime importance. This is true especially when response curves are involved. For example, it is of practically no importance what the absolute values of the signal voltages on a certain grid of an amplifier are at two different frequencies, but it is of first importance what the relative values are. The quality of the output with respect to frequency distortion depends on he relative values.

In order to familiarize the reader with the two types of curves plotted in the old way and according to the decibel system, the characteristic shown in Fig. 1 has been replotted in Fig. 2. The same data were used in plotting both. But the curves differ widely in shape.

The zero level was selected as the amplification at 400 cycles, because this is usually employed as a standard for comparison. The amplification at any other frequency is then given as the number of decibels above or below the amplification at 400 cycles.

Level Region

Naturally, the level region in the two curves coincides as far as the frequency axis is concerned, but on the decibel curve this level region coincides with the zero level line, while in the other it falls on the 25 amplification line.

Below 100 cycles the curve in Fig. 2 falls below the zero level line, meaning that the amplification for frequencies below 100 cycles is less than that at 400 cycles. At about 5,000 cycles there is a peak in the curve, and for a certain region about this peak the curve lies above the zero level. That means that the amplification in this region is higher than that at 400 cycles. Above 5,000 cycles the curve drops rapidly so that at 10,000 cycles it is again far below the zero level. The amplification is therefore much less in this region than it is in the middle register.

It has been found experimentally that the ear appreciates intensity differences according to a logarithmic law, that is, according to the number of decibels by which they differ. It makes little difference what the absolute intensities may be, as long as they lie within the limits of hearing. It is for this reason, mainly, that the logarithmic definition has been laid down.

One Decibel Is Minimum

It so happens that the smallest intensity difference that the human ear can detect is that represented by one decibel, and this is one reason why the decibel, rather than the bel, was chosen as the practical unit. The bel is ten times as large as the decibel, and is too large to be made a practical unit.

A response curve plotted in terms of the decibel is very convenient in judging the quality of an amplifier or of a complete receiver. If the curve does not deviate more than one decibel from the zero level in the essential frequency band, it is known that the quality will be practically perfect, for at no frequency will it rise or fall by an appreciable amount. Wherever it rises more than one decibel the response will be noticeably high, and the result may be an unpleasant blast. If it falls more than one decibel in any region, the response will be appreciably weak in that region. If it is in the bass, the quality will be thin and lacking in body. If it is in the treble and above, the quality will be boomy and lacking in crispness and articulation.

Comparing Powers

When comparing power outputs and different frequencies, or at the same frequency on different sets, the definition of the decibel is changed slightly, but only when using voltages and currents for the comparison of the powers. Suppose two voltage intensities V0 and V1 are compared and it is desired to compare also the corresponding power outputs. The definition then becomes 20 log (V0/V1). The reason for doubling the constant associated with the logarithm is that the

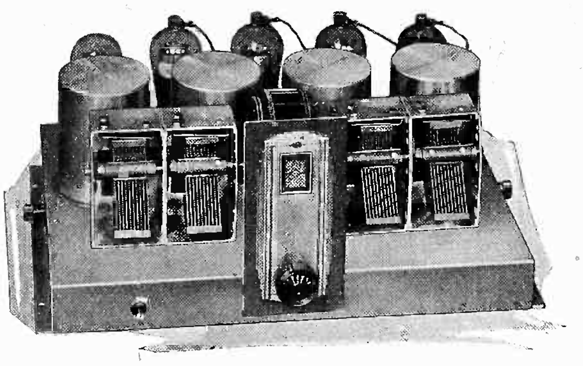
(Continued on next page)

Why the MB-29 is OK

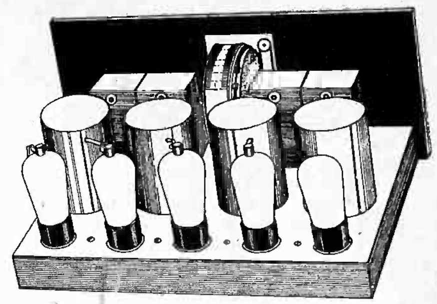
Each Stage Carefully Shielded and Filtered, Preventing Feedback

By J. E. Anderson

Technical Editor



EACH STAGE OF THE MB-29 IS SEPARATELY SHIELDED. THE CYLINDRICAL CONTAINERS ARE THE SHIELDS. THEY ARE ALUMINUM. INSIDE EACH SHIELD ARE THE FILTERS FOR EACH STAGE. NOTE THE NEW NATIONAL MODERNISTIC DIAL IN THE ILLUSTRATION AT LEFT. THE REAR VIEW OF THE MB-29 IS SHOWN AT RIGHT.



[In the issue of May 18th were published the first details of the MB-29 to be presented anywhere. This is a 5-tube tuner, using four of the new AC tubes (224) and a power detector (227). In the May 25th and June 1st issues the intimate technical discussion was carried forward with extreme thoroughness. This week the reasons for the soundness of the circuit—despite some contrary dictum—are set forth. Next week other features of this circuit will be published in the June 15th issue. This is the circuit that brought in nine coast-to-coast stations in one evening on the speaker. —EDITOR.]

* * *

SOME manufacturers of AC screen grid tubes have issued specific recommendations that no more than three of these tubes be used in the same receiver in the same frequency level. On the strength of these recommendations, we have been requested to correct the design of the MB-29, or to explain the discrepancy.

What's To Be Corrected

It would indeed be presumptious on our part to correct the design of two such eminent engineers as James Millen and Glenn H. Browning, especially a design which these two engineers have worked out with utmost care and precision, a design based not only on theoretic soundness, but on unchallengeable laboratory results. It is not the circuit that needs to be corrected, rather the idea entertained by some that all knowledge of the application of tubes is concentrated in the minds of engineers of some tube manufacturers.

But the discrepancy can be explained. When two or more screen grid tubes are used in hastily assembled receivers there is likely to be a great deal of feedback that will produce oscillation. This is difficult to control. To stop the feedback, and thus to stop the oscillation, it is necessary to shield the separate stages individually and to insert filters in the voltage supply leads. If this is not done, and done well, even a circuit embodying two of the tubes is almost uncontrollable. One having three of the tubes is then quite unmanageable, and one having more than three of the tubes is then hopeless.

MB-29 Is Stable

But this applies only to circuits in which utmost precautions against feedback have not been taken. It does not apply to the MB-29, for shielding and filtering in that circuit have been done with thoroughness. Each tube in that circuit feeds only the one following, and not any one preceding it.

Naturally, the amplification in a circuit containing four AC screen grid tubes is exceedingly high. There will be some stations which will overload even the second tube, provided the circuit is adjusted to maximum sensitivity. If it did not, it would not bring in distant stations with such good volume. Every circuit designed for very high sensitivity and distance getting ability must necessarily be such as to overload on local stations, when it is adjusted to maximum sensitivity. That is axiomatic.

Hence every super-sensitive receiver must have an effective sensitivity control by means of which it can be adjusted to suit the requirements. When the receiver is tuned to a local, high powered station, the sensitivity control is set so that each tube contributes only a small fraction of its possible amplication power. When the circuit is tuned to a weak distant station the control is set so that each tube contributes maximum amplification. Without such a sensitivity control the best receiver is useless.

The Sensitivity Control

As is well known, the amplification given by a screen grid tube depends largely on the voltage applied to the screen grids. By varying this voltage over a certain range, the amplification of the tube can be changed from zero to maximum possible with the particular circuit arrangement used. This fact has been made use of in the MB-29 circuit. The voltage applied to the screen grids has been made variable from zero to 67 volts, or to a higher value if desired.

The variation of the screen grid voltage is effected by means of the potentiometer R5, which has a value of 50,000 ohms. The range of voltage variation depends only on the voltage that is impressed across this potentiometer.

Since all the screen grids are connected to the same sliding point on the potentiometer, the screen grid voltage on all the tubes is the same at all times, and the amplification by each tube is varied in the same manner. It is thus apparent that the control is exceptionally effective.

(*Continued from preceding page*)

power is proportional to the square of the voltage. Hence the ratio of voltages must be squared before the logarithm is taken. The logarithm of the square of the quantity is equal to twice the logarithm of the quantity itself. Hence the factor 20 is used instead the factor 10.

If two powers are compared directly, of course, the factor 10 is used, for the factor 2 was used in deriving the powers.

We might illustrate the comparison of powers. Suppose one amplifier will develop a voltage of 100 across a loudspeaker and another amplifier only a voltage of 50 across the same speaker and at the same frequency. The ratio of these voltages is 2, the common logarithm of which is .301. The voltage output of one speaker is then up 3.01 decibels as compared with the other. But the louder speaker is up 6.02 decibels when the powers are compared.

That this gives the same results as if the powers directly were compared, using the factor 10, can be demonstrated with actual values. Suppose that the resistance of the speaker is 4,000 ohms. Since the voltage in one instance is 100 volts, the current is .025 milliamperes. And the power, being the product of the voltage and the current, is 2.5 watts. Using the 50 volts, the current is .0125 milliamperes and the power is .625 watt. The ratio of 2.5 and .625 is 4, the common logarithm of which is .602. Hence the power in one instance is up 6.02 decibels as compared with the power in the other instance.

Obtaining the Common Logarithm

The common logrithm can be obtained in almost any book on trigonometry or in books especially devoted to mathematical tables. It can also be obtained from any slide rule. Most computations for plotting curves of the character in Fig. 2 are made on slide rules, and the logarithm of the number desired is obtained as quickly as the number itself. Indeed, it is not necessary to read off the number at all, only the logarithm of it. Tables or the rule give only the fractional part of the logarithm. The whole number, if any, is obtained by counting the number of figures on the left of the decimal point of the number of which the logarithm is desired, and by subtracting one from the number of figures. For example, for the number 25.6 the table or the rule gives .408. Since there are two figures to the left of the decimal point, the logarithm is 1.408.

—J. E. ANDERSON.

Impedance Audio

Gives Good Reproduction with Little Tendency Toward Trouble

By Malcolm Maxim

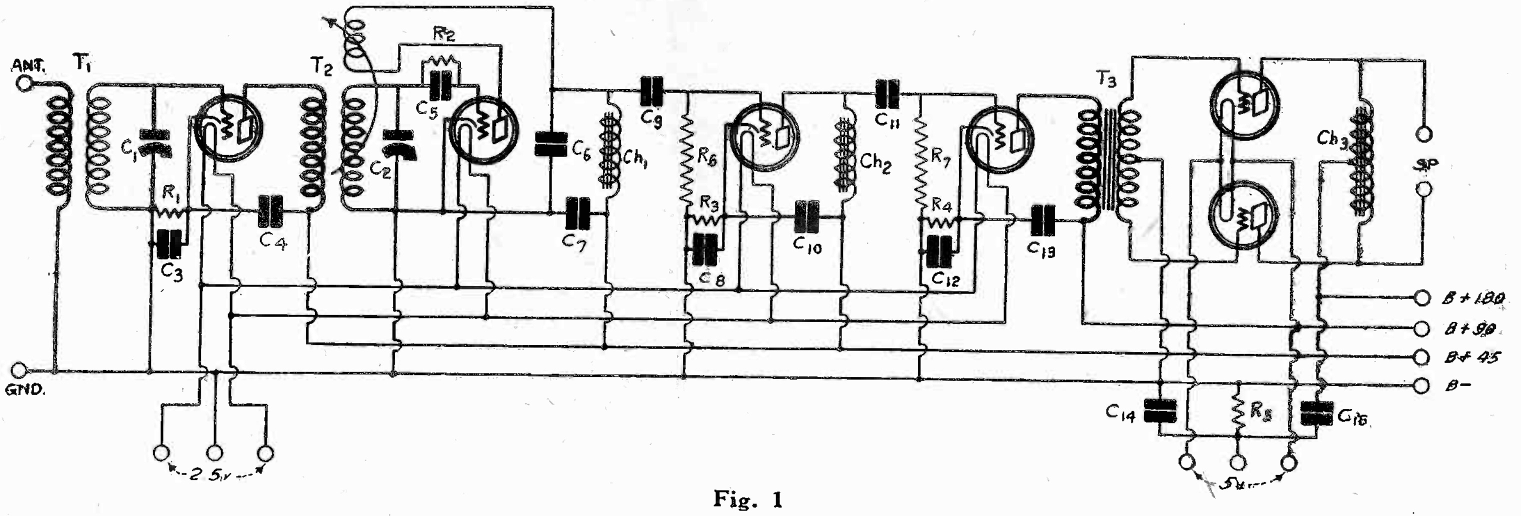


Fig. 1

A QUALITY RECEIVER IN WHICH IMPEDANCE-RESISTANCE COUPLING IS USED IN TWO STAGES AND TRANSFORMER FOR THE PUSH-PULL STAGE

THE impedance coupled amplifier has not been received by the radio fans as well as its virtues merit. It has many distinct advantages over other forms of coupling which are not appreciated. First it has an amplification characteristic practically as flat as that of resistance coupling, and it has a per-stage amplification, with the same tubes, which is slightly greater. It does not motorboat as readily as the resistance coupled circuit, and if it does, it oscillates at a frequency at which the oscillation may be stopped easily with condensers across the plate voltage supply. It does not amplify effectively the subaudible frequencies and therefore motorboating at these frequencies will not occur in it. It is these frequencies which give the greatest trouble in direct coupled amplifiers.

One reason why the impedance coupled circuit is relatively stable is that the coupling impedances introduce a lag in each of the plate signal currents so that it cannot produce oscillation-inducing feed back as readily as when there is no phase displacement of the currents.

Point in Its Favor

One point in favor of the impedance coupled circuit is that fine quality can be obtained with relatively inexpensive parts. For example, the secondary of a transformer which is unsuited for use in a transformer coupled circuit can be used with the assurance that the quality will be much better than the quality of the average set at the present time, and it must be admitted that the quality of the average set of today is pretty good.

One of the objections against the impedance coupled amplifier is that it cannot be used in push-pull, and since transformers have to be used for push-pull anyway, they might as well be used throughout the set. That is not a good reason. If first rate quality can be obtained with impedance coupling inexpensively, it seems good practice, not only from an engineering point of view but also from an economical point of view, to use impedance coupling in the first stages and push-pull transformer coupling for the final stage, if push-pull output is desired.

A combination impedance and push-pull transformer coupled receiver is shown in Fig. 1. This circuit contains heater type tubes throughout with the exception of the last stage, which contains a couple of filament type power tubes. They may be of any type provided that the various voltages applied are suited to the tubes used. It will be assumed here that the tubes are of the 171A type, because these tubes are admirable output tubes in a push-pull amplifier for home use. More volume can be obtained from them than will ever be tolerable in a home, even if a rather insensitive loudspeaker is used.

Adequate By-Passing Necessary

In order to get the best quality out of any receiver, regardless of coupling, it is necessary to by-pass adequately all the plate and grid leads. The circuit in Fig. 1 exemplifies a case of thorough by-passing.

Let us analyze the by-passing both in the radio and audio frequency portions of the circuit. First there is C3 which serves the grid bias resistor of the first tube. It aids greatly both to increase the sensitivity and the stability of the receiver. The value of this condenser might be .1 mfd., although a somewhat lower value can be used with satisfactory results. Then there is C4, which by-passes the plate circuit of the first tube. The value of this condenser may be the same as that of C3 because it operates at radio frequency. Note that both these condensers are connected to the cathode of the tube. It is always a good policy to by-pass direct to the cathode rather than to lead the signal currents to that point by a round-about route. This method of by-passing is used in all the succeeding tubes, changed only as local conditions may demand.

Plate Circuit By-Pass

No condenser is necessary in the grid circuit of the detector because the grid return is connected to the cathode. There can be no more direct route than that. But we do find a couple of by-pass condensers in the plate circuit of the detector. C6 is connected across the line so that its value must not be larger than is absolutely necessary. Neither is it necessary to use a large condenser here for it works at radio frequency, and also there is some distributed capacity in the coupling choke Ch1, which adds to the value of C6.

The circuit will not oscillate well if the total by-pass capacity is small, neither will it detect well. It has been found by experiment that .0005 mfd. is a very satisfactory compromise. Actually it may not be necessary to use more than .00025 mfd. because of the effect of the distributed capacity in the choke coil.

C7 works mainly at audio frequency and therefore this condenser should be large. This condenser is also in a critical position because if it permits any feedback, this is amplified by all the succeeding tubes and the effect of this feed back may be very great, causing distortion or actual oscillation at some frequency. A value of 2 mfd. has a very beneficent influence on the stability, but one of 4 mfd. is proportionately more effective. Since this condenser need not be rated at a high voltage there is no good reason why a large value condenser should not be used. One microfarad of prevention here is as good as 10 microfarads placed later in the circuit.

In the next two stages there are two grid by-pass condensers C8 and C9. They serve the same purpose as C3, except that they are functioning at audio frequency, and for that reason must have large values. The lowest value for each of these that will help much is 1 mfd., while 2 mfd. should be the lowest that should be used. These operate at very low voltage so that the cheapest condensers made may be used.

Plate By-passing

In the plate circuits of these two tubes are two condensers C10 and C13. These work at a slightly higher voltage than the grid condensers, but even so, the lowest voltage-rated condensers regularly manufactured can be used with safety. The size of either of these condensers is the same as the corresponding grid condenser.

There is no imperative reason why by-pass condensers should be used in the grid and plate circuits of a push-pull amplifier stage, provided the circuit is balanced. But perfect balance is very rare. Hence it is advisable to use the condensers. The connections are exactly the same as those for the single tube stages, except that allowance has been made for the fact that now the mid-tap of the filament transformer takes the place of the cathodes in the heated tubes.

Better Reception Looms

Synchronization Successful in Isolated Cases and Promises Much

By Dr. John H. Dellinger

CHIEF OF RADIO LABORATORY, BUREAU OF STANDARDS

The following is an excerpt from an address delivered by Dr. Dellinger before the recent convention of the Institute of Radio Engineers, at Washington, D. C.

THE broadcasting band, which has hitherto occupied the chief attention of the Federal Radio Commission, exhibits a number of very special engineering problems. Here the width of each channel in 10 kilocycles, which is necessary for satisfactory musical reception. Even this is not sufficient for musical reproduction of the highest quality. With only 90 such channels, and more than 600 stations on them, there was naturally, very great interference prior to the November, 1928, allocation. To remedy this the Commission had to choose among various alternatives.

It decided as a matter of policy not to reduce radically the total number of stations. It was then necessary to (a) limit the simultaneous operation of an excessive number of stations by making many of them divide time; (b) assign frequencies carefully selected with regard to geographical separation of stations, to reduce inter-channel interferences (i. e., disturbance of reception of a station on one frequency by other stations on adjacent frequencies); and (c) limit the power of stations so they would not cause interferences to other stations on the same frequency.

Calls Results Accomplished

The accomplishing of this constituted the allocation of broadcasting stations which the Commission put into effect on November 11th, 1928.

The most striking of the problems involved in the allocation was the carrying out of requirement (c), which determines power limitations. Stations assigned to the same frequency have not, up to the present, been able to maintain their frequencies with sufficient accuracy to prevent the existence of a slight difference (or beat) frequency, producing what is commonly known as heterodyne interference, or whistles.

Unfortunately the heterodyne interference reaches out to enormously greater distances from a station than the program. Consequently the operation of two or more stations on a channel results in an area of destructive interference far in excess of the area, in which program service is provided.

For instance, the program of a 5-kw station can be heard with fair intensity under good conditions at 100 miles, while the heterodyne interference from two such stations is heard at 3,000 miles. Two stations of 5 kw or more therefore cannot be assigned the same frequency in the United States.

It is possible, on the average, to put two or more 1-kw stations on the same frequency if they are at least 1,800 miles apart, and two or more ½-kw stations if they are at least 1,200 miles apart.

All stations subject to these restrictions have only a small service area, and give no service to remote rural areas. Such distant service is given only by stations having exclusive use of the channels to which they are assigned.

In order to provide rural service, 40 channels are each used by one station exclusively. The stations on the exclusive channels not only serve very great areas, but deliver a more satisfactory intensity at every point within those areas.

Their service is better for all concerned, the greater the power they use. This fact is not commonly understood by others than radio engineers. It is clear when the distinction between the exclusive and the other channels is comprehended. Service on the non-exclusive channels would be utterly ruined if the power limits fixed by the facts of heterodyne interference should be exceeded, and in consequence such stations cannot in general use more than 1 kw. But on the exclusive channels the service is better the higher the power level, and indeed such stations will not be serving the public most effectively until the level reaches hundreds of kilowatts.

Increased Service Area

There is some hope that the limitation of power and service on the non-exclusive channels may be overcome. If the frequencies of stations on the same channel are maintained to a certain high accuracy, the heterodyne or whistle becomes inaudible. The technique of frequency control is fast approaching this goal, and success has been attained in isolated instances.

The satisfactory service area of such "synchonized" stations is not yet known. It is likely that some additional fading and interference effects will be introduced but it is believed that the net service area will be substantially greater than when heterodyne interference exists.

The significance of this is that the present power limits for stations, on shared channels can be raised, better service given, and wider areas served. Synchronization is therefore looked for as the next great advance in broadcasting.

Different in Day Time

This discussion of broadcasting has been largely with reference to night conditions. Broadcast transmission is entirely different in the daytime. Transmission distances are much less, and somewhat greater power can be allowed the stations. Furthermore, additional problems are not as acute as are those of night-time transmission, they are being handled with care so that day-time broadcasting may be developed as a valuable service.

The difference between day and night transmission conditions raised one technical problem of considerable moment, viz., determination of the time when day ends and night begins, and thus at what hour daytime stations should close.

Investigation had revealed that the change from day to night radio conditions extends over a period of something more than an hour and a half, beginning about a half hour before sunset and closing a half hour after sunset.

The most reasonable time to chose as the transition point is the moment of sunset, and this was done in the Commission's General Order No. 41.

Most of the regulations of the Commission involve engineering problems. Examples include the General Orders on chain program limitation, visual broadcasting (television), increased power in daytime, and prohibition of damped waves.

The Broadcasting Committee of the Institute of Radio Engineers has been of great assistance to the Commission by the studies it has made of certain subjects leading to new regulations.

These are on such subjects as: The requirement of an artificial antenna in broadcasting stations for use during warming-up periods, etc.; the location of high-power stations with respect to populous areas; requirement of highly accurate frequency control; allowable ratio of day to night power; permissible intensity of harmonics; per centage modulation; and fidelity of transmission.

Complex Situation

All of the engineering work involved in Federal radio regulation has the peculiar difficulty that the facts dealt with are extremely complex. They are indeed rapidly shifting. Not only must allowance be constantly made for the flux of changes inherent in a rapidly developing art, but radio waves themselves exhibit extraordinary vagaries.

Orderly radio regulation must proceed on a consideration of the distances at which the waves are received. But distances vary enormously between day and night, from season to season, even from night to night, and are different over different kinds of terrain.

Knowing this is not counsel despair. These vagaries have, after all, certain discernible laws, becoming more and more calculable as the results of scientifice investigations accumulate.

It is not necessary to throw up our hands and say that the whole situation is chaotic. In spite of their vagaries, radio phenomena are subject to known engineering principles. An engineering principle is nothing but an organized body of facts affecting a practical situation. Violation of such engineering principles in radio regulation would sooner or later reduce the service of radio to the public.

Summarizing, the Federal regulation of radio involves extensive and difficult engineering problems. These are characterized by certain outstanding facts or principles.

First, radio waves spread out everywhere and potentially interfere with one another.

Secondly, at any given stage of radio technique, the available number of communication channels is definitely limited.

Another controlling principle, as the art stands today, is that heterodyne interference sharply limits the power that may be permitted any two or more broadcasting stations on the same channel.

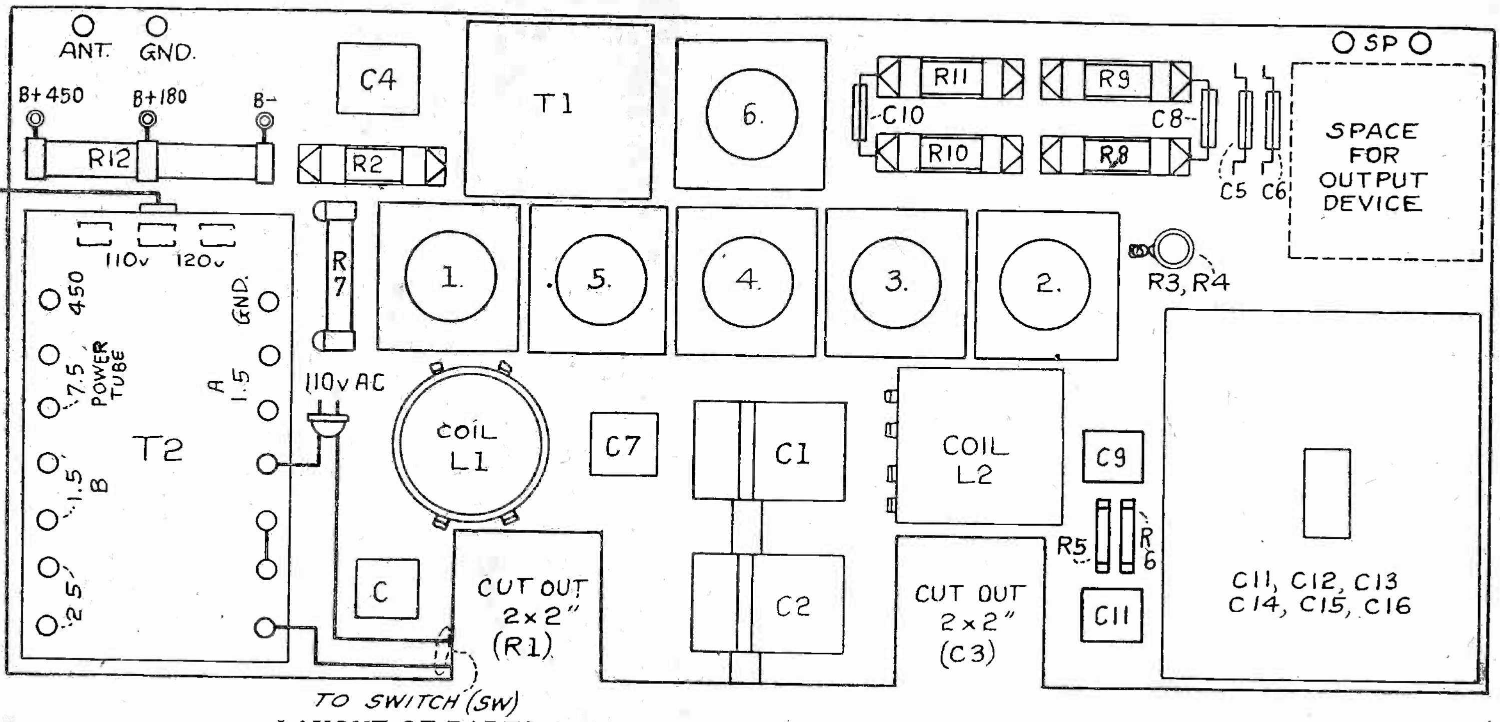
Finally, radio wave transmission is characterized by extreme vagaries. The facts and implications of each of these principles are subject to constant revision as radio progresses. Such facts constitute the natural limitations of radio. They are inescapable conditions of its Government regulation.

The 250 Universal

Complete AC Receiver on 8 1-2x20 Baseboard

By Capt. Peter V. O'Rourke

Contributing Editor.



LAYOUT OF PARTS OF THE RECEIVER. NOTE THE TWO CUTOUTS

[*The second and final instalment of this article on a compact receiver using six tubes, including rectifier, is published herewith. Part I was published last week, June 1.*]

AS grid voltage changes produce corresponding plate current changes, the plate current must accommodate this pulsation, otherwise tube distortion arises, as evidenced by the wobbling needle of a microammeter placed in series with the plate circuit. Without such precaution power detection would be more of a name than an achievement.

RF Channel

The radio part of the installation is sufficiently sensitive for most modern needs, with the aid of regeneration provided by the small condenser C3 connected from plate of the detector tube to midtap of the interstage coupler's primary. The regeneration will fail unless the connections of respective terminals of the primary of L2 are reversed in comparison with the connections of the terminals of the secondary of L2. But if regeneration fails, remove the plate and B plus connections of the primary of L2 and replace them to the opposite points to the one to which they formerly were connected.

Volume control is achieved by one of the best methods for AC receivers, by varying the bias on the radio frequency amplifier. This tube is the new 224 screen grid AC tube. The biasing resistor R1 is 0-5,000 ohms, but the zero position is never used, as that would stop the plate current in the tube. The bias may be varied from a volt or so negative to 25 volts negative, which brings the RF tube even beyond the best detecting point. Any preliminary detection is lost, as the succeeding coil will pass only radio frequencies, and these would be merely stray components when detection takes place, and would constitute a feeble input to the detector. Hence the volume is variable from the conventional shout to the still more conventional whisper. The resistor is bypassed to sustain the high amplification of which the tube is capable.

Source of Voltages

The voltages at the radio frequency side are derived as follows:

The RF tube and the detector both get their heater voltage from the same winding of the transformer, 2.5 volts (actually 2.15 volts). This is not the filament, because both the 224 screen grid AC tube and the 227 AC tube are of the heater type. The heater is connected to the power transformer and gets hot. This heat is communicated by the heater to the cathode, or functioning filament, by thermal radiation. The cathode emits the electrons.

The sum of the plate and grid voltages is 180 to 190, obtained by connecting to the midtap of a 9,000 ohm resistor that also bleeds current from the rectifier output. Besides this stabilizing bleeder current through all of R12 there is the plate current of all tubes save the last, through the midtap-to-B-minus half of R12.

The 224 tube takes the voltage from this midtap for its plate. Then another resistor, R2, which is .1 meg., drops the 180 to 75 to 80 volts, which voltage is applied to the screen grid or G post of the 224 tube. C4 bypasses RF currents to B minus, while C13 bypasses plate the lower half of the midtapped resistor R12 to the same point. C13 also serves to complete the circuit for C2 to the end of the plate winding or primary of L2.

The same plate voltage is applied to the detector as to the RF tube, but of course the current flow is much less, due to the drop in the load resistor R8 in the plate circuit.

As for the audio plate voltages, the first stage (tube 3) gets 180 ahead of the load resistor, but actually this is dropped to around 60 volts at the plate, whereas the same 180 volts applied through the primary of the transformer T1 affords about 120 volts on the plate.

Facts on Power Transformer

The power transformer has provisions for grounding the center taps of all the filament windings, except the power rectifier tubes. Thus the tuned circuits are grounded through the biasing resistors, the bypass condensers across these resistors, and the extra bypass condensor C13. The two fuse clips are marked 110 volts and 120 volts, and the fuse is to be put in the correct clip, as determined by your AC line voltage, or, you have no meter that reads that high, you may put the clip in the fuse in the clip that affords 1.4 volts for the 226 tubes or 2.15 volts or less for the heater tubes. The transformer is purposely designed to keep the heater voltages well under 2.25 volts even if the line is 120 volts and no means of reading any voltages is at hand.

In this transformer is the choke Ch, a husky one, so that only one choke is necessary for the filter circuit. The filter condensers are C14, C15 and C16, which are 2 mfd. each, the first being of 1,000 volts AC test, the two others of 800 volts AC test. These three, and C11, C12 and C13 are in the capacity bank. All other condensers are external.

The circuit diagram shows no output transformer, as it is assumed a dynamic speaker will be used. However, room is left on the baseboard for the inclusion of such a transformer, or of a condenser-choke output filter, should one use a magnetic speaker. Be sure that the output transformer or filter is of the 250 type. An ordinary one will not stand the 50 milliamperes.

Chain Restriction Due to Be Lifted

Washington.

The order of the Federal Radio Commission, prohibiting stations, 300 miles or less apart, from broadcasting the same chain program, which rule was never put into effect, is due to be abrogated entirely. It was meant to apply only to stations in cleared channels, but the effective date was advanced three times, due to serious objections from stations and some listeners.

It would finally become effective June 1st, but a prior abrogation order is expected. At least another postponement is promised.

Users Find Ce-Lec-Tor, Excellent Filter Trap

Commendations upon the working efficiency of the Ce-Lec-Tor, the new band-pass filter trap, are being received from all over the United States, according to Julien J. Proskauer, head of the Trutone Radio Sales Co., 114 Worth Street, New York City.

A fan from San Francisco wrote that he had no trouble cutting out such powerful stations as KGO and receiving distant stations from the middle Western and the Eastern states.

The Ce-Lec-Tor is sturdily built and compact. It is cased in black bakelite having the interior condensers and coils immersed in a special insulating wax which renders them impervious to moisture. Full information and details may be had by addressing this concern. Mention RADIO WORLD.—J. H. C.

World Wave Parley Needed, Says Craven

Washington.

Lieutenant Commander T. A. M. Craven, naval radio specialist, before the Senate Committee on Interstate Commerce recently predicted that it would be necessary soon to call an international conference to adjust the world radio situation, because the demands of nations for radio channels are conflicting. The naval officer testified in connection with the Couzens Bill for creating a Federal communications commission with full jurisdiction wire and radio services.

Emphasizing that the number of channels in the spectrum is definitely limited, he said that "engineers are having some difficulty in finding out how to use the channels in the most effective manner." He recommended that the Federal licensing authority should safeguard radio communication by assigning particular blocks of channels to particular services. Stations of different character and function, he said, cannot operate effectively on the same or adjacent channels if the channels are to be employed to their fullest extent.

A THOUGHT FOR THE WEEK

CENSORSHIP is un-American, undemocratic, non-republican, anti-a-lot-of-things, and a confounded nuisance generally. Careless broadcasters should remember that and forego sending over the air those things which will give the enemy an excuse for insisting on the opportunity of a radio censor. An ounce of commonsense is worth a ton of protest that's too late.

Right or Wrong?

(Answers below)

1. The shielding effect of a sheet of metal is greater the lower the specific resistance of that metal. It is also greater the higher the permeability of the metal.
2. Shielding is due to a reflection of the radio wave and the action of the shield is similar to the action of a mirror to light.
3. The value of a dry cell used as a grid battery is truly indicated by a voltmeter, even if the dry cell is practically exhausted.
4. There are only two ways of producing an electrical difference of potential, or an emf, namely, by a generator and by chemical means.
5. It is not possible to get a higher amplification per stage than the amplification constant of the tube.
6. A wire-wound resistor cannot be used in resistance coupled amplifiers because it has a high inductance which would introduce frequency distortion.
7. The only possible arrangement of two inductance coils which will result in no mutual inductance, or coupling, is that which makes the axes of the two coils at right angles.
8. More than three inductance coils can be placed so that there is no mutual inductance between any two.
9. Mutual inductance is a purely fictitious quantity. Two inductance coils placed close together have no inductance in common but they merely act as if they had.
10. Inductance of an air-core coil depends only on the geometry of it.

Answers

1. Right. Silver is the best shield material of the non-magnetic metals because it has a lower specific resistance than any other. Copper comes next, being only slightly inferior. Iron is the best of all due to its very high permeability.
2. Right. The waves cannot penetrate because eddy currents are induced in the metal, and these send out waves in the opposite direction to the incident waves. A light wave is of the same nature as a radio wave and responds essentially the same way.
3. Wrong. The value of the cell for bias is determined by the emf of the cell. A voltmeter of the ordinary type always reads less than the true emf.
4. Wrong. An emf can also be produced by heat, as in the thermo-couple.
5. Wrong. The statement holds true for resistance and impedance coupled circuits, but not for transformer coupled amplifiers. The limiting amplification with transformer coupling is the amplification factor of the tube times the step-up ratio of the transformer.
6. Wrong. The inductance of the coil is very small and does not affect the amplification adversely. A resistor may be wound so that its inductance is negligible.
7. Wrong. It is possible to place them in any angular relationship and still have the coupling zero provided that one coil is not inside the other.
8. Wrong. There are only three dimensions and therefore only three coils can be placed mutually at right angles.
9. Wrong. Mutual inductance is as real as self-inductance. When two coils are placed together, either lies in the induction field of the other, and the magnetic flux from one threads the other coil.
10. Right. In the electromagnetic system of measuring inductance is a length and is measured in linear units. The unit is the centimeter.

Hotel Wins Suit Over Copyright

Kansas City, Mo.

In a suit filed here by the American Society of Composers, Authors and Publishers against the La Salle Hotel of this city, Federal Judge Merrill E. Otis upheld the right of hotels to receive and transmit to guest rooms copyright music broadcast by radio stations. The decision is said to be the first of its kind.

Judge Otis held that in receiving the radio programs and transmitting them to the rooms the hotel owners did not "perform" the compositions, but merely "provided the means" for hearing the music.

The decision differentiated between radio programs and the playing of phonograph records and awarded the plaintiffs $250 damages for alleged playing of a record by the hotel. The playing of a record was held to be a "performance," as the music was permanently recorded and the rendition was made at a time that suited the hotel's purpose and convenience.

Chain of Radio Schools Planned

Plans for a nationwide radio chain to broadcast educational programs to all sections of the country were announced by Headmaster Ellsworth Tompkins of the WODA Free Grammar and High School of the Air, Paterson, N. J.

A high frequency relay system, transmitting complete courses in six academic subjects, will be used by the station to link together the stations of the chain. Application for the short wave length is now before the Federal Radio Commission. Tentative plans call for two stations in the South and several stations throughout the Middle West.

A complete grammar and high school course will be available to every radio listener when the chain begins operation. According to Commissioner of Education Richard E. O'Dea of Paterson, owner of WODA, the courses will be broadcast as good will programs, free from commercialism. None of the chain stations will be allowed to commercialize the school.

"The success of the WODA Free Grammar and High School, now in its second year with an enrollment of 1,000 pupils," said Commissioner O'Dea, "proves conclusively that there is a need for complete academic courses on the radio. It was with this thought in mind that the school alumni, composed of prominent educators in New Jersey, arranged courses so they are equally valuable to listener-students all over the country."

Broadcasting of the school will begin on an experimental basis during the summer. Several weeks will be given to preliminary tests to enable engineers of the station to work out signal strength charts and gather other important technical data. A 250-watt transmitter, similar to transmitters used for transcontinental and transoceanic work, has already been completed by engineers of WODA.

The school's curriculum would include English, grammar, arithmetic, algebra, history, Americanization, general science, social science, nature study and home economics.

POWER AMPLIFIERS

By J. E. Anderson and *Herman Bernard*

[Here is the second instalment of the noteworthy contribution of Anderson and Bernard to the all-too-scarce literature of power amplifiers. The series began last week, issue of June 1st. There will be an instalment each week for several months. Don't miss a single one.—Editor.]

Loudspeaker Coupling Devices

There are three principal methods of coupling the loudspeaker to the power amplifier: direct, output filter, and transformer.

The direct method of couping, shown in Fig. 9A, is used when the power tube delivers only a small plate current, or when the loudspeaker winding is such as to withstand the heating caused by considerable current. Ordinarily, this method of coupling is not used with tubes larger than the 112A. It has one advantage not possessed by any other, and that is it avoids the addition of all reactive devices which always introduce some frequency distortion. If the loudspeaker is wound to match the tube used, and if the plate current is small so that the current will not damage the winding, the connection gives the best quality.

Unfortunately, it is not practical to make speakers so as to carry heavy direct current, so that when larger tubes are used some output device is necessary. One of the most popular is the output filter, shown in Fig. 9B. The plate current flows through a high inductance choke Ch and the signal current through a stopping condenser C2 and the speaker, SP. This method of coupling requires that the speaker impedance be matched to that of the tube, because for AC this connection is essentially the same as that in Fig. 9A. The matching of impedances does not mean they should be made equal.

The choke coil Ch must have a high inductance and a low direct current resistance, and condenser C2 must have a large capacity. If the inductance is not high, part of the signal current will flow through the coil, especially the low frequencies, and if the condenser C2 is not large the low frequencies cannot flow through the speaker circuit. Hence the conditions imposed on the choke coil and the condenser are mainly for the purpose of allowing the low notes to reach the speaker. The DC resistance of the choke should be low so that the voltage drop in the coil be as low as possible.

Another popular output device, the transformer, is shown in Fig. 9C. This has the advantage, in common with the output filter, of preventing the direct current from reaching the speaker. Another point in favor of the transformer is that it can be used to match the tube and speaker impedances so as to get the maximum undistorted output. An output transformer is built into all dynamic speakers.

The output transformer used with push-pull amplifiers, shown in Fig. 9 D, shows an alternative connection. The loudspeaker may be connected directly between the two plates of the amplifier, as indicated by the dotted lines. This connection may be used when the sum of the plate impedances of the two tubes is comparable with the impedance of the speaker. For example, a high impedance magnetic speaker might be connected to the output of a power stage using two 245s. The direct plate current will not flow through the speaker.

E, F, and G in Fig 9 show the connections when AC tubes are used. In E and F the output filter has been used for illustration. If the connection A is desired the speaker is connected where Ch is and the condenser C2 is omitted. If the condenser in C is desired the primary of the transformer is connected where the choke is, the condenser C2 again being omitted.

It should be noted that in each of the circuits B, E and F the loudspeaker returns to filament or cathode. In B it returns to minus A, in E it goes to the cathode, and in F, to the mid-tap of the filament transformer. These are the best returns possible for the different types of tubes. The object of the direct filament, or cathode, return is to minimize feedback through the plate voltage supply.

It should also be observed that in each of the circuits in Fig. 9 there is a condenser C connected from B plus to the filament or cathode. While this condenser is not absolutely required in every instance, it always serves a good purpose. The object of this condenser is also to eliminate feedback. If the condenser is used at all it should be at least 1 microfarad. The larger it is the more effectively will it prevent feedback.

Battery Operated Amplifiers

Although battery operated amplifiers can be called power amplifiers only by courtesy since the undistorted power output is not considerable, they fall, within the bare technical classification, and formed the basis for the early lore of audio amplifiction.

Three types will be described, namely, two-stage transformer coupled, three-stage resistance coupled, and two-stage transformer coupled with the output stage to push-pull.

The most common in battery receivers is the two-stage transformer coupled, one form of which is shown in Fig. 10. This circuit comprises two audio transformers, T1 and T2, two amplifier tubes, (1), and (2), and output filter ChC1. In addition to the main elements it contains two Amperites (filament ballast resistors), R1 and R2, and a filament switch Sw. Filament, plate and grid batteries are supposed to be used with it.

The requirements of the audio transformers are the same as those of transformers used in any other similar circuit, regardless of the power supply, provided similar tubes are used. Since nearly all general purpose tubes are designed to have nearly the same output characteristics, most audio transformers designed for quality reception are suitable. Both transformers may be of the same design, but if one of two available transformers has a higher primary impedance, which usually means a lower step-up ratio, that should be used in the first stage, assuming the amplifier is to be connected to a detector tube,

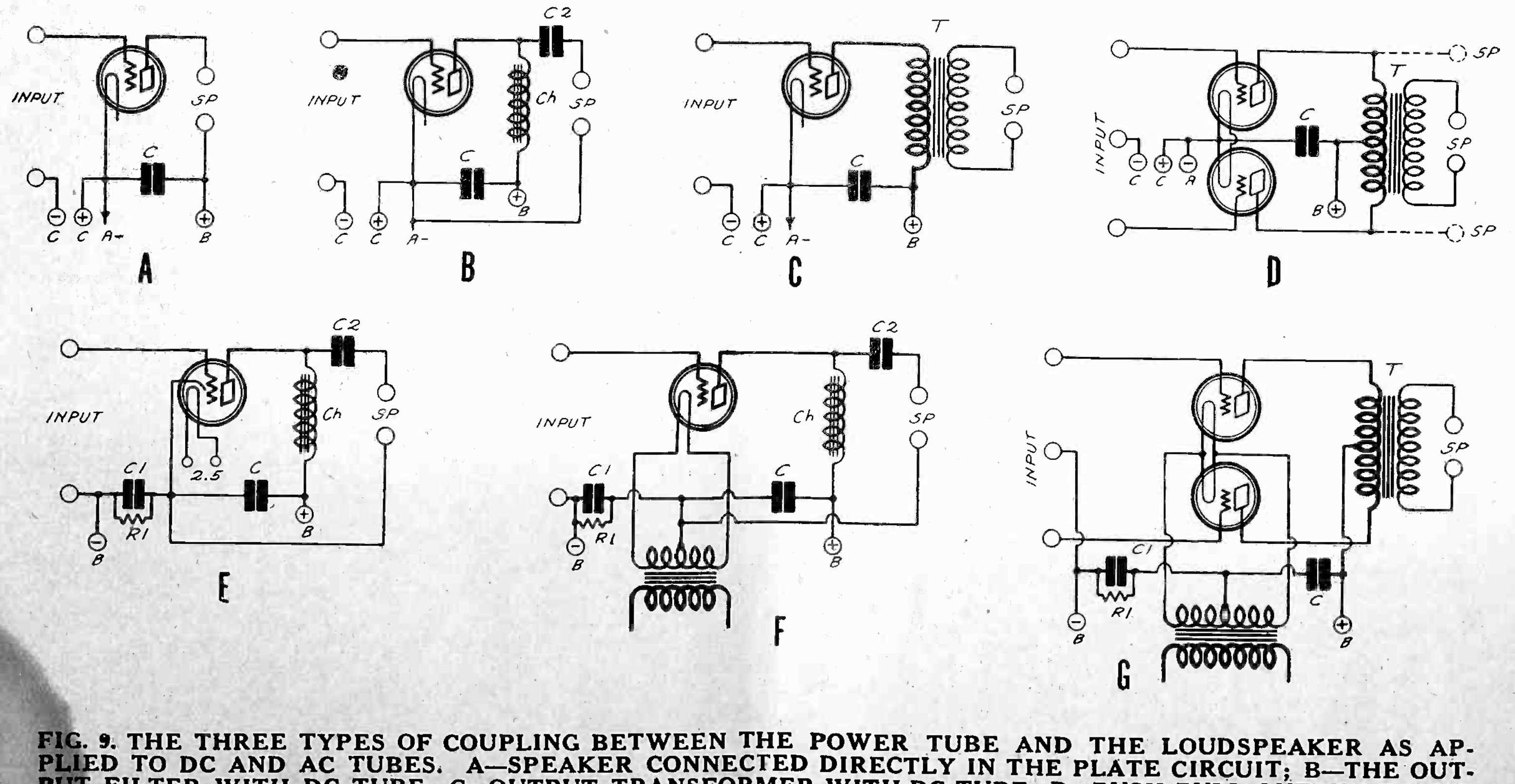


FIG. 9. THE THREE TYPES OF COUPLING BETWEEN THE POWER TUBE AND THE LOUDSPEAKER AS APPLIED TO DC AND AC TUBES. A—SPEAKER CONNECTED DIRECTLY IN THE PLATE CIRCUIT; B—THE OUTPUT FILTER WITH DC TUBE; C—OUTPUT TRANSFORMER WITH DC TUBE; D—PUSH-PULL OUTPUT TRANSFORMER WITH AC TUBES, AND THE PLATE-TO-PLATE CONNECTION; E—OUTPUT FILTER WITH HEATER TUBE; F—OUTPUT FILTER WITH AC FILAMENT TUBE; G—PUSH-PULL WITH AC FILAMENT TUBES.

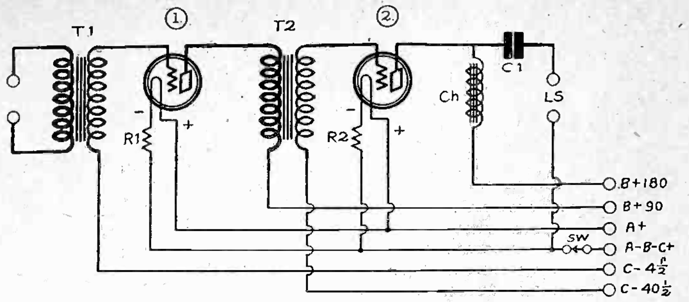


FIG. 10

TWO-STAGE, TRANSFORMER COUPLED, BATTERY OPERATED AUDIO FREQUENCY AMPLIFIER.

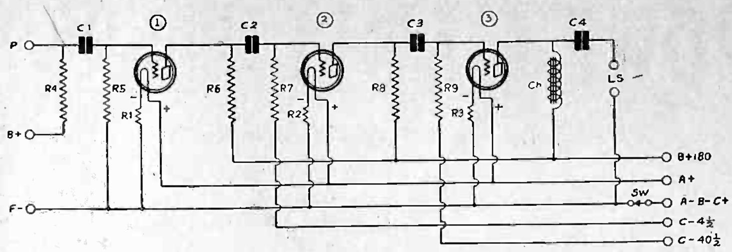


FIG. 11

THREE-STAGE, RESISTANCE COUPLED, BATTERY OPERATED AUDIO FREQUENCY AMPLIFIER.

since the impedance of the detector tube to audio frequencies is very high.

The choice of tubes for this amplifier depends on the purpose for which the circuit is to be used. If it is to be a portable amplifier, the first tube might be a 199. In that case the last tube should be a 120, the plate voltage being 135 volts instead of 180 volts, and the negative grid bias 22½ volts instead of 40.5 volts. The filament voltages must be adjusted to suit the tubes. Also, if the 120 tube is used it is not necessary to use an output filter, but the loudspeaker, or earphones, may be connected directly in the plate circuit of the second tube.

For broadcast reception in a home a better choice of tubes is a 201A for the first tube and a 171A for the second. An output filter is necessary with this combination of tubes, for the 171A requires a high plate current. The plate and grid voltage values given in Fig 10 assume that this combination of tubes is used. The plate voltage on the first tube is 90 volts and that on the second is 180 volts. The bias on the grid of the first tube is 4.5 volts and that on the second is 40.5 volts. These are standard values and easily obtainable.

The filament voltage source, of course, is six volts, obtained from a storage battery. The filament voltage is cut down to 5 volts, at .25 ampere, by means of 1A Amperites.

The choke Ch should be preferably a 100 henry coil, measured with no DC in the winding, and it should be large enough in physical dimensions to avoid undue drop in the inductance with the flow of direct current. Certainly it should not be less than 40 henries when 20 milliamperes are flowing.

The stopping condenser C1 should be not less than 4 mfd. The value depends somewhat on the speaker, but the capacity could not be too large in any case.

Since the amplifier is supposed to be used with plate and grid batteries, by-pass condensers have not been included in the circuit. If the plate battery is of the storage variety no by-pass condensers will be required at any time, but if dry cell plate batteries are used, the familiar B batteries, and if they are allowed to become exhausted, distortion or even oscillation might result without condensers. However, when distortion due to the battery resistance becomes appreciable, there is so little life left in the battery that it is not worth while to employ condensers to attempt to prolong it. Noticeable distortion of this enlarging type is one warning to replace the battery. The grid battery usually will last a year or more without replacement, no current is drawn from it, and its life in such use is about equal to its shelf life. Even if a voltmeter indicates a 50 per cent reduction in the voltage, the grid bias value of the batteries is practically the same as that of a new battery. This does not apply to all circuits.

It is of utmost importance to keep the filament storage battery fully charged. The amplifier will not work well when the voltage is below six volts. If the battery is permitted to discharge completely periodically, it will not last long. A hydrometer should be kept handy at all times for testing the charge.

Resistance Coupled Amplifier

A resistance coupled amplifier such as that shown in Fig. 11 is particularly suited to battery operation. Indeed, only in a battery operated circuit can this type of amplifier be used in its simple form. If any other source of plate voltage is used it is necessary to take utmost precautions against audio frequency oscillation. With batteries it gives little trouble, except when the batteries are old and nearly exhausted. When the circuit starts to misbehave, just as in the case of the transformer coupled circuit, it is time to replace the battery.

If a storage battery is used to supply the plate voltage there will be no trouble as long as the battery is good.

The first two tubes in this circuit may well be of the high gain type. A special purpose tube, the 240, with an amplification factor of 30 has been especially designed for the circuit. With two such tubes a total voltage step-up of 500 can be obtained between the grid of the first and the grid of the third tube. General purpose tubes also may be used, but with a lower gain. Tubes like 201A with an amplification factor of 8 might yield a gain of between 50 and 60, depending on the values of the coupling impedances.

The higher the coupling impedances the higher will be the amplification.

The lowest values for the resistors R4, R6, and R8 should be 100,000 ohms. If they are increased to 250,000 ohms the amplification will be considerably greater. For higher values the increase in the amplification will not be great.

But it is of no value to increase the coupling resistors if the grid bias resistors R5, R7 and R9 do not remain considerably larger than their corresponding plate resistors. The first two, R5 and R7, should be at least 2 megohms. The last, R9, should be equal to this if the circuit will operate without audio oscillation when such a value is used. If it must be lowered it should be kept as large as it can be without losing stability.

The values of the stopping condensers, in general, should be as large as practicable, but it is of doubtful value to increase the size if that requires using condensers with paper dielectric. The best condensers to use are those with mica dielectric, standard values of which come as high as .02 mfd. This is large enough provided the grid leak associated with any condenser is not less than 1 meg.

A high grid leak resistance and a large capacity condenser will permit full amplification of all the low frequencies. A low value leak and a low value stopping condenser will suppress the amplification of the low notes. The product of the capacity of the condenser in microfarads and the resistance of the leak in megohms should not be smaller than .02, unless, for any reason, it is desirable to suppress the low notes. This product of .02 holds no matter what is the capacity of the stopping condenser.

Satisfactory operation of battery amplifiers of this type have been obtained, with two high mu tubes, with 250,000 ohms for the plate resistors, .02 mfd. for the stopping condensers, and 2 megohms for the grid leaks. In some instances R9 has to be reduced to as low as 250,000 ohms.

There is another reason besides instability for reducing the value of the last grid leak. Leakage through and over the insulation of the grid often makes the grid positive notwithstanding the high value of applied grid bias. A low value of grid leak will maintain the potential of the grid at the correct operating value.

The amplifier shown in Fig. 11 is more stable than one containing only two tubes, in resistance coupling, provided that all the tubes, including the detector, receive their plate voltage from the same source. The use of high values of plate resistors increases the stability, and the return of the speaker to the A battery increases it still further.

There are two frequency regions in which instability might occur when the plate battery has a high resistance, at very low frequencies and at very high. The high frequency instability can be remedied by connecting a condenser, about 1 mfd., across the battery. The low frequency instability can be remedied by reducing R9, or by replacing a deflated B battery with a fresh one.

When this amplifier is connected to a detector tube the three terminals at the left should be connected to the tube as indicated. If the same storage battery is used for both the detector and the amplifier, the F connection should be omitted, for it is made automatically through the B battery. The B plus terminal may be connected to the 180 volt tap on the plate battery, or to any lower tap.

When the amplifier is connected to a phonograph pick-up unit, the P and the F terminals should be used. B plus detector then should not be connected to anything. The pick-up unit may also be connected across R5, or in place of R5.

The final tube in this amplifier is supposed to be a 171A, and for that reason the output filter ChC4 is employed. The specifications for this filter are the same as those given for the transformer coupled receiver in Fig. 10.

Since all the tubes specified are five volt tubes, the source of filament current should be a six volt storage battery. The three ballast resistors R1, R2, and R3 should be 1A Amperites.

The resistance coupled amplifier is capable of excellent quality provided that the plate voltage battery has a negligible internal resistance, or provided that special precautions be taken to nullify the feedback through any resistance that may exist.

* * *

[Part III of "Power Amplifiers" next week]

Radio University

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IS IT REALLY necessary to use a baffle board with a dynamic speaker to get the low notes? I have such a speaker and I can hear the low notes very well.

(2)—If it is necessary to use a baffle board with a dynamic, why is it not equally necessary to use one with magnetic speakers having a similar cone structure?

(3)—Can you suggest a simple way of demonstrating the effect of a baffle board, one which shows the difference convincingly?

(4)—If you recommend baffle boards, what do you consider the best size and best material for them?

DON McLEOD,
Toronto, Canada.

(1)—It is not necessary, but it is highly desirable to use a baffle with speakers having small cones or any small sound radiating surface. The low frequency cut-off due to the absence of a baffle board is not very sharp. The low notes come through, but with greatly reduced volume.

(2)—It is even more desirable to use a large baffle with a magnetic speaker having a small cone.

(3)—Get a baffle board of fairly large dimensions. Put the cone up against the aperture. Note the quality of the sound. Then tilt the speaker away from the aperture and note the striking difference. This is the simplest and the most convincing demonstration of the effect of the baffle board.

(4)—The larger the baffle board the better. A compromise is often struck on 24 in. or 36 in. square. There is no one material that is best. The material must be rigid so that it will not vibrate.

* * *

I RECENTLY got a severe shock from my power pack after I had turned off the power. Where did the voltage come from?

(2)—What precautions would you recommend to prevent such shocks in the future?

(3)—Can static-like noises be introduced by the ground used with the receiver? I have a set which I can use both with a loop and an antenna-ground, and there is not nearly so much noise in the output when I use the loop as when I use the antenna.

BORIS LENSKY,
Toledo, Ohio.

(1)—It came from the condensers in the filter.

(2)—Keep your fingers away from the power pack until the charges on the condensers have had a chance to leak off.

(3)—The ground is often a prolific cause of noise. But the loop does not necessarily demonstrate the fact, for the loop always picks up less noise than an antenna and ground. Install a good counterpoise and switch from the ground to the counterpoise, using the same antenna, and then compare the noise.

* * *

IS IT POSSIBLE to improvise high resistance voltmeter by using a 0-1 milliammeter in series with a high resistance?

(2)—If it is, please tell how to figure the resistance to be connected in series.

(3)—Is it also possible to use an ammeter to improvise a voltmeter?

WILLIAM H. FRANCIS,
Jefferson City, Mo.

(1)—That is how every 1,000-ohms-per-volt voltmeter is made.

(2)—Figure on 1,000 ohms for every volt you want to measure, full scale. If the range of the voltmeter is to be 0-1 volt, use 1,000 ohms. If you want the range to be 0-100 volts, use 100,000 ohms. If you want to make the scale 0-500 volts, use half megohm. Readings below the full scale are proportional to the scale. Use accurate resistors, for the accuracy of the readings will depend on this.

(3)—Not possible, except, perhaps, to measure the voltage of a storage A battery.

* * *

I FREQUENTLY read in technical articles and books that the time constant of the grid leak and grid condenser in a direct coupled circuit should be small to get full response on the high notes, but I have also seen statements in Radio World that it should be as large as possible. Which is correct?

(2)—Under what conditions should the time constant be small in order that the circuit respond quickly to rapidly changing voltages such as those occuring in high frequency signals?

(3)—How is the time constant measured and what is its meaning?

CHARLES H. BURT,
Baltimore, Md.

(1)—Somebody once made a mistake by saying the time constant should be small and some writers have carried on the error. The time constant should be large.

(2)—If the condenser and the resistance are in parallel and so placed in the circuit that the condenser must be charged up before the full voltage is attained, then the time constant should be small. The stopping condenser in a resistance or impedance coupled circuit is in series with the grid leak, and the only condition is that it be large so that it does not offer any impedance to the low frequencies.

(3)—The time constant is measured by the product of the resistance and the capacity, ohms and farads being the units. The results is measured in seconds. The meaning of the time constant might be explained as follows: Suppose a condenser of capacity C be charged to a voltage V and that a resistance of R ohms be connected across the charged condenser, then the time constant RC is the number of seconds that will elapse before the voltage across the condenser has been reduced to 1/2.718 of its original value. The number 2.718 is the base of natural logarithms.

* * *

THERE IS a terrific hum in my Screen Grid Universal receiver, which is operated by A and B battery eliminators. What is the cause of this hum?

(2)—The volume of this set is terrific and it cannot be controlled with the rheostat in the filament circuit of the screen grid tube, which has a resistance of 20 ohms. What would you suggest for controlling the volume?

(3)—Is it possible to use a 171A power tube in the last stage?

SIGWALD ORRE,
St. Paul, Minn.

(1)—The hum is due to a combination of two things, regeneration and residual hum in the eliminators. Control the regeneration and the hum will disappear, unless the eliminators are hopelessly overloaded.

(2)—Use the rheostat recommended—50 ohms.

(3)—Yes, it is possible if you apply the proper plate and grid potentials to the power tube. You should also use an output filter or transformer to protect the loudspeaker.

* * *

WHAT IS THE OBJECT of decreasing the filament voltage on AC tubes as compared with DC tubes? I refer especially to the reduction in the filament voltage in the design of the 245 tube.

(2)—Is it practical to heat the filaments of a 245 and one or more 227s by the same 2.5 volt winding?

(3)—Is there any marked advantage of using a 250 tube over a 245 in a regular home receiver? If so, what?

LOUIS G. WILLIAMS,
Paterson, N. J.

(1)—There are two objects. One is that if the filament voltage is low the hum produced in the tube due to the AC will be less the lower the filament voltage. The other is that it simplifies the filament transformer that may be used.

(2)—It is practical in most instances. There are circuit arrangements in which it is not advisable to use the same winding but in most circuits there is no reason why the same winding should not be used.

(3)—The 245 tube in conjunction with a good speaker will give enough undistorted volume for any home. The 250 will give much more but it is not needed. Of course, for a given output that from the 250 will contain less harmonic distortion than that from the 245, but the distortion cannot be detected by the ear until the volume is so loud as to be unpleasant.

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Georges Payen, Ste-Theole, co. Champlain, P. Q., Can.
Clarence D. Bussurs, 104 17th St., S. E., Washington, D. C.
A. J. Anderson, Angola, N. Y.
G. E. Helbeit, 6761 4th Ave., Los Angeles, Calif.
Robert H. Roth, Sidney, Ohio.
L. A. Morrow, care The Dow Drug Co., Springfield, Ohio.
J. E. Tracy, 220 Victoria St., Jacksonville, Fla.
R. L. Watson, 2050 John Ave., Butte, Mont.
Wm. A. Harding, 2013 No. 29th St., Phila., Pa.
Geo. Angus, Esq., 115 Hillsdale Ave., W. Toronto, Ont., Can.
B. C. Coleman, Box 1742, Yardley, Wash.
A. B. Erickson, 7935 Kimbark Ave., Chicago, Ill.
Ernest F. Wright, P. O. Box 273, Lansford, Pa.
Arthur Vinton, P. O. Box 83, Southbridge, Mass.
Chas. M. Ross, 403 King St., E., Hamilton, Can.
Bob Stutz, 1128 Mackow Dr., Toledo, Ohio.
L. Varela, Calle San Juan, Guayama, P. R.
J. C. Doss, 1026 Hanover Ave., Roanoke, Va.
Arthur Walker, 155 Abbott St., Lawrence, Mass.
Joe Rouh, R. F. D. No. 1, Kent, Iowa.
W. Baker, 611 Galt Ave., Verdun, Montreal, P. Q., Canada.
Edwin Anderson, 1068 71st St., Brooklyn, N. Y.
C. Wills, 132 Queen St. (East), (T2), Toronto, Can.
John McKenzie, 54 12th St., Norwich, Conn.
Fred J. Policky, Dwight, Nebr.
Howard B. Stevens, 49 High Street, Waltham, Mass.
H. E. Beavens, 216 10th St., S. E., Washington, D. C.
Robt. J. Craker, 703 Lassen St., Susanville, Calif.
E. C. McMullin, 2610 Lillian, Shreveport, La.
Harry Haskell, 10823 Magnolia Dr., Cleveland, Ohio.
Ellis G. Grover, 805 Clay St., LaPorte, Ind.
H. C. Lamming, 630 Belmont Rd., Grand Forks, N. Dak.
Ralph Ellis, 604 Hancock St., Peoria, Ill.
A. M. Chamer, 2109 1st Ave., No., Birmingham, Ala.
Ellwood W. Etchells, 25 Gray Terrace, Trenton, N. J.
Benj. B. Sheldon, Owosso, Mich.
Don La Faucette, 3935 4th Ave., So., Minneapolis, Minn.
Frank Cage, 3180 Almond St., Phila. Pa.
Orrin B. Nelson, Box 12, Osseo, Wisc.
Jacob E. Hagmayer, P. O. Box 121, Milford, Conn.
Chas. A. Winsor, Evansville, Wis.
E. Lord, 730 Albert St., Montreal, P. Q., Can.
John Meshnick, 150 Dan Lowe Terrace, St. George, N. Y.
C. R. Gober, Prospect St., R. F. D. No. 1, Allendale, N. J.
Ian McMillan, 144 12th St. E., North Vancouver, B. C., Can.
W. L. Forsythe, R. F. D. No. 2, Raleigh, N. C.
J. M. Doyle, Doyle Mfg. Co., 308 E. 3rd St., Cincinnati, Ohio.
Frank E. McHugh, 1811 Columbia Ave., Phila, Pa.
Harold G. Vandewort, P. O. Box 339, Morgantown, W. Va.
H. M. Vardon, 232 W. Hazeltine Ave., Kenmore, N. Y.
J. D. Robinson, 1303 Tennessee St., Dallas, Texas.
L. C. Cover, 170 E. 2nd St., Peru, Ind.
Wm. C. MacKay, 781 Washington St., Newtonville, Mass.
Sam H. Dooley, 217 Glenn St., Cumberland, Md.
P. J. Kuprion, 600 Barbee Ave., Louisville, Ky.
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Television Radio Shop, 115 Winter St., Haverhill, Mass.
Theodore C. Janes, 36 So. Union St., Burlington, Vt.
James Watkins, P. O. Box 72, Russell, Ky.
D. M. LeBlanc, 65 Richmond Hill Ave., Stamford, Conn.
J. E. Bures, P. O. Box 7117, Mexico, D. F., Mex.
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Ivan F. Pierson, 736 Evergreen, Bremerton, Wash.
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Choose Your Speaker from This Complete Array!

EXPONENTIAL TYPE HORNS

Modern acoustical science is striving to equal the performance of a large air column horn with powerful unit, while the horn enjoys its rightful popularity with trained experts. The larger the horn, the better, hence we offer two models: one with 7⅝ ft. tone travel, the other (where space permits) with 10 ft. tone travel. The material used is patented Racon. Nozzle is standard size.

Cat. 200
$7.50 Net

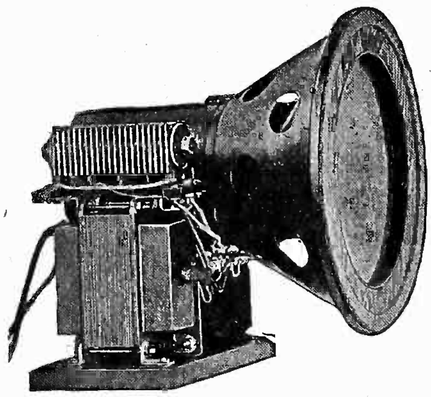
This horn has a 92-inch air column. No resonance peaks. Front, 18"x18". Depth, 13½". Weight, 5 lbs.

Driving motor, the unit needed to work the air column horns. Standard size thread. Cat. 202. Price, $3.50 net.

Cat. 300
$10.50 Net

The larger horn is preferable, where space permits. Air column, 120". Front, 18"x18". Depth, 13". Weight, 7 lbs.

DYNAMIC CHASSES and Baffle

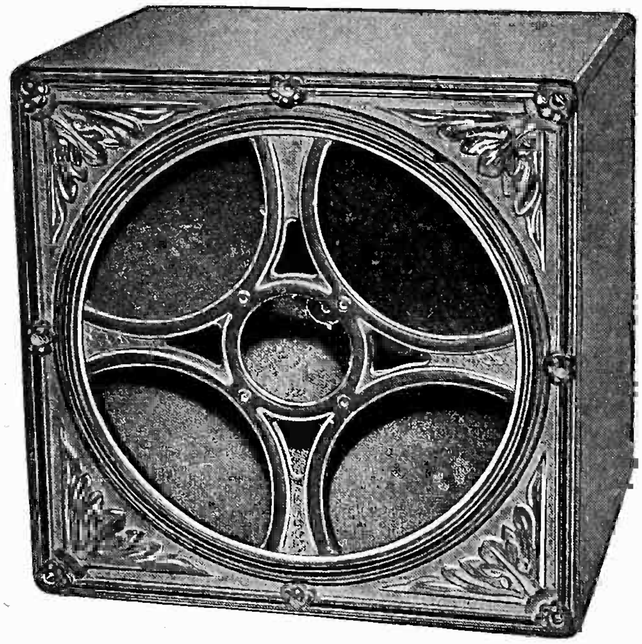


Cat. 110 A.C.; Price, $20.50 Net

The dynamic speaker is the most popular one by far, and here is your opportunity to get a real fine chassis at a low price. Cat. 110 A.C. operates directly from the 110-volt A.C. (alternating current) lamp socket, to which built-in plug is connected, while the tipped cords go to your receiver output. Dry rectifier and output transformer built in this model.

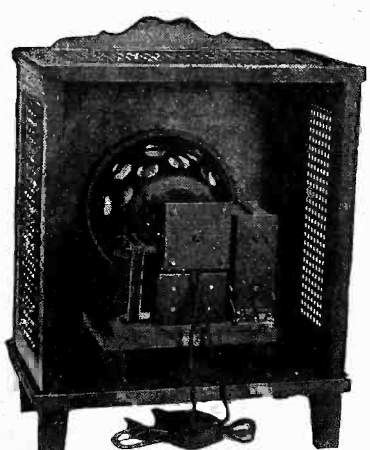
Those whose place is wired with 110-volt D.C. (direct current) should use Cat. 110 D.C. @ $17.50 net. Those who have no electricity should use the model that works from a 6-volt storage battery. Cat. 6 D.C. @ $14.75 net.

At left is illustrated an 18"x18" baffle, Cat. 111, with cane sides and top, for any dynamic speaker. Specify speaker. Walnut 5 ply veneer. Price $11.00 net.



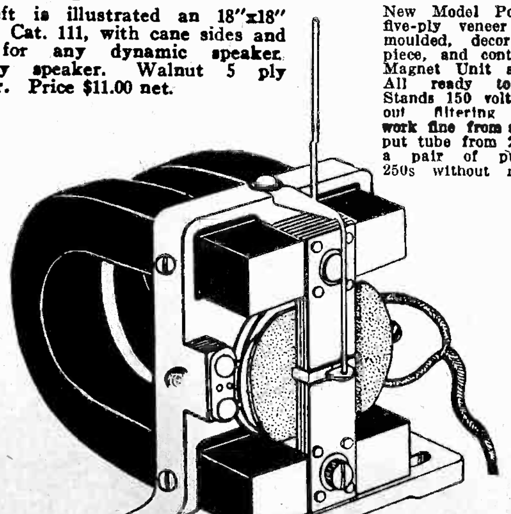
New Model Polo Speaker, with five-ply veneer walnut housing, moulded, decorated metal front piece, and containing Polo Twin Magnet Unit and Textile Cone. All ready to play. Stands 150 volts without filtering. Will work fine from any output tube from 201A to a pair of push-pull 250s without rattling.

Cat. 113
Price, $13.50 Net



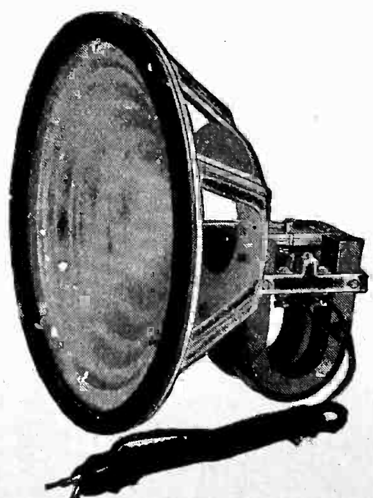
Cat. 111; Price, 11.00 Net

Cat. 110 A. C., shown inside, $20.50 extra.



Cat. 114
Price, $9.25 Net

Polo Twin Magnet Unit—weight, 3½ lbs., or twice as heavy as ordinary unit. Twin magnets double sensitivity. This unit gives more volume, clearer tone, and stands the gaff. Supplied with 10-ft. cord. Cat. 114. Tri-foot molded unbreakable metal mounting bracket and apex constitute Cat. 114A @ $0.75.



Cat. 115; Price, $11.50 Net

Molded 9" spider, unbreakable metal, with Textile cone and felt ring and apex, and Polo Unit mounted on the assembly, which stands on own feet. Cat. 115.

FILL OUT AND MAIL COUPON

ACOUSTICAL ENGINEERING ASSOCIATES,
143 West 45th Street, N. Y. City
(Just East of Broadway)

Please send me at once on 5-day money-back guarantee the following (check off):

- ☐ Cat. No. 200
- ☐ Cat. 300
- ☐ Cat. No. 110 A.C.
- ☐ Cat. No. 110 D.C.
- ☐ Cat. No. 6 D.C.
- ☐ Cat. No. 300
- ☐ Please send C.O.D.
- ☐ Remittance enclosed. Please send prepaid.
- ☐ Cat. No. 111
- ☐ Cat. No. 113
- ☐ Cat. No. 114
- ☐ Cat. 114A
- ☐ Cat. 115
- ☐ Cat. 116
- ☐ Cat. No. 202

Name ....

Address ....

City ....State ....

5-DAY MONEY-BACK GUARANTEE

LABOR STATION LOSES ITS PLEA FOR FULL TIME

Washington.

The application made by the Chicago Federation of Labor for full time and 50,000 watts on a cleared channel for its station, WCFL, has been denied by the Federal Radio Commission. The station's frequency is 770 kc.

After the application was filed the Commission notified the station that it was not satisfied that public interest, convenience, or necessity would be served by the grant, and the station was notified that it would be given a hearing on its application. Such hearing was held. The applicant was permitted to offer testimony to show that public interest would be served by the granting of the license requested.

WBBM, Glenview, Ill., and KFAB, Lincoln, Nebr., were made respondents because they operate on the same frequency with WCFL. The two stations were represented at the hearing by speakers who opposed the application and offered testimony to show that the granting of the application would not be in the public interest.

Super Power Clarostat Rated at 250 Watts

The newest addition to the Clarostat line is the Super-Power Clarostat, a heavy-duty adjustable resistor. It is a Clarostat compression device for obtaining stepless and noiseless resistance that remains set at any value desired. The Super-Power Clarostat is furnished in three resistance ranges.

Filament range ..	¼—10 ohms
Low range	25—500 ohms
Universal range ..	100—100,000 ohms

It is built for heavy-duty service and is capable of withstanding high temperatures when dissipating up to its maximum capacity of 250 watts. It is provided with a long shaft and special bracket, enabling it to be mounted clear of the panel for proper air circulation, or, again, for mounting on thick slate panel. It is intended as a heavy-duty line control, variable speed motor control, plate voltage control for transmitters, field control for shunt type generators, etc. Full information may be had from the Clarostat Manufacturing Co., Inc., 291 North Sixth Street, Brooklyn, N. Y. Mention Radio World.

Crosley Sends Programs via W8XAL on 49.5 m.

Cincinnati

Broadcasting the programs of WLW, the Crosley Radio Corporation's short-wave transmitter, W8XAL, is on the air once more after several months of silence during which it has been completely rebuilt and moved from the old WLW site at Harrison, O., to the new Crosley transmitter building at Mason, O.

W8XAL is licensed to operate with 250 watts power on a frequency of 6060 kilocycles (49.5 meters). One hundred per cent modulation is claimed.

The short-wave broadcasts are from 6:15 A. M. until 11:00 A. M.; from 1:30 P. M. until 2:30 P. M., and from 6:00 P. M. until the long-wave station signs off at night.

Chain Limitation Again Deferred

Washington.

Another postponement of the order of the Federal Radio Commission, adopted last November, proposing to limit duplication of chain broadcasting programs on cleared channels to stations separated by more than 300 miles, was announced by the Federal Radio Commission.

In a new general order (No. 63), the Commission announced that General Order No. 43, which provided for the restriction, has been deferred from June 1st to October 1st. This is the fourth time the order has been deferred, it having been originally promulgated to become effective with the reallocation of broadcasting stations of November 11th.

It was explained at the Commission that following the issuance of the order, a number of broadcasting stations complained vigorously, and the order was deferred pending further investigation.

Kolster Plans to Sue Nineteen Set Makers

Nineteen set manufacturers have been notified by Kolster Radio Corporation, through a subsidiary, the Federal Telegraph Company of California, of claims for infringement of four patents on gang condensers and vertical drum dials. Suit is threatened.

A test case is to be made and large damages demanded. Among the companies notified are Grigsby-Grunow Company, manufacturers of Majestic sets; National Carbon Company, makers of Everready sets; Crosley, Zenith, Sparks-Withington, makers of Sparton sets; Steinite, A. C. Dayton, Stewart-Warner, Silver-Marshall, Philco, All American Mohawk, Gilfillan and Sonora.

CeCo Licensed Under RCA Tube Patents

The CeCo Manufacturing Company, Inc., of Providence, R. I., third largest tube manufacturer, with a capacity of 45,000 tubes daily, has taken out a license from the Radio Corporation of America to manufacture under RCA tube licenses. CeCo is the second independent to obtain a license. The first was the Raytheon Manufacturing Company, the sale of whose tubes has since passed to exclusive control of the National Carbon Company, which is backed by General Electric.

RCA and Cunningham, the latter owned by RCA up to 51% of the stock, are first and second in tube production and sales.

Schnell Heads Staff Of Aero Engineers

Lt. Commander F. H. Schnell, U. S. Naval Reserves, for six years traffic manager of the American Radio Relay League, and more recently with the engineering and research laboratory of the Burgess Battery Co., has become chief radio engineer of Aero Products, Inc. of Chicago, specialists and manufacturers of short-wave radio equipment.

Commander Schnell is now working on some new developments in short-wave, which will shortly be announced from the Aero Products laboratories. Commander Schnell's experience in short-wave radio development covers a wide range of activities.

LAW IS ASKED FOR LIGHTS ON STATION MASTS

Washington.

The Federal Radio Commission is without authority to require radio stations to paint and illuminate their towers near commercial airways as a safeguard for aviation, nor has the Secretary of Commerce the power under the Air Commerce Act to make such a requirement, according to the opinion of the general counsel for the Commission, Bethuel M. Webster, Jr. Mr. Webster's opinion has been placed in the record of the hearings of the Senate Committee on Interstate Commerce on the Couzens bill (S. 6) to establish a Commission on Communications.

The matter was brought up at the hearings of the committee by the statement of Ira E. Robinson, a member of the Radio Commission, that the Assistant Secretary of Commerce, William P. MacCracken, Jr., had called the attention of the Commission to the failure of the Radio Corporation of America to light towers in Brunswick Meadows, N. J., and the taking off of the lights on the towers at Cleveland, Ohio. The opinion of Mr. Webster suggested additional legislation to cope with the situation.

Intelligence Confined to Earth, Says Maxim

According to Hiram Percy Maxim, the inventor, all intelligence is confined to the earth. Speaking at a dinner concluding the convention of the Hudson Division of the American Radio Relay League, a national organization of radio amateurs, he said:

"We have received nearly every frequency in the spectrum from the lowest relation to the highest, which is known as the Milliken Cosmic Ray.

"Is it not odd that of all these radiations from inter-stellar space there is not a scintilla of evidence that any of these radiations were sent out by an intelligent being. So may we not judge from that that on this little earth of ours resides the only intelligence of all cosmos?"

Transformer Leads for "Universal 250"

The connections for the power transformer used in the Universal 250, begun in last week's issue, and concluded in the present issue, are: red, to plate of 281 rectifier; brown, midtap of 7.5 volt power tube filament winding; blue, midtop of 1½ volts that are next to the 450-volt post; yellow, B—; green pair, 7.5 volts for filament of rectifier; black, to ground.

BID ON LEAGUE STATION

Geneva

Two important European radio companies, the Compagnie Generale de Telegraphie of Paris and the Telefunken Company of Berlin, have made a joint proposal to build the radio station which the League of Nations is considering erecting.

A THOUGHT FOR THE WEEK

A COMMERCIAL check-up of different businesses shows that there are nearly five hundred radio stores in Greater New York—and that a few of them are not in the Cortlandt street district.

For Those
Screen Grid Tubes—

Don't guess at grid bias voltages! Screen grid tubes are precision devices that do not react well to blacksmith methods. For the D.C. screen grid tube, try the 20-ohm HUM-DINGER as filament resistance and adjustable grid bias. For A.C. screen grid tube, try the VOLUME CONTROL CLAROSTAT.

Your dealer can show you both these devices, as well as other items of the CLAROSTAT line. And we'll gladly send you literature.

CLAROSTAT MFG. CO., Inc.
Specialists in Radio Aids
291 N. 6th St., Brooklyn, N. Y.

CLAROSTAT

LYNCH METALLIZED

Standohm — The "Self-supporting" Register. A big improvement in a well-known, standardized QUALITY resistance unit. Moderate in price. Efficient in operation.

ARTHUR H. LYNCH, INC.
1775 Broadway New York, N. Y.
Write for complete information

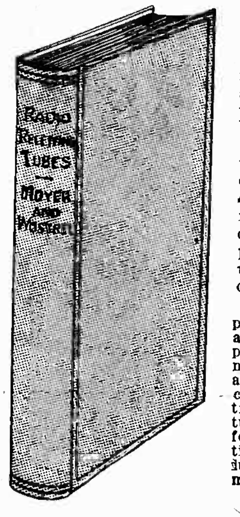
More Profits To Set Builders

One good radio idea may be worth millions. Barawik has thousands of ideas for radio set builders to make more money. **Barawik's Big Radio Book** will help you while elections are on and big national events stir the world.

Send for your copy today — NOW.

BARAWIK CO. 136A Canal Station, CHICAGO, U. S. A.

NEWEST BOOK ON VACUUM TUBES



"RADIO RECEIVING TUBES," by James A. Moyer and John F. Wostrel, first edition just off the press. No radio service man, experimenter or student of radio should be without this authoritative book on the principles and applications of vacuum tubes. It answers all your questions relating to receiving, amplifying and rectifying tubes. It is a complete discussion of tube principles, functions and uses, thoroughly up-to-date.

In this book the essential principles underlying the operation of vacuum tubes are explained in as non-technical a manner as is consistent with accuracy. The book covers the construction, action, reactivation, testing and use of vacuum tubes as well as specifications for vacuum tubes and applications for distant control of industrial processes and precision measurements.

Price $2.50

RADIO WORLD
145 West 45th Street, New York City
(Just East of Broadway)

FAMOUS NATIONAL

Velvet B Eliminator $16.13
180 Volts (280 Tube Free)

Latest Model National Velvet-B, Type 3580, in handsome crackle finish black metal casing, for use with sets up to and including six tubes. Input 105-120 volts AC, 50 to 60 cycles. Output, 180 volts maximum at 35 milliamperes. Three variable output intermediate voltages. (Det., RF, AF). Eliminator has excellent filter system to eliminate hum, including 30 henry choke and 18 mfd. Mershon condenser. No motorboating! (Eliminator Licensed under patents of the Radio Corporation of America and associated companies.)

Guaranty Radio Goods Co.
145 W. 45TH STREET
(Just East of Broadway)
NEW YORK CITY

GUARANTY RADIO GOODS CO.,
145 W. 45th St., N. Y. City

☐ Please send C. O. D. on 5-day money-back guaranty, one National Velvet B (180 volts maximum with three variable intermediate voltages), 280 tube free, at $16.13.

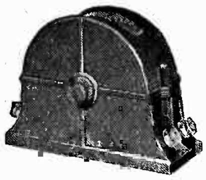
☐ Enclose find $16.13. Please send above. You are to pay cartage.

Name ....

Address ....

City .... State ....

5-DAY MONEY-BACK GUARANTY



VICTOREEN
Super Coils

Write for Free Blueprints of New Victoreen Circuits

Geo. W. Walker Co.
2825 Chester Avenue
Dept. B Cleveland, O.

Gothic Polo Speaker, $15.00

Housed in a beautiful Gothic structure of genuine walnut; hand-rubbed to an attractive finish, the Polo driving mechanism and cone combine best quality reproduction with finest appearance. The grille is specially constructed for two-tone effect, so popular in walnut these days. The Polo Speaker in the Gothic housing is an adornment, besides being an outstanding speaker in performance. The design of the cabinet is exclusive. The height is 12½". Shipping weight, 10 lbs. Cat. No. T.M.P.G.......

Guaranty Radio Goods Co.
145 West 45th Street
New York City

FREE!

Your Choice of Any One of These Nine Meters FREE!

☐ 0-6 Voltmeter D.C. .... No. 326
☐ 0-50 Voltmeter D.C. .... No. 337
☐ 6-Volt Charge Tester D.C. .... No. 23
☐ 0-10 Amperes D.C. .... No. 338
☐ 0-25 Milliamperes D.C. .... No. 325
☐ 0-50 Milliamperes D.C. .... No. 350
☐ 0-100 Milliamperes D.C. .... No. 390
☐ 0-300 Milliamperes D.C. .... No. 399
☐ 0-400 Milliamperes D.C. .... No. 394

Equip Yourself Now With Necessary Meters!

To do your radio work properly you need meters. Here is your opportunity to get them at no extra cost. See the list of nine meters at left. Heretofore we have offered the choice of any one of these meters free with an 8-weeks subscription for RADIO WORLD, at $1, the regular price for such subscription. Now we extend this offer. For the first time you are permitted to obtain any one or more or all of these meters free, by sending in $1 for 8-week's subscription, entitling you to one meter; $2 for 16 weeks, entitling you to two meters; $3 for 26 weeks, entitling you to three meters; $4 for 35 weeks, entitling you to four meters; $5 for 44 weeks, entitling you to 5 meters; $6 for 52 weeks, entitling you to six meters. Return this offer with remittance, and check off desired meters in squares at left.

RADIO WORLD will help you in your radio work, so you will be able to use the meters most valuably. Keep abreast of all the new circuits, intimate details on perfecting existing sets, and get inside track on sensitivity, distance reception, tonal quality, and news of radio, technical and non-technical. Enjoy the writings of Dr. Lee De Forest, McMurdo Silver, J. E. Anderson, Herman Bernard and a host of other radio engineers who contribute their knowledge to you through the medium of RADIO WORLD, the first and only illustrated national radio weekly. You can find no magazine that better caters to your needs than RADIO WORLD. Short waves? RADIO WORLD will tell you all about them. Extremely sensitive broadcast receivers? Their construction and operation are fully discussed with confident regularity. Power supplies —push-pull or otherwise? AC receivers? Seven grid tubes? Large receivers that give a super-abundance of performance—small, economical receivers that give performance out of all comparison to their size? Are you interested in these? Then you're interested in RADIO WORLD.

Present mail subscribers may renew their subscription under this remarkably generous offer. Put a cross in square. ☐

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RADIO WORLD
145 WEST 45TH ST., N. Y. CITY

Alphabetical List of Stations by Call Letters; Location and Frequency

[FROM LIST REVISED AND CORRECTED BY FEDERAL RADIO COMMISSION AND RELEASED ON MAY 28TH.]

Station Location Frequency

WAAF—Chicago, Ill., 920
WAAM—Newark, N. J., 1250
WAAT—Jersey City, N.J., 1070
WAAW—Omaha, Nebr., 660
WABC-WBOQ—N.Y. City, 860
WABI—Bangor, Me., 1200
WABZ—New Orleans, La., 1200
WADC—Akron, O., 1320
WAFD—Detroit, Mich., 1500
WAGM—Royal Oak, Mich., 1310
WAIU—Columbus, O., 640
WAPI—Birmingham, Ala., 1140
WASH—Gd. Rapids, Mich., 1270
WBAK—Harrisburg, Pa., 1430
WBAL—Baltimore, Md., 1060
WBAP—Fort Worth, Tex., 800
WBAW—Nashville, Tenn., 1490
WBAX—Wilkes-Barre, Pa., 1210
WBBC—Brooklyn, N. Y., 1400
WBBL—Richmond, Va., 1370
WBBM-WJBT—Chicago, Ill., 770
WBBR—Rossville, N. Y., 1300
WBBY—Charleston, S. C., 1200
WBBZ—Ponca City, Okla., 1200
WBCM—Bay City, Mich., 1410
WBIS—See WNAC
WBMS—Fort, Lee., N. J., 1450
WBNY—New York, N. Y., 1350
WBOQ—See WABC
WBOW—Terre Haute, Ind., 1310
WBRC—Birmingham, Ala., 930
WBRE—Wilkes-Barre, Pa., 1310
WBRL—Tilton, N. H., 1430
WBSO—Wellesley H., Mass., 780
WBT—Charlotte, N. C., 1080
WBZ—Springfield, Mass., 990
WBZA—Boston, Mass., 990
WCAC—Storrs, Conn., 600
WCAD—Canton, N. Y., 1220
WCAE—Pittsburgh, Pa., 1220
WCAH—Columbus, Ohio, 1430
WCAJ—Lincoln, Nebr., 590
WCAL—Northfield, Minn., 1250
WCAM—Camden, N. J., 1280
WCAO—Baltimore, Md., 600
WCAP—Asbury Pk., N. J., 1280
WCAT—Rapid City, N.D., 1200
WCAU—Philadelphia, Pa., 1170
WCAZ—Carthage, Ill., 1070
WCBA—Allentown, Pa., 1440
WCBD—Zion, Ill., 1080
WCBM—Baltimore, Md., 1370
WCBS—Springfield, Ill., 1210
WCCO—Minneapolis, Minn., 810
WCDA—Cliffside, Pk., N.J., 1350
WCFL—Chicago, Ill., 970
WCGU—Coney Island, N.Y.,1400
WCKY—Harrison, O., 1480
WCLB—Lg. Beach, N.Y., 1500
WCLO—Kenosha, Wis., 1200
WCLS—Joliet, Ill., 1310
WCMA—Culver, Ind., 1400
WCOA—Pensacola, Fla., 1120
WCOC—Columbus, Miss., 880
WCOH—Yonkers, N.Y., 1210
WCRW—Chicago, Ill., 1210
WCSH—Portland, Maine, 940
WCSO—Springfield, O., 1380
WDAE—Tampa, Fla., 620
WDAF—Kansas City, Mo., 610
WDAG—Amarillo, Tex., 1410
WDAH—El Paso, Tex., 1310
WDAY—W. Fargo, N. D., 1280
WDBJ—Roanoke, Va., 930
WDBO—Orlando, Fla., 620
WDEL—Wilmington, Ind., 1120
WDGY—Minneapolis, Minn., 1180
WDOD—Chattanooga, Tenn., 1280
WDRC—New Haven, Conn.,1330
WDSU—New Orleans, La., 1270
WDWF_WLSI—Cr'nst'n,R.I.1210
WDZ—Tuscola, Ill., 1070
WEAF—New York, N.Y., 660
WEAI—Ithaca, N. Y., 1270
WEAN—Providence, R.I., 550
WEAO—Columbus, O., 550
WEAR—Cleveland, O., 1070
WEBC—Duluth, Minn., 1280
WEBE—Cambridge, O., 1210
WEBQ—Harrisburg, Ill., 1210
WEBR—Buffalo, N. Y., 1310
WEBW—Beloit, Wis., 600
WEDC—Chicago, Ill., 1210
WEDH—Erie, Pa., 1420
WEEI—Boston, Mass., 590
WEHS—Evanston, Ill., 1310
WELK—Phila, Pa., 1370
WEMC—Berrien Spgs., Mch. 590
WENR-WBCN—Chicago, Ill., 870
WEPS—Gloucester, Mass., 1200
WEVD—New York, N. Y., 1300
WEW—St. Louis, Mo., 760
WFAA—Dallas, Texas, 1040
WFAN—Philadelphia, Pa., 610
WFBC—Knoxville, Tenn., 1200
WFBG—Altoona, Pa., 1310
WFBJ—Collegeville, Minn., 1370
WFBL—Syracuse, N. Y., 900
WFBM—Indianapolis, Ind., 1230
WFBR—Baltimore, Md., 1270
WFDF—Flint, Mich., 1310
WFI—Philadelphia, Pa., 560
WFIW—Hopkinsville, Ky., 940
WFJC—Akron, O., 1450
WFKD—Philadelphia, Pa., 1310
WFLA-WSUN—Clrw'tr Fla, 900
WGAL—Lancaster, Pa., 1310
WGBB—Freeport, N. Y., 1210
WGBC—Memphis, Tenn., 1430
WGBF—Evansville, Ind., 630
WGBI—Scranton, Pa., 880

Station Location Frequency

WGBS—New York City, 1180
WGCM—Gulfport, Miss., 1210
WGCP—Newark, N. J., 1250
WGES—Chicago, Ill., 1360
WGH—Newport News, Va., 1310
WGHP—Detroit, Mich., 1240
WGL—Ft. Wayne, Ind., 1370
WGMS—See WLB-WGMS
WGN_WLIB—Elgin, Ill., 720
WGR—Buffalo, N. Y., 550
WGST—Atlanta, Ga., 890
WGY—Schenectady, N. Y., 790
WHA—Madison, Wis., 940
WHAD—Milwaukee, Wis., 1120
WHAM—Rochester, N. Y., 1150
WHAP—N. Y. City, 1300
WHAS—Louisville, Ky., 820
WHAZ—Troy, N. Y., 1300
WHBC—Canton, Ohio, 1200
WHBD—Bellefontaine, O., 1370
WHBF—Rock Island, Ill., 1210
WHBL—Sheboygan, Wis., 1410
WHBP—Johnstown, Pa., 1310
WHBQ—Memphis, Tenn., 1370
WHBU—Anderson, Ind., 1210
WHBW—Philadelphia, Pa., 1500
WHBY—W. De Pere, Wis., 1200
WHDF—Calumet, Mich., 1370
WHDH—Gloucester, Mass., 830
WHDI—Minneapolis, Minn. 1180
WHDL—Tupper Lake, N.Y.,1420
WHEC-WABO-Roch'st'r,NY.1440
WHFC—Cicero, Ill., 1310
WHIS—Bluefield, W. Va., 1420
WHK—Cleveland, Ohio, 1390
WHN—New York, N.Y., 1010
WHO—Des Moines, Ia., 1000
WHP—Harrisburg, Pa., 1430
WIAS—Ottumwa, Iowa, 1420
WIBA—Madison, Wis., 1210
WIBG—Elkins, Park, Pa., 930
WIBM—Jackson, Mich., 1370
WIBO—Chicago, Ill., 570
WIBR—Steubenville, O., 1420
WIBS—Elizabeth, N. J., 1450
WIBU—Poynette, Wis., 1310
WIBW—Topeka, Kan., 1300
WIBX—Utica, N. Y., 1200
WICC—Bridgeport, Conn., 1190
WIL—St. Louis, Mo., 1200
WILL—Urbana, Ill., 890
WILM—Wilmington, Del., 1420
WINR—Bay Shore, N. Y., 1210
WIOD—Miami Beach, Fla., 560
WIP—Philadelphia, Pa., 610
WISN—Milwaukee, Wis., 1120
WJAD—Waco, Texas, 1240
WJAG—Norfolk, Nebr., 1060
WJAK—Kokomo, Ind., 1310
WJAR—Providence, R.I., 890
WJAS—Pittsburgh, Pa., 1290
WJAX—Jacksonville, Fla., 1260
WJAY—Cleveland, Ohio, 620
WJAZ—Chicago, Ill., 1480
WJBC—La Salle, Ill., 1200
WJBI—Red Bank, N. J., 1210
WJBK—Ypsilanti, Mich., 1370
WJBL—Decatur, Ill., 1200
WJBO—New Orleans, La., 1370
WJBU—Lewisburg, Pa., 1210
WJBW—New Orleans, La., 1200
WJBY—Gadsden, Ala., 1210.
WJJD—Mooseheart, Ill., 1130
WJKS—Gary, Ind., 1360
WJR—Detroit, Mich., 750
WJSV—Mt.Vernon Hills,Va.,1460
WJZ—New York, N. Y., 760
WKAQ—San Juan, P. R., 890
WKAR—E. Lansing, Mich., 1040
WKAV—Laconia, N. H., 1310
WKBB—Joliet, Ill., 1310
WKBC—Birmingham, Ala., 1310
WKBE—Webster, Mass., 1200
WKBF—Indianapolis, Ind., 1400
WKBH—La Crosse, Wis., 1380
WKBI—Chicago, Ill., 1310
WKBN—Youngstown, O., 570
WKBO—Jersey City, N.J., 1450
WKBP—Battle Creek, Mch.,1420
WKBQ—New York, N. Y., 1350
WKBS—Galesburg, Ill., 1310
WKBV—Brookville, Ind., 1500
WKBW—Buffalo, N. Y., 1470
WKBZ—Ludington, Mich., 1500
WKEN—Buffalo, N. Y., 1040
WKJC—Lancaster, Pa., 1200
WKRC—Cincinnati, O., 550
WKY—Okla. City, Okla., 900
WLAC—Nashville, Tenn., 1490
WLAP—Louisville, Ky., 1200
WLB-WGMS—Minneapolis, 1250
WLBC—Muncie, Ind., 1310
WLBF—Kansas City, Mo., 1420
WLBG—Ettrick, Va., 1200
WLBL—Stevens Pt., Wis., 900
WLBV—Mansfield, Ohio, 1210
WLBW—Oil City, Pa., 1260
WLBX—L. I. City, N.Y., 1500
WLBZ—Bangor, Maine, 620
WLCI—Ithaca, N. Y., 1210
WLEX—Lexington, Mass., 1360
WLEY—Lexington, Mass., 1420
WLIB-WGN—See WGN-WLIB
WLIT—Philadelphia, Pa., 560
WLOE—Chelsea, Mass., 1500
WLS—Chicago, Ill., 870
WLSI-WDWF—See WDWF
WLTH—Brooklyn, N. Y., 1400
WLW—Mason, Ohio, 700
WLWL—New York, N. Y., 1100
WMAC—Cazenovia, N. Y., 570

Station Location Frequency

WMAF—Dartmouth, Mass., 1360
WMAK—Buffalo, N. Y., 900
WMAL—Washington, D.C., 630
WMAN—Columbus, Ohio, 1210
WMAQ—Chicago, Ill., 670
WMAZ—Macon, Ga., 890
WMBA—Newport, R. I., 1500
WMBC—Detroit, Mich, 1420
WMBD—Peoria Hts., Ill., 1440
WMBG—Richmond, Va., 1210
WMBH—Joplin, Mo., 1420
WMBI—Addison, Ill., 1080
WMBJ—Pittsburgh, Pa., 1500
WMBL—Lakeland, Fla., 1310
WMBO—Auburn, N. Y., 1370
WMBQ—Brooklyn, N. Y., 1500
WMBR—Tampa, Fla., 1210
WMC—Memphis, Tenn., 570
WMCA—New York, N.Y., 570
WMES—Boston, Mass., 1500
WMMN—Fairmont, W. Va., 890
WMPC—Lapeer, Mich., 1500
WMRJ—Jamaica, N. Y., 1420
WMSG—New York, N. Y., 1350
WMT—Waterloo, Iowa, 1200
WNAC-WBIS—Boston, 1230
WNAD—Norman, Okla., 1010
WNAT—Philadelphia, Pa., 1310
WNAX—Yankton, S. D., 570
WNBF—Binghamton, N.Y., 1500
WNBH—N'w Bedf'rd, Mass.,1310
WNBJ—Knoxville, Tenn., 1310
WNBO—Washington, Pa., 1200
WNBR—Memphis, Tenn., 1430
WNBW—Carbondale, Pa., 1200
WNBX—Springfield, Vt., 1200
WNBZ—Saranac Lk., N.Y. 1290
WNJ—Newark, N. J., 1450
WNOX—Knoxville, Tenn., 560
WNRC—Greensboro, N.C., 1440
WNYC—New York, N.Y., 570
WOAI—San Antonio, Tex., 1190
WOAN—Lawrenceburg, Tenn. 600
WOAX—Trenton, N. J., 1280
WOBT—Union City, Tenn., 1310
WOBU—Charlestown, W.Va., 580
WOC—Davenport, Ia., 1000
WOCL—Jamestown, N. Y., 1210
WODA—Paterson, N. J., 1250
WOI—Ames, Iowa, 560
WOK-WMBB—See WMBB
WOKO—Poughkeepsie, NY., 1440
WOL—Washington, D.C., 1310
WOMT—Manitowoc, Wis., 1210
WOOD—Gd. Rapids, Mich., 1270
WOQ—Kansas City, Mo., 610
WOR—Newark, N. J., 710
WORD—Chicago, Ill., 1480
WOS—Jefferson City, Mo., 630
WOV—New York, N.Y., 1130
WOW—Omaha, Nebr., 590
WOWO—Ft. Wayne, Ind., 1160
WPAP-WQAO—See WQAO
WPAW—Pawtucket, R.I., 1210
WPCC—Chicago, Ill., 570
WPCH—New York, N.Y., 810
WPG—Atlantic City. N.J.,1100
WPOE—Patchogue, N. Y., 1420
WPOR-WTAR—See WTAR
WPRC—Harrisburg, Pa., 1200
WPSC—State College, Pa., 1230
WPSW—Philadelphia, Pa., 1500
WPTF—Raleigh, N. C., 680
WQAM—Miami, Fla., 1240
WQAO-WPAP—N.Y.C., 1010
WQBC—Utica, Miss., 1360
WQBZ—Weirton, W.V., 1420
WRAF—LaPorte, Ind., 1200
WRAK—Erie, Pa., 1370
WRAW—Reading, Pa., 1310
WRAX—Philadelphia, Pa., 1020
WRBC—Valparaiso, Ind., 1240
WRBI—Tifton, Ga., 1310
WRBJ—Hattiesburg, Miss., 1500
WRBL—Columbus, Ga., 1200
WRBQ—Greenville, Miss., 1210
WRBT—Wilmington, N. C., 1370
WRBU—Gastonia, N.C., 1210
WRC—Washington, D. C., 950
WREC—Memphis, Tenn., 600
WREN—Lawrence, Kans., 1220
WRHM—Friedley, Minn., 1250
WRJN—Racine, Wis. 1370
WRK—Hamilton, Ohio, 1310
WRNY—New York, N.Y., 1010
WRR—Dallas, Tex., 1280
WRUF—Gainesville, Fla., 1470
WRVA—Richmond, Va., 1110
WSAI—Cincinnati, O., 1330
WSAJ—Grove City, Pa., 1310
WSAN—Allentown, Pa., 1440
WSAR—Fall River, Mass., 1450
WSAZ—Huntington, W.V., 580
WSB—Atlanta, Ga., 740
WSBT—South Bend, Ind., 1230
WSDA-WSGH—See WSGH
WSGH-WSDA—Bklyn.,NY. 1400
WSIX—Springfield, Tenn., 1210
WSM—Nashville, Tenn., 650
WSMB—New Orleans, La., 1320
WSMK—Dayton, Ohio, 570
WSOA—Deerfield, Ill., 1480
WSPD—Toledo, Ohio, 1340
WSSH—Boston, Mass., 1420
WSUI—Iowa City, Ia., 580
WSUN-WFLA—See WFLA
WSVS—Buffalo, N. Y., 1370
WSYR—Syracuse, N. Y., 570
WTAD—Quincy, Ill., 1440
WTAG—Worcester, Mass., 580
WTAM—Cleveland, O., 1070
WTAQ—Eau Claire, Wis., 1330

Station Location Frequency

WTAR-WPOR—Norf'lk, Va., 780
WTAW—College Station, 1120
WTAX—Streator, Ill., 1210
WTBO—Cumberland, Md., 1420
WTFI—Toccoa, Ga., 1450
WTIC—Hartford, Ct., 600, 1060
WTMJ—Milwaukee, Wis., 620
WWAE—Hammond, Ind., 1200
WWJ—Detroit, Mich., 920
WWL—New Orleans, La., 850
WWNC—Asheville, N. C., 570
WWRL—Woodside, N.Y., 1500
WWVA—Wheeling, W.Va., 1160
KCRC—Enid, Okla., 1370
KDB—Santa Barbara, Cal.,1500
KDKA—Pittsburgh, Pa., 980
KDLR—Devils Lake, N.D., 1210
KDYL—Salt Lake, Utah, 1290
KEJK—Beverly Hills, Calif., 1170
KELW—Burbank, Calif., 780
KEX—Portland, Ore., 1180
KFAB—Lincoln, Nebr., 770
KFAD—Phoenix, Ariz., 620
KFBB—Great Falls, Mont., 1360
KFBK—Sacramento, Calif., 1310
KFBL—Everett, Wash., 1370
KFDM—Beaumont, Tex., 560
KFDY—Brookings, S.Dak., 550
KFEL—Denver, Colo., 940
KFEQ—St. Joseph, Mo., 560
KFGQ—Boone, Iowa, 1310
KFH—Wichita, Kans., 1300
KFHA—Gunnison, Colo., 1200
KFI—Los Angeles, Calif., 640
KFIF—Portland, Ore., 1420
KFIO—Spokane, Wash., 1230
KFIZ—Fond du Lac, Wis., 1420
KFJB—Marshalltown, Ia., 1200
KFJF—Okla., City., Okla., 1470
KFJI—Astoria, Ore., 1370
KFJM—Gd. Forks., N.D., 1370
KFJR—Portland, Ore., 1300
KFJY—Fort Dodge, Iowa, 1310
KFJZ—Fort Worth, Tex., 1370
KFKA—Greeley, Colo., 880
KFKB—Milford, Kans., 1050
KFKU—Lawrence, Kans., 1220
KFKX-KYW—See KYW
KFKZ—Kirksville, Mo., 1200
KFLV—Rockford, Ill., 1410
KFLX—Galveston, Tex., 1370
KFMX—Northfield, Minn., 1250
KFNF—Shenandoah, Iowa, 890
KFOR—Lincoln, Nebr., 1210
KFOX—Long Beach, Calif, 1250
KFPL—Dublin, Tex., 1310
KFPM—Greenville, Tex., 1310
KFPW—Siloam Spgs., Ark.,1340
KFPY—Spokane, Wash., 1390
KFQA-KMOX—See KMOX
KFQD—Anchorage, Alaska, 1230
KFQU—Holy City, Calif., 1420
KFQW—Seattle, Wash., 1420
KFQZ—Hollywood, Calif., 860
KFRC—San Francisco, Cal., 610
KFRU—Columbia, Mo., 630
KFSD—San Diego, Calif., 600
KFSG—Los Angeles, Calif., 1120
KFUL—Galveston, Tex., 1290
KFUM—Colo. Springs, Col.,1270
KFUO—Clayton, Mo., 550
KFUP—Denver, Colo., 1310
KFVD—Culver City, Calif., 710
KFVS—Cape Girardeau, Mo.1210
KFWB—Hollywood, Calif., 950
KFWC—S. Pomona, Calif., 1200
KFWF—St. Louis, Mo., 1200
KFWI—San Francisco, Cal., 930
KFWM—Oakland, Calif., 930
KFXD—Jerome, Idaho, 1420
KFXF—Denver, Colo., 940
KFXJ—Edgewater, Colo., 1310
KFXR—Okla. City, Okla., 1310
KFXY—Flagstaff, Ariz., 1420
KFYO—Abilene, Tex., 1420
KFYR—Bismarck, N.D., 550
KGA—Spokane, Wash., 1470
KGAR—Tuscon, Ariz., 1370
KGB—San Diego, Calif., 1360
KGBU—Ketchikan, Alaska, 900
KGBX—St. Joseph, Mo., 1370
KGBZ—York, Nebr., 930
KGCA—Decorah, Iowa, 1270
KGCI—San Antonio, Tex., 1370
KGCR—Watertown, S.D., 1210
KGCU—Mandan, N. D., 1200
KGCX—Vida, Mont., 1420
KGDA—Dell Rapids, S.D., 1370
KGDE—Fergus Falls, Minn,1200
KGDM—Stockton, Calif., 1100
KGDR—San Antonio, Tex., 1500
KGDY—Oldham, S. D., 1200
KGEF—Los Angeles, Calif., 1300
KGEK—Yuma, Colo., 1200
KGER—Lg. Beach, Calif., 1370
KGEW—Ft. Morgan, Colo., 1200
KGEZ—Kalispell, Mont., 1310
KGFF—Alva., Okla., 1420
KGFG—Okla. City, Okla., 1370
KGFI—Corpus Christi, Tex.,1500
KGFJ—Los Angeles, Calif., 1420
KGFK—Hallock, Minn., 1200
KGFL—Raton, N. Mex., 1370
KGFW—Ravenna, Nebr., 1420
KGFX—Pierre, S. D., 580
KGGC—San Francisco, Cal.,1420
KGGF—Picher, Okla., 1010
KGGM—Albuquerque, N.M., 1370
KGHF—Pueblo, Colo., 1320
KGHG—McGehee, Ark., 1310
KGHI—Little Rock, Ark., 1500

Station Location Frequency

KGHL—Billings, Mont., 950
KGHX—Richmond, Tex., 1500
KGIQ—Twin Falls, Idaho, 1320
KGIR—Butte, Mont., 1360
KGIW—Trinidad, Colo., 1420
KGIX—Las Vegas, Nev., 1420
KGJF—Little Rock, Ark., 890
KGKB—Brownwood, Tex., 1500
KGKL—San Angelo, Tex., 1370
KGKO—Wichita, Falls, Tex 570
KGKX—San Point, Idaho, 1420
KGO—Oakland, Calif., 790
KGRC—San Antonio, Tex., 1370
KGRS—Amarillo, Tex., 1410
KGU—Honolulu, Hawaii, 940
KGW—Portland, Ore., 620
KGY—Lacey, Wash., 1200
KHJ—Los Angeles, Calif., 900
KHQ—Spokane, Wash., 590
KICK—Red Oak, Iowa, 1420
KID—Idaho Falls, Idaho, 1320
KIDO—Boise, Idaho, 1250
KIT—Yakima, Wash., 1370
KJBS—San Francisco, Cal., 1070
KJR—Seattle, Wash, 970
KLCN—Blytheville, Ark., 1290
KLO—Ogden, Utah, 1370
KLRA—Little Rock, Ark., 1390
KLS—Oakland, Calif., 1440
KLX—Oakland, Calif., 880
KLZ—Dupont, Colo., 560
KMA—Shenandoah, Iowa, 930
KMBC—Independence, Mo., 950
KMED—Medford, Ore., 1310
KMJ—Fresno, Calif., 1200
KMMJ—Clay Center, Nebr., 740
KMO—Tacoma, Wash., 1340
KMOX-KFQA—St. Louis, 1090
KMTR—Hollywood, Calif., 570
KNX—Hollywood, Calif., 1050
KOA—Denver, Colo., 830
KOAC—Corvallis, Ore., 560
KOB—State College, N.M., 1180
KOCW—Chickasha, Okla., 1400
KOH—Reno, Nev., 1370
KOIL—Council Bluffs, Ia., 1260
KOIN—Portland, Ore., 940
KOL—Seattle, Wash., 1270
KOMO—Seattle, Wash, 920
KOOS—Marshfield, Ore., 1370
KORE—Eugene, Ore., 1420
KOY—Phoenix, Ariz., 1390
KPCB—Seattle, Wash., 1210
KPJM—Prescott, Ariz., 1500
KPLA—Los Angeles, Calif., 1000
KPO—San Francisco, Cal, 680
KPOF—Denver, Colo., 880
KPPC—Pasadena, Calif., 1200
KPQ—Seattle, Wash., 1210
KPRC—Houston, Tex., 920
KPSN—Pasedena, Calif., 950
KPWF—Westminster, Calif.1490
KQV—Pittsburgh, Pa., 1380
KQW—San Jose, Calif., 1010
KRE—Berkeley, Calif., 1370
KRGV—Harlingen, Tex., 1260
KRLD—Dallas, Tex., 1040
KRMD—Shreveport, La., 1310
KRSC—Seattle, Wash., 1120
KSAC—Manhattan, Kans., 580
KSCJ—Sioux City, Ia., 1330
KSD—St. Louis, Mo., 550
KSEI—Pocatello, Idaho, 900
KSL—Salt Lake City, U., 1130
KSMR—Santa Maria, Calif, 1200
KSO—Clarinda, Iowa, 1380
KSOO—Sioux Falls, S. D., 1110
KSTP—St. Paul, Minn., 1460
KTAB—Oakland, Calif., 550
KTAP—San Antonio, Tex., 1420
KTAT—Ft. Worth, Tex., 1240
KTBI—Los Angeles, Calif., 1300
KTBR—Portland, Ore., 1300
KTBS—Shreveport, La., 1450
KTHS—Hot Springs, Ark., 800
KTM—Los Angeles, Calif.,780
KTNT—Muscatine, Iowa, 1170
KTSA—San Antonio, Tex., 1290
KTSL—Shreveport, La., 1310
KTUE—Houston, Tex., 1420
KTW—Seattle, Wash., 1270
KUJ—Longview, Wash., 1500
KUOA—Fayetteville, Ark., 1390
KUOM—Missoula, Mont., 570
KUSD—Vermillion, S.D., 890
KUT—Austin, Tex., 1120
KVI—Tacoma, Wash., 760
KVL—Seattle, Wash., 1370
KVOA—Tucson, Ariz., 1260
KVOO—Tulsa, Okla., 1140
KVOS—Bellingham, Wash., 1200
KWBS—Portland, Ore., 1500
KWCR—Cedar Rapids, Ia., 1310
KWEA—Shreveport, La., 1210
KWJJ—Portland, Ore., 1060
KWK—St. Louis, Mo., 1350
KWKC—Kansas City, Mo., 1370
KWKH—Kennonwood, La., 850
KWLC—Decorah, Iowa, 1270
KWSC—Pullman, Wash., 1390
KWTC—Santa Ana, Calif., 1500
KWWG—Brownsville, Tex.,1260
KWYO—Laramie, Wyo., 600
KXA—Seattle, Wash., 570
KXL—Portland, Ore., 1250
KXO—El Centre, Calif., 1200
KXRO—Aberdeen, Wash., 1420
KYA—San Francisco, Cal.,1230
KYW-KFKX—Chicago, Ill., 1020
KYWA—Chicago, Ill., 1020
KZM—Hayward, Calif., 1370

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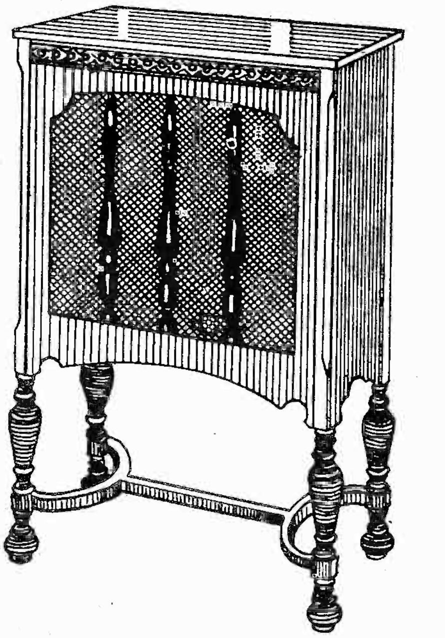

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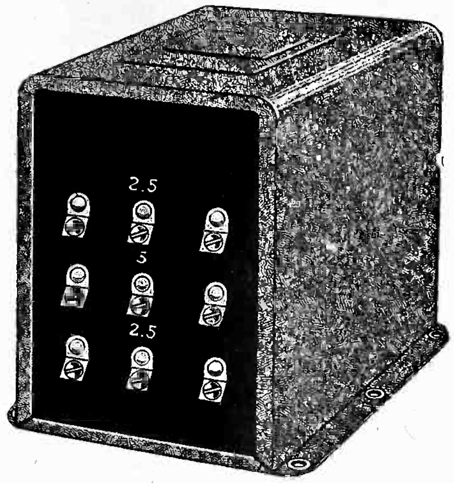

The heater type tube draws 1.75 ampere at 2.5 volts. If several such tubes are used a heavy-duty filament transformer is necessary. The top 2.5-volt winding of this filament transformer easily carries **NINE AMPERES**, or enough current for five heater type tubes. The bottom 2.5-volt winding stands four amperes, or enough current to heat **TWO MORE** such tubes, a total of **SEVEN TUBES!** The power tube, if of the 5-volt type, may be heated from the 5-volt central winding. 5-volt power tubes in push-pull may be heated from this winding.

All three windings are tapped at the exact electrical center. This precision location, made with the aid of an impedance bridge, accounts for absence of hum otherwise caused by the last tube when heated directly with AC. The heater type tubes are *indirectly* heated by AC, since the filament that glows is fed by AC but communicates heat to the cathode or electron emitter.

The heater type tube is represented by the 227, excellent as radio amplifier and audio amplifier, and the exclusive type of AC detector tube. Also the new AC screen grid tubes, with the same filament voltage and current, are of the heater type.

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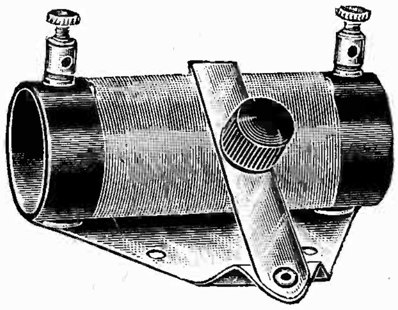

Remove aerial lead from set. Connect aerial instead to one of the binding posts of the Aerial Tuner. Connect the other binding post of the Aerial Tuner to antenna post of your set. Then move the lever of the Aerial Tuner until any weak station comes in loudest. The lever need not be moved for every different frequency tuned in. The Aerial Tuner acts as an antenna loading coil and puts the antenna's frequency at any frequency in the broadcast band that you desire to build up. It makes high wavelengths come in loud as low wavelengths. It helps separate stations and clear up reception. Makes great improvement in Summer reception. Price, $1.00.

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Reliable, prompt, accurate, in every-day language, 25c per question. Radio Information Bureau, 1426 South Clifton Park, Chicago.

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ELIMINATE AERIAL. Greater distance, volume, selectivity with "Little Black Box." Rosens Shop, 616 Plant St., Utica, N. Y.

RADIO RECEIVING TUBES, by Moyer and Wostrel, first edition just off the press. No radio service man, experimenter or student of radio should be without this authoritative book on the principles and applications of vacuum tubes. It answers all your questions relating to receiving, amplifying and rectifying tubes. Price postpaid, $2.50 Radio World, 145 W. 45th St., New York.

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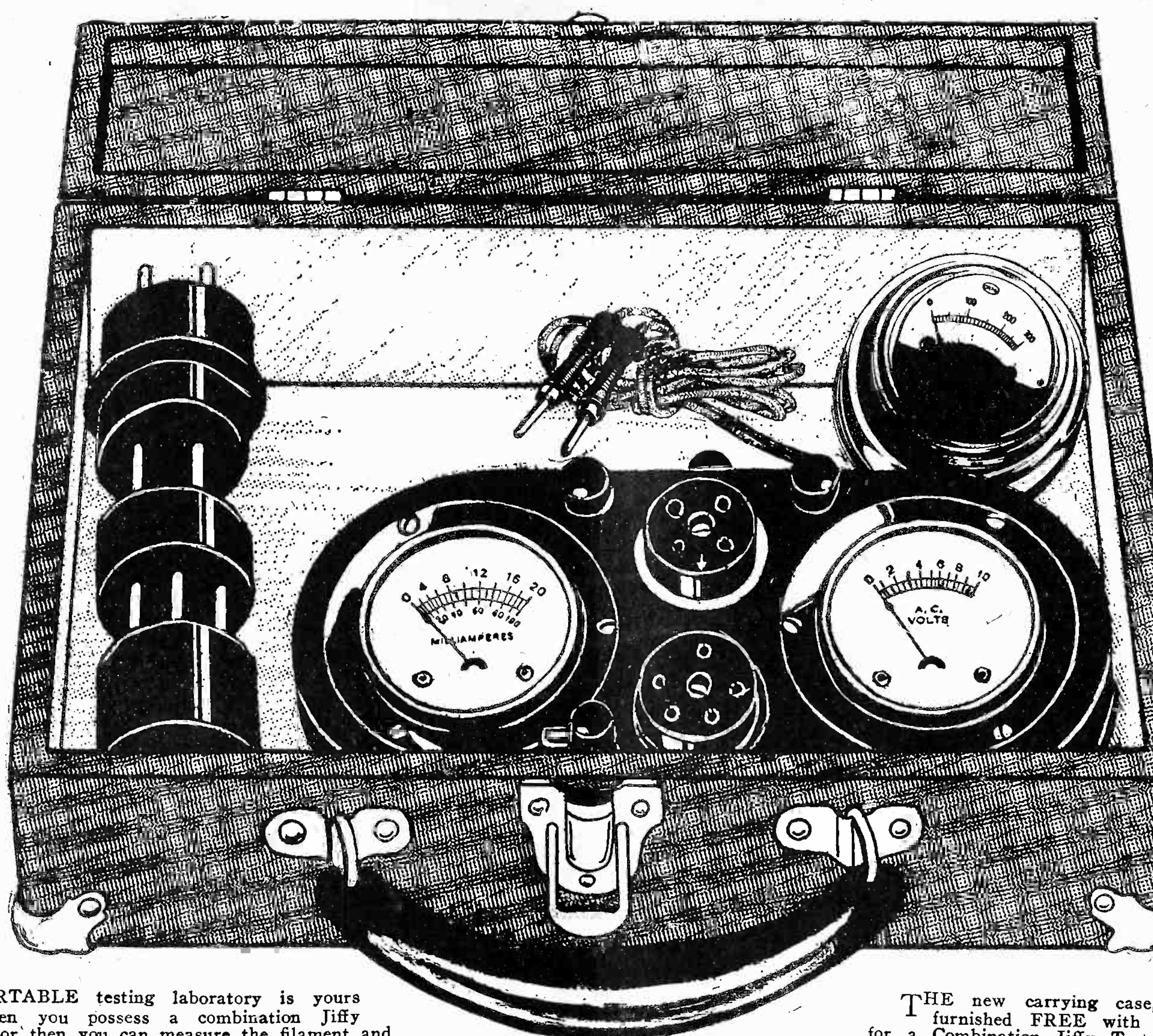
Build your own with our castings. Set of machined castings, $8.00; not machined, $5.00. Full set blue prints and instructions included. Prices of complete parts on request.
IMPERIAL RADIO SPEAKER CO.
1453 East 174th St., Cleveland, Ohio

RADIO WORLD, published every Wednesday, dated Saturday of same week, from publication office, Hennessy Radio Publications Corporation, 145 West 45th Street, New York, N. Y., just east of Broadway. Roland Burke Hennessy, President, M. B. Hennessy, Vice-President; Herman Bernard, Secretary. Roland Burke Hennessy, Editor; Herman Bernard, Managing Editor; J. E. Anderson, Technical Editor; Anthony Sodaro, Art Editor.

New Style DeLuxe Leatherette Carrying Case FREE with each Jiffy Tester!

This combination of meters tests all standard tubes, including the new AC screen grid tubes and the new 245 tube, making thirteen tests in 4½ minutes! Instruction sheet gives these tests in detail.



A PORTABLE testing laboratory is yours when you possess a combination Jiffy Tester, for then you can measure the filament and plate voltages of all standard tubes, including AC tubes, and all standard battery-operated or AC screen grid tubes; also plate voltages up to 500 volts on a high resistance meter that is 99% accurate; also plate current.

The Jiffy Tester consists of a 0-20, 0-100 milliammeter, with change-over switch and a 0-10 volt AC and DC voltmeter (same meter reads both), with two sockets, one for 5-prong, the other for 4-prong tubes; a grid bias switch and two binding posts to which are attached the cords of the high resistance voltmeter; also built-in cable with 5-prong plug and 4-prong adapter, so that connections in a receiver are transferred to the Tester automatically. Not only can you test tubes, but also opens or shorts in a receiver, continuity, bias, oscillation, etc. The instruction sheet tells all about these tests.

In addition you can test screen grid tubes by connecting a special cable, with clip to control grid (cap of tube) and other end of special cable to the clip in the set that went to the cap before the tube was transferred to the tester.

THE new carrying case, which is furnished FREE with each order for a Combination Jiffy Tester, contains the entire outfit, including the three meters, cable and plug, and three adapters (one for 4-prong tubes, two for 199 tubes). This case is 10½x 7¾x3½" and has nickel corner pieces and protective snap-lock. The case is made of strong wood, with black leatherette overlay.

To operate, remove a tube from the receiver, place the cable plug in the vacant receiver socket, put the tube in the proper socket of the Tester, connect the high resistance meter to the two binding posts, and you're all set to make the thirteen vital tests in 4½ minutes!

The Combination Jiffy Tester is just the thing for service men, custom set builders, experimenters, students, teachers and factories. Order "Jiffy 500." The price is only $14.50.

If a 0-600 AC and DC high resistance meter (99% accurate) is desired, so house electricity line voltage and power transformer voltages can be measured, as well as plate voltage, instead of the 0-500 DC voltmeter, order "Jiffy 600" at $15.50.

GUARANTY RADIO GOODS CO., 145 W. 45 St., N. Y. City. (Just East of Broadway).

☐ Please ship at once on 5-day money-back guaranty one "Jiffy 500," at $14.50, consisting of
(1) One Two-in-One 0 to 10 voltmeter for AC and DC. Same meter reads both. Scale especially legible at 1½ to 7½ volts. This meter reads the AC and DC filament voltages.
(2) One DOUBLE reading DC milliammeter, 0 to 20 and 0 to 100 milliamperes, with change-over switch. This reads plate current.
(3) One 0-500 volts high resistance voltmeter, 99% accurate; with tipped 30" cord to measure B voltages.
(4) One 5-prong plug with 30" cord for AC detector tubes, etc., and one 4-prong adapter for other tubes.
(5) One grid switch to change bias.
(6) One 5-prong socket.
(7) One 4-prong socket.
(8) Two binding posts.
(9) One handsome moire metal case.
(10) One instruction sheet.
(11) One de luxe carrying case.
(12) One screen grid special cable.

☐ If 0-300 DC high resistance 99% accurate voltmeter is preferred to 0-500, put check here. Price is same, $14.50.

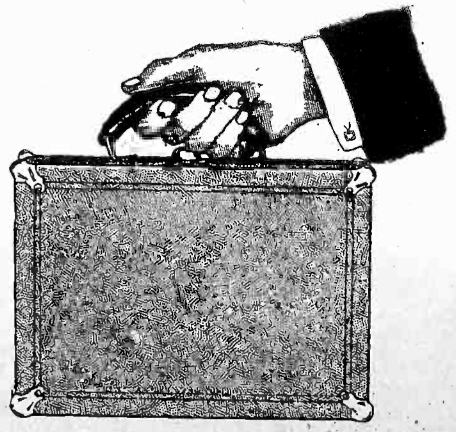
☐ Same as above, except substitute a 0-600-volt AC and DC high resistance 99% accurate voltmeter (same meter reads both) for the 0-500 DC meter. Price $15.50.

NAME ....

ADDRESS ....

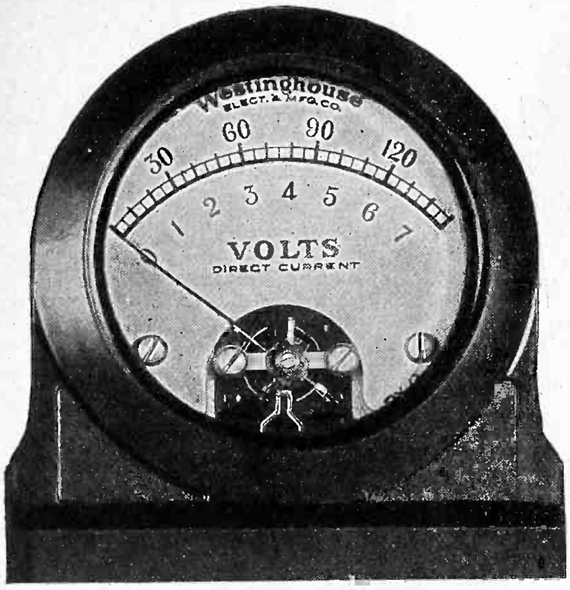
CITY .... STATE ....

FIVE-DAY MONEY-BACK GUARANTY



The new de luxe leatherette carrying case is compact and handy. Size 10½" long, 7¾" wide, 3½" deep.

Westinghouse 0-7½, 0-150 VOLT-METER FREE!



This beautiful Westinghouse meter given FREE! Read generous offer!

Double range direct current meter, O-7½ volts legible to ¼ volt, and O-150 volts, legible to 5 volts. The d'Arsonval Movement (dynamic principle) is used. Resistance is about 100 ohms per volt. A mirror strip, for observing the needle so as to hide its own reflection, facilitates closest reading, in conjunction with knife-edge. End-stops are built in. So is a zero corrector. The casing is moulded bakelite. The meter is illustrated full size. At rear are three posts—the common minus and the two positive posts. A connecting cable is furnished with each meter, lugs at one end, tip plugs at other. Send $6 for year's subscription for Radio World (52 numbers) and get this genuine Westinghouse table model meter FREE! Present subscribers may renew under this offer by stating subscription expiration date and enclosing $6.

Radio World, 145 W. 45th St. New York City

"Look for the Green Box"

The Only Tubes with 5-Day Money-Back Guarantee in Each Box

222 Screen Grid Tube **$3.50**

240 High Mu Tube **$1.25**

Great for Detector or in audio channels where a resistor or impedance coil is in the plate circuit. Fil. 5 volts DC, plate 90 to 180 volts.

POWER TUBES

250	$6.00	210	$4.50
171A	1.50	112A	1.50

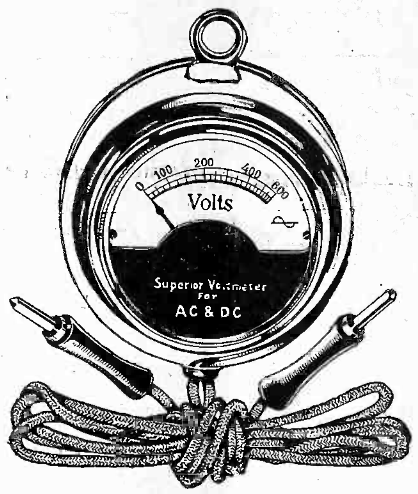
OTHER TYPES

280	$2.50	281	$3.50
227	2.25	226	1.25
201A	1.00	199	1.25

KELLY TUBE COMPANY
Walter J. McCord, Manager
57 DEY STREET, NEW YORK CITY
Suite 6 Tel. BARclay 8459

O-600 V. AC and DC
High Resistance Meter

Same Meter Reads Both AC and DC
Accurate to 1 per cent.



The O-600 volt AC and DC meter (Cat. No. 600), with 3-ft. cord, de luxe tips and hanger $7.00.

THE output voltages of all B eliminators, the voltages of all B batteries, as well as the house current line voltage, whether AC or DC, and the voltage across power transformer secondaries, can be accurately measured by this meter. The full scale is 0-600 volts, and this same meter measures both AC and DC. Since it is a high resistance meter, of extraordinary range, and accurate to 1% plus or minus, it is advisable to get this meter for your testing purposes, since it is like two meters in one —AC and DC. You can find trouble more quickly. Without it you can't tell if a power transformer secondary is delivering voltage. 10-day money-back guaranty

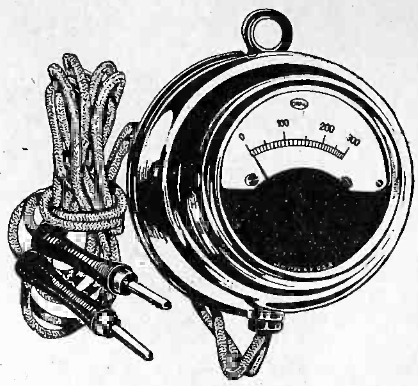
GUARANTY RADIO GOODS CO.,
145 West 45th Street, N. Y. City.
(Just East of Broadway)

Please ship at once one 0-600 volts AC and DC high resistance voltmeter, accurate to 1% plus or minus (Cat. No. 600); meter equipped with 3-ft. cord, moulded tip receptacles, tips and hanger.
[Put cross in proper square below.]

☐ $7.00 enclosed.
☐ I will pay postman $7.00 plus few cents extra for postage.

Name ....
Address ....
City .... State

Individual
METERS
For Portable or Panel Use



High resistance 0-300 Voltmeter, accurate to 1%. Measures any DC voltage to 300, including B eliminators. Provided with 30" cord, with luxurious jack tips and hanger. Meter full nickel de luxe finish. No. 346F. **$4.50**
No. 347F, same as above, but 0-500 volts, $8.00

POCKET AND PORTABLE VOLTMETERS

No. 8—For testing A batteries, dry or storage, 0-8 volts DC scale $1.00
No. 10—For testing A batteries, dry or storage, 0-10 volts DC scale 1.00
No. 13—For testing A batteries, dry or storage, 0-16 volts DC scale 1.00
No. 50—For testing B batteries, dry or storage, but not for B eliminators, 0-50 volts DC scale 1.00
No. 39—For testing B batteries, dry or storage but not for B eliminators, 0-100 volts DC scale 1.25
No. 40—For testing A and B batteries, dry or storage, but not for B eliminators; double reading, 0-8 volts and 0-100 volts DC scale.. 1.75
No. 42—For testing B batteries, dry or storage, but not for B eliminators; 0-150 volts DC scale 1.50
No. 348—For testing AC current supply line, portable, 0-150 volts 4.00

PANEL AC VOLTMETERS

(Panel meters take 2-5/64" hole)

No. 351—For reading 0-15 volts AC $2.25
No. 352—For reading 0-10 volts AC 2.25
No. 353—For reading 0-6 volts AC 2.25

(See No. 348 under "Pocket and Portable Voltmeters.")

PANEL VOLTMETERS

No. 335—For reading DC voltages, 0-8 volts, $1.00
No. 310—For reading DC voltages, 0-10 volts, 1.00
No. 316—For reading DC voltages, 0-16 volts, 1.00
No. 326—For reading DC voltages, 0-6 volts, 1.00
No. 337—For reading DC voltages, 0-50 volts, 1.00
No. 339—For reading DC voltages, 0-100 volts, 2.25
No. 342—For reading DC voltages, 0-150 volts, 2.25
No. 340—For reading DC voltages, double reading, 1-8 volts, 0-100 volts 1.50

VOLTAMMETERS

No. 18—For testing amperage of dry cell A batteries and voltage of dry or storage A batteries, double reading, 0-8 volts, and 0-40 amperes DC $1.25
No. 35—For testing amperage of dry cell A batteries and voltage of B batteries (not B eliminators); double reading, 0-50 volts, 0-40 amperes DC 1.50

PANEL MILLIAMMETERS

No. 311—For reading 0-10 milliamperes DC..$1.75
No. 395—For reading 0-20 and 0-100 ma. DC.... 1.50

VOLTAGE REGULATOR

No. 218—For preventing excess voltage on the filament and cathode of AC tubes, by compensating for excess line voltage $5.00

POCKET AMMETER

No. 1—For testing dry cells, 0-50 ampere DC scale pocket meter .... $ .75

Immediate Shipment

GUARANTY RADIO GOODS CO.,
145 West 45th Street, New York City.
Just East of Broadway

Send me the following individual meters (quantity in square):

☐ Cat. No. ☐ Cat. No. ☐ Cat. No.
☐ Cat. No. ☐ Cat. No. ☐ Cat. No.

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TEN-DAY MONEY-BACK ABSOLUTE GUARANTY!

A COMPLETE CATALOG containing detailed information on condensers and resistors may be had free on request.

AEROVOX
BUILT BETTER
CONDENSERS AND RESISTORS
74½ Washington St., Bklyn., N. Y.

THE RESEARCH WORKER will keep you abreast of developments in radio. It may be had free on request.

Blueprint of the AC Diamond

BUILD this 4-tube receiver, using one 222 tube, two 227 and one 112A (or 171A), and enjoy tone quality, selectivity and ease of control. The official blueprint gives the picture diagram life size, both top and bottom views; also schematic diagram and list of parts. You can use your present B eliminator externally, but the filament trasformer is a part of the circuit.

Enjoy the convenience of AC operation, and still have just as selective and sensitive receiver, by building the AC Diamond. If you have 110-volt, 50 to 60 cycle AC house current, then this is the circuit for you. Fine performance. No hum.

Radio World, 145 W. 45 St., N. Y. City (Just East of Broadway)
☐ Inclosed please find $1.00 for which send at once official blueprint of the 4-tube AC Diamond.
☐ 30c for the March 23d and 30th issues (1929) describing this circuit.
☐ $3.00 for 6 months subscription for Radio World. Send blueprint and two AC Diamond issues FREE.

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Most Selective Diamond

Follow Blueprint

THIS IS THE BATTERY MODEL

Here is the circuit of circuits—the design that makes a neighboring cleared-channel, high-power broadcaster snap out of audibility at a slight turn of the dial.

No need to worry about the selectivity requirements imposed on receivers by the reallocation.

Volume "to fill the house"—even on distance. Tone quality excellent.

Get the official blueprint of the laboratory model of the new SG 4-tube Diamond, exactly as built by Herman Bernard, the designer.

RADIO WORLD
145 W. 45th St., N. Y. City
(Just E. of B'way)
☐ Enclosed please find $1.00 for which please send at once the official blueprint of the new, highly selective 4-tube screen grid Diamond of the Air battery model.
☐ 60 cents extra for the February 9th, 16th, 23rd and March 2nd (1929) issues of Radio World, containing Bernard's articles on the construction of this receiver.
☐ $3.00 for 6 months (26 numbers) subscription for Radio World. Send Diamond blue print and four Diamond issues FREE, in addition to 26 current issues.

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