June 22d, 1929 15 Cents

RADIO WORLD

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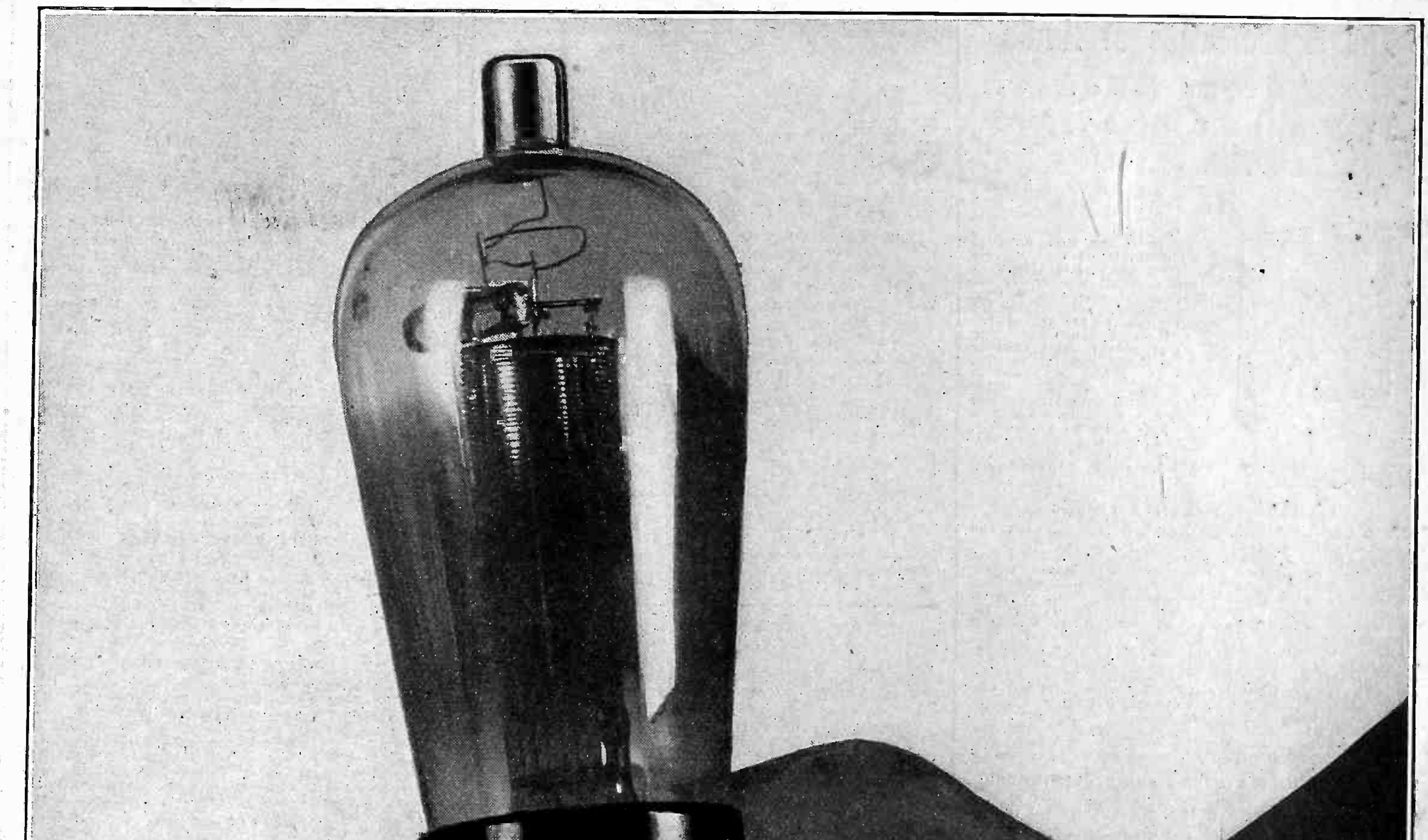
The First and Only National Radio Weekly

378th Consecutive Issue—Eighth Year

BYPASS CONDENSERS OFTEN INEFFECTIVE

EXPERIMENTS WITH SPACE CHARGE GRID

CONDENSER SPEAKER PROMISES MUCH



A FISTFUL OF POWER. SEE PAGES 6 AND 7.

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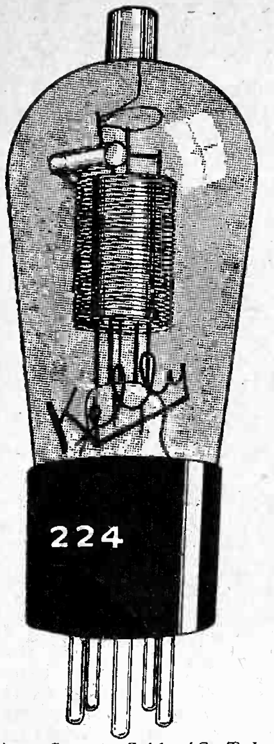
Leaders—224 and 245!

What These Marvelous Tubes Do



224 *Screen Grid AC Tube*

The Radio Trade Show in Chicago established the 224 AC Screen Grid Tube and the 245 AC Power Tube, both new, as by far the leading tubes for 1930. The master designers of circuits have chosen these tubes, the 224 for radio frequency amplification, the 245 for output tube. They merely confirmed what experimenters already had established—extreme sensitivity, great distance and fine stability are possible with the 224, while maintaining needle-point selectivity.

The 224 is capable of RF amplification of a higher order than engineers are able to capitalize in full. The tube can easily be worked at a gain of 60, as compared with 8 for the 201A.

Indirect heating is used. The filament, called heater, requires 2.5 volts and draws 1.75 ampere. The plate voltage should be 180, the screen grid voltage (G post of socket) 75 volts. The control grid connection is made to the cap at top of tube. The cathode is the electron emitter. Negative bias, 1.5 volts. Type of socket required: UY (five-prong).

Ordinary coils may be used with this tube by doubling the number of turns on the primary.

If still greater amplification is desired a larger primary may be used, and if still greater selectivity is desired, the primary may be reduced, but should have at least one-third more turns than for ordinary tubes.

"Look for the Green Box"

The 245 has a low filament voltage, 2.5 volts, at a relatively high current, 1.25 ampere. This eliminates the objectionable hum. The tube requires only 250 volts on the plate to be able to handle about as great undistorted power as the 210 does at 350 volts. A single 245 output tube will handle, without overload, the largest input to a last stage as would be required in any home. It works well into a dynamic speaker, or, by filtering the output, into a magnetic speaker. In push-pull two 245s give superb tone at doubled power handling capacity. The 250 requires 50 volts negative bias at 250 volts on the plate and draws 32 milliamperes under those conditions. The direct filament heating method is used. Type of socket, UX (*four*-prong).

There never was a power tube so excellently suited to home use—one that **handles such large** input without strain, yet which operates on a plate voltage now regarded as in the "medium" class. Use this power tube and know supreme performance.

OTHER SPECIAL PURPOSE TUBES

222 Screen Grid, for battery or AC eliminator operation; 3.3 volt filament, @ .132 ampere; 135 volts plate 22 to 45 volts screen grid; negative bias 1.5 volts..$3.50

240 high mu tube, for detector or audio circuits, where a resistor or impedance coil is in the plate circuit; amplification factor, 31. Filament 5 volts, @ .25 ampere; plate 135 to 180 volts, negative bias 1.3 to 3 volts..$1.25

280 full-wave rectifier, 125 mils at 300 volts or less; 5-volt filament @ 1.25 amperes....................$2.50

281 half-way rectifier, 7.5-volt filament............$3.50

227 detector and amplifier for AC circuits, indirect heating type; 2.5 volts filament @ 1.75 amperes; 90 to 180 volts plate, negative bias 1.5 to 6 volts; excellent for power detection $2.25

226 AC amplifier; 1.5 volts filament @ 1.05 amperes; 90 to 150 plate volts; negative bias 2.5 to 4.5 volts.$1.25

112A output tube for battery or AC operation; filament 5 volts @ .25 ampere; 135 plate volts; 9 volts negative bias $1.50

171A power tube for battery or AC operation; 5 volts filament @ .25 ampere; 180 plate volts @ 40 volts negative bias $1.50

250 power tube, 7.5-volt filament @ 1.25 amperes; 450 plate volts; 80 volts negative bias $6.00

210 power tube $4.50

GENERAL PURPOSE TUBES

201A, 5-volt filament @ .25 ampere; 45 to 135 volts on plate, 5-volt positive for detector to 4.5 negative bias, for amplifier $1.00

199, 3.3-volt filament @ .06 ampere; 45 to 90 volts on plate; 3.3-volt positive bias for detector, to 4.5 negative for amplifier.......................................$1.25

PUSH-PULL PAIRS

The 250, 245, 171A and 112A are sold in matched pairs for push-pull, insuring balanced, symmetrical circuits. Order MP 250, MP 245, MP 171A or MP 112A. The matched tubes are of equal mutual conductance. They are boxed together and bear "Matched Pair" identification stickers. No extra charge for matching.

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(Walter J. McCord, Manager.)

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☐	245	☐	201A	☐	281
☐	226	☐	240	☐	250
☐	227	☐	199	☐	210
☐	112A	☐	171A	☐	MP.

If ordering C.O.D. put a cross here ☐

If enclosing remittance with order put a cross here ☐

On prepaid orders we pay cartage. On C.O.D. orders you pay cartage plus post office money-order fee.

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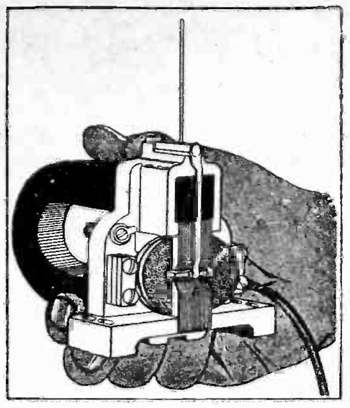

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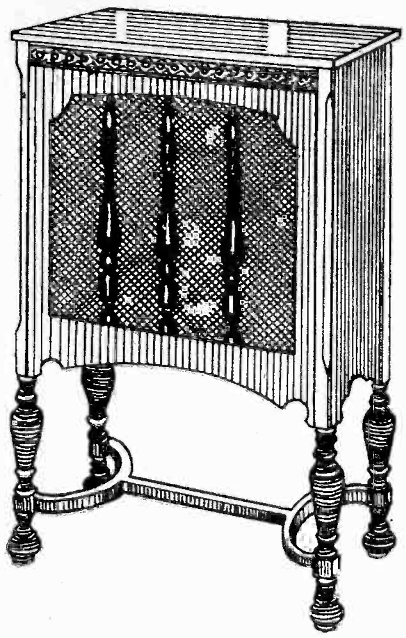

The speaker cabinet is walnut finish, 33" high, 24½". wide,. 17½". deep,. with. carved. legs. Golden cloth grille covers front opening. .Built inside is No. 595 molded wood horn with baffle and No. 203 driving motor unit that stands 250 volts without filtration. Horn and motor removable. Table alone is worth price asked. Remit with order and we pay cartage on Aristocrat Floor Speaker.

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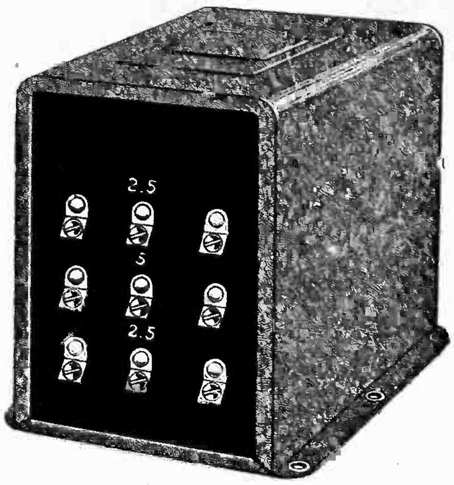
Filament Transformer



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.

The transformer is beautifully finished in crackled glossy black, with bakelite front, and comes equipped with 52-inch AC cable with plug. Six riveted mounting holes for baseboard or subpanel. Size, 3¾ in. high, 2⅝ in. wide, 3 in. deep. Shipping weight, 6 lbs.

Cat. F226A, for 50-to-60 cycles, 105-to-120 volts AC, Net Price $6.00

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If you want one of each, put a cross in a square next to the name of each of the two other magazines. If you want a two-year subscription for ONE of the above magazines, with the two-year subscription for RADIO WORLD (same grand total of 128 numbers), put two crosses before the name of one magazine.

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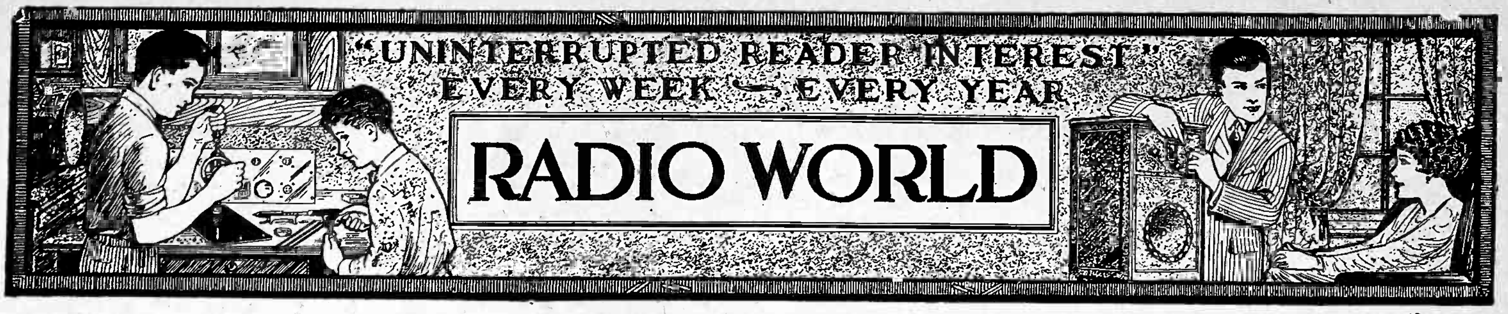

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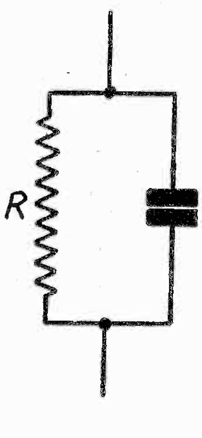
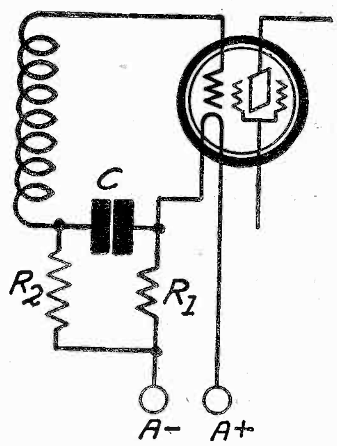
Bypass Yes and No

The Relative Reduction of Impedance Counts

By J. E. Anderson
Technical Editor



1A



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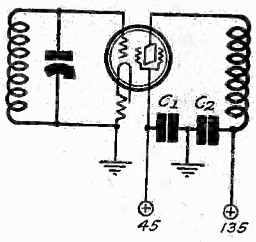

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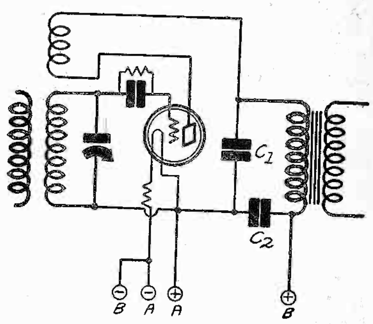


2B

FIG. 1
(A.)—A BY-PASS CONDENSER CONNECTED ACROSS A RESISTOR.
(B.)—A CONDENSER, R2, CONNECTED IN SERIES WITH A GRID BIAS RESISTOR R1 TO MAKE THE CONDENSER C RELATIVELY MORE EFFECTIVE AS A BY-PASS.

FIG. 2
(A.)—SCREEN GRID RADIO FREQUENCY AMPLIFIER IN WHICH TWO BY-PASS CONDENSERS C1 AND C2 ARE USED.
(B.)—C1 MUST BE SMALL BECAUSE IT IS ACROSS THE LINE AND ACROSS A HIGH IMPEDANCE.

BY-PASS condensers are used in large numbers in radio frequency circuits, audio frequency amplifiers and current supply filters. In the radio frequency portion of the circuit it is seldom that such condensers exceed .5 mfd. In audio frequency amplifiers and filters they often are as high as 18 mfd.

What determines the size of a condenser that should be used in a given position? Why are condensers smaller in radio frequency sections of a receiver than in the audio amplifier and in current supply filters?

The first thing that enters into the choice of size of condenser is the purpose of that condenser. Then comes the frequency at which it is to work, and finally the resistance or other impedance across which it is connected.

Formula for Impedance

In most instances a bypass condenser is connected across a resistance to lower the impedance of the circuit, as in Fig. 1A. The effective value of a resistance and a condenser in parallel is R divided by the square root of the quantity $(1+C^2W^2R^2)$, in which C is the capacity of the condenser connected across the resistance R, and w is 6.28 times the frequency of the current flowing through the parallel circuit.

This formula tells directly how much a given condenser reduces the impedance of a resistor and it also tells how effective the condenser is. Suppose the resistance is only one ohm and that it is in such a critical position that the impedance must be reduced to one per cent. of the value of the resistance. That is, the impedance is to be reduced to .01 ohm. Let the frequency at which it is to work be 550,000 cycles. Substituting in the formular given above we find that 10,000 equals $1+C^2W^2$. Since unity is negligible in comparison with 10,000 we may put 100 equals Cw. We know that w is equal to 6.28 times 550,000. Hence C must be equal to 23.4 microfarads.

A condenser of this size is never used in the radio frequency amplifier. Indeed, it is rarely used in audio frequency amplifiers or current supply filters, If there is a resistance of one ohm in the radio frequency amplifier that needs bypassing, a common size of condenser is .001 mfd. Just how much does this reduce the impedance at 550 kc? Substitution in the formula shows that the impedance is reduced from one ohm to .999994 ohm, which is only six parts in a million.

Reduction Greater at 1500 kc

The reduction in the impedance is a little greater at 1,500 kc. Indeed, it is reduced by 45 parts in one million. Hence it is obvious that a condenser of .001 microfarad does little good when connected across a resistance of one ohm. This fact may explain why bypass condensers sometimes fail to suppress oscillation in radio frequency amplifiers.

Now let us see how effective bypass condensers are when they are connected across 1,000 ohms, first at 550 kc and then at 1,500 kc. We substitute in the same formula, using 1,000 ohms.

The impedance of the parallel combination of 1,000 ohms and a .001 mfd. condenser is 277 ohms at 550 kc and 106 at 1,500 kc. The reduction is substantial. Now if there is a one ohm grid bias resistor which must be bypassed to prevent oscillation it is quite feasible to connect a 1,000 ohm resistor in series with it so as to make the .001 mfd. condenser more effective and yet not alter the grid bias. How this can be done is shown in Fig. 1B. R1 is the low value resistance to be bypassed and R2 is the high value resistance which is used to make C relatively more effective.

The value of R2 is not limited to 1,000 ohms. It could well be 10,000 ohms.

Bypassing Across Plate

Frequently a bypass condenser of about .01 mfd. is connected across a resistor in the plate circuit of a radio frequency amplifier. Just how effective is it? The resistance to be bypassed may be 1,000 ohms. The question is to determine how the impedance of the parallel combination of 1,000 ohms .01 mfd. Let us consider 550 kc. since the reduction in the impedance at that frequency will be the least in the broadcast band.

Substituting in the formula we find that the impedance is 289 ohms. That is a substantial reduction.

The reduction is approximately the same for the same condenser and at the same frequency when the condenser is connected from the screen grid to the filament, because the resistance to be bypassed is of the same order of magnitude.

Obviously it is better to use much larger condensers even at radio frequency when resistances of 1,000 ohms or less are to be bypassed when the resistances are in critical positions. Hence the condensers C1 and C2 in Fig. 2A should be no smaller than .01 mfd. and it would be preferable if they were as large as 1 mfd. When a resistor or a radio frequency choke coil is connected in series with the screen grid or plate lead the condensers may be smaller.

Bypassing at Audio Frequency

Condensers of 2 mfd. are often used for bypassing at audio frequencies. Just how effective is such a condenser when connected across a one ohm grid bias resistor at a frequency of 50 cycles? It reduces the impedance by two parts in ten million. In other words, it serves no purpose. Even at 5,000 cycles it reduces the impedance by only 9 per cent. Hence if there is a one ohm grid bias resistor in a circuit there is no object of putting a 2 mfd. condenser across it unless there is a much larger resistor in series with the condenser which is not a part of the grid bias resistor.

But a grid bias resistor is often 1,000 ohms or more. How effective is the 2 mfd. condenser in reducing the impedance at 50 and 5,000 cycles? At 50 cycles the reduction is about 18 per cent., and at 5,000 the impedance is only 159 ohms instead of 1,000 ohms.

Condenser C2 in Fig. 2B may be assumed to be across 1,000 ohms, therefore the conclusions apply as determined with respect to the grid bias resistor just discussed. They do not apply, however, if a resistor be connected in the plate lead to B plus. Suppose we insert a 10,000 ohm resistor in series with this lead. The total resistance now is 11,000 ohms and C2 will be relatively more effective. At 50 cycles the total impedance is 4,583 ohms, a substantial reduction at this frequency.

Apparent Discrepancy

Now some one may ask the purpose of adding a 10,000 ohm resistor when that increases the actual impedance a 50 cycles from 847 ohms to 4,583 ohms. The object of the condenser in the first place is to prevent signal current from flowing into the plate voltage supply, assumed in the above to be 1,000 ohms. The added 10,000 ohm resistor aids greatly in preventing the current from reaching the 1,000 ohm resistor and forces it through the condenser. It is the relative reduction in the impedance that counts.

A bypass condenser across the primary of an audio transformer such as C1 in Fig. 2B must be small when considered from the view point of audio frequencies and large when considered from the view point of radio frequency. Let the value of C1 be .0005 mfd. At 550 kc the reactance is 578 ohms. This is negligible in comparison with the plate resistance of the tube, which may be of the order of 20,000 ohms. Hence this condenser is satisfactory.

The inductance of the primary of the transformer may be assumed to be 100 henries, so that its reactance at 10,000 cycles is 6.28 million ohms. The reactance of C1 at 10,000 cycles is 31,800 ohms. Hence the reactance of the condenser is only 1/200 of the reactance of the primary. Hence the condenser will act as a short circuit and the amplification on the 10,000 cycle frequency will be very low. If a smaller condenser is used the detection will not be so good. The .0005 mfd. condenser is a fair compromise between detection and audio suppression at the high frequencies.

Consider now the bypass condenser C1 in Fig. 3. Assume that the effective plate load resistance is 100,000 ohms. Let C1 be .0005 mfd. At 10,000 cycles the reactance, as before, is 31,800 ohms, or about one-third of the value of the resistance. There is much reduction in the amplification due to the condenser, and therefore the capacity must be kept small. Again about .0005 mfd. is a good compromise.

Common Bypass

There are many instances in which condensers are distributed in the receiver when they are actually connected in parallel. There is no good reason for this practice. For example, suppose there is an audio amplifier having three tubes, all of which have the same plate voltage. There are then three apparent places where condensers may be connected to advantage. Then if the detector is also connected to the same voltage source there is another place where a condenser may be put. Actually the four condensers are in parallel and a single condenser could be used just as well. A single condenser of the same capacity as the sum of the capacities of the four separate condensers would not cost so much as the four smaller condensers, and it would not take up so much room. It would be much easier to put into the circuit, with less chance of making a mistake. And the single condenser would perform the same function as the four.

[In some instances in push-pull circuits the bypass condenser across a biasing resistor is not only unnecessary, but injurious, as will be explained in an article next week, issue of June 29th.]

A Fistful in Each 2

Why This Valve Has Become of Its Use As Amp the Space Charge

By Capt. Peter

Contributing

THE AC screen grid tube is destined to be the most popular of all radio frequency amplifier tubes, because it has more favorable characteristics than any other tube. Also it will be used as a detector in many future receivers, as well as audio frequency amplifier.

The technique for this tube as a radio frequency amplifier has been worked out sufficiently, so that already many receivers now on the market embody this tube. The use of the tube as a detector is now being discussed both from theoretical and practical viewpoints. The use of the tube as an audio amplifier is merely being suggested as possibly desirable.

Why is this tube becoming the most popular tube with such rapidity? Because it has a greater amplification constant than any other tube that has been offered the public, because it has a higher mutual conductance than any other high mu tube, because it is operated with alternating current on the heater, because it has a very low grid-to-plate capacity.

The heater voltage is 2.5 volts, either AC or DC, the heater current 1.75 amperes. Thus the tube has the same heater characteristics as the 227 type tube, and can be connected to the same transformer winding as these tubes.

Voltages Needed

It requires a plate voltage not in excess of 180 volts and a screen voltage of 75 at this plate voltage. Lower voltage may be used provided that the screen and plate voltages are reduced in proportion. The plate current is about 4 milliamperes and the screen current one-third as much. These values are for normal values of heater, plate, screen and grid potentials, and for no external load.

The required grid bias on the control grid with 180 volts on the plate and 75 volts on the screen is 1.5 volts. The amplification constant of the tube is 420. It is clear that the signal voltage cannot swing 1.5 volts in either direction without distortion. If it did the amplitude of the signal voltage in the plate circuit would be 630 volts, and there are only 180 volts DC in the plate circuit.

The mutual conductance of the tube itself is 1,050 micromhos which compares with 350 for the DC screen grid tube. The plate resistance is only 400,000 ohms, which compares with 850,000 ohms for the DC tube. The mutual conductance in any tube is the quotient of the amplification constant by the resistance.

Suppose the load resistance of the AC screen grid tube is 500,000 ohms. The total resistance in the plate circuit is then 900,000 ohms, and the amplification is 5/9 of 420, or 233. If the tube is used in an audio frequency amplifier preceding a 245 type tube requiring a maximum input of 50 volts a voltage of only 50/233 volt is needed to load up the power tube. That is, it is only necessary to impress .214 volt on the control grid of

# of Power 24 Tube

he Most Popular— Discussion lifier or Detector, Method Included

V. O'Rourke
Editor

the screen grid tube. It appears, then, that one of the things the tube will do is to eliminate tubes from the amplifier.

On of the main advantages of the screen grid tube is that it has a very low plate-to-grid capacity. In the AC tube this capacity is only .01 mmfd. At a frequency of 10,000 cycles this has an impedance of 1.59 billion ohms, compared with the load resistance of 500,000 ohms. Thus there will be no appreciable suppression of the high frequency audio notes. In the three-element tube one of the limitations is the suppression of high notes due to the plate-to-grid capacity.

Stable RF Amplification

The small grid-to-plate capacity also permits the tube to be used efficiently at high radio frequencies without oscillation. Indeed, the tube was especially designed for this purpose. It is quite feasible to design a radio frequency amplifier with this tube at a step-up of 50 per stage without the use of any neutralization. The only precaution that must be taken is to shield the stages so that there will be no feedback by external coupling, electric or magnetic. The fact that the step-up is so high requires more thorough shielding than in a circuit using ordinary tubes.

The plate-to-cathode and grid-to-cathode capacities are also smaller in the AC screen grid tube than in the DC, and this fact adds further to the efficiency of the tube at high radio frequencies. The grid-to-cathode capacity is only 5 mmfd. and the plate-to-cathode capacity is only 12 mmfd. These compare with 6 and 15, respectively, for the DC tube.

Operation from Common Transformer

One of the advantages of the AC screen grid tube is that it has the same filament voltage as the 227 and 245 type tubes. Thus it is practical to use a single transformer winding for all the tubes in an AC receiver. This materially simplifies the construction. Of course, it is not practical to use a low-power 2.5 volt winding to supply the heaters. The current required by each tube of the heater type is 1.75 amperes. Many transformers now on the market will not carry much more than this. Hence if two or more tubes are put on the winding the transformer will heat up dangerously and the voltage on each tube will not be the rated 2.5. It is necessary to use a transformer which has been designed to carry a very heavy current. For example, if there are 5 heater tubes in the circuit, the total current will be 8.75 amperes. Certainly the transformer should be designed to carry at least 9 amperes in this case.

There is only one fact that makes it inadvisable to use the same heating winding for an AC screen grid tube as for a tube of the 245 type. If the power tube is given a bias, by means of the usual voltage drop in a resistor, of 50 volts, there will be a positive voltage of this amount on the heater with respect to the cathode on the heater type tubes. The AC screen grid tube's heater requires a negative voltage of 9 volts or less. Any higher voltage, whether positive or negative, endangers the tube. This does not apply to the case where the bias on the power tube is obtained with a battery or battery substitute not depending on a drop in the plate circuit of the power tube.

Even if all the heater type tubes are put on one winding and the power tube on another, there is considerable simplification of the transformer. It is better to have only two filament windings than four.

Space Charge Tube

The AC screen grid tube, like the DC tube, can be used in the space charge connection. When this is done the screen grid becomes the control grid and the inner grid (cap) is given a positive voltage.

In the space charge connection the tube immediately loses some of its valuable characteristics. The capacity between the plate and the screen grid, now the control grid, is high, the amplification factor is greatly reduced, and it is no longer self-neutralizing. But the mutual conductance remains high because the internal resistance is low. The object of giving the inner grid a positive voltage is to accelerate the electrons from the cathode and thus to overcome retarding effect of the space charge, or the electrons distributed in the space between the cathode and the plate. It is this acceleration which reduces the internal resistance.

The space charge connection can be used in detector circuits and in audio frequency amplifiers where suppression of the highest audio notes is relatively immaterial.

When this connection is used it is best to employ resistance or impedance coupling.

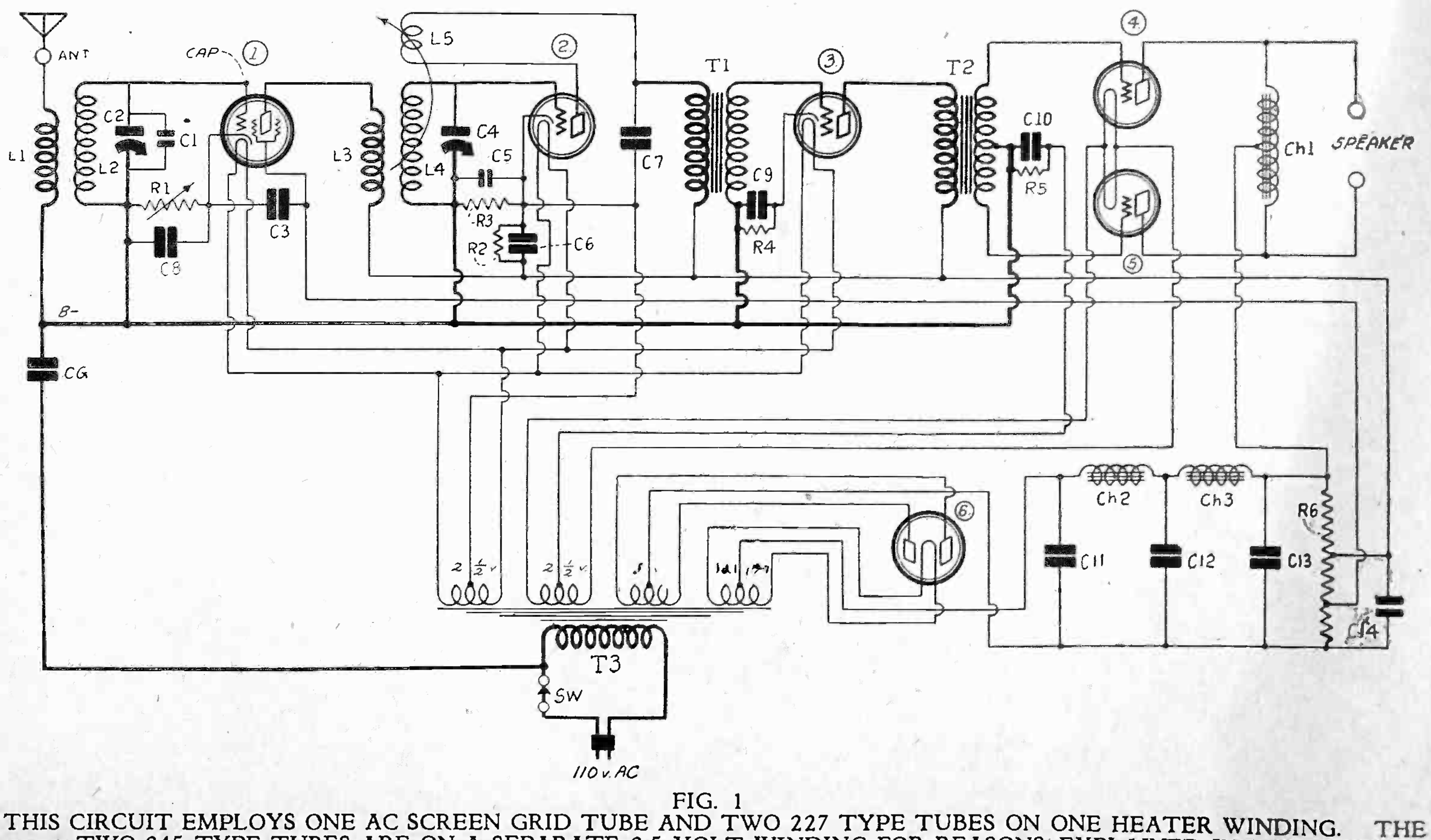


FIG. 1
THIS CIRCUIT EMPLOYS ONE AC SCREEN GRID TUBE AND TWO 227 TYPE TUBES ON ONE HEATER WINDING. THE TWO 245 TYPE TUBES ARE ON A SEPARATE 2.5 VOLT WINDING FOR REASONS EXPLAINED IN THE TEXT.

Space Charge or Not

Screen Grid Experiments Invited—Simple Audio

By Herman Bernard

Managing Editor

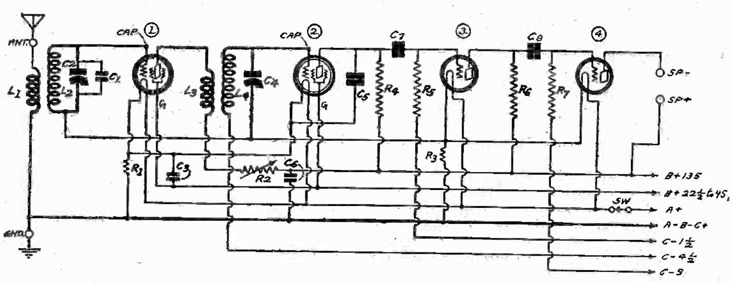
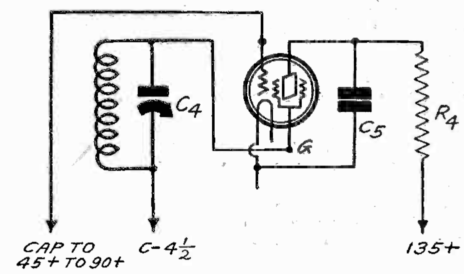


FIG. 1

TWO SCREEN GRID TUBES ARRANGED IN A TUNER THAT FEEDS AN AUDIO AMPLIFIER WELL ABLE TO REPRODUCE SPEAKER VOLUME. THE DETECTOR IS A SCREEN GRID OF NEGATIVE BIAS TYPE.

FIG. 2

SPACE CHARGE DETECTOR. FOR THIS HOOKUP INCREASE THE CAP VOLTAGE TO 67 OR 90. BY THE OTHER METHOD THE G POST GETS A POSITIVE VOLTAGE INSTEAD BUT OF A LOWER ORDER.



THE use of the screen grid tube has not been fully explored. This applies even to the 222 battery model, which soon will have been on the market two years, and, of course, to the recently introduced 224 AC type. The two models are similar in use and performance, but by no means identical. Some may take the viewpoint they are dissimilar, although related. Either way, they are different. It depends on how much importance you assign to the difference. Certainly even the standard voltages do not agree:

Type	Plate Volts	S. G. Volts	Bias Volts
222	135	45	—1.5
224	180	75	—1.5

Even the grid biases do not agree. The same bias prevails for a 33 1-3% difference in plate voltage.

On the operational side there is a difference, too. The screen grid tube of either type may be used (a) as a screen grid tube, as shown in Fig. 1, or (b) as a space charge tube, as shown in Fig. 2. The screen grid method, with cap to the tuned circuit, is the only one desirable for radio frequency and amplification. The space charge method lends itself to detection or audio amplification, where a resistor or an impedance coil is on the plate circuit. As a space charge detector the tube functions well as a grid bias detector. In audio circuits the problem of stability arises when the tube is used as a space charge grid tube.

Chance to Experiment

Fig. 1 lends itself to experimentation. The two screen grid tubes are of the battery-operated type, 222, both used in screen grid fashion. L1L2 is an antenna coupler, of standard design. L3L4 is special, in that the primary L3 has about twice as many turns as would be used for general purpose tubes. On a 2½" diameter tubing L1L2 would consist of 12 and 48 turns, L2L3 of 24 and 48 turns, both on .0005 mfd. The wire is No. 24 insulated.

Note how the negative bias is obtained. Tube 1 gets 1.7 volts, because the grid return is made to negative filament of a 5-volt tube fed from a 6-volt battery, while the 222 filament gets 3.3 volts. Negative filament of the first 222 tube is —2.7 in respect to the A battery minus (6—3.3). The negative filament of the 5-volt tubes is 1 volt negative in respect to A battery minus. As —2.7 was measured from A minus, if it is measured from F— of a 5-vole tube the difference is 1 volt less, or 1.7. This measurement is correct when the grid return is made as shown.

Rotor Connection Common

The rotor of the tuning condenser C4 goes to the same point as the rotor of C2 and the end of L2. But the detector grid coil L4 goes to C—4½, for grid bias detection, which takes place when 135 volts are applied to a .5 to 1 meg. resistor R4.

The audio amplification is enough to operate a speaker if a high mu tube, 240, is used in socket 3, with R6 a .25 to .5 meg. resistor. R7 has to be small to prevent audio gurgling. About .5 meg will work well, or a little lower resistance value may be used.

Both G posts of sockets holding screen grid tubes in Fig. 1 are shown connected to B+22½. This is to prevent self-oscillation at radio frequencies. However, the lead may be lifted to +45 on the batteries as an experiment, especially as the volume control (25,000 ohm Clarostat) is an oscillation stifler.

Compare results obtained this way with those obtained when the space charge method is used, as in Fig. 2. Louder signals, but not purer ones, may result when the space charge tube's grid return is to A—, rather than to C—4½, but the extra bias is fully justified.

Pointers on Parts

The last tube is a 112A, with 9 volts negative bias, and requires no output filter for any speaker whatsoever.

Constants not previously stated are: C1, a midget condenser, adjusted once and left thus; R1, 10 ohms; R3, a 112 amperite or 2 ohms; R5, 5 to 8 meg.; C7, C8, .02 mfd.; C6, as large as you have; C5, .0005 mfd.

The circuit should be built with tube 1 at left, tube 4 next, tube 3 next, tube 2 at right, all in line. A 7x17" subpanel is large enough. The coils are near the front panel, extreme left and right. A double condenser (two sections, each .0005 mfd.) may be used, with flat type dial, by this method of layout. A Hammarlund MLD 23 is suggested. If factory-made coils are desired use Screen Grid Coil Company's RF5 for L1L2 and R5 for L3L4. For .00035 mfd. these coils are RF3 and R.3.

Experimental Suggestions

In using the tube as a grid bias detector in screen grid fashion microphone effects will be present, but when the space charge grid method is used these are absent. To cure microphonism put a metal shield over the tube, the type of shield that simulates the shape of the tube and fits over the socket. The box type stage shield is not meant.

The space charge grid develops higher grid-to-filament capacity and requires readjustment of the equalizing condenser, by use of more capacity. This detail must be attended to in switching from screen grid to space grid detection. If the change-over is made in the other direction of course less equalizing capacity is needed.

When the space grid method is used the detector plate bypass condenser may be omitted, as the capacity in the plate circuit is automatically enlarged.

The leak-condenser method of detection is not shown, but may be tried. The grid condenser should be about .0001 mfd., or less than half the capacity otherwise used. The leak value should be more than .5 meg. The higher the value of the louder signals, up to overload. The grid return (coil connection only) would go to A+ when the leak condenser method is tried. It is to be expected that the grid bias method will prove more satisfactory under actual circuit conditions, although a dissociated tube under test might seem to provide good detection by the leak-condenser method. The operating circuit changes this situation.

Good Audio Channel

Excellent tone at moderate volume is reproducable by the audio amplifier in Fig. 1, although the detector output is indeed modest, due to the tuner. But locals will be plenty loud enough. If a more sensitive tuner is used, say two or more stages of tuned radio frequency amplification, all signals will be louder, and the fine quality of which the audio amplifier is capable will not be invalidated.

The audio amplifier will not motorboat on B batteries, nor on a well-filtered B supply. What seems to be motorboating, if any disturbance arises, will prove to be RF oscillation. R2 will control that.

Condenser Speakers

Have Preponderance of Good Points

By James H. Carroll

Contributing Editor

THE outstanding radio developments during the 1929 season are the application of the heater type tube, the placing of the AC screen grid and the 245 power tubes on the market, the perfection of the inductor-dynamic speaker, and the announcement of the condenser type speaker. Push-pull audio amplification and power detection have also been emphasized during the season.

The trend seems to be in the direction of eliminating all but the heater type tubes, except in the power stage and toward a wider use of push-pull amplification. Most of the receivers announced for the coming season have this form of amplification.

In most instances the receivers of the 1930 season will be sold with the loudspeaker built in, so that the complete radio installation will be in compact and convenient form. The dynamic speaker leads at the present time, but there is no doubt that the new inductor-dynamic will figure prominently in the near future, because it has certain inherent advantages which lend simplicity to the receiver assembly.

The Electro-static Speaker

The so-called electro-static speaker has been announced, and the public is keenly interested in its possibilities

But since the electro-static, or more logically, the condenser type speaker has been announced, occasionally an individual is found who has heard one in operation. He reports splendid results, irreproachable quality. Such reports keep the interest alive and may induce many to tolerate their present loudspeaker a while longer until they will be able to procure one of the condenser speakers. Some suspicious individual has suggested that those rare persons who go around reporting having heard a condenser speaker in operation are the emissaries of the manufacturers, and that the sole object of their enthusiasm is in the direction of sales.

The idea of a condenser speaker is not new. It is much older than radio as we know it. The principle upon which it works is as old as electricity. Indeed, it was one of the first things worked out when knowledge of electricity was as new as radio is today. Yet there has been no commercial application of it until the present. But that is not against the speaker, for the dynamic was known for at least thirty years before it came to be applied commercially. When that came, it came with a rush. It may be the same with the condenser speaker. If it has all the virtues that are claimed for it, there is no doubt about the rush.

F. K. Vreeland is credited with a patent on a condenser speaker as far back as 1907, the year of the birth of the three-element vacuum tube, and it is said that a successful model of it has been perfected recently. Working models of condenser speakers have also been made in Germany by Hans Vogt and others. Condenser headphones made in Germany have been in this country for several years and are capable of unexcelled quality as long as they stand up, which is not long. They deteriorate rapidly whether or not in use.

Deterioration a Problem

It is this difficulty of deterioration which has held up progress of condenser loudspeaker development. It may be that this explains why we had nothing until now in this or any other country. As soon as this problem has been solved satisfactorily we shall be able to use condenser speakers, and we may have something exceptionally good to listen to.

There is no doubt of the possibilities of the condenser speaker. It works essentially on the same principle as the condenser microphone, and there does not exist a practical microphone which is superior to this. But the microphone is not subject to deterioration to the same extent as the speaker. This is because in the microphone the dielectric between the two plates of the condenser is air while in the loudseaker it is an elastic membrane, usually rubber. It is the rubber which deteriorates with time. The condenser speaker will be practical as soon as somebody discovers a substitute for the rubber membrane which will hold up. There is a great fortune in that discovery.

The condenser speaker is particularly effective on the bass frequencies, one reason for which is that it has a relatively large radiating surface. Another advantage is that it has a comparatively high impedance and so can be used in conjunction with tubes having a high output impedance. It will not require any step-down output transformer. Since high impedance tubes can be used, the power to operate the speaker can be made up of low current and high voltage, rather than high current and low voltage. This fact will make filtering of the plate voltage supply a simpler matter.

But the condenser speaker has disadvantages too. It is not so effective on the high audio notes. This is not because it is a poor sound radiator on the high frequencies. It is as good in this respect as any other radiating surface of the same size. The loss of the high notes results from the capacity of the condenser, an unavoidable feature if the speaker is to be made large enough to radiate the bass, as well as sensitive enough to radiate much power on any frequency.

Since the size of the radiating surface determines the effectiveness at the bass frequencies as well as the capacity which reduces the response at the high, it is possible to proportion the radiating surface so that the response will be good at both the high and the low frequencies. Any lack of bass can be compensated for by using a baffle board. The baffle will aid in the radiation of the bass but it will not increase the capacity which cuts down the high notes. Indeed, the baffle will help the radiation of sound on the high frequencies too.

It is well known that dynamic speakers require an external power source for polarizing the field. This has always been used by magnetic speaker proponents as an argument against dynamics. In a sense it is a disadvantage, but this is more than offset by the results.

In the condenser speaker, too, a polarizing potential is needed. No current is required, however, only potential. And the DC voltage needed is rather high, from 600 volts upward. Many objections are raised against this. It is inconvenient to provide an extra source of potential. The voltage is so high that it may be dangerous. And extra expensive equipment is needed.

Potential Not Dangerous

These objections have no weight when balanced against superior performance. In the first place it is no more inconvenient to supply the required voltage than to use the speaker itself. The voltage supply readily can be built into the speaker assembly, and it will take very little room. As to the danger, there is none. Suppose the voltage is 1,000 volts. If this were a battery, or a generator, it would be dangerous to life. If it were an eliminator such as is used for power amplifiers, it might result in an unpleasant shock. But for a condenser speaker neither of these sources is required. The high voltage supply can be designed so that no appreciable power can be taken from it. And then it would be quite harmless. Possibly a shock from the device would not feel pleasant but it would not be more than a severe tickle.

Battery eliminators are already available for supplying the potential to condenser speakers, when and if promises are substantiated. One of these is a compact little device employing a single 201A tube for rectification. High and low voltage windings, as well as chokes and condensers, are built in, and the whole device can be held in one hand.

There are two types of condenser speaker, unilateral and bilateral. The unilateral has two plates, one fixed and one movable. The signal and the polarizing voltages are impressed between these two plates. As the signal voltage varies, the movable plate vibrates just as any other loudspeaker diaphragm or piston.

The bilateral type of speaker contains two fixed plates and one movable, the movable plate being placed midway between the two fixed plates. The polarizing voltage is impressed between the center plate and the two fixed plates. That is, the center plate is made positive and the two fixed plates negative, potential difference between the center plate and the fixed plates being the same. The signal voltage is impressed between the center and the fixed plates simultaneously in such manner that when the total effective voltage between one pair is increased by a certain amount it is decreased by the same amount between the other two. That is, the bilateral type speaker is a push-pull speaker. The moving plate in the center is held in an unstrained position when no signal is impressed, or in a balanced position. The signal voltage upsets the balanced in proportion to the strength of the signal.

The effect of the push-pull arrangement is to make the speaker more sensitive and free from distortion.

POWER AMPLIFIERS

By J. E. Anderson and Herman Bernard

[A notable series of expository articles on power amplifiers, by J. E. Anderson and Herman Bernard, was begun in the June 1st issue, in which the components of battery, DC and AC power amplifiers were analyzed, and illustrated with fifteen diagrams. Types of audio couplers were also described and compared. In the June 8th issue loudspeaker coupling devices and battery-operated amplifiers were explained. A special analysis of resistance-coupled audio was included. There were nine illustrations. Last week, in the June 15th issue, the exposition was carried forward to the DC supply of A, B and C voltages, e.g., for operation from 110-volts DC obtained from the convenience outlet. Ohm's law was explained in conjunction with the design of a DC supply. Then the part was begun that treats of AC fully, with rectifier and filter analysis exceptionally well set forth. The AC topic is continued this week. In the June 25th issue next week will be another fine instalment of this notable series. The articles will continue from week to week. Follow them closely.—Editor.]

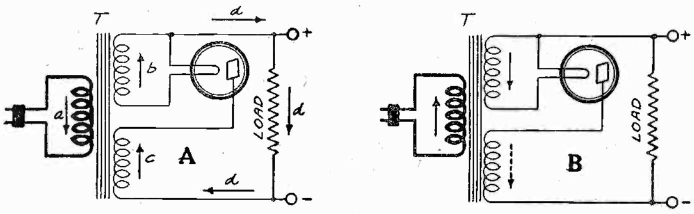


FIG. 16
(A)—CIRCUIT OF A HALF-WAVE, VACUUM TUBE TYPE RECTIFIER DURING THE ACTIVE HALF-CYCLE.
(B)—THE SAME CIRCUIT AS IN A DURING THE INACTIVE HALF-CYCLE.

Suppose the current in the primary flows in the direction indicated by the arrow (a) in Fig. 16A. There will then be a current in the filament circuit in the direction indicated by the arrow (b). There will also be a voltage induced in the high voltage winding in the direction indicated by the arrow (c). But will there be a current? The direction of the voltage is such that the plate is positive with respect to the filament. Hence electrons will be attracted from the hot filament to the plate. This is equivalent to an electric current from the plate to the filament, and there will be a current through the external circuit as indicated by the arrows (d).

While the plate is positive with respect to the filament, the direction of the current is such that the filament end of the load resistance is positive and the plate end of the load is negative.

The primary current will flow as indicated by arrow (a) for only half cycle, which for 60-cycle current has a duration of 1/120th part of a second. The current will rise and fall as indicated by the first loop in Fig. 17.

At the end of the first half-cycle the current will reverse in the primary as well as in the heater winding, as indicated by the arrows in Fig. 16B. The voltage in the plate winding will also reverse and act in the direction indicated by the dotted arrow. Now the plate of the tube is negative with respect to the filament, and therefore no electrons are attracted from the filament to the plate. Indeed, they are driven back to the filament. Hence there will be no current through the external circuit, or through the load. The arrow representing the voltage has been dotted to show that the voltage produces no current, and the second loop in Fig. 17 also has been dotted to indicate the absence of current.

During the third half-cycle all the events of the first half-cycle are repeated, and therefore the loop in Fig. 17 representing the current in this phase has been drawn in a solid line. The process is continued as long as there is an alternating current in the primary of the transformer, current pulses being produced in one direction only with total absence of current half of the time.

It is the function of the filter to smooth out the pulsations into a steady, direct current. The condensers in the filter store up part of the electricity from the pulses, and they discharge this electricity during the half-cycles when the tube does not supply any. The choke coils in the filter maintain a steady flow, part time taking the current from the tube and

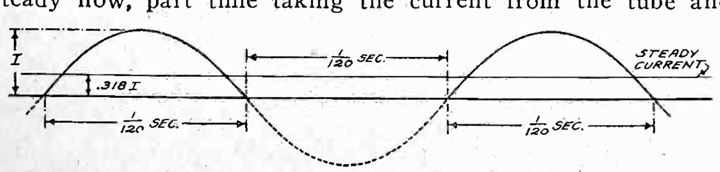


FIG. 17
APPROXIMATE FORM OF THE RECTIFIED CURRENT BEFORE FILTERING AS PRODUCED BY A HALF-WAVE RECTIFIER. THE DOTTED LOOP INDICATES NO CURRENT.

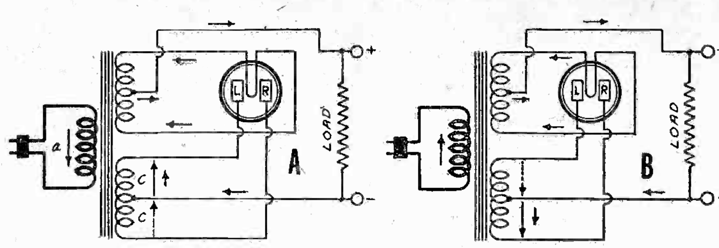


FIG. 18
(A)—CIRCUIT OF A FULL-WAVE RECTIFIER SHOWING THE DIRECTION OF CURRENT AND VOLTAGES DURING THE HALF-CYCLE WHEN THE PLATE L IS ACTIVE.
(B)—THE SAME CIRCUIT DURING THE HALF-CYCLE WHEN PLATE R IS ACTIVE.

part time from the condensers. The property of the coil is to resist changes in the current, increases as well as decreases. The value of the steady current is the mean value of the current during a complete cycle, or .318 of the peak value of the current.

The current output of a rectifier and filter is steady only if the filtering is very good. If the filtering is not adequate there will be ripples in the current. In a half-wave-rectifier the frequency of the main ripple will be the same as the frequency of the supply current, but there will also be ripples at harmonic frequencies, that is, two, three, four, and so on, times the frequency of the supply. But these will be very small.

The effectiveness of the filter in removing the ripple depends on the capacity of the condensers and the inductance of the chokes. The larger they are the less ripple will remain in the output. Also, the more condensers and more chokes used, the steadier will the output current be. Again, the smaller the current that is drawn from the rectifier-filter, the less ripple for any given filter and type of rectification.

During the half-cycle in which no current flows the voltage rises to a higher value than during the half-cycle in which current does flow, and since the average value of the current is only .318 of the maximum, a higher input voltage is required in order to get the required value of steady current. Therefore the filter condensers used must be designed to withstand comparatively high voltages.

Full-Wave Rectifier

A more satisfactory rectifier is one in which current flows every half-cycle. This type is known as full-wave rectifier and is shown in Figs. 18A and 18B, and the corresponding rectified current curve is shown in Fig. 19. It will be observed that the full-wave rectifier is essentially the same as the half-wave rectifier, except that the tube has two equal plates and the high voltage winding is center-tapped.

Consider the half-cycle during which the primary current flows in the direction indicated by arrow (a) in Fig. 18A. The high voltage is then in the direction indicated by the long arrows (c). This voltage makes plate L positive, and plate R negative, with respect to the filament. Therefore current flows between plate L and the filament, and the direction of this current in the external circuit is indicated by the short arrows. The portion of the circuit containing plate L is active because current flows. The portion containing plate R is inactive for no current is produced by the voltage, indicated by the dotted arrow.

The active portion of this circuit corresponds with Fig. 16A and the inactive portion corresponds with Fig. 16B.

When the current in the primary of the transformer reverses, the current flows as indicated in Fig. 18B. The portion of the circuit containing plate L is now inactive while that containing plate R is active. The important thing to note is that the current in the external circuit flows in the same direction in both instances. Therefore there will be no time during which the rectifier as a whole is inactive, but current will flow every half-cycle.

The filament current has not been indicated in A or B in Fig. 18, because the current is equally effective in heating the filament whether it is flowing in one direction or the other.

In Figs. 18A and 18B the positive terminal has been connected to the center of the filament heating transformer, whereas in Figs. 16A and 16B it has been connected to one side. It makes practically no difference whether the connection is made to the center or one side in either the full-wave or half-wave rectifier.

Fig. 19 shows the current pulses contributed by the two sides of the full-wave rectifier. The loops are marked L and R according to which plate contributes them.

The filtered current from the full-wave rectifier is the mean current of a half-wave rectifier multiplied by 2.

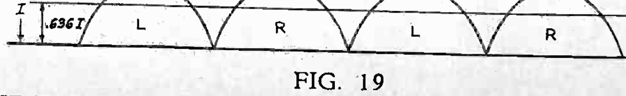


FIG. 19
THE FORM OF THE RECTIFIED CURRENT FROM A FULL-WAVE RECTIFIER BEFORE FILTERING

But it does mean that for a given current output, the maximum current in one instance is twice the maximum in the other. And from this it follows that the output from a full-wave rectifier is more easily filtered, for the fluctuations to start with are not so great. The half-wave rectifier for a given current output has the greater maximum current peaks

The frequency of the main ripple component from a full-wave rectifier is twice the frequency of the supply current. For example, if the supply is 60-cycle current, the main ripple will have a frequency of 120 cycles. There will be a ripple component at 60 cycles and other components at the higher harmonics of 60, but these will be very small compared with the 120-cycle ripple.

Not only is the output of the full-wave rectifier easier to filter than that of a half-wave rectifier because the original fluctuations are smaller, but also because the ripple frequency is higher. Condensers and chokes of given values will be just twice as effective at 120 cycles as at 60 cycles.

Taking into consideration that the ripple frequency is twice as great in the full-wave rectifier as in the half-wave, and that the original fluctuations are only half as great, it would seem, other conditions being equal, that the output of the full-wave rectifier is four times more easily filtered than the output of the half-wave rectifier. And so it is.

Another advantage of the full-wave rectifier is that its voltage regulation is better. That is, the output voltage does not fluctuate so much when the amount of current drawn from it is changed. There are two reasons for this. First the rectifier tube has a lower resistance because it is conductive during both half-cycles, and second, because the filter chokes need not be so large and therefore have less resistance.

The Gaseous Type Rectifier

A typical circuit of a full-wave gaseous type rectifier is given in Fig. 20. The current to be rectified is supplied by a voltage step-up transformer T, the secondary of which is center-tapped. There are two rectifying elements inside the tube composed of the central plate A and the two points K. Current can flow only from the points K to the plate A and not in the opposite direction. Hence the plate A is the anode, or positive terminal, and the Ks take turns being the cathode, or negative terminal.

The functioning of this tube is similar to that of the filament type rectifier. Consider the half-cycle during which the primary current flows in the direction indicated by arrow (a). The secondary voltage is then in the direction of the long arrows placed near the center-tapped winding. Current then flows around the current as indicated by the short arrows, because it can flow only from K to A.

When the primary current reverses, the upper half of the center-tapped winding becomes active, but the current in the external circuit does not change direction. Therefore the rectified output current has the form indicated in Fig. 19. Condensers C, C across the two halves of the high voltage winding are called buffer condensers and they serve to improve the rectification characteristic of the tube. The value of each is usually .02 mfd. to .1 mfd.

Filtering Rectified Output

Since the output current of every type of rectifier contains considerable ripple, it is necessary to employ filters to remove the fluctuations and to make the current truly steady and continuous.

The simplest filter, shown in Fig. 21A, consists of a single condenser C across the output of the rectifier and across the load. If the condenser has a large capacity, and if the load resistance is high, this type of filter takes out a large proportion of the ripple. The output current from a full-wave rectifier may be represented by a curve such as that in Fig. 21B. Io represents the mean value of the partly filtered current, and I represents the amplitude of the ripple. The frequency of the ripple is twice the frequency of the current supplied to the rectified by the step-up transformer.

More thorough filtering can be effected by inserting a high inductance choke coil L in series with the line, as shown in Fig. 22A. This coil tends to keep the current steady, opposing both increases and decreases. But if the coil works into a high resistance it is not effective, and therefore it is desirable to connect another condenser C2 across the load resistance. The coil then works into the comparatively low impedance of the condenser C2, rather than into the high resistance of the load.

The greater the inductance of L the more complete is the filtering. The effective inductance is not that of the coil when no direct current is flowing, but that when the mean output current is flowing in the coil. This is considerably less inductance, for the larger the current the lower the inductance. The filtering is also more thorough the larger condenser C2 is. The wavy curve in Fig. 22B represents the form of the output current after it has passed by the filter comprising the two condensers C and C2 and through the choke L. Io as before, represents the mean value of the current and I represents the amplitude of the residual ripple. The amplitude of this ripple has been exaggerated to emphasize it. Actually the amplitude may not be greater than one per cent. of the mean current.

Although the ripple is as small as one per cent. of the steady current, it is too large for use on an amplifier. Hence it is necessary to add another filter section consisting of a choke coil L2 and a condenser C3, Fig. 23A. If the first filter section reduced the ripple to one per cent. of the steady current, and if the second section is just like the first, the residual ripple is reduced to one per cent. of one per cent. This is so small that the current may be considered to be pure DC. The undulations in the output current are so small that the wavy curve does not appreciably deviate from the mean current curve, as shown in Fig. 23B.

When the ripple is as low as one per cent. of one per cent. the current may be used for audio frequency amplifiers without any noticeable hum resulting. It also can be used to supply a radio frequency amplifier and detector without hum, provided that there is no oscillation or excessive regeneration in the radio circuit. It is assumed that there is no oscillation or regeneration in the audio amplifier. If there is, even a very small residual hum will become noticeable. But if a circuit oscillates, or regenerates excessively, at audio frequencies, the amplifier is not satisfactory, and it becomes necessary to treat the circuit so as to stop the regeneration.

The filter given in Fig. 23A has come to be regarded as standard, and it is the one most frequently used. But there are other forms. Fig. 24, for example, shows a two-section filter in which one of the choke coils is tuned with a condenser C4. The inductance of L2 and the capacity of C4 are proportioned so that L2C4 forms a tuned circuit at the principal ripple frequency, that is, at 120 cycles in a full-wave rectifier using 60-cycle current supply.

L2 and C4 form a parallel tuned circuit at the resonant frequency, and one characteristic of such a circuit is that its impedance at the resonant frequency is extremely high. Hence if L2 and C4 are adjusted to resonate at the principal ripple frequency, say 120 cycles, the ripple is almost completely suppressed.

C4 admits the higher harmonic ripple frequencies, but these are

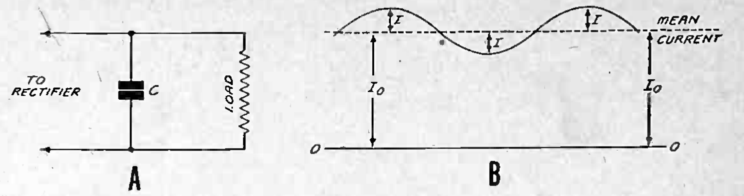


FIG. 21
(A)—SIMPLE FILTER CIRCUIT CONSISTING OF A SINGLE CONDENSER ACROSS THE OUTPUT OF THE RECTIFIER AND ACROSS THE LOAD
(B)—THE FORM OF THE FILTERED CURRENT AFTER IT HAS PASSED BY THE CONDENSER IN A. I IS THE AMPLITUDE OF THE RESIDUAL RIPPLE.

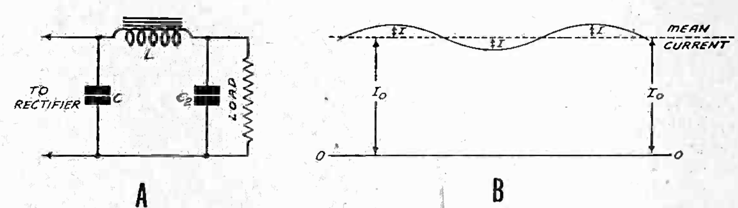


FIG. 22
(A)—SIMPLE FILTER CONSISTING OF TWO CONDENSERS C AND C2 ACROSS THE LINE AND A CHOKE COIL L IN SERIES WITH THE LINE
(B)—THE FORM OF THE FILTERED OUTPUT AFTER IT HAS PASSED BY THE TWO CONDENSERS AND THROUGH THE COIL IN A. I IS THE AMPLITUDE OF THE RESIDUAL RIPPLE.

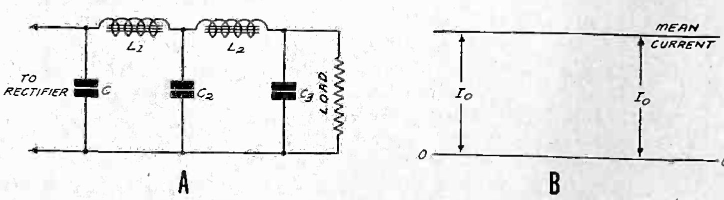


FIG. 23
(A)—A FILTER CONSISTING OF THREE CONDENSERS C, C2 AND C3 AND TWO CHOKES L1 AND L2. THIS IS A TWO-SECTION FILTER.
(B)—THE FORM OF THE FILTERED CURRENT AFTER HAVING PASSED THROUGH THE TWO-SECTION FILTER IN A. THE RESIDUAL RIPPLE IS NOW SO SMALL THAT THE ACTUAL CURRENT CURVE COINCIDES WITH THE MEAN CURRENT CURVE.

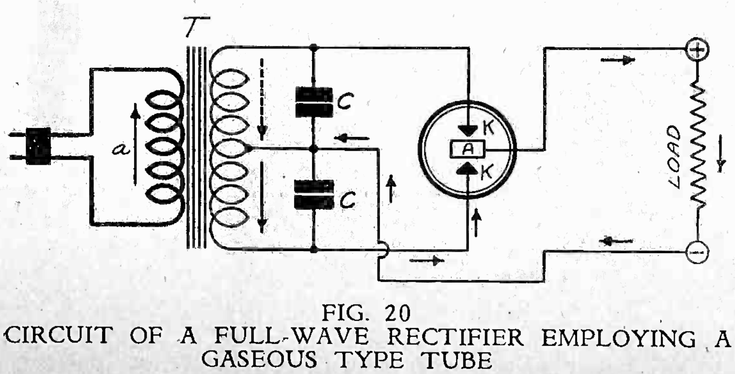


FIG. 20
CIRCUIT OF A FULL-WAVE RECTIFIER EMPLOYING A GASEOUS TYPE TUBE

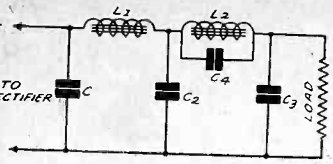


FIG. 24

A TWO-SECTION FILTER IN WHICH THE SECOND CHOKE COIL, L2, IS TUNED TO THE PRINCIPAL RIPPLE FREQUENCY BY MEANS OF CONDENSER C4. BETTER RIPPLE SUPPRESSION AND BETTER REGULATION CAN BE SECURED WITH THIS CIRCUIT THAN WITH THE CIRCUIT IN FIG. 23A

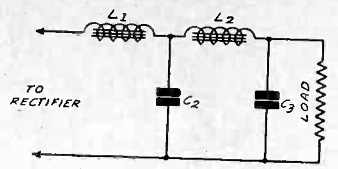


FIG. 25

A TWO-SECTION FILTER IN WHICH THE FIRST BY-PASS CONDENSER HAS BEEN OMITTED. BETTER REGULATION AND LONGER LIFE OF THE RECTIFIER TUBE ARE TWO OF THE ADVANTAGES CLAIMED FOR THIS CIRCUIT

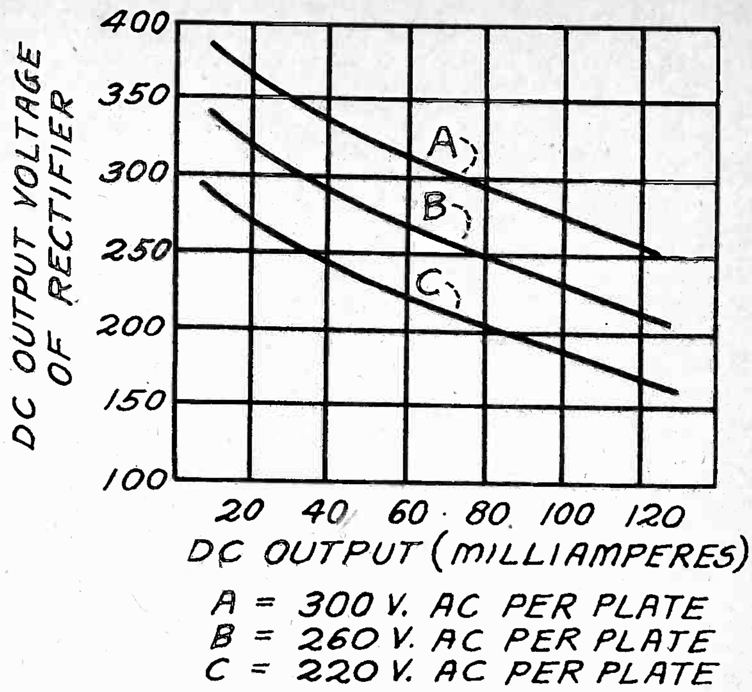


FIG. 26

TYPICAL REGULATION CURVES OF A FULL WAVE RECTIFIER-FILTER EMPLOYING 280 TYPE TUBE WORKING INTO A FILTER LIKE THAT IN FIG. 23A.

almost completely suppressed by the untuned filter section comprising C and L1, as well as by the other condensers, C2 and C3, across the line. Therefore the gain by the use of a tuned section is considerable.

There is another advantage gained by the use of a tuned filter section. Ordinarily, L2 would have to be a high inductance choke coil, which is necessarily wound with comparatively fine wire. This means that the resistance of L2 would be high, which would impair the voltage regulation of the filter. When L2 is tuned, a much lower inductance value must be used, which means that for a given size of core only a small amount of heavy wire may be used. The resistance of the coil will then be lower and the regulation of the voltage better. Indeed, if the tuned filter is to be as effective as possible in eliminating the ripple at the resonant frequency the resistance of L2 must be very low, for the lower it is the higher is the impedance of the tuned circuit at the resonant frequency.

If L2 is not tuned its inductance should be 30 henries or more. If it is tuned, and if a 1 mfd. condenser is used, the coil should have an inductance or about 1.75 henries. This coil may be made to have a very low resistance, keeping the physical dimensions the same as those for the 30 henry coil.

Another special filter is given in Fig. 25. This is essentially the same as that in Fig. 23A, except that condenser C has been omitted. The omission has been recommended by the enginers of E. T. Cunningham, Inc., as a means of protecting the filament type rectifier tube. The argument against the use of a condenser next to the rectifier tube is that it offers a very low impedance to the tube so that for every half-cycle a large current pulse is demanded of the tube for charging the condenser.

Some of the advantages claimed for the circuit without condenser C are: (a) improved regulation; (b) improved efficiency, (c) reduced emission demand on the rectifier tube; (d) reduced heating of the tube; and (e) increased life of the tube.

Advantages gained by the use of the condenser are : (a) greater output voltage with a given fixed transformer voltage and (b) better filter action.

When condenser C is omitted from the position next to the rectifier tube, it should not be omitted from the filter circuit, but should be added to the final condenser C3.

The first condenser should not be omitted in a half-wave rectifier because the charge on the condenser is needed to supply current during the half-cycle when the tube is inactive.

Any method that promises better regulation is always interesting because better uniformity of results obtain. What regulation means, and how its importance uses, constitutes an important branch of the study of power amplifiers, and we proceed to discuss it.

Suppose the power transformer supplying the rectifier is wound for an effective voltage of 300 volts. The current is rectified and sent through a given filter and a variable load. What is the rectified output voltage across the load? It is not a fixed quantity but varies with the load. The higher the load resistance, that is, the lower the rectified current that is drawn from the rectifier-filter, the higher is the voltage across the load. As the resistance of the load is decreased, that is, as the current drawn is increased, the voltage falls. The variation in the voltage across the load as the current changes is referred to as the regulation. If the output voltage varies much as the current is varied through a definite range, the regulation is poor; if the voltage varies just a little, or not at all, the regulation is good.

The output voltage may be considerably higher than the effective AC voltage across each half of the center-tapped winding in a full-wave rectifier. For no load, that is, for no output current, the voltage may be about 41 per cent. higher than the effective voltage across each half of the transformer. But when current is drawn the voltage is always lower than this. When the output terminals are short-circuited there is no output voltage at all. Hence the voltage may vary from zero to 1.41 times the effective AC voltage impressed on each plate of the full-wave rectifier.

What causes the voltage delivered to drop as the current is increased? Resistance in the rectifier and the filter. First there is the DC resistance in the high voltage windings of the transformer, then the plate to filament resistance of the rectifier tube, and finally the resistance in the filter choke coils. When current flows in the circuit there is a voltage drop in all of these resistances, and the greater the current, the greater the voltage drop. It is only the voltage drop across the load resistance which is useful. The voltages dropped in the other resistors decrease the total useful voltage. When the load is short-circuited all the voltage is dropped in the transformer, the tube and the chokes, and hence there is no output.

A regulation curve of a rectifier-filter is the relation, graphically shown, between the output voltage and the output current for a fixed value of AC input voltage. Three such curves for a 280 rectifier tube working into a filter like that in Fig. 23A are shown in Fig. 26. The ordinates give the DC voltage across the load resistance and the abscissas the current drawn from the circuit. The AC voltages associated with the three curves are effective values and equal to one-half of the total effective voltages across the center-tapped winding when no current is drawn.

If these curves were horizontal, or parallel with the current axis, the regulation would be perfect. The slope of any curve is a measure of the regulation. The greater the slope the poorer the regulation.

It is clear that the slope of any curve does not remain constant but decreases as the current drawn increases. Thus the regulation improves as the current is increased. Unfortunately, this improvement in the regulation is accompanied by a decrease in the effective filtration, an increase in the power loss, and shortening of the life of the rectifier tube.

Poor regulation of a current supply, or B battery eliminator, invariably results in distortion of the signal. When the signal is strong there is a sudden increase in the current requirements and this causes a decrease in the output voltage. The signal will not be amplified as much as it should. The distortion is largely of the wave form type, which is harmonic distortion.

Poor regulation also indicates that the current supply has a high internal resistance to direct current. It may or may not indicate a high resistance to alternating current. Usually, if the resistance is high for direct current it is also high for alternating current, especially for low frequencies.

Good filtering does not necessarily mean that the AC resistance of the current supply device is low, looking from the amplifier, but it does mean that the resistance to AC is low, looking from the rectifier. If the last condenser, C3 in Fig. 23A, is very large, the AC resistance looking from the amplifier is low. This resistance is lowered still further by the voltage divider which is associated with the load.

A low AC resistance for all frequencies looking from the amplifier is essential for good performance of the rectifier-filter. If the resistance is low some of the effects of poor regulation will be annulled. If it is high, feedback will result in the amplifier, and this will cause frequency distortion or actual oscillation at some frequency. The AC resistance of the filter-rectifier, looking from the amplifier, is a large part of the common impedance among the tubes served. The other part of the common impedance is the reactance due to the various chokes and condensers, and this reactance may be either inductive or capacitive, depending on the frequency.

The Voltage Divider

Every rectifier-filter designed to deliver current at different voltages must have a voltage divider, which usually consists of a resistor across the output, with one or more taps on it.

To design properly a voltage divider it is necessary to know the current distribution as well as the voltages desired. It is impossible to say what the value of the resistance between any two voltage taps should be if the voltage alone is known, because the voltage difference between the two points is the product of the current and the resistance. Also, it is not practical to adjust the position of the taps with the aid of a voltmeter, because the voltmeter takes current, so that the voltage will not be the same when the meter is removed as it was when the meter was in position. A voltmeter of 1,000 ohms per volt can be used to get a close approximation to the voltage, for such a meter takes only a small current, but a less sensitive voltmeter will take possibly more current than that which flows in the resistor itself. With such a meter not even a rough approximation to the correct voltage can be obtained.

A simple voltage divider is shown in Fig. 27A, which consists of two resistances R1 and R2 in series, with a tap X at the junction. If it is assumed that no curent flows into the tap the total voltage between the positive and negative sides of the line is divided in proportion to the values of the resistors, that is, the voltage between X and plus is to R1 as the voltage between minus and X is to R2. This holds because the same current flows in R1 and R2. The current *i*, flowing in the main load does not affect the division but it does affect the total voltage across R1 and R2. The larger this current the lower the total voltage, as was explained in connection with voltage regulation.

Referring again to Fig. 27A, suppose that the total voltage across R1 and R2 is 180 volts and that R1 is 15,000 and R2 is 10,000 ohms. The total resistance is then 25,000 ohms. Hence the current through the resistors is 180/25,000 amperes, or 7.2 milliamperes. The voltage drop in R1 is therefore 108 volts and the drop in R2 is 72 volts.

The current flowing through the voltage divider is known as the "bleeder current" because it flows whether or not the rectifier-filter is delivering any useful power.

There are three objects of the bleeder current. First, it prevents a sudden and high rise of the voltage across the condensers in the filter when the load is removed, that is, when the filaments in the amplifier are turned off or when the line to the amplifier is opened. Second, it provides a means for obtaining lower voltages than the maximum, that is, it enables the voltage divider to function. Third, it brings the current operating point of the rectifier-filter to a place where the regulation is better. The first two of these functions are the more important.

Only infrequently may it be assumed that no current flows in a tap on the voltage divider. The only case where this assumption is justified is when the tap is used to supply a grid potential. When the tap is connected to a plate of a tube, or to a screen grid, some current flows, and this must be taken into account in determining the positions of the taps on the voltage divider resistance.

Fig. 27B shows a voltage divider suitable for an amplifier involving 224 AC screen grid and 245 type tubes. The maximum voltage is 300 volts, which provides the plate and grid voltages for the 245 tube or tubes. The next lower voltage is 180, which provides voltage for the plate of the screen grid tube, or for any other tubes which may be operated at this voltage. The lowest voltage is 75 volts, intended primarily for the screen grid (G post of socket) of the 224 tube. The 75-volt tap terminates in an arrow on the resistor strip, indicating that the voltage is adjustable.

Current is taken by all of the taps in Fig. 27B, as is indicated by the arrows. But the amount of current taken by any tap is not known, for it depends on the filament temperature of the tubes, on the grid bias on the tubes, on the number of tubes on a given tap, and on the nature of the coupling devices used in the amplifier. Hence the current in any section of the voltage divider is unknown.

However, in section R1 all the plate current flows, as well as the bleeder current of the amplifier, except the plate current of the tubes on 300 volts. In section R2 the bleeder current and the current taken by the 75-volt tap flows. In section R3 only the bleeder current flows.

In the design of a voltage divider certain simplifying assumptions sometimes may be made. Suppose the bleeder current is large, so that the current taken by the screen grids is small in comparison. Then it is permissible to assume that the same current flows in both R2 and R3, and that this is the bleeder current. Let the bleeder current be 20 milliamperes. The 180 volts equals .020 x (R2+R3). Hence the sum of the two lower resistors should be 9,000 ohms. A 10,000-ohm potentiometer could then be used for R2 and R3, with the 75-volt tap connected to the slider. The bleeder current would be 18 milliamperes. Hence both the 180- and 75-volt potentials would be adjusted regardless of how much current were drawn from the 180- and 300-volt taps.

Now it remains to determine the value of R1. We might find by measurement in the 180-volt lead that the current is 15 milliamperes. This measurement should be made after the 180-volt potential and the grid and filament voltages on the tubes served by the 180-volt tap have been adjusted to the desired values.

Having determined the current to be 15 milliamperes under normal operating conditions, we know that the current in R1 is 33 milliamperes. The voltage drop in this resistor is also known, being the difference between 300 and 180 volts. Therefore we know that R1 must have a value of 3,636 ohms. For a different current distribution the resistance would have another value.

Fig. 27C shows a voltage divider suitable for a circuit comprising 250 power tubes, battery type screen grid tubes (222) and other amplifier tubes requiring voltages from 45 to 180 volts. The placement of the taps is determined in the same way as in the preceding example. The first thing to do is to determine the value of the bleeder current, making it large enough to permit simplifying assumptions, yet not so large as to lower the total available voltage excessively or to affect adversely the filtering. When the bleeder current has been determined, and neglecting the current to the 45-volt tap, R3 and R4 may be determined. The 45 volt tap should be adjustable, as indicated by the arrow termination. Next the current to the 135-volt tap should be measured so that R2 may be determined. Then the current to the 180-volt tap should be measured to give data for determining R1.

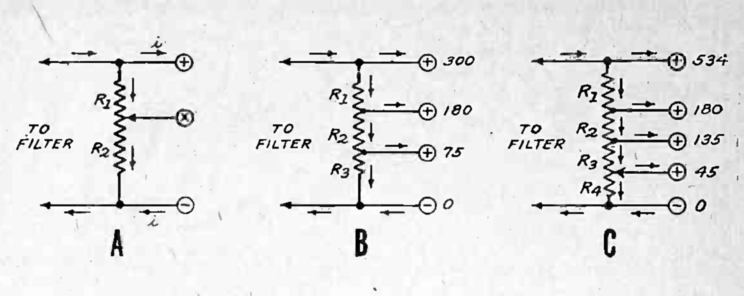


FIG. 27

(A)—A VOLTAGE DIVIDER HAVING A SINGLE TAP WHICH IS ASSUMED TO TAKE NO CURRENT.

(B)—A TYPICAL VOLTAGE DIVIDER DESIGNED TO SUPPLY A CIRCUIT USING 245 POWER TUBES, AC SCREEN GRID TUBES AND OTHER TUBES REQUIRING THE VOLTAGES INDICATED.

(C)—A VOLTAGE DIVIDER DESIGNED FOR A CIRCUIT USING 250 POWER TUBES, BATTERY TYPE SCREEN GRID TUBES, AND OTHER TUBES REQUIRING THE VOLTAGES GIVEN.

It is well to use a voltage divider strip with adjustable taps so that there will be no limitation on the resistance values that may be selected. But if strips of fixed taps are used it is possible to use the tap which gives the voltage nearest to that desired, and then adjust the grid bias on the tubes served to suit the plate voltage actually obtained.

If a high resistance voltmeter, one of 1,000 ohms per voltage, is used, fair accuracy may be attained without measuring the current in the various taps. It should be remembered that even a 1,000 ohms per volt reads lower than the actual voltages. But the discrepancy is small and should not seriously affect the operations of the amplifier.

The suggestion was made that the current drawn from a certain tap be measured under normal operating conditions. This is not always easy to comply with, for the object of the adjustment is to bring about normal operating conditions, and the normal current cannot be measured before normal conditions have been brought about.

The current that will be drawn from any tap can be determined quite accurately without any measurement at all. Let us illustrate how this may be done.

Let us suppose that two 201A tubes are connected to the 135 volt tap and that these tubes are properly biased and that they are working into primaries of audio transformers. Under these conditions the current taken by each tube is known. Let us say that the bias is such that each tube takes 6 milliamperes. Therefore 12 milliamperes will flow from the 135 volt tap. That figure can be used in place of the result of measurement, at least for purposes of calculating the resistances in the voltage divider.

In the same manner the current from any tap can be estimated. It is only necessary to count the number of tubes of various types served by a given tap and then take from tube tables the normal current for each tap for the plate voltage in question. If there are any other conductors taking current from the same tap the current should be estimated and added to the total.

It will be noted that the highest voltages in Figs. 27A and 27B are higher than the rated plate voltages for the tubes. The difference is the grid bias intended for the power tubes. For example, the 534 volts are divided in the ratio of 450 for the plates and 84 for the grids. The bias on the tubes served by the other taps is so small that allowance need not be made for it.

No by-pass condensers are shown in Fig. 27, A, B, or C, because only DC voltages were considered. When the voltage divider is used with an amplifier there will also be signal currents flowing in the various taps and resistors, and each of these currents must be provided with a low impedance path to the negative side of the line, or to the filament. Hence a by-pass condenser should be connected from every tap to the negative side. These condensers may be connected either in the amplifier or in the voltage divider.

(*Part V next week, issue of June 29th*)

A Question and Answer Department conducted by Radio World's Technical Staff. Only Questions sent in by University Club Members are answered. Those not answered in these columns are answered by mail.

RADIO UNIVERSITY

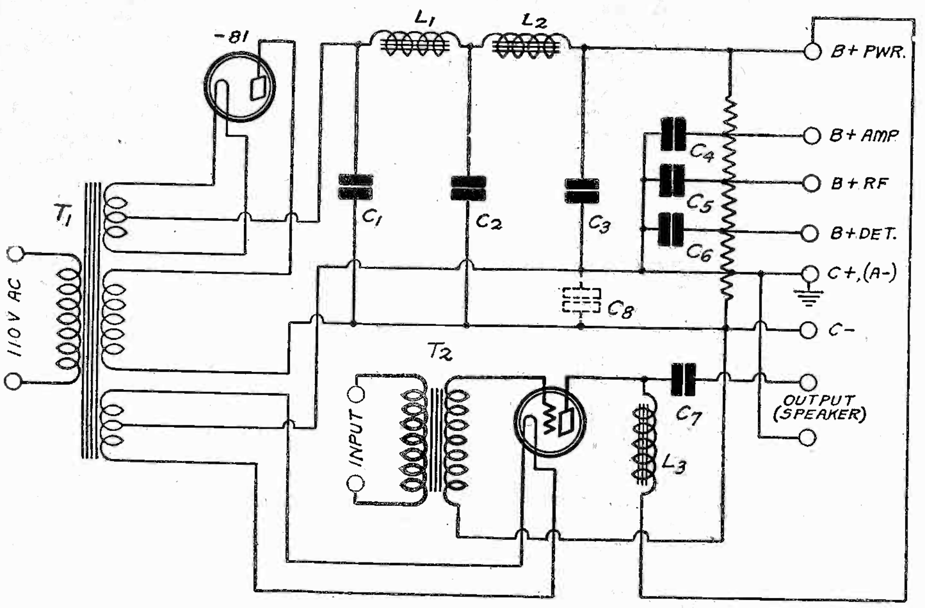


FIG. 762
B SUPPLY WITH ONE-STAGE AUDIO, USING A HALF-WAVE RECTIFIER.

IN BUILDING my present receiver I used ample radio frequency amplification, power detector and two stages of impedance coupled audio amplification, as there was enough detector output to enable loading up the last tube with the two stages of moderate-amplification audio. However, when I turn the set on it sounds like a clocking hen until the heater type tubes get warm enough to function. This sounds like incipient motor-boating, and while it disappears about the time when the program starts to become audible, some visitors commented on the preliminary knocking sound, and I should like to do something to avert their criticisms.—M. L. B.

This condition results primarily from the fact that your audio circuit is capable of good low-note reproduction, and to the high value of voltage actually applied to the plates of the heater tubes during the heaters' warming-up process. The preliminary motorboating is not a vice, since it disappears before the program begins to be audible. This proves the interference's relationship to the proper functioning of the tube. As the plate current begins to flow at near its normal value, the voltage drop in the plate loads increases proportionately, and reduces the effective voltage on the plates commensurately. This increase in current flow also reduces the voltage at the B plus terminals of the eliminator, on the basis of the regulation of the rectifier tube and its associated circuit. The heavier natural drain pulls the voltage down. The only remedy would be heater tubes of instantaneous action, but none such tubes exist.

* * *

WHEN IS A GROUND an aerial? My set works well when the aerial is left off, the ground connected to the antenna post of the receiver, and nothing connected to the ground. I should say it works as well that way as if the aerial were used in the accustomed place and the ground in its regular position. How come?—J. J. K.

A self-grounding effect is produced by the A battery and B batteries, if used, or by the power transformer in AC sets. Thus when seemingly nothing is connected to the ground post, B minus, which is self-grounded, actually is connected there, so that an external ground lead, especially if rather long, may be at a higher radio frequency potential than the self-ground. In that instance you simply have an antenna, one end of which goes to external ground, the other end to the set. Hence you have aerial and ground. But an outdoor aerial, connected to the antenna post, and a short ground lead from a cold water pipe or a radiator, with all connections securely made, will give better results. Compare stations that come in weakly, rather than strong ones, since on loud stations it is sometimes hard for the ear to tell there is any volume difference at all, though that difference may be nearly 50 per cent. However, use any method that you think works your set best.

* * *

IS A COIL of wire an inductance?—T. M.

No. That is a popular definition, but not a scientific one. A coil is no more an inductance than a steam engine is a puff of steam or a pistol is a bullet. All wire, coiled or straight or twisted, has inductance. Inductance is more compactly obtained by coiling. Inductance is a property of the wire that relates to the number of lines of force in the magnetic field of the wire under stated conditions. Nobody ever saw inductance, but its manifestations have been studied and measured. Defining inductance is as difficult as defining electricity. An extended exposition is required. It will surprise many to learn that inductance is measured in linear length. Europeans express it directly in terms of the meter. We use an equivalent method, with the henry as the unit.

* * *

I DESIRE TO USE a 245 output tube incorporated in a B supply with 281 rectifier. Please show diagram.—A. L.

Fig. 762 shows the wiring. The secondaries of the power transformer T1 are, top to bottom, 7½ volts, 300 volts, 2½ volts. L1L2 are a SM Unichoke 331. C1, C2, C3 are 2 mfd. each, 600-volt AC rating. C4, C5, C6 are 2 mfd. each, C7 and C8, 4 mfd. each. T2 is an audio transformer to which detector plate and B+ detector are connected. L3 is an output filter choke. The output potentiometer is an Aerovox Pyrolim type A, 1,500 ohms being used from C— to C+.

* * *

THE LID of my table model cabinet rests on top of the 281 rectifier tube, because in building the set I did not allow sufficient room, not having counted the thickness of the baseboard in connection with the unusual height of the rectifier tube. How can I avoid this situation, so that if the cabinet lid should fall it won't break another 281 tube?—M. C.

Remove the 281 socket. Drill a 1" hole through the baseboard at this point. Then elevate the baseboard sufficiently to permit mounting the socket on bottom of the baseboard, so that the socket prong holes are accessible through the 1" opening. The filament and plate wiring of the rectifier can be brought to the top of the baseboard through holes specially drilled, or simply by bringing the wires around the back of the baseboard.

* * *

IF THE WATTAGE is known, is the current known?—C. F. O'B.

No. The wattage is the product of the current and the voltage. Infinite combinations of current and voltage would produce the same wattage. Often, however, when the wattage is stated the current is known because the voltage is known from experience, reputation, or other disclosure. Thus a 25-watt lamp draws .208 ampere, since the voltage at which the wattage rating was established is imprinted on the glass, with the wattage, thus: 25 watts, 120 volts. The test voltage of 120 is used because this is the highest voltage usually obtained in practice from AC or DC lines rated at 110 volts. However, with radio devices, other than tubes, the wattage gives no clue to the current, because the current depends on the voltage, and nobody knows what voltage will be used, and the range of useful voltages is large.

* * *

OUR BABY is just beginning to walk. What type of cabinet or console would you suggest that would be immune from all attacks by said infant during the three trying years to come? —L. G.

A cabinet or console of such perfect security as to render all attacks by an infant futile is impossible of attainment except by armor-plating. This from one who knows.

* * *

IS IT NECESSARY to use a large coupling condenser between the plate of a tube and the grid of the next tube in a resistance-coupled audio amplifier?—S. M.

That depends on what you consider large. The product of the grid leak and the grid condenser, where the capacity is in microfarads and the resistance in megohms, should be at least .02. Therefore with a high value of grid leak the capacity may be less than otherwise. Thus the condensed may be .02 mfd. if the leak is 1 meg. or more. The condenser that you mistakenly refer to as a coupling condenser does not couple one tube to the next, but is simply a stopping condenser used for keeping the positive plate voltage off the grid of the succeeding tube, which grid must be maintained negative. For a detailed discussion of this entire topic see the second instalment of "Power Amplifiers," published in the June 8th issue of RADIO WORLD, page 13, column 1.

IS IT BETTER to incorporate the coils and the condensers in separate shields in building a shielded receiver, or should one use a large can and place all the parts in it? I notice that in several descriptions of shielded receivers, the front portions of the can are left off. Wouldn't it be better to place them on? Must the cans be grounded? If so, does it matter whether the plus A or the minus A is also brought to the ground?—M. A.

The separate shields should be used for best results. Using a common shield does only one thing, and that is to prevent the coils from acting as miniature antennas, thus making the set a bit more selective. There is no shielding unless the can is complete. If the front is left off the shielding may as well be omitted. Ground the shields. A minus is the usual connection to the shields in battery sets.

* * *

MY SUPER-HETERODYNE is extremely selective yet it does not cut all interference. It heterodynes with certain stations. What can I do to remedy this condition? The receiver was built of the very best parts throughout but still I do not like the quality. The signals are muffled and throaty. What is the reason?—A. D.

The cause of the interference is lack of selectivity in the radio frequency level. Another tuner and radio frequency amplifier will remedy this condition. The cause of the muffled or throaty signals is too great selectivity in the intermediate frequency filter.

* * *

IS THERE ANY ADVANTAGE in using an output filter consisting of a choke and a condenser over an output transformer? What should be the inductance of the choke coil and the capacity of the condenser in an output filter? What should the ration of the transformer be if this method of output is employed?—S. W.

Each method has advantages over the other but perhaps the choke and condenser method has the more. There is less danger of saturating the core, the inductance used can be larger, and it is possible to shunt the AC component of the output around the B voltage source. The inductance of the choke used across the speaker should be about 100 henrys when working with normal plate current in its winding. Good results will be obtained even if the inductance is as low as 35 under the same conditions. The condenser should have a capacity of at least 4 mfd. The type of transformer depends on the type of tube and on the type of speaker. The primary impedance should be somewhat larger than the impedance of the tube and the secondary impedance should be the same as the impedance of the speaker. Often that means a ratio of 1-to-1.

* * *

WHY DO CERTAIN transformer manufacturers recommend the use of a low ratio transformer next to the detector and a somewhat higher ratio in the amplifier stage when the rule has long been just the opposite. Is there any advantage in the newer method and is it worth while to switch the transformers around in my old set?—J. L.

The detector has a higher impedance than the amplifier tube, hence the transformer coupled to the detector should have a higher impedance. The lower ratio transformer has a higher impedance. The newer method gives a little better amplification on the low notes.

* * *

WHY DOES the resistance of a coil increase with frequency? I understand that the resistance of a wire is directly proportional to its length and inversely and proportional to its cross-section. Don't these remain the same as the frequency varies? —D. M.

There are two reasons why the resistance of a coil goes up with the frequency. The first is that the effective area of the cross-section of the wire does not remain the same as the frequency is increased, but decreases rapidly. The second is that at the higher frequencies there are greater losses due to eddy currents in surrounding metal bodies, as well as greater dielectric losses. The decrease in the effective area is known as the skin effect. The current travels in a thin layer on the surface of the wire and the higher the frequency the thinner the layer in which current flows. The increase in radio frequency resistance with frequency, that is the skin effect, depends on the conductivity of the wire, on the diameter and on the permeability of the material of which the wire is made. For magnetic metals of high permeability such as iron the skin effect is very large. Even for comparatively low frequencies the current travels on the surface to such an extent that the resistance of the wire is several times the direct current resistance. For fine wires the skin effect is not nearly so pronounced as for heavy wires. It is for this reason that radio frequency conductors are frequently stranded, that is, made of a large number of very fine wires. The foregoing applies to resistance to radio frequencies. The direct current resistance is proportional to the length of the wire. Do not confuse the AC and DC resistances.

* * *

SEVERAL QUESTIONS REGARDING PUSH-PULL have been puzzling me and therefore I ask you kindly to answer them. First, there is the capacity effect between the grid and plate of a tube, and if two tubes are used in push-pull this capacity must be present to an added extent. As this capacity may be one reason for unbalance sometimes encountered in push-pull circuits, I am wondering whether there is not some way of counteracting this effect directly? It seems to me that

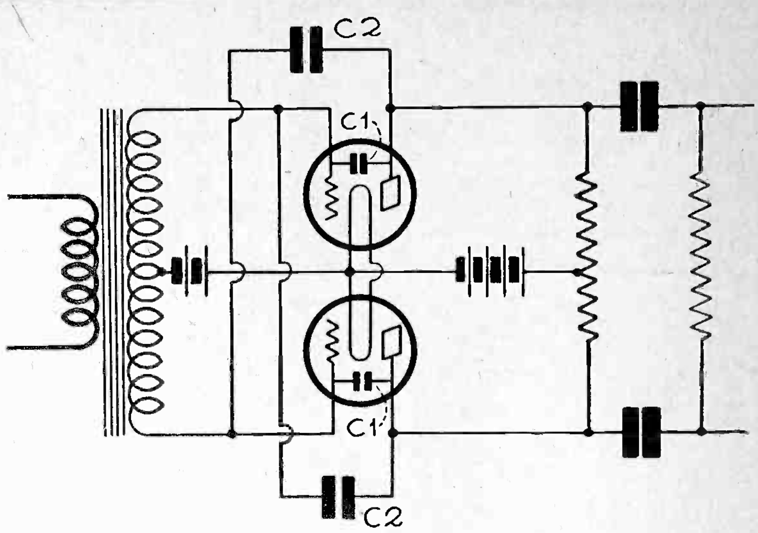


FIG. 763

HOW THE CAPACITY EFFECT OF THE GRID AND PLATE ELEMENTS OF A TUBE IS BALANCED OUT. C2 AT TOP NEUTRALIZES C1 AT BOTTOM, C2 AT BOTTOM NEUTRALIZES C1 AT TOP. THE OUTPUT IS RESISTANCE-COUPLED, A NOVELTY IN PUSH-PULL.

if this is accomplished that the effect that even a small capacity may have upon frequency response would be nullified. This small capacity, due to the height of the amplification, must have an attenuating effect upon the higher frequencies, particularly if the load is resistive. Is there not some way of taking the output from a detector through resistors for push-pull input to the first audio stage, and can not a commensurate push-pull resistance coupled output be obtained from the first audio?—A. B. L.

The capacity effect between the grid and plate exists, as you say, and it may be balanced out by the introduction of neutralizing condensers. See Fig. 763. The two neutralizing condensers are C2, each connected from plate of one tube to grid of the other. The inter-electrode capacity is shown by the small symbols, both marked C1. Therefore lower C2 balances out the capacity of upper C1, and the others the same. The diagram also shows a resistance coupled push-pull output, where the plate load is an electrically center-tapped resistor of a total resistance of about 200,000 to 300,000 ohms. The electrical center must be accurately established, and it is advisable to use a potentiometer with a movable arm to B plus, so that differences in the plate resistances of the two tubes may be compensated. The isolating condensers must be equal also. There is no way of satisfactorily taking the output of a detector through push-pull resistance coupling, as the circuit works one-sidedly, that is, the other side is inactive. A coil is necessary, and a push-pull output transformer may be used, as shown in the diagram.

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NEW STATIONS ARE REGARDED AS HINDRANCE

Washington.

Improvement in radio reception, which has resulted from the reallocation of broadcasting facilities effected November 11th, should not be jeoparded by the licensing of additional broadcasting stations and further crowding of the broadcast band, William D. L. Starbuck, Radio Commissioner, said.

W. D. L. Starbuck

Calling attention to the increasing number of applicants from all sections of the country for permission to operate stations, he said that the broadcast band is overcrowded. There are now more than 600 stations on the air.

"It is a fact, in spite of the overcrowding of broadcasting stations which now exists, that the listening public is enjoying better reception than was possible before the allocation of November, 1928.

"The Commission desires to maintain this condition and to improve it, and to this end does not encourage the establishment of new stations. It is not believed that new stations contribute to a condition of good reception but rather that they are detrimental in greatly increasing interference and reducing the service area of existing stations."

Inventor Sues Over Majestic's "B" Design

Chicago.

Suit has been brought against Hartman Furniture & Carpet Company in Danville, Illinois, for the sale of Majestic radio sets made by Grigsby Grunow Company, of Chicago, for alleged infringement of three patents of Philip E. Edelman. One patent relates to a voltage divider for use in B eliminator packs. Another covers the use of two choke coils whose fields are set so as to buck each other for the elimination of hum from the circuit. The third covers an arrangement of rectifier and filter circuits with a regulator for compensating for the voltage drop as the output current is increased. These are said to be controlling patents covering the use of AC power packs for radio sets.

Edelman is the author of several books on radio, the first of which was copyrighted in 1912. His attorneys are Banning & Banning.

Pilot Corporate Name Undergoes a Change

The name of the Pilot Electric Manufacturing Company has been changed to the Pilot Radio & Tube Corporation. The organization will continue to function as before, no changes in either management or policy being contemplated.

The officers of the corporation are Isidor Goldberg, president; Henri Sadacca, vice-president, and James I. Benjamin, secretary and treasurer.

Dill Asks Census Include Receivers

Washington.

Senator Dill, of the State of Washington, has promulgated a bill to have the number and class of radio sets counted in conjunction with the 1930 personal census. Opposition to the measure developed in the House.

STORMS BRING LOUD SIGNALS

Washington.

The Bureau of Standards of the Department of Commerce made the following announcement:

"A study of the variation in long-wave daylight signal intensity observed at the laboratory for special radio transmission research at the Bureau of Standards, at Washington, and of the disturbances in terrestrial magnetism, reveals a marked increase in the intensity of long-wave signals following severe magnetic storms.

"In the case of long distance reception from European stations, there is a general tendency for the signal intensity to be below normal for several days before the maximum of the magnetic disturbance, and to show a definite increase from one to three days after the passage of the storm.

"Observations taken on stations at moderate distances, i. e., the Radio Corporation stations at Tuckahoe and New Brunswick, N. J., and Rocky Point, L. I., give somewhat different results. While the intensity of signal from these stations is high from two to four days after the storm, as in the case of the distant stations, there is also a decided increase in signal strength from two to four days before the magnetic disturbance."

Richmond is Elected President of R. M. A.

Chicago.

H. B. Richmond, treasurer of General Radio Corporation, has been elected president of the Radio Manufacturers Association, succeeding Herbert H. Frost, who served three terms. Major Frost is a vice-president of Kolster. A sterling silver plaque was presented to the Major as a token of esteem.

T. K. Webster, Jr., president of the Ekko Company, was elected treasurer.

Mr. Richmond is the first president to come from the engineering profession. He is a graduate of Massachusetts Institute of Technology.

Although he joined the ranks of General Radio Company as engineer in 1919 most of his activities have been along administrative lines. He is a member of the Institute of Radio Engineers and of the American Institute of Electrical Engineers. At M. I. T. he was president of the Electrical Engineering Society, one of the student branches, and vice-president of the Radio Society.

Mr. Richmond is an expert rifleman. During his first year at college he won the freshman rifle-shot medal.

NEW 60-STATION CHAIN

A coast-to-coast chain of sixty stations is planned by the American Broadcasting Company of Seattle, Wash. The company plans to add New York and Washington (D. C.) stations to the chain and have the sixty stations in operation within a year.

LABOR STATION GOES TO COURT FOR FULL TIME

Washington.

The Chicago Federation of Labor, operating WCFL, at Chicago, as the organized labor broadcasting station, has petitioned the Court of Appeals of the District of Columbia to reverse the decision of the Federal Radio Commission denying it a cleared channel and full-time operation with 50,000 watts power.

The petition, filed by E. M. Nockels, secretary, and Hope Thompson, attorney, contended that the Commission's decision was contrary to the law, against public interest, convenience and necessity, and contrary to the evidence in the record.

Seeks Wider Scope

The petition sets forth that the station is operated in the interests of the entire membership of organized labor. The improved assignment is desired, it is asserted, to permit the promulgation of the "policies, principles and ideals of the Federation."

"The Federal Radio Commission, by its decision, denies to this vast body of citizens any adequate facilities in this great new field of communication, partly on the theory that radio should not be used for propaganda purposes, and partly, no doubt, for other reasons to be assigned by the Commission," the petition sets forth. "In so denying one single frequency to organized labor the Federal Radio Commission, in its decision, disregarded the public interest, necessity and convenience in denying the appellant the means and opportunity to render this service."

Wants 770 kc Exclusively

The station now operates on the 970-kilocycle channel with 1,500 watts in daylight hours only. It sought assignment on the 770-kilocycle channel, now occupied by KFAB, Lincoln, Nebr., and WBBH, Chicago, Ill., with unrestricted hours of operation and the maximum power of 50,000 watts.

Officials of the American Federation of Labor, including its president, William Green, appeared in favor of the WCFL application at hearings held by the Commission last April.

The Chicago Federation also sought two or more short-wave channels to be employed in rebroadcasting programs of WCFL throughout the United States and to foreign countries.

U. S. Offers Afternoon Programs to Europe

Schenectady, N. Y.

To provide Europeans with an American radio program at a convenient hour, WGY's short-wave station W2XAF has inaugurated a series of afternoon broadcasts on two different frequencies. These programs also afford engineers of the British Broadcasting Company an opportunity to carry on experiments in reception and rebroadcasting of trans-Atlantic programs.

The afternoon schedule of W2XAF, effective at once, follows: Sunday, 2:30 to 5:30 p. m., 15,340 kilocycles; Monday, 2:00 to 4:00 p. m., 13,660 kilocycles; Tuesday, 2:00 to 3:00 p. m., 15,340 kilocycles; Thursday, 2:00 to 4:00 p. m., 13,660 kilocycles; Friday, 2:00 to 3:00 p. m., 15,340 kilocycles. All time references are Eastern Daylight Saving Time.

NEW WARNING ON TRANSFERS

Washington.

The Federal Radio Commission held a hearing on the application of the Clarke Electrical Company, of Danville, Va., for permission to establish a broadcasting station in that city.

Thomas F. Little, of Newport News, owner of WGH in that city, had entered into an agreement with the Clarke Company to transfer the WGH station license for $2,700 payment for station equipment.

Ira E. Robinson, Commission chairman, declared that under the law a station license may not be transferred by the licensee without authority of the Commission.

"The law specifically prohibits the transfer of a station license from one party to another without authority of this Commission," he said. "When this Commission granted you this valuable franchise it was for your use as a trustee of the public, and when you decided that you had no further use for the license it must revert back to the Commission. It is not within your province to allocate stations and wavelengths in Virginia. That is one of the problems before the Commission."

Mr. Little voluntarily relinquished his license to WGH after examination by the Commission. He explained he had made a practice of leasing or selling stations but that he now proposes to operate one station himself.

Engineer Tours U. S. to Study Reception

Schenectady, N. Y.

K. B. Hoffman, maintenance engineer of WGY, began a national survey of the United States to ascertain facts concerning average reception of WGY and the other General Electric Company stations KGO, of Oakland, Calif., and KOA, of Denver, Colo., since November 11th, 1928, when the reallocation ordered by the Federal Radio Commission was put into effect.

Mr. Hoffman travels in a car especially equipped with radio. His western route takes him through Chicago, Denver and Salt Lake City to San Francisco, and on his return he will travel by slow stages through Los Angeles, Phoenix, Fort Worth, New Orleans and Montgomery. The investigation will deal more especially with reception in small cities, villages and in rural sections which have no local station from which to get radio entertainment.

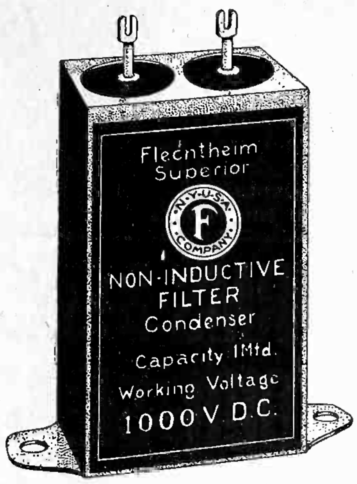
Mr. Hoffman will invite listeners, radio editors and radio dealers to fill out questionnaires. The radio survey car in which Mr. Hoffman is making his tour is equipped with a long wave and a short wave receiver and a loudspeaker.

Home Talkies Planned With Radio Receiver

The Vision Tone Sales Company, of Texas, with headquarters at Dallas, announces a new invention combining a radio, a phonograph and a motion picture machine, with records and films synchronized to create talking pictures in the home.

Films with synchronized records will be rented at 10 cents a night on the circulating library plan.

Compact Condenser New Flechtheim Item



ACTUAL SIZE ILLUSTRATION OF NEW 1 MFD. CONDENSER, 1,000 VOLTS DC, 750 VOLTS AC TEST

A. M. Flechtheim & Co., Inc., of 136 Liberty Street, New York City, announces a high voltage condenser of small physical size. "We have succeeded in making a 1,000 volt DC continuous working condenser in a metal container 2" high, 1⅛" wide and ⅝" deep, considerably less than one-quarter of the size of present standards for a 1 mfd. 1,000 volt condenser," said Leon L. Adelman, chief engineer.

"This new unit is wound in non-inductive manner, and had an accuracy of capacity within 5% plus or minus of rating. It has a power factor appreciably less than 1%. It has an insulation resistance of more than 600 megohms per microfarad and its breakdown voltage is three times its safe rating of 1,000 volts DC (750 rms AC)."

W2XCL Is Licensed for Television Tests

W2XCL, 323 Berry Street, Brooklyn, N. Y., operating since March 27th under a construction permit issued by the Federal Radio Commission, has been licensed as an experimental visual broadcasting station to transmit in the 2,000-2,100 kilocycle channel (142.9-150 meters). The Pilot Radio & Tube Corporation owns the installation.

Television broadcasting on a regular schedule will begin soon from W2XCL, said James I. Benjamin, treasurer. A new system of disc scanning and a simple method of maintaining synchronization will be used.

NEW RESISTANCE FOLDER

A new folder on resistance in radio, ranging from an adjustable grid-leak of 1/10 to 10 megohms to a super-power variable resistor of 250 watt rating, has just been issued by the Clarostat Manufacturing Company, Inc., 291 North Sixth Street, Brooklyn, N. Y. A copy will be sent to any interested person upon request. Mention Radio World.

SCHNELL IS GENERAL MANAGER

Lieut. Commander F. H. Schnell has been made general manager of Aero Products, Inc., Chicago. James Barnes, formerly of Thordarson Mfg. Co., has joined Aero Products as radio engineer.

A THOUGHT FOR THE WEEK

A CERTAIN announcer in a Mid-West broadcasting station has one of those soft voices that occasionally go off into a diminuendo that threatens at times to reach the point of disappearance. Surely in these days it would not be nice to refer to him as a speakeasy, would it, now?

HOTEL HAS NEW GUEST TUNERS

A new system for distributing radio programs to individual rooms in hotels, hospitals, apartment houses and staterooms on ships was announced recently and demonstrated in the Hotel Lincoln, New York City, where the system is now in operation.

At present the system comprises six receivers of conventional design located in the "studio room" on the 29th floor of the hotel. Each of these receivers is tuned to a different station, and all receivers are operated from the same antenna on the roof of the hotel. The six receivers are battery-operated and are completely shielded except for their connection to the common antenna.

The output of these receivers is carried to the transmission room on the floor below, where a monitor operator is stationed. The function of this operator is to listen in and to select the programs and to control the volume and modulation of the transmitted signals.

In the transmission room are six minature transmitters which receive the signals from the six receivers. The oscillators for these transmitters operate at different frequencies from those of the carriers of the signals selected. When the signals have been impressed on the new frequencies they are impressed on the steel framework of the building.

Receivers located in the rooms can be tuned in to any one of the six programs by a simple switching arrangement. No antenna is used for the individual receivers because all that is necessary is to connect a single wire to the radiator in the room, or to any other metal which is in electrical contact with the framework of the building.

The entire system is carefully shielded so that the signals on the new frequencies do not get outside the building.

The new distributing system was invented by Dr. F. L. R. Satterlee, long a prominent figure in the X-ray and radio fields; Louis Kalozsy, a Hungarian engineer and inventor, and Samuel Saltzman, chief electrician for the Chanin Theatres Corporation.

WEBC Asks Court To Grant Full Time

Washington.

The Head-of-the-Lakes Broadcasting Co., Inc., operating WEBC, at Superior, Wis., filed with the Court of Appeals of the District of Columbia a petition for review of the Federal Radio Commission's decision denying it full-time operation.

The notice of appeal states that the station was denied its application for full-time operation on the 1,280 kilocycle channel, which it now shares with WDAY, at Fargo, N. D. The Commission's finding that the public interest would not be served by granting the application "is not supported by the testimony before the Commission," the petition contends.

NAMES N. Y. REPRESENTATIVE

The Automatic Radio Manufacturing Co., of Boston, Mass., manufacturers of Tom Thumb Portable Radio, announces the appointment of the Friedman-Snyder Co., 15 Park Place, New York City, as its representatives in the Metropolitan area.

GRIMES JOINS PILOT

David Grimes, radio inventor, has been appointed chief research engineer of the Pilot Radio & Tube Corporation, I. Goldberg, president of the firm, announced.

List of Stations by *Frequency* With Wavelength *Conversion*

[REVISED AND CORRECTED FROM THE RECORDS OF THE FEDERAL RADIO COMMISSION, TO NOON, JUNE 12TH]

** Canadian shared*
*** Canadian exclusive*
S-Studio

550 KC, 545.1 METERS
WEAN-Providence, R. I.
WGR-Buffalo, N. Y.
WEAO-Columbus, O.
WKRC-Cincinnati, O.
KFUO-Clayton, Mo.
S-St. Louis, Mo.
KSD-St. Louis, Mo.
KFDY-Brookings, S. D.
KFYR-Mismark, N. D.
KTAB-Oakland, Calif.

560 KC, 535.4 METERS
WDGY-Minneapolis, Minn.
WHDI-Minneapolis, Minn.
WIOD-Miami, Fla.
WLIT-Philadelphia
WFI-Philadelphia
KFDM-Beaumont, Tex.
WNOX-Knoxville, Tenn.
WOI-Ames, Iowa
KFEQ-St. Joseph, Mo.
KOAC-Corvallis, Ore.
KLZ-Dupont, Colo.

570 KC, 526 METERS
WNYC-New York, N. Y.
WMCA-Hoboken, N. J.
S-New York, N. Y.
WSYR-Syracuse, N. Y.
WMAC-Cazenovia, N. Y.
WSMK-Dayton, O.
WKBN-Youngstown, O.
WWNC-Asheville, N. C.
KGKO-Wichita Falls, Tex.
WNAX-Yankton, S. D.
WPCC-Chicago, Ill.
WIBO-Desplaines, Ill.
S-Chicago, Ill.
KUOM-Missoula, Mont.
KXA-Seattle, Wash.
KMTR-Hollywood, Cal.

***580 KC, 516.9 METERS**
WTAG-Worcester, Mass.
WOBU-Charleston, W. Va.
WSAZ-Huntington, W. Va.
KGFX-Pierre, S. D.
KSAC-Manhattan, Kans.
WSUI-Iowa City, Iowa

590 KC, 508.2 METERS
WEEI-N.Weymouth, Mass.
WEMC-Berrien Spgs.,Mich.
WCAJ-Lincoln, Nebr.
WOW-Omaha, Nebr.
KHQ-Spokane, Wash.

***600 KC, 499.7 METERS**
WTIC-Hartford, Conn.
WCAC-Storrs, Conn.
WCAO-Baltimore, Md.
WREC-Whitehaven, Tenn.
WOAN-Lawrenceburg,Tenn
WEBW-Beloit, Wis.
KFSD-San Diego, Calif.
KWYO-Laramie, Wyo.

610 KC, 491.5 METERS
WFAN-Philadelphia
WIP-Philadelphia
WDAF-Kansas City, Mo.
WOQ-Kansas City, Mo.
KFRC-San Francisco

620 KC, 483.6 METERS
WLBZ-Bangor, Maine
WDBO-Orlando, Fla.
WDAE-Tampa, Fla.
WJAY-Cleveland, O.
WTMJ-Brookfield, Wis.
KGW-Portland, Ore.
KFAD-Phoenix, Ariz.

***630 KC, 475.9 METERS**
WMAL-Washington, D. C.
WOS-Jefferson City, Mo.
KFRU-Columbia, Mo.
WGBF-Evansville, Ind.

640 KC, 468.5 METERS
WAIU-Columbus, O.
KFI-Los Angeles, Calif.

650 KC, 461.3 METERS
WSM-Nashville, Tenn.

660 KC, 454.3 METERS
WEAF-Bellmore, N. Y.
S-New York City
WAAW-Omaha, Nebr.

670 KC, 447.5 METERS
WMAQ-Addison, Ill.
S-Chicago, Ill.

680 KC, 440.9 METERS
WPTF-Raleigh, N. C.
KPO-San Francisco

****690 KC, 434.5 METERS**

700 KC, 428.3 METERS
WLW-Mason, Ohio

710 KC, 422.3 METERS
WOR-Kearny, N. J.
S-Newark, N. J.
KFVD-Culver City, Calif.

720 KC, 413 METERS
WGN-WLIB-Elgin, Ill.
S-Chicago, Ill.

****730 KC, 413 METERS**

740 KC, 405.2 METERS
WSB-Atlanta, Ga.
KMMJ-Clay Center, Nebr.

750 KC, 399.8 METERS
WJR-Silver Lake, Mich.
S-Detroit, Mich.

760 KC, 394.5 METERS
WJZ-Boundbrook, N. J.
S-New York, N. Y.
WEW-St. Louis, Mo.
KVI-Des Moines, Wash.
S-Tacoma

770 KC, 389.4 METERS
KFAB-Lincoln, Nebr.
WBBM-WJBT-Glenview,
S-Chicago, Ill.

***780 KC, 384.4 METERS**
WBSO-Wellesley, Mass.
WTAR-WPOR-Norfolk, Va.
WMC-Memphis, Tenn.
KELW-Burbank, Calif.
KTM-Santa Monica, Cal.
S-Los Angeles, Calif.

790 KC, 379.5 METERS
WGY-Schenectady, N. Y.
KGO-Oakland, Calif.

800 KC, 374.8 METERS
WBAP-Ft. Forth, Tex.
KTHS-Hot Springs Nat'l Park, Ark.

810 KC, 370.2 METERS
WPCH-Hoboken, N. J.
S-New York, N. Y.
WCCO—Anoka, Minn.
S-Minneapolis.

820 KC, 365.6 METERS
WHAS-Jeffersontown, Ky.
S-Louisville, Ky.

830 KC, 361.2 METERS
WHDH-Gloucester, Mass.
KOA-Denver, Colo.

****840 KC, 356.9 METERS**

850 KC, 352.7 METERS
KWKH-Kennonwood, La.
WWL-New Orleans, La.

860 KC, 348.6 METERS
WABC-WBOQ-N. Y. City
KFQZ-Hollywood, Calif.

870 KC, 344.6 METERS
WLS-Crete, Ill.
S-Chicago, Ill.
WENR-WBCN-Chicago

***880 KC, 340.7 METERS**
WQAN-Scranton, Pa.
WGBI-Scranton, Pa.
WCOC-Columbus, Miss.
KLX-Oakland, Calif.
KPOF-Denver, Colo.
KFKA-Greeley, Colo.

***890 KC, 336.9 METERS**
WJAR-Providence, R. I.
WKAQ-San Juan, P. R.
WMMN-Fairmont, W. Va.
WMAZ-Macon, Ga.
WGST-Atlanta, Ga.
KGJF-Little Rock, Ark
WILL-Urbana, Ill.
KUSD-Vermillion, S. D.
KFNF-Shenandoah, Iowa

900 KC, 331.1 METERS
WFBL-Syracuse, N. Y.
WMAK-Martinsville, N. Y.
S-Buffalo, N. Y.
WKY-Okla. City, Okla.
WFLA-WSUN-Clearwater, Fla.
WLBL-Stevens Point, Wis.
KHJ-Los Angeles, Calif.
KSEI-Pocatello, Idaho
KGBU-Ketchikan, Alaska

****910 KC, 329.5 METERS**

920 KC, 325.9 METERS
WWJ-Detroit, Mich.
KPRC-Houston, Tex.
WAAF-Chicago, Ill.
KOMO-Seattle, Wash.

***930 KC, 322.4 METERS**
WIBG-Elkins Park, Pa.
WDBJ-Roanoke, Va.
WBRC-Birmingham, Ala.
KGBZ-York, Nebr.
KMA-Shenandoth, Iowa
KFWM-Oakland, Calif.
KFWI-San Francisco

940 KC, 319.0 METERS
WCSH-Portland, Maine
WFIW-Hopkinsville, Ky.
WHA-Madison, Wis.
KOIN-Sylvan, Ore.
S-Portland, Ore.
KGU-Honolulu, T. H.
KFEL-Denver, Colo.
KFXF-Denver, Colo.

950 KC, 315.6 METERS
WRC-Washington, D. C.
KMBC-Independence, Mo.
WHB-Kansas City, Mo.
KFWB-Hollywood, Calif.
KPSN-Pasadena, Calif.
KGHL-Billings, Mont.

****960 KC, 312.3 METERS**

970 KC, 309.1 METERS
WCFL-Chicago, Ill.
KJR-Seattle, Wash.

980 KC, 305.9 METERS
KDKA-Wilkins Township.
S-Pittsburgh, Pa.

990 KC, 302.8 METERS
WBZ-E. Springfield, Mass.
S-Boston, Mass.
WBZA-Boston, Mass.

1000 KC, 299.8 METERS
WHO-Des Moines, Iowa
WOC-Davenport, Iowa
KPLA-Los Angeles, Calif.

***1010 KC, 296.9 METERS**
WQAO-WPAP-Cliffside, N. J.
S-New York, N. Y.
WHN-New York, N. Y.
WRNY-Coytesville, N. J.
S-New York, N. Y.
KGGF-Picher, Okla.
WNAD-Norman, Okla.
KQW-San Jose, Calif.

1020 KC, 293.9 METERS
WRAX-Philadelphia.
KYW-KFKX-Chicago.
KYWA-Chicago.

****1030 KC, 291.2 METERS**

1040 KC, 288.3 METERS
WKEN-Grand Island, N.Y.
S-Buffalo, N. Y.
WKAR-E. Lansing, Mich.
WFAA-Dallas, Tex.
KRLD-Dallas, Tex.

1050 KC, 285.5 METERS
KFKB-Milford, Kans.
KNX-Los Angeles, Calif.
S-Hollywood, Calif.

1060 KC, 282.8 METERS
WBAL-Glen Morris, Md.
S-Baltimore, Md.
WTIC-Hartford, Conn.
WJAG-Norfolk, Nebr.
KWJJ-Portland, Ore.

1070 KC, 280.2 METERS
WAAT-Jersey City, N. J.
WTAM-Cleveland, Ohio
WEAR-Cleveland, Ohio
WCAZ-Carthage, Ill.
WDZ-Tuscola, Ill.
KJBS-San Francisco

1080 KC, 277.6 METERS
WBT-Charlotte, N. C.
WCBD-Zion, Ill.
WMBI-Chicago, Ill.

1090 KC, 257.1 METERS
KMOX-KFOA-Kirkwood
S-St. Louis, Mo.

1100 KC, 272.6 METERS
WPG-Atlantic City, N. J.
WLWL-Kearny, N. J.
S-New York, N. Y.
KGDM-Stockton, Calif.

1110 KC, 270.1 METERS
WRVA-Richmond, Va.
KSOO-Sioux Falls, S. D.

***1120 KC, 267.7 METERS**
WDEL-Wilmington, Del.
WCOA-Pensacola, Fla.
WTAW-College Sta., Tex.
KUT-Austin, Tex.
WISN-Milwaukee, Wis.
WHAD-Milwaukee, Wis.
KFSG-Los Angeles, Calif.
KRSC-Seattle, Wash.

1130 KC, 265.3 METERS
WJJD-Mooseheart, Ill.
WOV-Secaucus, N. J.
S-New York, N. Y.
KSL-Salt Lake City, Utah.

1140 KC, 263 METERS
WAPI-Birmingham, Ala.
KVOO-Tulsa, Okla.

1150 KC, 260.7 METERS
WHAM-Victor Township
S-Rochester, N. Y.

1160 KC, 258.5 METERS
WWVA-Wheeling, W. Va.
WOWO-Ft. Wayne, Ind.

1170 KC, 256.3 METERS
WCAU-Byberry, Pa.
S-Philadelphia, Pa.
KTNT-Muscatine, Iowa
KEJK-Beverly Hills, Calif.

1180 KC, 254.1 METERS
WDGY-Minneapolis, Minn.
WHDI-Minneapolis, Minn.
WGBS-Astoria, L. I.
S-New York City.
KEX-Portland, Ore.
KOB-State College, N. M.

1190 KC, 252 METERS
WICC-Easton, Conn.
S-Bridgeport, Conn.
WOAI-San Antonio, Tex.

***1200 KC, 249.9 METERS**
WABI-Bangor, Maine.
WNBX-Springfield, Vt.
WEPS-Gloucester, Mass.
WKBE-Webster, Mass.
WIBX-Utica, N. Y.
KGW-Stockton, Calif.
WHBC-Canton, Ohio.
WLAP-Louisville, Ky.
WLBG-Ettrick, Va.
WNBO-Washington, Pa.
WPRC-Harrisburg, Pa.
WKJC-Lancaster, Pa.
WNBW-Carbondale, Pa.
WABZ-New Orleans, La.
WJBW-New Orleans, La.
WBBY-Charleston, S. C.
WBBZ-Ponca City, Okla.
WFBC-Knoxville, Tenn.
WRBL-Columbus, Ga.
KGCU-Mandan, N. D.
WJBC-LaSalle, Ill.
WJBL-Decatur, Ill.
WWAE-Hammond, Ind.
WRAF-Laporte, Ind.
WMT-Waterloo, Iowa
KFJB-Marshalltown, Iowa
WCAT-Rapid City, S. D.
KGDY-Oldham, S. D.
WIL-St. Louis, Mo.
KFWF-St. Louis, Mo.
KFKZ-Kirksville, Mo.
KGDE-Fergus Falls, Minn.
KGFK-Hallock, Minn.
WCLO-Kenosha, Wis.
WHBY-West DePere, Wis.
KFWC-Ontario, Calif.
S-Pomona, Calif.
KPPC-Pasadena, Calif.
KXO-El Centro, Calif.
KMJ-Fresno, Calif.
KSMR-Santa Maria, Calif.
KGEK-Yuma, Colo.
KGEW-Ft. Morgan, Colo.
KFHA-Gunnison, Colo.
KVOS-Bellingham, Wash.
KGY-Lacey, Wash.

***1210 KC, 247.8 METERS**
WJBI-Red Bank, N. J.
WGBB-Freeport, N. Y.
WINR-Bayshore, N. Y.
WCOH-Greenville, N. Y.
S-Yonkers, N. Y.
WOCL-Jamestown, N. Y.
WLCI-Ithaca, N. Y.
WPAW-Pawtucket, R. I.
WDWF-WLSI-Cranston, R. I.
WMAN-Columbus, Ohio
WJW-Mansfield, Ohio
WEBE-Cambridge, Ohio
WBAX-Wilkes-Barre, Pa.
WJBU-Lewisburg, Pa.
WTAZ-Richmond, Va.
WMBG-Richmond, Va.
WSIX-Springfield, Tenn.
WRBU-Gastonia, N. C.
WJBY-Gadsden, Ala.
WMBR-Tampa, Fla.
WRBQ-Greenville, Miss.
WGCM-Gulfport, Miss.
KWEA-Shreveport, La.
KDLR-Devils Lake, N. D.
KGCR-Watertown, S. D.
KFOR-Lincoln, Neb.
WHBU-Anderson, Ind.
KFVS-Cape Girardeau, Mo.
WEBQ-Harrisburg, Ill.
WSBC-Chicago, Ill.
WCRW-Chicago, Ill.
WEDC-Chicago, Ill.
WCBS-Springfield, Ill.
WTAX-Streator, Ill.
WHBF-Rock Island, Ill.
WIBA-Madison, Wis.
WOMT-Manitowoc, Wis.
KPQ-Seattle, Wash.
KPCB-Seattle, Wash.

1220 KC, 245.8 METERS
WCAD-Canton, N. Y.
WCAE-Pittsburgh, Pa.
WREN-Lawrence, Kan.
KFKU-Lawrence, Kan.

1230 KC, 243.8 METERS
WNAC-Boston
WBIS-Boston
WPSC-State College, Pa.
WSBT-South Bend, Ind.
WFBM-Indianapolis, Ind.
KYA-San Francisco, Calif.
KFIO-Spokane, Wash.
KFQD-Anchorage, Alaska

1240 KC, 241.8 METERS
WGHP-Fraser, Mich.
S-Detroit, Mich.
KTAT-Ft. Worth, Tex.
WJAD-Waco, Tex.
WQAM-Miami, Fla.
WRBC-Valparaiso, Ind.

1250 KC, 239.9 METERS
WGCP-Newark, N. J.
WODA-Paterson, N. J.
WAAM-Newark, N. J.
WLB-WGMS-Minneapolis
WRHM-Fridley, Minn.
KFMX-Northfield, Minn.
WCAL-Northfield, Minn.
KFOX-Long Beach, Calif.
KXL-Portland, Ore.
KILO-Boise, Idaho

1260 KC, 238 METERS
WLBW-Oil City, Pa.
WJAX-Jacksonville, Fla.
KVOA-Tucson, Ariz.
KWWG-Brownsville, Tex.
KRGV-Harlingen, Tex.
KOIL-Council Bluffs, Ia.

1270 KC, 236.1 METERS
WJDX-Jackson, Miss.
WEAI-Ithaca, N. Y.
WFBR-Baltimore, Md.
WASH-Grand Rapids, Mich.
WOOD-Furnwood, Mich.
S-Grand Rapids, Mich.
WDSU-New Orleans, La.
KWLC-Decorah, Iowa
KGCA-Decorah, Iowa
KTW-Seattle, Wash.
KOL-Seattle, Wash.
KFUM-Colo. Springs, Col.

1280 KC, 234.2 METERS
WCAM-Camden, N. J.
WCAP-Asbury Park, N.J.
WOAX-Trenton, N. J.
WDOD-Chattanooga, Tenn.
WRR-Dallas, Tex.
WDAY-Fargo, N. D.
WEBC-Superior, Wis.
S-Duluth, Minn.

1290 KC, 232.4 METERS
WNBZ-Saranac Lake, N. Y.
WJAS-Pittsburgh, Pa.
KTSA-San Antonio, Tex.
KFUL-Galveston, Tex.
KLCN-Blytheville, Ark.
KDYL-Salt Lake City

1300 KC, 230.6 METERS
WBBR-Rossville, N. Y.
WHAP-Carlstadt, N. J.
S-New York, N. Y.
WEVD-Woodhaven, N. Y.
S-New York, N. Y.
WHAZ-Troy, N. Y.
KFH-Wichita, Kan.
WIBW-Topeka, Kan.
KGEF-Los Angeles
KTBI-Los Angeles
KFJR-Portland, Ore.
KTBR-Portland, Ore.

1310 KC, 228.3 METERS
WKAV-Laconia, N. H.
WEBR-Buffalo, N. Y.
WNBH-New Bedford, Mass.
WOL-Washington, D. C.
WGH-Newport News, Va.
WRK-Hamilton, Ohio
WAGM-Royal Oak, Mich.
WFDF-Flint, Mich.
WNAT-Philadelphia, Pa.
WFKD-Frankford, Pa.
S-Philadelphia.
WHBP-Johnstown, Pa.
WFBG-Altoona, Pa.
WRAW-Reading, Pa.
WGAL-Lancaster, Pa.
WRBI-Tifton, Ga.
WSAJ-Grove City, Pa.
WBRE-Wilkes-Barre, Pa.
WMBL-Lakeland, Fla.
WKBC-Birmingham, Ala.
KGHG-McGehee, Ark.
WOBT-Union City, Tenn.
WNBJ-Knoxville, Tenn.
KRMD-Shreveport, La.
KTSL-Cedar Grove, La.
S-Shreveport, La.
KFPM-Greenville, Tex.
WDAH-El Paso, Tex.
KGFI-Corpus Christi, Tex.
KFPL-Dublin, Tex.
KFXR-Okla. City, Okla.
WKBS-Galesburg, Ill.
WEHS-Evanston, Ill.
WCLS-Joliet, Ill.
WKBB-Joliet, Ill.
WKBI-Chicago, Ill.
WHFC-Cicero, Ill.
KWCR-Cedar Rapids, Ia.
KFJY-Ft. Dodge, Ia.
KFGQ-Boone, Ia.
WBOW-Terre Haute, Ind.
WJAK-Marion, Ind.
WLBC-Muncie, Ind.
WIBU-Poynette, Wis.
KFBK-Sacramento, Calif.
KGEZ-Kalispell, Mont.
KFUP-Denver, Colo.
KFXJ-Edgewater, Colo.
KMED-Medford, Ore.
WJDZ-Winston Salem, N. C.

1320 KC, 227.1 METERS
WADC-Akron, Ohio
WSMB-New Orleans, La.
KGIO-Idaho Falls, Idaho
KGIQ-Twin Falls, Idaho
KGHF-Pueblo, Colo.
KID-Idaho Falls, Idaho

1330 KC, 225.4 METERS
WDRC-New Haven, Conn.
WSAI-Harrison, Ohio
S-Cincinnati
WTAQ-Washington, Wis.
S-Eau Claire, Wis.
KSCJ-Sioux City, Iowa

1340 KC, 223.7 METERS
WSPD-Toledo, Ohio
KFPW-Siloam Springs, Ark.
KMO-Tacoma, Wash.

1350 KC, 221.1 METERS
WBNY-New York, N. Y.
WMSG-New York, N. Y.
WCDA-New York, N. Y.
WKBQ-New York, N. Y.
KWK-St. Louis, Mo.

1360 KC, 220.4 METERS
WLEX-Lexington, Mass.
WMAF-South Dartmouth, Mass.
WQBC-Utica, Miss.
WJKS-Gary, Ind.
WGES-Chicago, Ill.
KFBB-Great Falls, Mont.
KGIR-Butte, Mont.
KGB-San Diego, Calif.

1370 KC, 218.8 METERS
WMBO-Auburn, N. Y.
WSVS-Buffalo, N. Y.
WCBM-Baltimore, Md.
WBBL-Richmond, Va.
WHBD-Bellefontaine, O.
WHDF-Calumet, Mich.
WJBK-Ypsilanti, Mich.
WJDW-Emory, Va.
WIBM-Jackson, Mich.
WRAK-Erie, Pa.
WELK-Philadelphia.
WJBO-New Orleans, La.
WHBQ-Memphis, Tenn.
WRBT-Wilmington, N. C.
KGFG-Okla. City, Okla.
KCRC-Enid, Okla.
KGCI-San Antonio, Tex.
KGRC-San Antonio, Tex.
KFJZ-Ft. Worth, Tex.
KGKL-San Angelo, Tex.
KFLX-Galveston, Tex.
WFBJ-Collegeville, Minn.
WGL-Ft. Wayne, Ind.
KGDA-Dell Rapids, S. D.
KFJM-Grand Forks, N. D.
KWKC-Kansas City, Mo.
KGBX-St. Joseph, Mo.
WRJN-Racine, Wis.
KGAR-Tucson, Ariz.
KIT-Yakima, Wash.
KOH-Reno, Nev.
KZM-Hayward, Calif.
KRE-Berkeley, Calif.
KGER-Long Beach, Calif.
KLO-Ogden, Utah
KOOS-Marshfield, Ore.
KFBL-Everett, Wash.
KVL-Seattle, Wash.
KFJI-Astoria, Ore.
KGFL-Raton, N. M.
KGGM-Albuquerque, N.M.

1380 KC, 217.3 METERS
WCSO-Springfield, Ohio.
KQV-Pittsburgh, Pa.
KSO-Clarinda, Ia.
WKBH-LaCrosse, Wis.

1390 KC, 215.7 METERS
WHK-Cleveland, O.
KLRA-Little Rock, Ark.
KOY-Phoenix, Ariz.
KUOA-Fayetteville, Ark.
KOW-Denver, Colo.
KWSC-Pullman, Wash.
KFPY-Spokane, Wash.

1400 KC, 214.2 METERS
WCGU-Coney Isl., N. Y.
WSGH-WSDA-Bklyn, N Y
WLTH-Brooklyn, N. Y.
WBBC-Brooklyn, N. Y.
KOCW-Chickasha, Okla.
WCMA-Culver, Ind.
WKDF-Indianapolis, Ind.

1410 KC, 212.6 METERS
WBCM-Hampton, Mich.
S-Bay City, Mich.
KGRS-Amarillo, Tex.
WDAG-Amarillo, Tex.
KFLV-Rockford, Ill.
WHBL-Sheboygan, Wis.
WSGP-Savannah, Ga.

1420 KC, 211.1 METERS
WHDL-Tupper Lake, N.Y.
WHIS-Bluefield, W. Va.
WLBH-Patchogue, N. Y.
WMRJ-Jamaica, N. Y.
WLEY-Lexington, Mass.
WTBO-Cumberland, Md.
WSSH-Boston, Mass.
WPOE-Patchogue, N. Y.
WIBR-Steubenville, O.
WILM-Wilmington, Del.
WEDH-Erie, Pa.
WMBC-Detroit, Mich.
WKBP-Battle Creek, Mich.
WQBZ-Weirton, W. Va.
KGFF-Alva, Okla.
KTAP-San Antonio, Tex.
KTUE-Houston, Tex.
KFYO-Abilene, Tex.
KICK-Red Oak, Iowa
WIAS-Ottumwa, Iowa
WLBF-Kansas City, Kan.
WMBH-Joplin, Mo.
KGFW-Ravenna, Neb.
KFIZ-Fond du Lac, Wis.
KFXY-Flagstaff, Ariz.
KGFJ-Los Angeles, Calif.
KFQU-Holy City, Calif.
KGGC-San Francisco.
KFXD-Jerome, Idaho
KGIW-Trinidad, Colo.
KGCX-Vida, Mont.
KFIF-Portland, Ore.
KORE-Eugene, Ore.
KFQW-Seattle, Wash.
KXRO-Aberdeen, Wash.

1430 KC, 209.7 METERS
WBRL-Manchester, N. H.
WHP-Harrisburg, Pa.
WBAK-Harrisburg, Pa.
WCAH-Columbus, Ohio
WGBC-Memphis, Tenn.
WNBR-Memphis, Tenn.

1440 KC, 208.2 METERS
WHEC-WABO-Rochester, N. Y.
WOKO-Mt. Beacon, N. Y.
S-Poughkeepsie, N.Y.
WCBA-Allentown, Pa.
WSAN-Allentown, Pa.
WNRC-Greensboro, N. C.
WTAD-Quincy, Ill.
WMBD-Peoria Hts., Ill.
KLS-Oakland, Calif.

1450 KC, 206.8 METERS
WBMS-Fort Lee, N. J.
WNJ-Newark, N. J.
WIBS-Elizabeth, N. J.
WKBO-Jersey City, N. J.
WSAR-Fall River, Mass.
WFJC-Akron, Ohio
KTBS-Shreveport, La.
WTFI-Toccoa, Ga.

1460 KC, 205.4 METERS
WJSV-Mt. Vernon, Va.
KSTP-Westcott, Minn.
S-St. Paul, Minn.

1470 KC, 204 METERS
WKBW-Amherst, N. Y.
S-Buffalo, N. Y.
KFJF-Okla. City, Okla.
WRUF-Gainesville, Fla.
KGA-Spokane, Wash.

1480 KC, 202.6 METERS
WJAZ-Mt. Prospect, Ill.
S-Chicago, Ill.
WSOA-Deerfield, Ill.
S-Chicago, Ill.
WORD-Batavia, Ill.
S-Chicago, Ill.
WCKY-Villa Madonna, Ky.
S-Covington, Ky.

1490 KC, 201.2 METERS
WBAW-Nashville, Tenn.
WLAC-Nashville, Tenn.
KPWF-Westminster, Calif.

1500 KC, 199.9 METERS
WMBA-Newport, R. I.
WLOE-Chelsea, Mass.
WMES-Boston, Mass.
WNBF-Binghamton, N. Y.
WMBQ-Brooklyn, N. Y.
WLBX-L. I. City, N. Y. C.
WCLB-Long Beach, N. Y.
WWRL-Woodside, N. Y.
WAFD-Detroit, Mich.
WKBZ-Ludington, Mich.
WMPC-Lapeer, Mich.
WMBJ-Wilkinsburg, Pa.
S-Pittsburgh, Pa.
WOPI-Bristol, Tenn.
WPSW-Philadelphia.
KGHI-Little Rock, Ark.
WRBJ-Hattiesburg, Miss.
KGKB-Brownwood, Tex.
KGDR-San Antonio, Tex.
KGHX-Richmond, Tex.
WKBV-Brookville, Ind.
KPJM-Prescott, Ariz.
KWBS-Portland, Ore.
KWTC-Santa Ana, Calif.
KDB-Santa Barbara, Calif.
KUJ-Long View, Wash.

Alphabetical List of Stations by Call Letters; Location and Frequency

[FROM FEDERAL RADIO COMMISSION LIST REVISED UP TO NOON, JUNE 12TH]

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—Covington, Ky., 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
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
WHB—Kansas City, Mo., 950
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.
WJDW—Emory, Va., 1370
WJDX—Jackson, Miss., 1270
WJDZ—W. Salem, N. C., 1310
WJJD—Mooseheart, Ill., 1130
WJKS—Gary, Ind., 1360
WJR—Detroit, Mich., 750
WJSV—Mt.Vernon Hills,Va., 1460
WJW—Mansfield, O., 1210
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
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
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
WQAN—Scranton, Pa., 880
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
WSBC—Chicago, 1210
WSBT—South Bend, Ind., 1230
WSDA-WSGH—See WSGH
WSGH-WSDA—Bklyn.,NY. 1400
WSGP—Savannah, Ga., 1410
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
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
KGHF—Pueblo, Colo., 1320
KGGM—Albuquerque, N.M., 1370
KGHG—McGehee, Ark., 1310
KGHI—Little Rock, Ark., 1500
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—Sand 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
KMIC—Inglewood, Calif., 1120
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
KWG—Stockton, Calif., 1200
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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Alphabetical List of Stations by Call Letters; Location and Frequency

[FROM FEDERAL RADIO COMMISSION LIST REVISED UP TO NOON, JUNE 12TH]

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—Covington, Ky., 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
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
WHB—Kansas City, Mo., 950
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.
WJDW—Emory, Va., 1370
WJDX—Jackson, Miss., 1270
WJDZ—W. Salem, N. C., 1310
WJJD—Mooseheart, Ill., 1130
WJKS—Gary, Ind., 1360
WJR—Detroit, Mich., 750
WJSV—Mt. Vernon Hills, Va., 1460
WJW—Mansfield, O., 1210
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
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
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
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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
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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
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WPSC—State College, Pa., 1230
WPSW—Philadelphia, Pa., 1500
WPTF—Raleigh, N. C., 680
WQAM—Miami, Fla., 1240
WQAN—Scranton, Pa., 880
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
WSBC—Chicago, 1210
WSBT—South Bend, Ind., 1230
WSDA-WSGH—See WSGH
WSGH-WSDA—Bklyn., NY. 1400
WSGP—Savannah, Ga., 1410
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
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
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
KMIC—Inglewood, Calif., 1120
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
KWG—Stockton, Calif., 1200
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
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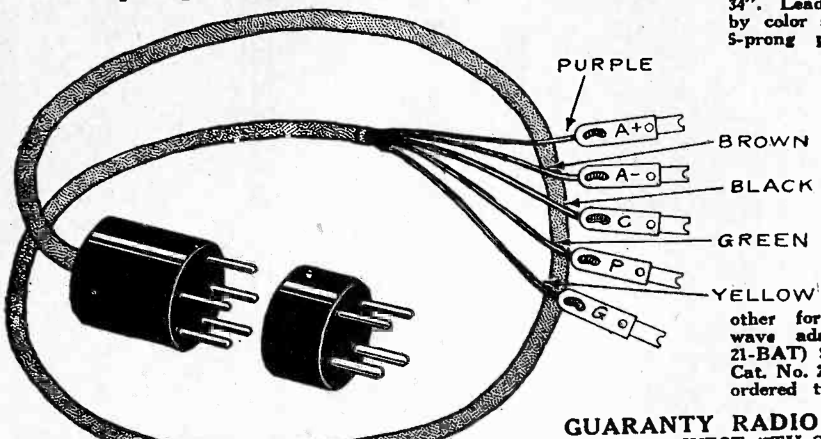

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