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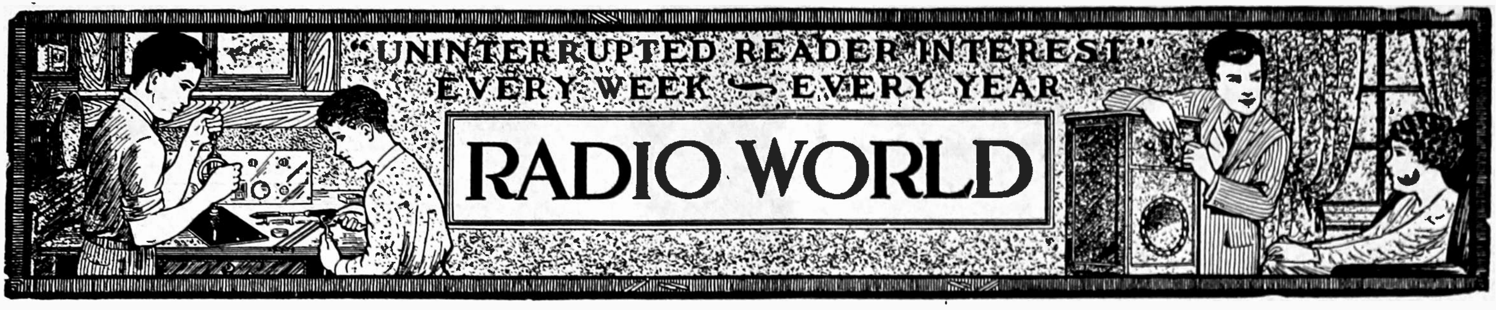

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The First Complete Receiver Circuit with

Non-Reactive Audio

The Tone-Marvelous NR-4 Uses Only Four Tubes

By Roger T. Rawley

HERE is the first circuit offered to constructors, embodying non-reactive audio frequency amplification and including a tuner with radio frequency stage.

The potential across the divider, in excess of 300 volts, is apportioned to the detector tube (the second 224) and the power tube, a 245. This voltage is utilized in series in non-reactive circuits, so that, in general, any voltage used for the detector is taken away from the total, leaving the remainder for the power tube plate potential. No deduction need be made for the bias of the power tube, as this is voltage derived from the potential drop in the plate resistor, R2.

However, in the radio frequency stage, the screen grid and plate voltages are taken off the B supply in parallel, the more familiar practice, with very slight diminution of the total available potential for the non-reactive circuit.

HOW ABOUT 374 VOLTS ARE OBTAINED

The necessary higher voltage than 300 is obtained from a power transformer that is rated at 300 volts at 80 milliamperes when filter chokes totalling 800 ohms resistance are used. Here the maximum drain, which is through only a part of the voltage divider, is only about 50 milliamperes, so, due to the regulation of the 280 rectifier, more than 300 volts are available. The excess is made greater still by use of a single choke, Ch, with a direct current resistance of about 400 ohms. As the current is only 50 milliamperes, the drop in the choke is 20 volts, instead of 64 volts in 800 ohms. Hence, 300 + 30 regulation + 44 = 374 volts. The 280 tube will stand this voltage at 50 milliamperes.

The diagram has been arranged so as to make it easy to distinguish the features of the newly popular non-reactive circuit and the radio frequency stage. With this in view, the positive of the B supply is shown below in Fig. 1, instead of on top. Thus at a glance one can appreciate that the output potential of the rectifier is dropped across the voltage divider R4, zero potential being (1), and the higher potentials being (2), (3), (4) and (5) respectively.

Let us take the detector tube as the first example.

The cathode is connected to grounded negative B through a biasing resistor, R2, so that negative bias detection is used. The screen grid is connected to the first elevated potential, (2). The plate voltage is applied at point (4). So if 124 volts are read between (1) and (4), then, if 374 constitute the total, 250 volts remain for the power tube. R3 should drop 50 volts under those conditions, and can be of a chosen value to produce that result. Then the power tube grid is negative 50 volts in respect to its grid return. Note that the grid of the power tube and the plate of the detector tube return to the same point. However, the voltages for the power tube are reckoned in respect to the midtap of its filament winding, which midtap (4) is positive 50 volts in respect to the grid. The rated bias for a 245 tube with 250 plate volts is 50 volts negative. The detector voltages are reckoned in respect to its cathode.

WHERE PLATE VOLTAGE IS OBTAINED

The power tube plate voltage is the drop between (4) and (5), between the power tube filament center and the plate connection to maximum of the B supply. The actual voltage effective on the plate will be less than 250, due to the drop in the loudspeaker winding. No output filter is shown, since dynamic speakers are

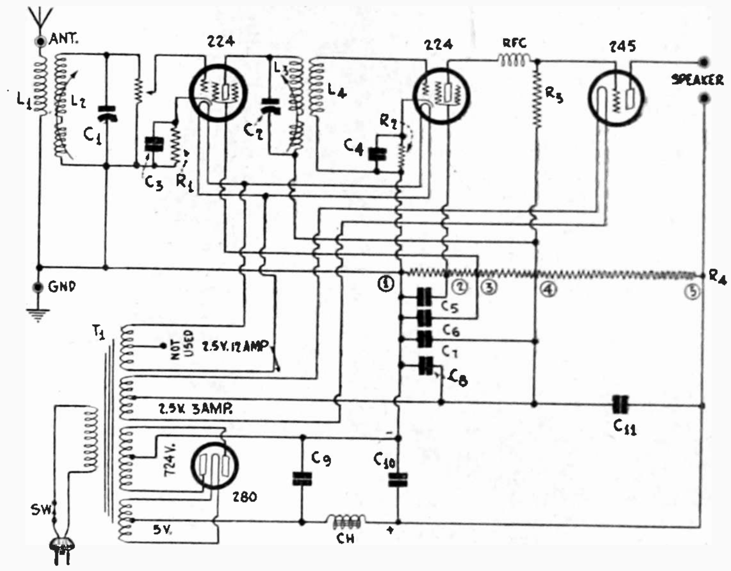

FIG. 1
A COMPLETE CIRCUIT, USING A STAGE OF SCREEN GRID AF AHEAD OF A NON-REACTIVE AUDIO AMPLIFIER OF THE TYPE SO POPULAR AT PRESENT.

LIST OF PARTS

L1L2, C1—Bernard antenna tuner assembly, including link, coil, condenser. Cat. BT-L-AC.
L3L4, C2—Bernard interstage tuner assembly, including link, coil, condenser. Cat. BT-R-AC.
R—Volume control, 0-500,000 ohm Electrad Tonatrol potentiometer.
R1—800 ohm Electrad resistance strip.
R2—20,000 ohm resistor leak with mounting (1.02 meg.).
R3—0.5 meg. resistor leak with mounting.
R4—Multi-Tap Voltage Divider.
C3—.01 mfd. condenser.
C4, C5, C6, C7, C8, C11—Six 1 mfd. 200 volt. DC.
C9, C10—Two 1 mfd. 1,000 volt DC.
RFC—Shielded RF choke, 65 millihenrys.
T1—Polo filament-plate supply. Cat. PFPS.
Ch—Polo single choke. Cat. PSC.
Ant., Grid., Sp—, Sp+—Four binding posts, drilled metal subpanel with sockets on.
SW—One pendant AC switch with 12 ft. AC cable.
Tubes—Two 224, one 245, one 280.
Subpanel and front panel insulators.
Two dials.
7x18" bakelite drilled front panel.

Fixed Resistance Values

Guesswork Eliminated from Design That

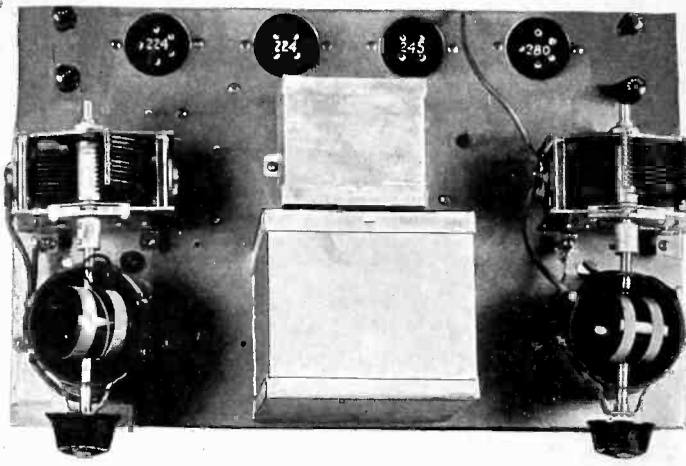

FIG. 2
VIEW OF THE NR-4, WITH NON-REACTIVE AUDIO AMPLIFIER .

used so widely, and have output devices built in, and also because the modern magnetic speakers, including the inductors, will stand the 32 milliamperes without need of a filter.

245 AMPLE OUTPUT

The 245 power tube is ample for this circuit, since it has an undistorted power output of 1,600 milliwatts maximum, under the stated voltage conditions. This is in excess of any load that will be placed upon it, as the audio amplification gain is about 372. What the actual load on the power tube will be will depend on how the radio frequency amplifier is worked, and the field strength of the station tuned in. The RF tube may be worked at enormous gain, by using high voltage or may be worked at a lower level at lower voltages.

Enough volume is obtained for speaker operation either way, and the tone quality is particularly good, in fact, about as good as there is.

What the sensitivity is depends on the RF gain and the operating point of the detector. There should be no expectation of covering enormous distances with this receiver, but the finest kind of reproduction of those stations received certainly is to be expected. For instance, in New York City, all the locals are tuned in clearly, without interference, and there are some 25 stations rated as locals.

IMPROVED SELECTIVITY

Selectivity is better than one is accustomed to in a stage of RF and a detector, due principally to the higher bias used on the detector, which increases the detector input impedance and incidentally reduces hum.

The circuit is arranged so that it is easy to follow the diagram, and the parts chosen are such that no variable resistors are introduced, except the volume control, and this control should not interfere with the biasing, screen grid or plate voltage, as the entire apportionment in the chain would be upset thereby.

The circuit, as diagrammed, is stable at audio frequencies.

There is an interdependence in the audio voltages and currents so close in its intimate relationship as not to be found in circuits of more familiar patterns. The principal factors are:

(1)—The plate voltage is applied to the power tube and current is used for its voltage effects on the detector.

(2)—The resistance value of R3, in conjunction with the voltage applied thereto, in part determines the bias on the last tube and the voltage drop in the detector load.

(3)—The bias on the detector tube also determines in part the drop in R3 and the bias on the last tube.

DEVIATION FROM RATED VALUES

In getting the circuit to work properly it may be necessary to deviate slightly from the rated current at existing power tube plate voltage. For instance, with 200 effective plate volts, the circuit shown was made operative when 22 milliamperes were flowing, under signal load, instead of 32 milliamperes, and thus was the voltage 200, when R2 was .02 meg. (20,000 ohms) and R3 was 0.5 meg. (500,000 ohms). The deviation is due mainly to the use of commercial values of fixed resistance for R2 and R3.

From the foregoing it is obvious that if too high a value is chosen for R3 the voltage drop will be too great, or if the detector plate voltage is too high, the same result is obtained, while R2 works in the other direction, the lower its value the greater the drop in R3. A mischievous combination would result in full voltage on the plate, 374 or more, with no current flowing whatsoever in the power tube plate circuit. This fact of "all voltage and no current" will puzzle many, until they realize that for any given plate voltage the negative bias may be raised so high as to cut off the plate current.

So, for operating purposes, you may choose 0.5 meg. for R3 and select a value for R2 which will enable the power tube to function, as when that functioning takes place the rest of the circuit will give good results. R2 may be 20,000 ohms (.02 meg.) for good detection, or even .01 meg., because the sum of the plate and screen currents is so exceedingly small.

WHICH TAPS WERE USED

There is a small problem at the detector. The bias required for detection must be obtained. Then, with this bias, the rest of the constants, including voltages, must be so chosen that the drop in R3 is correct for a required plate voltage on the 245 and consequent power tube plate current. Except by alteration of the point of connection (4), and or by using another detector screen voltage, this detecting point depends on R2. The higher the screen grid voltage or plate voltage, the larger the current through R2, excepting of course that the plate voltage always must be higher than the screen grid voltage.

So many chances exist for going wrong with adjustable resistors that this non-reactive amplifier is made wholly free of them, in fact, so is the radio frequency amplifier, except alone for the volume control.

The Multi-Tap Voltage Divider was used. This has fifteen taps, but two are interconnected, as there are two resistors in series, hence the junction is considered as one tap. On that basis, the taps used were the lower extreme lug (1), negative and ground; the second for the screen of the detector tube (2), while counting from the other end, the fourth was used for RF plate, and also for the power tube filament center tap (4). Under those conditions R2 was .02 meg., as diagrammed.

HOW TO BUILD AMPLIFIER

In constructing the receiver, follow the circuit diagram implicitly. Any changes should be on the basis of directions to be given presently. Insert the resistance values as stated. Do not connect the speaker in circuit when you make the test at first. Put a choke coil in place of the speaker, or simply connect plate to B plus, without any load, as the current difference will not be substantial. Just as it is possible to get around 374 volts on the last tube, and no current, so it is also possible to get 100 milliamperes and only a little voltage, and the high current would flow through the speaker winding under mistaken conditions.

Right or

(1)—In the Loftin-White amplifier the voltages to be applied to the various elements are not critical.

(2)—In this circuit the grid bias on the power tube does not depend in any way on the grid voltage, screen voltage and plate voltage on the first tube.

(3)—An inductance in an electrical circuit is like a weight in a moving body or like a flywheel in rotating machinery.

(4)—A condenser in an electrical circuit is like a spring in a mechanism such as the hair spring in a watch.

(5)—Electricity behaves toward a condenser as air behaves toward a bottle.

(6)—Repeat tuning in a radio frequency amplifier receiver is due to detection in the radio frequency tubes, especially in the first tube in the circuit.

(7)—Most of the repeat tuning can be eliminated by tuning the input circuit of the receiver so that only the desired carried is effective on the grid of the first tube.

(8)—When a phonograph is connected to an audio amplifier it should be connected from the grid of the first amplifier tube to the negative of the grid bias battery or resistor.

(9)—Resistance coupled amplifiers are the most stable because there are no reactances to emphasize any one frequency.

(10)—It makes no difference how long the filament leads are between the power transformer and the tubes. The voltage across the tubes is independent of the length.

ANSWERS

(1)—Wrong. The voltages are very critical and if they are not adjusted to the correct values the amplifier will not work at all.

(2)—Wrong. The bias on the grid of the last tube depends on the current that flows in the coupling resistor just ahead of the tube and this current depends on all the voltages applied to the tube ahead of the power tube.

n Non-Re-active Circuit

Requires Careful Apportionment of Values

So test the power tube for plate current and plate voltage. If you have a Jiffy Tester simply plug into the power tube socket and put the power tube in the tester socket. If the current is from 20 to 35 milliamperes you may safely connect the speaker and try out the set.

The plate current will decrease as a signal is tuned in, due to the signal increasing the plate current flow through R3. The circuit should be balanced for operation on a signal, that is, around 20 milliamperes should flow when a strong station is being received. Hence on weak stations, or no station being tuned in, the current will be greater, possibly by 30 per cent. However the values stated take that in account, and no other requirement for balance actually should exist.

In actual operation the starting values are not the ones to be reckoned with, as the detector tube is a heater tube, and the values are not effective until the tube heats up and current flows therein. So even if the current is considerably in excess of expectations, wait a few second or so and you will find the current recedes and assumes a permanent no-signal value. This should be in excess of the current present when a signal is to be tuned in.

The high starting current in the last tube will not hurt the speaker, as the current quickly recedes.

The radio frequency voltage may be as you desire. Medium voltages are shown on the voltage divider illustration. The screen grid voltage (3) may be moved to the left to get rid of RF oscillation, if any, while if moved to the right, volume will increase. Select which screen grid voltage best suits your requirements. This applies to the RF tube.

COILS USED

The radio frequency coils used are Bernard tuners. These come already assembled with condensers included, as Cat. BT-L-AC for the antenna coil L1L2, and BT-R-AC for the interstage coil, L3L4. These may be mounted on the chassis to give clockwise or counterclockwise tuning, or half and half, so that the hands are turned in opposite directions to make the two circuits operate in the same electrical direction.

The condenser shafts are connected to the coil shafts and the same motion turns both. You are assured of tuning in the entire band of wavelengths, as a moving coil as part of the secondary first bucks, then aids the fixed part of the secondary, adding variometer tuning to the condenser tuning.

The only trick is to get both moving coils operating in the same direction, that is, both aiding when they should aid and both bucking when they should buck.

As the circuits are independently tuned, it is easy to check up

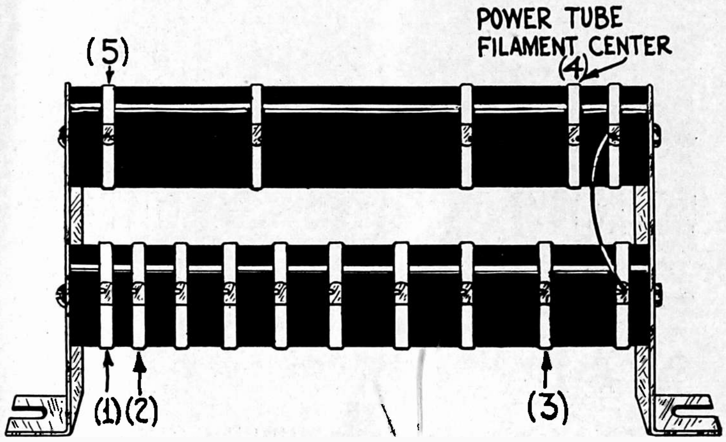

FIG. 3
CONNECTIONS TO THE VOLTAGE DIVIDER, CORRESPONDING TO NUMERICAL DESIGNATIONS IN FIG. 1.

on this. Tune in a station on the highest receivable wavelength, requiring the plates to be almost entirely enmeshed. Suppose it is 526 meters and comes in around 95. It is obvious the highest wavelength could not be tuned in, so reverse the moving coil, simply by turning it alone around 180 degrees. This will require retuning, and the station that came in at 95 will come in at 85 or thereabouts. Do the same with the other circuit, but remember that the dials will not track. Use an equalizing condenser if you desire to bring the readings about the same. Put the condenser across the tuning condenser in the circuit that now calls for the engagement of greater capacity to attain resonance, which on normal dials is the circuit that tunes numerically higher than the other to the same resonant frequency. This is usually the secondary in the antenna circuit.

The antenna coil is the one with two windings on the outside form, a small one for the aerial-ground circuit, a large one connected in series with the moving segment. The extremes of the secondary are brought out to lugs at the factory, so there are only the four usual connections, and it makes no difference which end of secondary goes to grid.

Also on the other coil there are only four connections. In the second coil the primary in the plate circuit is the combination winding, while the secondary is the large fixed winding on a separate form inside.

It is desirable to have the primary tuned and not the detector grid in this instance as the 224 detector in the non-reactive audio amplifier works better that way, but the rotor of the tuning condenser then may not be grounded as it is when mounted on the steel chassis, provided the chassis is connected to ground and made B minus.

It is desirable to throttle radio frequencies at the detector plate, especially as the audio channel is a good RF amplifier, so a shielded radio frequency choke coil is used. It is hard to locate a condenser in this plate circuit so that the return will not result in negative feedback, hence decreased amplification, so an RF choke is preferable.

TROUBLE SHOOTING

The apportionment of voltages, in conjunction with the specified voltage divider, plate-grid resistor and two independent biasing resistors is such that good results should obtain. The actual milliampere reading on the last tube proved to be 22 ma and the effective (not applied) plate voltage 200.

The radio frequency side will work well under these conditions, and without squealing. However, the RF side may be made more selective, but less stable, by moving the power tube filament center to the junction of the two resistors in the voltage divider, connecting the RF plate return to the same place, and the RF screen grid to the lug next further down.

It is advisable to avoid regenerative effects because of resonance hum. It will be noted that the circuit produces virtually no hum. Turn the condensers to full capacity setting and try to hear a hum. It can be heard, but it is so faint as to be wholly unobjectionable.

Now tune in a station. The circuit should not hum. If it does, it is due to hum modulation impressed on an oscillatory RF or detector tube.

All hum heard is present in the power tube. The filament winding of this circuit is accurately center-tapped in the Polo block. But if resonance hum is experienced it is necessary to unbalance the filament of the last tube. Disconnect the red center tap lead of the 2.5 volt 3 ampere winding, put a 20-ohm potentiometer across this winding, and use the center lug of the potentiometer as the lead to replace the red one. Turn the potentiometer knob until the hum disappears. Then cut off the red lead or tape the end and coil it up for future use.

Vrong?

(3)—Right. Inductance is what is known as electrical mass and it responds to changes in current just as a mass responds to changes in velocity.

(4)—Right. A condenser has the property of electrical resilience. The capacity is the reciprocal of this property. For every formula involving a condenser there is a counterpart in mechanics in which the compliance of a spring enters the same way as the capacity of the condenser.

(5)—Right. A condenser might be considered equivalent to a bottle. The leads to the condenser are the mouth and pipes leading to the bottle. A bottle can be charged with air just as a condenser can be charged with electricity. The back voltage in the condenser corresponds to the back pressure in the bottle.

(6)—Right. The grid voltage plate current curves of tubes are always bent more or less and the greater the curvature the greater the detection. If the first tube detector doubles the frequency of the carrier the other tubes amplify the double frequency.

(7)—Right. If the first tube receives only the carrier frequency any detection on this frequency cannot result in appreciable interference.

(8)—Right. The first tube is to operate as an amplifier and when the pick-up unit is connected as suggested the tube becomes an amplifier, or remains so.

(9)—Wrong. This statement is often made, but it is not based on experimental evidence. The resistance coupled amplifier is usually the most unstable, judging by experimental evidence, instead of inadequate theoretical considerations.

(10)—Wrong. The filament leads should be as short as practicable because if there is considerable current flowing the voltage drop in the leads will be so high that the tubes will not get enough. An alternative for short leads is to use heavy leads.

A Complete History of

The Development of Audio Channels on AC o

By J. E

Technic

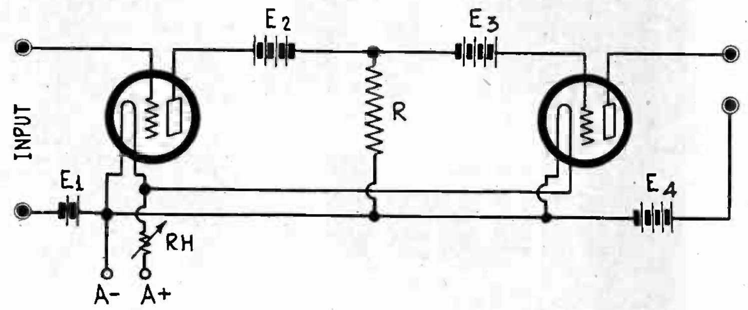

FIG. 1
THE ARNOLD METHOD OF COUPLING TUBES WITH A NON-REACTIVE RESISTANCE. SEPARATE PLATE AND GRID BATTERIES ARE USED FOR THE TWO TUBES.

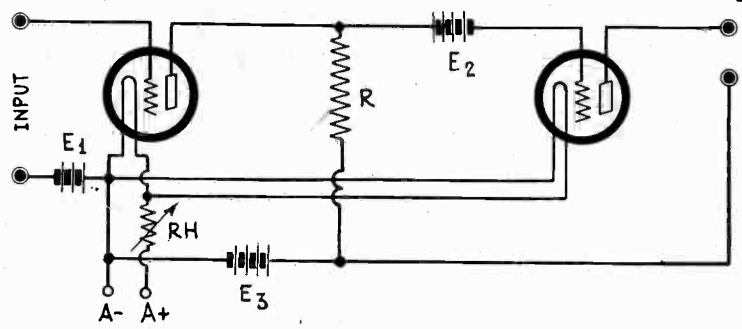

FIG. 2
A VARIATION OF THE ARNOLD CIRCUIT IN WHICH A COMMON PLATE BATTERY IS USED FOR THE TWO TUBES, BUT SEPARATE GRID BATTERIES.

NON-REACTIVE amplifiers are nearly as old as the vacuum tube amplifier itself. They had their origin in the pre-broadcasting era and were then used for the purpose of amplifying audio frequency currents whenever it was essential to maintain the highest form of quality. From time to time these circuits have been published but very little popular interest in them has been aroused until recently.

It is the purpose of this article to review the development of this type of circuit from the beginning to the present time.

In Figs. 1, 2 and 3 we have three different non-reactive, direct coupled circuits given in Van der Bijl's book on the thermionic vacuum tube and there credited to Dr. H. D. Arnold and R. V. L. Hartley of the Western Electric Company, now the Bell Telephone Laboratories. That book came out in 1920 and the circuits had been patented at that time, so that they were not new ten years ago. But the interest in them at this time is brand new for heretofore the interest in such circuits have been limited to laboratories.

THE ARNOLD CIRCUIT

In Fig. 1 we have the simple Arnold circuit in which the two tubes are coupled by means of a resistance R. The various batteries shown in the diagram are not a part of the coupling scheme for they merely serve to give the grids and the plates the proper voltages. Battery E1 serves to maintain the grid of the first tube at a suitable negative voltage for amplification. Its value depends on the intensity of the signal impressed on the input terminals of the circuit, on the amplification constant of the tube, and on the plate voltage applied to that tube by battery E2. For a weak signal 1.5 volts would be sufficient regardless of the voltages and the amplification constant but for signals of considerable amplitude the bias should be higher.

An unusual feature of this circuit is the position in which the plate battery of the first tube is placed, between the plate and the top of the coupling resistor.

The steady current driven through the plate circuit of the first tube by battery E2 makes the grid of the second tube negative by the amount of voltage drop in the resistance R. If the current and the resistance are high this bias is likely to be excessive for amplification in the second tube. Of course, the drop in R depends directly on the value of the voltage of battery E2. The higher the voltage the higher the current and hence the higher the bias on the second tube.

In order to make the second tube operative it is necessary to provide a battery E3 in the grid circuit of the second tube, placed so that the voltage drop in R is counterbalanced in the proper degree. It will be observed that this coupling arrangement is similar to that now used in the Loftin-White circuits and that the provision for obtaining the proper bias on the second tube is also similar. Suppose that the necessary bias on the second tube in Fig. 1 is 50 volts and that the drop in R is 100 volts. It is clear that the voltage of battery E3 must be 50 volts. Note particularly that the positive terminal of battery E3 is connected to the grid of the second tube. Battery E4 serves to provide the proper plate voltage on the second tube.

VACUUM TUBE VOLTMETER

The circuit in Fig. 1 is frequently used as a vacuum tube voltmeter in which the first tube acts as the rectifier of the voltage to be measured and the second tube acts merely to amplify the voltage. The circuit can be used for measuring both DC and AC voltages. It is particularly suitable for measuring peak voltages when the voltage of E1 is increased until the current in the first plate circuit is zero. The amplifier serves to amplify the extremely small voltage developed across R and thus to make the voltmeter more sensitive.

However, we are not now interested in vacuum tube voltmeters. It is as a distortionless amplifier that we are interested in the circuit, an amplifier which amplifies DC as well as AC and which does not offer any frequency discrimination in the audio frequency range.

CIRCUIT NOT PRACTICAL

The circuit in Fig. 1 is not practical because of the necessity of using four batteries. The circuit in Fig. 2 is a slight modification of the circuit in Fig. 2. One battery has been eliminated and for that reason it is a more practical circuit. The first grid battery is as it was in the first circuit, but batteries E2 and E4 have been combined into E3 and placed in the more customary position below the coupling resistance R.

This change in the plate battery position necessitates a change in the grid bias battery for the second tube. It has been labeled E2 in this case. Note that now the negative of the grid bias battery is toward the grid. The way Fig. 2 is connected the grid of the second tube would be positive by the amount of drop in this internal resistance of the first tube, that is to say, by the voltage of E3 diminished by the voltage drop in R. Of course, this positive voltage on the grid of the second tube would render the tube inoperative as an amplifier. Hence it is necessary to use E2 and to make its value such that it exceeds the voltage of the drop in the first tube by the amount of bias needed on the second tube. For example, suppose the voltage of E3 is 150 volts and the drop in R is 100 volts. The drop in the tube would be 50 volts. Now suppose the voltage on the grid of the second tube should be 40 volts negative. It would then be necessary to make the voltage of E2, Fig. 2, equal to 90 volts.

Even three batteries in a two-tube circuit are too many and the circuit is not particularly practical. Yet the circuit has its applications and is capable of practically undistorted output. As long as both the tubes in the circuit are operated with filament batteries there is no other simple way of obtaining negative bias on the second tube except by the use of battery E2. Later we shall see how a more complex arrangement, still non-reactive, can be used with success.

THE HARTLEY REGENERATIVE CIRCUIT

It should be pointed out here that as far as quality is concerned the circuit in Fig. 1 is superior to that in Fig. 2, and with the same tube and voltages it will give a greater amplification, provided that the resistance in the Battery E3, Fig. 2, has appreciable value. If a storage B battery be used there is practically no difference between the circuits, but if a dry cell battery be used there will be sufficient feed back through that battery to reduce the amplification by a considerable amount, especially when the battery is old.

In Fig. 3 we have the Hartley, non-reactive, regenerative amplifier. While this circuit follows the idea of that in Fig. 1, it could also be arranged on the basis of Fig. 2. It would only be necessary to make a slight change in the position of some of the batteries, and the polarities of the grid batteries.

Let us analyze the circuit to see in what manner it is regenerative. Suppose there is an increase in the bias of the first tube. That is, a signal is impressed and we consider an instant when the impressed voltage is in the same direction as the grid bias. We indicate the change in the actual voltage of the grid by placing a minus sign next the grid. This change in the grid voltage produces a decrease in the plate current of that

Non-Reactive Circuits

attery Operation by Series Voltage Application

nderson

or

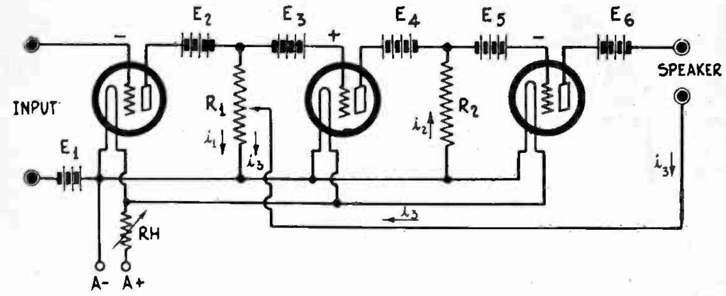

FIG. 3
THE HARTLEY REGENERATIVE, NON-REACTIVE AMPLIFIER IN WHICH A PORTION OF THE OUTPUT ENERGY OF THE THIRD TUBE IS IMPRESSED ON THE INPUT OF THE SECOND

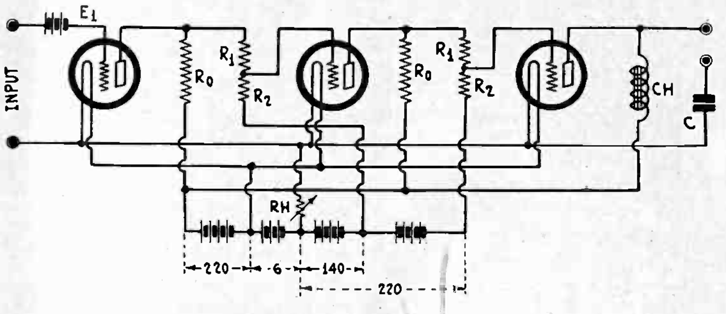

FIG. 4
THE MORGAN NON-REACTIVE AMPLIFIER IN WHICH COMMON PLATE AND GRID BATTERIES ARE USED, THE GRID BATTERY VOLTAGE BEING ADJUSTED SO THAT EACH TUBE GETS THE PROPER BIAS

tube. We indicate this decrease by the symbol i_1 and an arrow pointing downward to emphasize the direction.

VOLTAGE ON SECOND GRID

When the current in R1 decreases the voltage on the second grid increases, and this fact we indicate by placing a plus sign next the second grid. This increase in the actual voltage on the grid of the second tube causes an increase in the plate current of that tube, and we indicate this increase by the symbol i_2 and an arrow pointing upward.

This increase in the current through R2 causes an increase in the bias on the third tube, which fact we indicate by putting a minus sign next the grid. The increase in the bias on the third tube causes a decrease in the plate current of that tube, that is, through the speaker or other load. We indicate this decrease in the current by the symbol i_3 and an arrow pointing downward.

Due to the fact that each tube amplifies the change in the plate current through R2 is much larger than the change in the current through R1, and the change in the current through the load is much larger than the change in the current through R2. It follows that the change in the current through the load is very much larger than the change in the current through R1.

Now note that the return lead of the speaker or load is connected to a point on R1 somewhat higher than the lower end. Hence the plate current in the third tube flows through a portion of resistance R1. It will be observed that the change in the plate current of the first tube is in the same direction as the change in the third current through this common portion of R1. Hence the twice-amplified change i_3 aids the change i_1 in increasing the voltage on the grid of the second tube. That is to say, the change in the current in the first tube is in phase with the change in the plate current of the third tube and both tend to decrease the bias on the second tube. This amounts to regeneration.

OSCILLATION POSSIBLE

The regeneration may be so great that sustained oscillation will be maintained, which will happen if the plate current of the third tube is returned to a point too far up resistance R1. In one typical case the coupling resistances were 100,000 ohms and the required common portion for oscillation was only 370 ohms. The required resistance for oscillation is of the same order of magnitude as in the common voltage supply to start motorboating in a resistance coupled amplifier of the ordinary kind, provided the amplifier has three plate circuits. Indeed, the resistance in the Hartley amplifier is less because there is no bucking effect in the second resistor R2.

The advantage of this non-reactive, regenerative amplifier is that almost any degree of amplification, without frequency distortion, can be obtained. It is assumed that the load does not contain any reactance. If the load is a loudspeaker there will be a certain reactance, which may make the circuit regenerate more at some frequencies than at others. There are many applications of amplifiers in which the load is a pure resistance, and in such cases the regenerative feature could be used to advantage.

THE MORGAN AMPLIFIER

In Fig. 4 we have one version of the Morgan non-reactive amplifier. This circuit is a comparatively recent addition to resistance coupled circuits, having been published during the early part of 1929. A close study of this amplifier will show that it is based on the idea back of the circuit in Fig. 2. A common plate battery is used for all the three tubes as well as a common filament battery. A grid bias battery is used for the first tube and another for the third tube. For the bias on the second tube a portion of the battery for the third tube is used. The voltages of the common batteries are given on the diagram. The voltage of E1 would depend on the signal and the tube. In most cases of application to radio receivers E1 should have a value of from 1.5 to 4.5 volts.

If this circuit is to function properly it is essential not only that the applied voltage be as indicated but that the resistances have the proper values. In a published circuit the resistors had the following values: R0, .5 megohm; R1, .75 megohm, and R2, one megohm.

The Morgan amplifier shown above is operated with storage batteries throughout, with the exception of E1, which may be a dry cell. Storage batteries are recommended because a three-tube amplifier of this type would be unstable if there were appreciable resistance in the common batteries for the same reason that the Hartley circuit above is unstable. However, the Morgan amplifier has been built successfully for operation with B supply units, the condition being that the common impedance be reduced to a negligible value by means of condensers across the voltage source. If the voltages are the same the same values of resistors can be used in the coupler.

CHOICE OF TUBES

The first two tubes in the amplifier in Fig. 4 are supposed to be 240 and the last tube a 171A. If other tubes are selected changes in the voltages must be made. Even when the specified tubes are used it may be necessary to make slight changes in the voltages because not all tubes of the same type have the same characteristics.

Those who have built the Morgan amplifier according to the design in Fig. 4 claim that it is unexcelled in quality. There is no reason why it should not be so, provided it is stabilized, for it is non-reactive. The only reactances in the circuit are those of the output choke coil Ch and the condenser C. If both the inductance and the capacity are large these reactances should have little effect on the quality. Then in some instances it is possible to do away with them and connect the speaker directly in the plate circuit of the power tube.

THE JOHNSTON CIRCUIT

In Fig. 5 we have what is known in Europe as the Johnston circuit. This amplifier was thoroughly discussed in a long series of articles in the Swedish magazine "Radio" during 1928. It had previously appeared in a British publication, according to the Swedish writer. Before this time it has received practically no attention in America, but recently a slight variation of the circuit has appeared under the name Loftin-White.

Why this potentially excellent circuit received little attention in America is obvious. The high DC voltage required to operate the circuit is available only in a few isolated places. In Europe, on the other hand, DC voltages from 220 to 250 are quite common for lighting and power purposes. Hence the circuit found favor in Europe while it received no attention here. Another reason why the circuit did not become popular here is that even a voltage of 250 volts distributed among several tubes does not give any one tube a voltage that is considered essential here. In Europe requirements have been more modest although now there is much demand for more and more powerful sets.

PRINCIPLE OF JOHNSTON CIRCUIT

In view of the present interest in the Loftin-White circuit let us analyze the Johnston circuit. The first requirement is a

Johnson, Paris, Loftin-

Family of Non-Reactive and Kindred Design

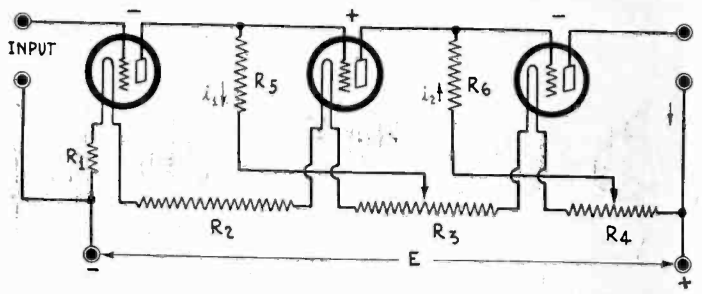

FIG. 5
THE JOHNSTON NON-REACTIVE AMPLIFIER IN WHICH THE HIGH VOLTAGE SOURCE PROVIDES NOT ONLY THE PLATE CURRENT BUT ALSO THE FILAMENT CURRENT

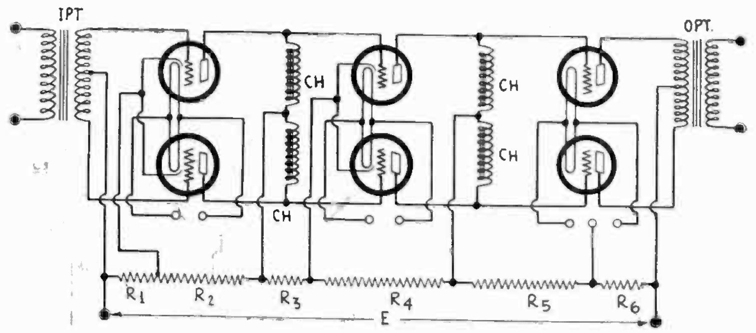

FIG. 6
THIS PUSH-PULL REACTIVE, DIRECT COUPLED AMPLIFIER WAS DEVELOPED BY MR. G. H. PARIS. STABILITY AND EASE OF ADJUSTMENT ARE TWO OUTSTANDING ADVANTAGES

high DC voltage source which cannot only supply the plate current and voltage but also the filament current.

All the tubes must be alike as to filament current requirements, although they do not have to have the same filament voltage rating. If the current requirements are different it is possible to put suitable shunts across the filaments of those tubes which draw less current than the tube which takes maximum. Thus it is possible to combine .25 ampere tubes with .06 ampere tubes. As the circuit in Fig. 5 is drawn all the tubes are supposed to draw the same filament current.

Grid bias for the first tube is derived from the voltage drop in R1. Suppose the filament current is .25 ampere and the first tube is a 240. Then the value of R1 should be 6 ohms to give the grid a bias of 1.5 volts.

The plate voltage on the first tube is sum of the voltage drops in the filaments of the first two tubes, the drop in R2, and the drop in that portion of R3 which is to the left of the return of R5 to the voltage divider. The point where this return is made must be determined experimentally because it not only determines the voltage on the plate of the first tube but also the bias on the second.

The bias on the grid of the second tube is the voltage drop in R5 diminished by the voltage between the right end of R2 and the return point of R5. Now if the second tube is also a 240 its effective bias should be about 3 volts, assuming that the plate voltage on that tube is sufficient to warrant such a high bias. Let R5 have a value of 100,000 ohms. If we assume a plate current of .2 milliamperes, th edrop in R5 will be 20 volts, 17 volts more than enough. Since there is a drop of 5 volts in the filament of the second tube, R5 must be returned to a point 12 volts from the positive end of the second tube's filament, and since the current is .25 ampere the resistance between the return point on R3 and the positive end of the filament should be 48 ohms.

DETERMINING THE VOLTAGE DISTRIBUTION

The voltage on the plate of the first tube should be about 90 volts. To get this voltage on the plate the drop in R2 should be 78 volts, and therefore R2 should be 312 ohms.

Now let us skip to the power tube, assumed to be a 171A. This tube should have 180 volts on the plate, and therefore the drop in R4 should be 175 volts. Therefore the resistance of R4 should be 700 ohms.

Let us assume that the value of R6 is 100,000 ohms and that the plate current through it is .4 milliamperes. There will be a drop in it of 40 volts. But the bias on the power tube should be 40.5 volts. Therefore R6 must be returned to a point near the negative end of the filament of the power tube, and not to R4 as shown. If the drop in R6 turns out to be in excess of 45 volts the return of R6 should be made to the positive end of the filament of the power tube, or to a point higher up as shown. In order to get a plate current of .4 milliamperes through R6 the applied voltage on the middle tube should be 180 volts. That is to say, the voltage drop in R3 should be 175 volts. Hence R3 should have a value of 700 ohms, the same as R4.

TOTAL VOLTAGE REQUIRED

Adding up all the voltage drops we find that the total voltage required to operate the circuit is 444.5 volts. Since the current flowing is at least .25 ampere the wattage required to operate thiss three tube circuit would be close to 112 watts. This is excessive unless a motor-generator is available for supplying the high voltage. However, it is not necessary to use the high voltages called for in the above tentative design. It would be quite feasible to make the voltage on the first tube 45, that on the middle tube 90 and that on the final tube 135 volts. This could be done even if the total voltage were not greater than 220 volts by making use of a tube requiring a lower grid bias than the 171A and by returning the second coupling resistor as shown in Fig. 5.

The Johnston circuit is relatively stable because the current in the voltage divider is large compared with any changes in the plate current which may result from a signal. Notwithstanding this oscillation may occur and much attention has been given to securing operating stability. It is not necessary to discuss this feature of the circuit, for the amplifier itself is not practical in the form shown, in view of the fact that it can be assembled with heater tubes in which the filament current can be taken from separate transformer windings. When this is done we arrive at a circuit like the Loftin-White amplifier, for in principle the Johnston circuit is identical with this newer version.

THE PARIS PUSH-PULL AMPLIFIER

In Fig. 6 is shown the diagram of a push-pull direct-coupled amplifier developed by Mr. G. H. Paris of Duluth, Minn. This circuit was applied in practice during 1928 and it gave excellent results, although it is not a non-reactive amplifier. The coupling choke coils are either equal single coils or center-tapped chokes. The circuit can be assembled for either heater type tubes or three-element tubes provided that the filaments of each stage are heated by a separate winding.

The essential feature of the Paris circuit is the same as that in the Johnson or the Loftin-White. A high voltage is necessary so that it can be divided up among the stages. For equal voltages on the plates and grid the circuit requires a higher voltage source than a resistance coupled circuit of the same general type, because no voltage can be saved by utilizing the drops in the coupling impedances for bias on the succeeding stages. The DC voltage drops in the chokes are not sufficient to provide bias for some of the tubes, especially the power tubes. Hence the coupling impedances must be returned to a point on the voltage divider which is negative with respect to the filament or cathodes.

Suppose, for example, that the resistance in each choke is 500 ohms and that the plate current is 6 milliamperes. The drop will then be 3 volts. If the tubes following the coupler require a bias greater than this it is necessary to provide additional bias by returning the couplers to suitable points. This additional bias is taken from the total available voltage.

STABILITY OF CIRCUIT

The stability of the Paris circuit is greater, perhaps, than that of any other amplifier having the same number of stages. In the first place it is balanced so that if there is any common impedance between two stages there is practically no feedback through that impedance. In the second place there is practically no common impedance. Moreover, the adjustment of one stage is not greatly dependent on that of another since the DC voltage drop in the coupling impedance plays a minor role. The circuit is not a DC amplifier and therefor there can be no cumulative effect on the bias as there is in resistance coupled amplifiers.

It is clear that the Paris arrangement can be applied to single side circuits as well as to push-pull.

The circuit developed by Mr. Paris was called to the writer's attention in private correspondence about the same time that the articles on the Johnston circuit came out in the Swedish magazine *Radio*. The Paris circuit was such a great departure from circuits previously known that the writer undertook a study of it, especially with resistance coupling between stages.

White, Morgan Circuits

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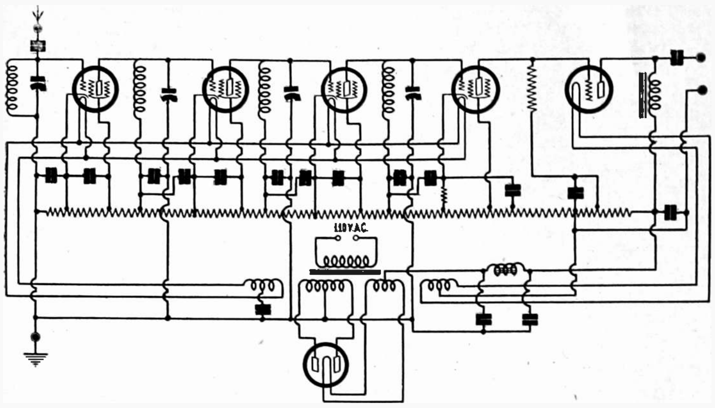


FIG. 7
IN THIS SUGGESTED CIRCUIT THE RADIO FREQUENCY AMPLIFIER AS WELL AS THE AUDIO IS DIRECT COUPLED

This study led to the publication of a number of curves on vacuum tubes as well as to a number of push-pull, direct coupled amplifiers using resistances instead of choke coils. These circuits will be found in Radio World beginning September 15, 1928. The object of running curves on tubes was to get the proper data on which to base the design of the push-pull resistance coupled amplifiers without resorting to the cut and dried methods.

One outstanding charateristic of non-reactive amplifiers, whether single-sided or push-pull, is instability. Another is that, once they have been adjusted, they are capable of unexcelled quality.

DIRECT COUPLED RADIO CIRCUITS

It is possible to use direct coupling in the radio frequency end of the receiver as well as in the audio end. Of course, there is no particular advantage in doing so, but those who wish to try it will find a suggested circuit in Fig. 7. Still another arrangement is depicted in Fig. 8.

In Fig. 9 the heaters of the three tubes are connected in series. It is possible to operate all three tubes on a six-volt battery, or preferably an eight-volt battery, and also on a single 7.5 volt winding of a transformer.

Note that the plate circuits of the first two tubes are connected in parallel in the usual manner. This is possible from the fact that a radio frequency coupling transformer is used between the RF amplifier and the detector. Different screen grid voltages are required on the two tubes and for that reason the screens are returned to different points on that voltage divider. While the screen of the detector is returned to a higher point than the screen of the radio frequency amplifier the connection should be the reverse in practice, for the detector takes a much lower screen voltage than the amplifier due to the high coupling resistance used. If the return of the screen of the amplifier is made to the slider of a potentiometer this can be used as a volume control.

Grid bias for the RF amplifier and the detector tubes are obtained independently. The bias resistor for the amplifier should be 300 ohms, shunted by a .5 mfd. condenser. The bias resistor for the detector depend sentirely on the value of the resistor connected between the coupling resistor and the cathode. If the coupling resistor has a value of 1,800 ohms and the variable resistance 25,000 ohms, the proper bias for best operation can be found by adjusting the variable resistor. The condenser across the bias resistor should not be smaller than 2 mfd.

There is danger in connecting the heaters of the two final tubes as in Fig. 9. It will be noted that the heaters of these tubes are in close proximity to conductors which are high potential difference. The danger, however, is minimized by the fact that the heater circuit is not connected to any point of the amplifier circuit.

PUSH-PULL NON-REACTIVE AMPLIFIER

The revived interest in non-reactive amplifiers has brought in requests for push-pull circuits of the same type. Apparently there are many fans who would like to experiment with the circuit in its symmetrical form. To provide these experimenters with a circuit to work on we include Fig. 10. Those who would like to have additional circuits of this type are referred to the series of articles in Radio World already referred to.

At the outset we wish to state that this circuit is not strictly non-reactive because of the presence of the condensers C1 and

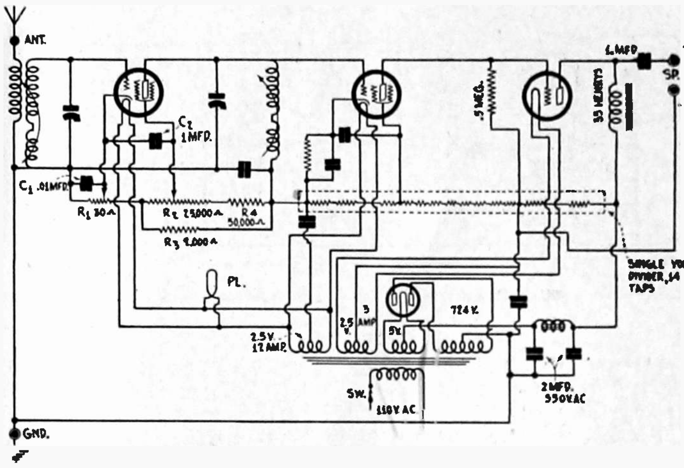


FIG. 8
ANOTHER CIRCUIT IN WHICH THE RADIO FREQUENCY AMPLIFIER IS COUPLED DIRECTLY IN THE SAME MANNER AS THE AUDIO FREQUENCY AMPLIFIER

C2. The purpose of these condensers will be explained fully in a later article. For the present they may be omitted and the input signal impressed across the two equal resistors R2 and R3. The omission of the condensers renders resistance R1 also superfluous.

When the condensers are omitted it is necessary to impress the signal on the circuit by means of a transformer, either of the push-pull or ordinary variety, or else connect a phonograph pick-up unit across the two equal resistances.

USE OF CRYSTAL DETECTOR

The reason why the push-pull circuit cannot be coupled to a detector in the usual fashion has been explained many times and is that if it is attempted only one side of the push-pull amplifier will be active. The other side will be dead as if all the grids were grounded.

It is, however, possible to use a crystal detector provided that no part of the crystal circuit is grounded. When a crystal rectifier is used the output of this detector may be connected across the two equal resistances R2 and R3, or it may be connected across the single resistance R1 with the condensers in the circuit as shown. This connection is slightly superior since it eliminates any unbalancing effect that the direct current component in the crystal circuit may have on the bias values of the two screen grid amplifier tubes.

If each of the condensers C1 and C2 be made one microfarad and the resistances that follow have values of one megohm, the effect of the reactances will be so small that there will not be the slightest appreciable depression of the amplification of the bass notes as low as 30 cycles.

The tubes in the amplifier in Fig. 10 are supposed to be 224 in the first stage, 245 in the power stage and a 280 in the rectifier. While the heaters of both the 224 and the 245 require 2.5 volts it is not safe to use the same winding to supply the power because of the high voltage that would exist between the heaters and the cathodes of the 224 tubes. Hence two filament windings of 2.5 volts have been provided by a separate filament transformer. If the power transformer has two independent filament windings not used for anything else they may be used in place of the separate transformer. The insulation between the windings in the transformer will be high enough to withstand any voltage that may exist.

DESIGN OF VOLTAGE DIVIDER

The voltage divider in this circuit is extremely simple. R6 may be a 20 ohms rheostat or any other resistance of equal value provided the resistor will carry about 75 milliamperes. The actual current under proper adjustment of the circuit will be approximately 74 milliamperes, but there may be considerable variation from this due to variations in tubes and in the voltage supply. If the current is 75 milliamperes and the bias resistor R6 is 20 ohms the bias on the screen grid tubes will be 1.5 volts, the rated bias for these tubes. Small variations in this bias can be compensated for as will be pointed out later, if it becomes necessary to make any adjustments.

Now as is usual in discussing circuits of this type we skip to the power tube to make the proper adjustments of voltages on that tube. The plate voltage on that tube should be 250 volts, measured from the mid-tap of the output transformer or push-pull speaker. This voltage is equal to the drop in the potentiometer P2. Now we can select any resistance we choose

Push-Pull Non-Reactors

Mineral Rectifier or Phonograph

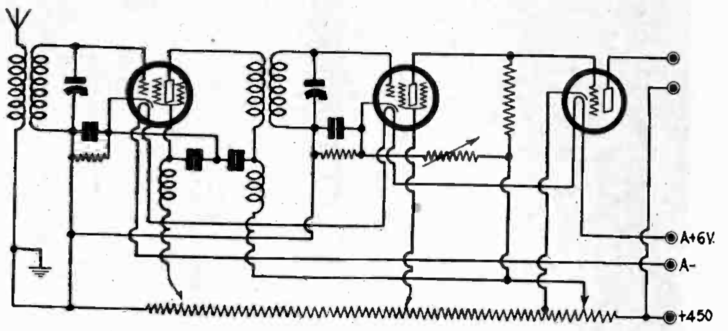


FIG. 9
IN THIS CIRCUIT THE HEATERS ARE CONNECTED IN SERIES. WHILE A SIX-VOLT BATTERY WILL OPERATE THE THREE TUBES AN EIGHT-VOLT BATTERY WOULD BE PREFERABLE. NOTE THAT IN THIS CIRCUIT THE PLATE CIRCUITS OF THE RF AND THE DETECTOR TUBES ARE IN PARALLEL

for this potentiometer. Our choice will depend on current economy, availability of the potentiometer, and on the effect that the current tapped from it will have on the total voltage drop. We can select a potentiometer of 25,000 ohms because this is a standard commercial value. Since the voltage across it is 250 volts the current through it will be 10 milliamperes. This is not excessive in view of the fact that the two power tubes take a total of 64 milliamperes. It is also so large that any current detoured from it by the tap will be negligible.

THE CRITICAL VOLTAGE ADJUSTMENTS

The next step in the development of this amplifier is to select the values of the coupling resistors R4 and R5. If we choose high values the amplification by the screen grid tubes will be high, provided we can get high enough voltage on the plates of these tubes. Let us choose tentatively values of .5 megohm.

Now the drop in one of these resistances less the drop in the left portion of P2 will be the bias on the corresponding power tube. This bias is to be 50 volts. It is not possible without curves to tell just what the drop in either of the coupling resistors will be. But it is reasonable to assume that it will be .2 milliamperes. If that is the cause the drop in either of the coupling resistors will be 100 volts. Hence the slider on P2 is set 50 volts to the right of the center tap of the power tube filament transformer, or one fifth of the way over.

In choosing the value of P1 we should be guided by the total voltage available and by the current which will flow through this resistance. Let us choose tentatively a value of 2,000 ohms. The current through it will be close to 73 milliamperes. This would make the voltage drop in it equal to 146 volts. Adding to this the 50 volts from the drop in a fifth of P2 we get a total applied voltage of 196 volts on the 224 tubes. We thus require a total voltage of 397.5 volts to operate the circuit. That should be the voltage across C10, for example. This does not preclude successful operation of the circuit even if the total voltage is as low as 350 volts. It is only necessary to readjust the positions of the sliders of the two potentiometers.

ADJUSTING SCREEN VOLTAGE

The most critical voltage, possibly, is the screen grid voltage on the two screen grid tubes. That is to say, the position of the slider on P1 is the most critical. It will be found that as the slider is moved toward the negative end the current in the plate circuits of the two 224 tubes will increase, and this increase will manifest itself by a decrease in the current in the plates circuits of the two power tubes.

PRACTICAL ADJUSTMENT HINTS

As far as bias in the power tubes is concerned it can be adjusted quite easily by moving the slider on P1, but this alone does not adjust the circuit to the best amplying condition because the proper setting of this slider for bias on the power tubes may not coincide with the proper setting of the screen grid voltage for amplification in the screen grid tubes. Hence it is necessary not only to adjust the slider on P1 but also that on P2. While proper adjustments could be effected by varying the value of the grid bias resistor R6 it is best to leave this fixed and to adjust the P1 and P2 sliders.

In adjusting the circuit it is recommended that a milliammeter having a range of 0-100 be used. Connect this in the circuit so that the current of one of the power tubes flows through it. A high resistance voltmeter is also a useful aid in adjusting the circuit. With this the voltages in the various sections of the voltage divider can be measured with sufficient accuracy, although the voltages on the plates on the screen grid tubes cannot be measured with it.

First set the slider on P2 at the extreme negative end and then adjust the slider on P1 until the meter reads 32 milliamperes. The bias on the corresponding power tube is then correct, assuming that the voltage across P2 is 250 volts. It will now be found that if the slider on P2 be moved toward the positive the plate current will decrease, indicating that the bias is being increased, and this increase is due to an increase in the plate current of the screen grid tube involved. But the current can be brought back to the proper value by moving the slider on P1 toward the positive.

If a signal is being received during the adjustments it is possible to find experimentally the best settings of both sliders. The best adjustment is that which gives the greatest signal strength while the steady reading current in the tube is kept at 32 milliamperes.

In case the total voltage available is less than that specified above it may be best to use one megohm values of R4 and R5. The drop will be slightly higher in them and a little more voltage can be conserved by moving the slider of P2 toward the positive.

BY-PASS CONDENSERS

We have not yet mentioned the by-pass condensers. As always, the larger these are the better, but it may not be necessary to use larger values than one microfarad in any position. Push-pull requires less than single sided amplifiers. Note that the condensers are connected so that the by-passing is done to the cathodes, or to the center tap of the power tube filaments. Exceptions are those which are strictly parts of the B supply, which are connected in the usual manner. These condensers also have the customary values, 2,2 and 4, for example.

There is one reason why the by-pass condensers in a push-pull amplifier should not be large, and that is the self-balancing tendency in case the signals are unequal in the two sides. But the advantage of large by-passing far outweighs this effect.

DISADVANTAGES OF PUSH-PULL

The successful operation of an amplifier of the type shown in Fig. 10 depends on the equality of the two tubes in a stage. If they are not equal it is impossible to effect the proper adjustment of the two sides at the same time. Suppose, for example, that the upper screen grid tube passes more current than the lower when the voltages are the same on all the elements. The bias on the upper power tube will then be greater than that on the lower. The balance will be entirely upset. If the upper tube is adjusted for amplification the lower may draw too much current. If, on the other hand, the lower tube is adjusted for amplification, the bias on the upper may be so large that the plate current is entirely cut off.

There are various methods of remedying this condition. First, the screen grid tubes may be selected because they have identical characteristics. Second, the resistances R4 and R5 may be made unequal by the correct amount. Or if they are unequal to start with and that is in part responsible for the unbalance the tubes may be switched around.

However, it may be impossible to remedy the situation by these simple changes. In that case it will be necessary to adjust the different voltages on the two screen grid tubes independently. We have three chances here of effecting equality as far as the bias on the two power tubes are concerned. First, we can make the bias voltages on the two screen grid tubes unequal by returning R2 and R3 to different points on R6. Second, we can return the screens to different points on P1, and third, we can return R4 and R5 to different points on P2.

ADVANTAGES OF PUSH-PULL

Symmetrical amplification has many advantages over single sided amplification. First, there will be less distortion due to overloading of tubes and to curvature of the tube characteristics. That is the usual point in which push-pull is superior. Second, there will be less feedback through any common impedance that may exist between two stages. If the circuit is truly symmetrical there will not be any feedback at all. Third, there is less hum in the amplifier. One side of the circuit bucks out the hum in the other side. This effect is only complete when the symmetry is complete, but even partial symmetry will effect a

and Crystal Detectors

Pickup Feeds Symmetrical Audio Circuit

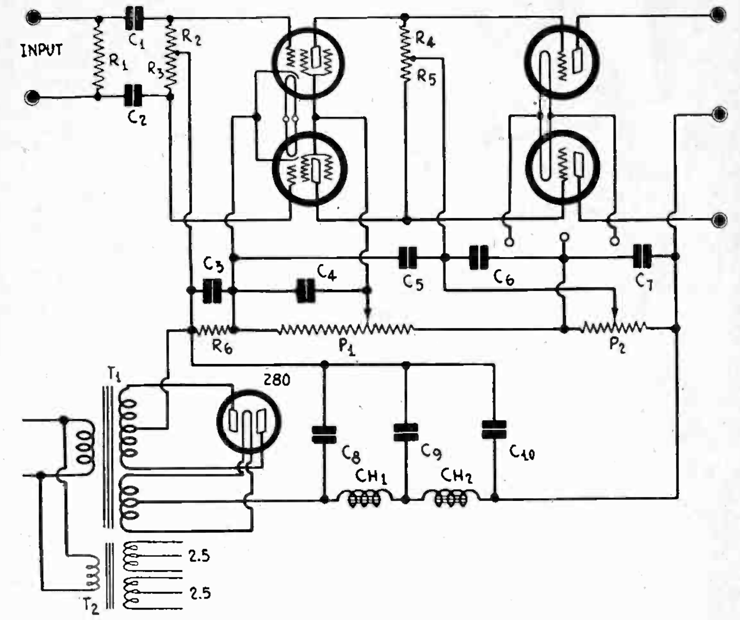


FIG. 10
A PUSH-PULL NON-REACTIVE AMPLIFIER WHICH HAS MANY ADVANTAGES OVER A SINGLE SIDED AMPLIFIER. SUCH AN AMPLIFIER IS ONLY AS GOOD AS THE SYMMETRY AND THE VOLTAGE ADJUSTMENTS.

great improvement. As a result of this hum-bucking the B supply need not be so thoroughly filtered as that required in a single sided amplifier.

Before passing to another subject let us emphasize the fact that the push-pull amplifier in Fig. 10 cannot be connected after an ordinary detector tube without the intervention of a transformer of some kind. To show this let us assume that the upper terminal be connected to the plate of the detector and the lower to B plus. Now as far as the signal is concerned the lower terminal will be at ground potential. Therefore, since C2 is a condenser of very large capacity, the grid of the lower screen grid tube will be at ground potential. But the cathode of that tube will also be at ground potential. Hence there will be no appreciable signal voltage drop in R3, and the lower side of the circuit will be quite dead. Of course, the amplifier will operate but it will not be a push-pull circuit. Only the upper half will be effective.

The circuit can, however, be operated with a crystal detector, as has been stated, provided that no part of the crystal circuit is grounded. It can also be used for amplification of phonograph pick-up signals. Another application would be to push-pull microphones, either of the double-button carbon type or the condenser type. When these are used the central point on the microphone circuit should be grounded, either directly or through a large condenser.

A high quality coupling transformer can be used between the detector and the amplifier without killing one side, and the secondary of this transformer may be connected either across the input terminals shown or across the resistors R2 and R3.

A SUITABLE INPUT

In the first article on the non-reactive amplifier in the Jan. 18th issue we showed a double tuner as a possible tuner to precede the two tube Loftin-White circuit. Some have tried this tuner and reported fair success. Others have reported total failure. Perhaps it will be recalled that this tuner was not put forward with any assurance that it would be a signal success. Indeed, doubt was cast upon it, and it was only published as a report of a development by others.

There is no question at all that such a simple tuner will suffice if the receiver is used close to a broadcasting station. Likewise there is no doubt at all that the circuit will fail to receive distant stations, and not so distant at that. After all, there is no substitute for amplification. A tuner does not amplify; it selects more or less. Even a non-reactive circuit of two tubes using one screen grid tube adjusted to do its utmost will not amplify enough to put a super-heterodyne or a neuterodyne in the shade. Let there be ample radio frequency amplification ahead of the two tube audio circuit and there will be ample signal strength. Whether or not the radio frequency

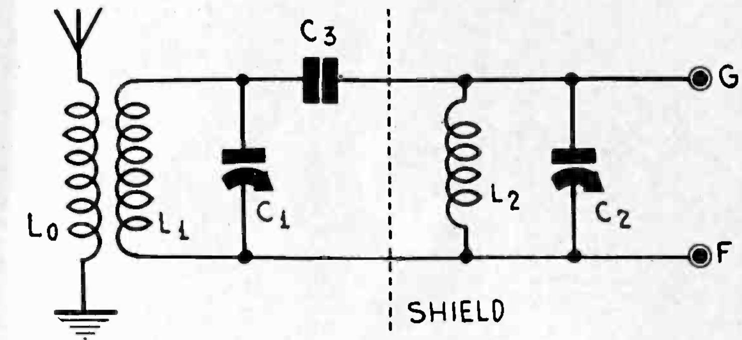


FIG. 11
A DUAL TUNER THAT HAS BEEN SUGGESTED AS SUFFICIENT TO PRECEDE THE LOFTIN-WHITE TWO-TUBE AMPLIFIER. A TUNER OF ANY KIND IS NOT A SUBSTITUTE FOR AMPLIFICATION.

amplification is ample or not depends entirely on conditions and on the place.

REGARDING COUPLING CONDENSER

We print the dual tuner suggested for the convenience of our readers so that we may have something definite to talk about. It is found in Fig. 11.

There is a coupling condenser C3 between the two tuned circuits. This condenser should be very small. If it is large the two tuned circuits might as well be connected together at the top as well as at the bottom. And when that is done there results only one tuned circuit consisting of two equal inductances in parallel and two equal condensers, also in parallel. It would be better to do away with C3 and the second tuner.

When C3 is very small there are two equal tuned circuits loosely coupled together, and the two can be tuned independently of the other. The mutual effect will be smaller, the smaller the coupling condenser. Let this condenser be a midget. An electrolytic condenser of 52 mfd. will not work.

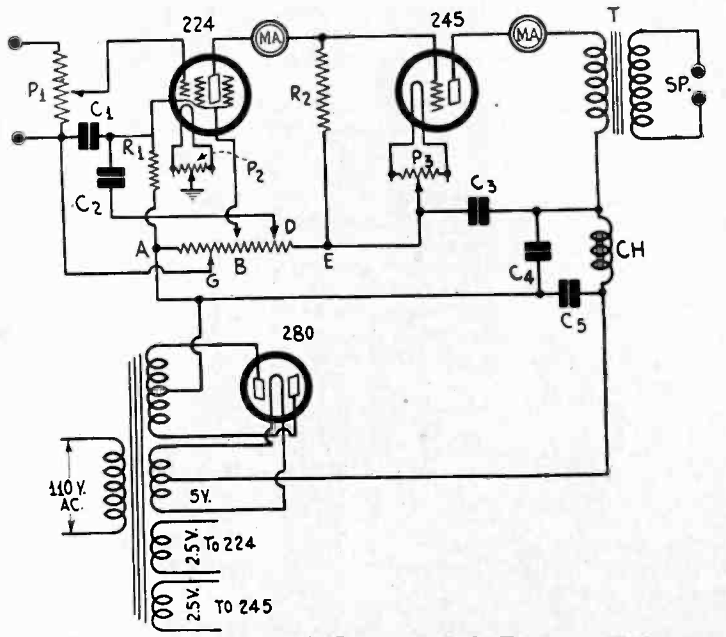


FIG. 12. A NON-REACTIVE AMPLIFIER SHOWING WHERE TO CONNECT THE MILLIAMMETERS WHILE ADJUSTING THE VOLTAGES.

When adjusting non-reactive amplifiers milliammeters are useful as an aid in determining when the grid bias is correct. The meters should be placed as shown in this diagram. The meter in the plate circuit of the first tube should be a microammeter having a range of 0-100 microamperes and the meter in the plate circuit of the power tube should be a milliammeter having a range of about 0-100 milliamperes.

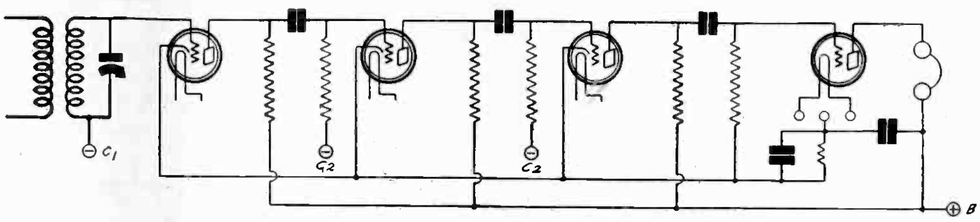
This arrangement applies to a single sided amplifier but since either side of a symmetrical amplifier is of the same type the connection is the same for that type of circuit. Few fans will have a microammeter sensitive enough to measure the current flowing in the plate circuit of the first tube and ordinary milliammeters will not measure the small current with any useful degree of accuracy. When no sensitive meter is available it is best to rely on the final meter and adjust the circuit until the plate current in the power tube is correct and until the amplification is satisfactory.

How Methods of Bias

Plate Voltage and Tube Structure Compel

By Herbert

FIG. 1
A resistance coupled amplifier using three-element tubes in which the grid bias should be adjusted to fit the applied plate voltages.



SHOULD the grid bias on a tube be adjusted according to the applied voltage in the plate circuit or to the effective voltage on the plate of the tube? That question is frequently asked. The answer is neither yes nor no, because it depends on the kind of tube that is in question.

The voltages specified by the manufacturers are the actual voltages on the plates of the tubes, and when the coupling devices are transformers or chokes, either radio or audio, the actual voltages on the plates are practically the same as the applied voltages in the plate circuits, but when the couplings are resistors the actual voltages on the plates may be totally different from the applied voltages.

When the manufacturers of tubes give performance curves it is understood that the voltages involved are those on the plate and the output power and plate currents are based on this supposition. There is usually a discrepancy between the load conditions and the currents to be expected but very little attention has been given to it. Perhaps it is this discrepancy which accounts for the many questions that are asked concerning grid bias and plate voltage.

DIFFERENT TUBES, DIFFERENT RULES

The same rules do not apply to screen grid tubes as to three-element tubes and due to this fact many mistakes have been made in designing resistance coupled amplifiers with screen grid tubes.

Let us first discuss the three-element tube. For this tube it is the voltage in the plate circuit that counts in determining the grid bias to be used. This is true no matter what kind of load is put on the tube, transformer, choke, or high resistance.

One might suppose that when a very high resistance is used in the plate circuit the grid bias should be adjusted according to the actual plate voltage since at first thought it looks reasonable that a drop in the resistance, which may amount to 95 per cent of the total voltage in the plate circuit, should be taken into account when selecting the bias. But this is not the case. It makes no difference whether the plate coupling resistance is one ohm or ten million. The bias to be selected is the same provided that the voltage in the plate circuit is the same.

When the coupling resistance is of the order of one megohm the steady state current in the plate circuit may be of the order of a few microamperes and where there is a very small resistance it may be of the order of a few milliamperes. Whatever the plate current may be the grid voltage has the same relative effect on that current since the effect depends on the amplification constant of the tube, and this is practically independent of the effective plate voltage, so long as this voltage is greater than a few ohms.

DIFFERENT BIAS POSSIBLE

From this it is not to be supposed that for any given voltage in the plate circuit only one particular bias must be used in the grid circuit. Dierent bias values may be used, depending on the signal voltage amplitude that is to be impressed on a given tube. The bias must always be at least as great as the peak value of the strongest signal that is to be applied to the tube. If the signal is so great that the required bias would reduce the plate current to zero, or to a point on the characteristic where there is considerable curvature, the only alternative is to increase the voltage on the plate circuit.

This does not necessarily mean that the effective voltage on the plate should be increased. That would do little good, if, for example, it were increased by reducing the value of the coupling resistance. It would do harm to increase the effective voltage in this manner. It would not only introduce a greater percentage of distortion but it would also decrease the effective voltage amplification. The only correct way of increasing the effective voltage on the plate is to increase the voltage in the plate circuit, leaving the plate coupling resistance at its original value or else increasing it. The increase in the effective voltage on the plate in this case is only incidental to increasing the voltage in the plate circuit.

In dealing with three-element tubes the best thing to do is to forget all about the effective voltage on the plate. It will take care of itself. The only concern should be that the applied voltage is high enough to support the signal which will be applied in the grid circuit.

A WORKING RULE

A good working rule in selecting an applied plate voltage is to multiply the grid bias that must be used by the amplification factor of the particular tube used and then make the plate voltage equal to or greater than the product thus obtained. For example, suppose the grid bias must be 4.5 volts to prevent the grid ever from going positive and let the tube be one having an amplification factor of 30. The product of 4.5 and 30 is 135, which should be the least voltage to be applied in the plate circuit. It would be better to make the voltage in this case 180 volts in order to prevent distortion when the grid swings to 9 volts negative. But the 135 volts will work all right.

If the tube in this case is one having an amplification factor of 8 the applied voltage would only have to be 36 volts, or 45 for good measure. This, however, is not practical for a tube that has an amplification of only 8 would have to be bias much more than 4.5 in order to get a substantial signal voltage out of it. Of course, it depends on the position of the tube in the amplifier. If it is first 4.5, or even less, would be sufficient. If, on the other hand, it is next to the power tube the bias may have to be as high as 13.5 volts. This would call for a plate voltage at least 108 volts. To eliminate distortion from curvature when the grid voltage swings to 26 negative, the applied

Solution of Problems

At the recent Motorboat Show in New York City radio receivers were shown installed on large and small craft.

Compactness seems to be the general trend. Craft sold equipped with sets usually have the apparatus in an out-of-the-way corner of the main cabin. In some of the larger boats loud speakers are installed in several parts of the craft, permitting the yachtsman to enjoy radio concerts from either the bridge or main cabin.

Problems of installing radio aboard the small pleasure boat, while not as difficult, are comparable to those encountered in the installation of sets on automobiles. The ignition system of the gasoline engine has a tendency to cause interference. However, because of the additional room available on the boat, it is possible to carry a separate storage battery for heating the filaments of the tubes in the set, thereby eliminating the necessity for elaborate shielding to prevent interference.

Radio sets designed for use on pleasure boats are not much unlike in design to the standard receivers used in the home. They differ, however, in method of obtaining power for operation. Because of the limited power facilities it is necessary to obtain plate voltage for operating the set from drycell batteries, rather than operate it from the lighting plant.

A number of radio set manufacturers are making battery operated receivers especially for use aboard pleasure craft. These receivers are only slightly different from sets built for home use, differing in power operation and the use of tubes and associated apparatus for battery operation. Such sets are usually table models. Technically they contain three or four stages of standard or screen-grid radio-frequency amplification. All other tubes are of the —01A type, with the exception of the final stage of audio amplification. In the majority of receivers of this type tubes of the —71A type are employed in push-pull amplification for the final magnifier.

Loudspeakers preferably are of the magnetic type, although a

Determination Differ

Different Manner of Reaching Requirements

E. Hayden

voltage should be at least 180 volts. It is always better to use a high voltage than one that is just barely enough. There is no need of worrying about the danger to the tube because it is the plate current which will do the damage, not the voltage, and the current through a high coupling resistor will be negligible even if the voltage were twice as high as that specified by the manufacturers, assuming that the plate coupling resistance is at least equal to the internal plate resistance of the tube.

It is not until the actual voltage on the plate of the tube exceeds that specified as the maximum safe voltage that the tube is in danger. Here is one case where the actual voltage on the plate has any significance. If the applied voltage in the plate circuit is higher than that actually needed the amplification will be slightly greater and the distortion will be less, as was stated above.

AN EXAMPLE OF RESISTANCE COUPLING

In Fig. 1 is an example of a resistance coupled amplifier in which the tubes are of the three-element type. In this circuit the applied plate voltages are the same on all the tubes and equal to that on the power tube. If that tube is a 245 the plate voltage should be 250 volts, which is not too high if the plate coupling resistors are 100,000 ohms or higher. They could well be as high as one megohm.

The grid bias posts have been left blank because different bias values may be needed on all the tubes. The first tube operates a bias detector, or power detector since the plate voltage is high, and therefore C1 should have a very high value, best found experimentally.

The bias on the second tube would depend on the amplification constant of that tube and on the signal voltage delivered to it by the detector. Suppose the tube is a 227 and the signal voltage may be as high as 1.5 volts, which is quite possible. The bias should then be no less than 1.5 volts. But since the plate voltage is very high there is no reason why the bias should not be 3 or 4.5 volts. It is assumed that the coupling resistor following the second tube is high enough to prevent an excessive current flowing the circuit.

THIRD BIAS DETERMINED

The bias on the third tube depends on the amplification factor of that tube and on the signal voltage delivered to its grid. Suppose the tube as before is a 227 and that the signal voltage

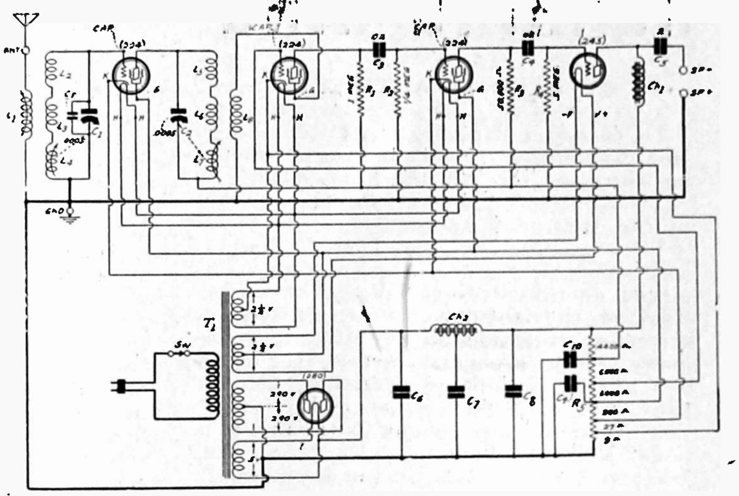


FIG. 2
A CIRCUIT CONTAINING A RESISTANCE COUPLED SCREEN GRID TUBE IN WHICH THE BIAS MUST BE ADJUSTED TO FIT THE COUPLING RESISTANCE, THE APPLIED PLATE VOLTAGE AND THE SCREEN VOLTAGE.

is 1.5 times the amplification in the second tube. This may well be 7 times, so that the signal voltage that can be expected at the grid of the third tube is 10.5 volts.

Thus the bias on the third tube should exceed 10.5 volts. Suppose we make it 13.5 volts. The amplification in the third tube may also be 7 so that the output voltage will be 73.5 volts. Now the power tube will take a voltage of only 50 volts before it overloads. Hence there is ample latitude and the power tube will be the first one to overload. The bias on the power tube will be determined automatically by the grid bias resistor provided.

When we are dealing with screen grid tubes the situation is entirely different. The effective voltage on the plate counts and counts heavily. If we should attempt to ignore the voltage drop in the plate coupling resistor and use the applied plate, screen grid voltages as recommended we would not get any amplification at all. It can be shown by curves taken on such a tube that the effective plate voltage should be at least twice as great as the applied screen voltage at every part of the grid voltage cycle if the tube is to amplify properly. If at any time the screen grid voltage is higher than the effective plate voltage the screen will take practically all the electrons from the cathode or filament and there will not be any left for the plate.

SCREEN GRID TUBE ADJUSTMENT

There is a way to offset the effect of the screen grid voltage to some extent when it is higher than the effective plate voltage, and that is by increasing the grid bias on the tube. For any given combination of applied plate and applied screen voltage there is one control grid voltage which will render the circuit operative regardless of the value of the coupling resistance, but the tube will not necessarily function well.

If we keep the control grid voltage, the applied plate voltage, and the coupling resistance at fixed values there is also one value of screen grid voltage which will render the circuit operative, and that screen voltage is usually only a small fraction of the voltage recommended for the screen in a circuit in which there is little drop in the plate circuit. This reduction will render the circuit operable but it will not necessarily make it operate well. If we wish to retain the high amplification of which a screen tube is capable there is no other way of doing it than by increasing the applied plate voltage to very high values. Indeed, the applied value should be so high that after the drop in the load resistance has been discounted the net voltage on the plate should be at least twice as high as the screen grid voltage, and that when the control grid voltage has the maximum value, that is, when it is near zero. When this condition is fulfilled the screen grid tube will amplify enormously and it will amplify with no more distortion than a three-element tube.

The conclusion is that the grid bias for a three-element tube must be adjusted according to the applied plate voltage and the bias on a screen grid tube should be adjusted to the particular combination of screen voltage, applied plate voltage, and the value of coupling resistance used.

# of a Set on a Boat

number of small boats are equipped with battery operated dynamic reproducers. This latter type of reproducer is operated from the storage battery supplying the filament potential.

In installing the receiver aboard the pleasure boat, says the N. Y. "Herald-Tribune," it is desirable to stow it away where it is conveniently reached, but as far from the motor and the water line as possible.

Keeping it away from the engine will lower the tendency of ignition interference and permit the operation of the receiver while traveling.

Salt water plays havoc with a radio set and for this reason it should be located in a dry place where it is shielded from spray and excessive dampness. As an additional precaution it is desirable to locate the receiver in a cabinet which may be closed tight when the set is not in operation.

Erection of an antenna aboard the small boat is not near so difficult a problem as in the case of the automobile.

While modern receivers require only a small aerial to give satisfactory results, in the case of the smallest of cabin pleasure craft it is possible to erect a pick-up system which will give results comparable to those obtained at the home installation.

For an aerial, one or two wires may be strung from stem to stern over the crossbar of the mast. This allows the use of approximately thirty feet of wire at a minimum, and is ample for the modern set, particularly those of the screen-grid variety.

Ground connection may be obtained by attaching a wire to the propeller shaft housing. However, if this should prove noisy, either of two methods may be employed. Perhaps the simplest, but the most inconvenient, is to trail twenty or thirty feet of wire in the water and attach this to the ground post of the receiver. The other method is to fasten copper wire or strip to the hull of the boat below the water line. If the craft has a metal keel this may be used quite well as the grounding connection.

SLEEP IS LOST, THRILL GAINED HEARING KING

BY REED M. ANTWEEP

The voice of King George IV of England was heard 'round the world when he addressed recently the London Naval Arms Conference, in the Royal Gallery of the House of Lords.

The reception in the United States was particularly good. The program was picked up by wire by 5SW, Chelmsford, England, and sent out on short waves received on this side of the Atlantic and impressed on broadcast carried frequencies by the National Broadcasting Company and Columbia Broadcasting Station System chains, and the Canadian National Railways chain.

When it was 11 A.M. in London it was 6 A.M. Eastern Standard Time, 5 A.M. Central Time, 4 A.M. Mountain Time and 3 A.M. Pacific Time, in the United States, so the percentage of listeners in respect to the number of receivers in those time belts was proportional to the lateness of the hour. Mountain Time dwellers, or in ths case victims, found it hard indeed to get up early enough to listen in, even for a King.

The President of the United States, as an E. S. T. early bird, not only managed to hear the King, but preliminary remarks as well, and had done a little exercising in the basement of the Whte House prior to that. President Hoover commented on the clearness of the reception of the King's voice, the absence of interference, and the fact that so many spoke in English.

In the Pacific Time Zone all one had to do to hear the King was to stay up late, while in Eastern Standard Time one had to get up early, and the difference between a delight and ordeal made His Majesty's voice more of a magnetic attraction in the Far West. What radioists were interested in principally was hearing the King's voice, rather than in what he might have to say, since the broadcasting was a real feat, and there was a thrill of hearing a King across the ocean and a continent.

More than 125 stations in the United States and 13 stations in Canada attended to the wholly satisfactory distribution of the treat over the North American Continent. All one had to do, besides getting up early enough, or staying up late enough, was to tune in a local station and hear His Majesty's voice in one's own home for the first time in the history of this or any other world.

The King was in good luck, because the static bombardment at dawn was terrific, and had engineers worried. The explosions and rumbles, like distant cannon combining their irritating fusillade with the sound of breakers attacking a coast of granite cliffs, threatened to furnish the King's speech with punctuation he never intended, and confound his words with atmospherics that even nature should avoid in deference to a King. But just as His Majesty started to speak the air cleared up, and things went along brilliantly.

Breaking of light on the intervening waters, at points that had been subject to interference, gave the short waves their familiar opportunity to carry beter in daylight than in darkness, a condition exactly opposite to action on broadcast frequencies.

There was some confusion in American homes, as the King was late. His Majesty is noted for his orthodox promptness, but a white fog in London one of those truly rare occasions, since in London the air gets a little thick at times but you could not call it a fog—made it impossible for all the King's horse and henchmen to ket him on time at the House of Parliament.

In fact, outriders preceded the royal carriage with lanterns. It was explained by a bystander loyal to the traditions and prestige of London that it is a quaint custom to preced the King with lanterns at 11 a.m. if he is to address an arms was perfectly posible to see without lanterns through the —er— thick weather, if one only new hokw.

The confusion, slight though it was, arose from the eight-minute lateness of the King, and the further fact, most astonishing to Americans, that His Majesty went on the air without any introduction whatsoever.

In this country listeners are used to the most florid and grandiose introductions of nobodies, and to think that the king of the greatest kingdom on earth should take the air without so much as a how-do-you-do nearly took the breath away from those who were not asleep. All persons not aslep or working the early run on the railroads and street car lines were deemed to be listening in.

And at the end no announcer so much as said, "Thank you, Your Majesty; you did great."

Besides the King there were other speakers, including Premier MacDonald of Great Britain, Premier Tardieu, of France, Foreign Minister Grandi of Italy, M. Wakatsuki, of Japan, and Secretary of State Stimson.

Copenhagen, Denmark; Geneva, Switchwerland, and topmost Alpine points, as well as Germany, heard the program well, all of it, all tongues, all speakers. The only thing that did not come in were the remarks introducing the King, and, as already hinted, there weren't any such.

So another historic event in broadcasting pased into history, from which it is not likely to emerge.

Engineer's Heroism Saves King's Talk

The speech by King George went over the Columbia Broadcasting System due to the heroic completion of an open circuit through the body of Harold Vivian, chief control operator.

Someone tripped over the generator wire just before His Majesty was to speak. Thousands of listeners were eagerly awaiting the royal voice. Vivian grabbed the several ends, one in each hand. The shocks of the 250-volt charge and the leakage of current through his body to the floor shook his arms with spasms. But he held on until new wires could be connected. By that time his hands had been slightly burned and he was feeling the effects of the ordeal. As soon as the broadcast was finished he was sent home to bed. But officials of the company said last night that he was not seriously hurt.

The King's speech lasted six minutes. It was not preceded by any announcement. His voice was heard clearly by the audience here. But none of the thousands of the Columbia's listeners was aware that save for Vivian's presence of mind and his pluck in clinging to the frayed ends of the broken wires their wait to hear the King would have been in vain.

Columbia Expe

The stage has been reached when chain s
Committee on Interstate Commerce learned f
Broadcasting System, which expects to show
The Columbia System is owned 50-50 by P
of individual stockholders, and owns its key, WA
Chicago, and WCCO, Minneapolis. The C. B. S
Prior to Jan. 1, 1928.........................
From Jan. 1, 1928, to Dec. 31, 1928,............
From Jan. 1, 1929, to Dec. 31, 1929............
Mr Paley said the Columbia network, serv
ent," and depends for its earnings solely on s
brought competition and variety into chain pr
for the benefit of listeners, he declared.
"In a broad sense," he said, "the Columbia
that regulates and chooses the Congress—the
Discussing the legislation before the Comm
constructive legislation.
"The one thing I hope above all else is tha
vent us from continuing on a sound business b
Mr. Paley pointed out that approximately
devoted to service or "sustaining" or self-co
or paid advertising programs.
Service programs are given to the network
stations accept the first five hours of the spo
without compensation. After these initial fiv
stations $50 per hour, Mr. Paley said, but in is
Of the sustaining or service programs offe
are popular music, 26 per cent. symphony, o
tive; 4 per cent. religious; 3 per cent. dramatic,
Frederic William Wile, who broadcasts wee
night," receives $175 per week, Mr. Paley said.
The "American School of the Air," planned b
the Office of Education and of the Departm
be inaugurated, Mr. Paley said.
In a statement issued by Mr. Paley is the fo
"In conducting Columbia on what we consi
sarily keep uppermost in our minds the need
strue as the keystone of any successful busi
to devote approximately 75 per cent. of our t
sponsored programs.
"For instance, in the current week, only 22
were sponsored. It may properly be observ
generally are acute and enlightened in mainta
ments with the dramatic or musical quality of
"Most sponsors have come to realize that th
is inserted. They now are voluntarily refining
announcement of sponsorship is prevalent am
ing advertisers.
"In addition to the improvement of advertis
larly to each of our 71 associated stations well-

NBC Asks Flex

Sympathy with the resolve to regulate broad
too stiff to cope with changing conditions, w
dent of the National Broadcasting Company, be
merce, on the bill for a communications comm
"I wish to state first of all that I have no ob
protect the public interest in radio broadcasti
feel sure that I am in complete accord with t
"I shall therefore endeavor to lay before y
to you in dealing with a very young art that
radio broadcasting as we see it today would
problem would be much simplified from a legis
"Under those circumstances I should expect
measures in the form of legislation. But, sin
broadcasting change almost from day to day,
ures may have flexibility adequate to accommo
dently expect.
"If we are to establish a communications c
I earnestly hope that the body will operate un
specific instructions that might handicap future
"To cite just one proof of the rapidity of ch
were endeavoring to exchange programs with B
tion was good and sometimes very poor. We w
program from across the Atlantic.
"By December we were able to state with r
Christmas programs with England, Germany a
success. When developments of such import a
art itself must necessarily be regarded as quite
"Only three years ago broadcasting was sea
obstacles. Now programs are sent out with cer
"We still have before us the old problem pr
On the basis of the present status of radio bro
'cleared channels' may be obtained.

ts 1929 profit

Washington.

s can get "out of the red," the Senate William S. Paley, president of the Columbia fit for 1929, for the first time in two years. ount-Famous-Lasky Corporation and a group New York City, also an interest in WBBM, ws the following:

..............................Loss, $205,424
..............................Loss, $172,655
..............................Slight profit

1 affiliated stations, is "absolutely independ- f time for sponsored programs. It has ıs, and is constantly adding to its features

n is regulated by the same supreme power le."

Mr. Paley said he did not oppose broad,

legislation will be enacted which will pre- he declared.

er cent. of Columbia's time on the air is tory programs, as contracted to "sponsored"

ns free of charge, he said, and in turn these l advertising programs offered by Columbia ırs, Columbia pays the majority of its cases pays stations up to $100 per hour.

y Columbia, Mr. Paley said, 29 per cent. and chamber music; 14 per cent. instruc- 2 per cent. civic.

The Political Situation in Washington To-

e Columbia System with the approval of of the Interior and Agriculture, will soon

g:

be a sound business basis, we must neces- endering real public service, which I con- enterprise. We have found ourselves able on the air to service, as contrasted with

cent. of the programs over our system ere that sponsors of network broadcasts careful balance of advertising announce- programs.

blic will tune out if too much advertising presentations to a point where the briefest the largest and most successful broadcast-

rograms, we are now able to furnish regu- ced programs."

ole Regulation

Washington.

ıg, but hope that regulation will not be xpressed by Merlin Hall Aylesworth, presi- the Senate Committee on Interstate Com- on. In a statement Mr. Aylesworth said:

n to governmental regulation designing to On fundamental principles and purposes I ommittee.

l the facts I have that may be of assistance veloping rapidly. If we could assume that ain in *status quo* for even five years the point of view.

committee to formulate specific regulatory ne technical, engineering phases of radio my earnest hope that the regulatory meas- the technical advancement that we confi-

ssion that shall control radio broadcasting, road powers and not be hampered by too ress.

in radio broadcasting, last Summer we and European stations. Sometimes recep- unable to announce with certainty any

able certainty that we would exchange Holland, and we did so with outstanding king place within a six-month period the hful and fluid.

because we could not combat weather of reception every month of the year.

ed by the need for more 'cleared channels.' ting it is not easy to determine how those

Wants Broadcasts on Birth Control

At the annual meetng in New York City of the American Birth Control League, the National Broadcasting Company was called "narrow and unprogressive" because of its refusal to broadcast addresses delivered in November at the National Birth Control Conference.

Forrest Bailey, director of the American Civil Liberties Union, making the characterization, added that there is need of a movement to impress upon commercial radio broadcasting stations their obligation to their patrons of transmitting subjects of vital importance, an advanced position, he said, in regard to all controversial subjects of great public interest.

Censorship is based on prejudice, Mr. Bailey contended, adding that while commercial broadcasting enterprises may well use their prerogative, refusing to grant the use of their facilities to broadcasts which they consider obnoxious, irritating or improper, it would be absurd, however, to adopt a medieval point of view and regard all topics relating to sex as improper and obscene.

Such attitude, he said, was rejected long ago by science and human advancement.

Radio Broadcasting, Mr. Bailey added, became a monopoly under private ownership, and to assure the freedom of the air he advocated socialization of the industry.

TALK IS TUNED IN AND NOT OUT

Villanova, Pa.

Radio colleges will be an established influence in the educational life of America within the next five years, the Rev. Dr. James H. Griffin, president of Villanova College, forecasts. The Rev. Dr. Griffin is making a study of the efficacy of educational broadcasts. He said:

"Listeners no longer dial away from every radio talk. They have learned that special broadcasts, such as the one from the American Philosophical Society in which Dr. Elihu Thomson, the famous inventor, and Dr. Harlow Shapley, Harvard astronomer, took part, are entertaining as well as informative.

"Broadcasting is entering a new cycle. It has passed the novelty stage and it is putting behind it the days when listeners demand only entertainment."

He regards educaton over the air not as a competitor of the college but as an adjunct. He believes broadcasts may help to solve the problem of continuing the education of the graduate after he leaves college.

"The success of educational broadcasting depends upon making the program interesting to the last minute, through dramatization," he asserts. "The person before the microphone must realize he cannot depend upon his appearance and gestures to hold the attention of the listeners."

Educational broadcasts derive their strength from the fact that the listeners are in receptive mood, he believes. Hence, the lecturer does not have to overcome mental indifference or resistance in the student.

HOOVER WANTS $206,640 MORE FOR THE BOARD

Washington.

The estimate of supplemental funds required for the Federal Radio Commission for 1931 was submitted by President Hoover to the House, calling for $206,640.

The Budget Bureau had written to the President:

"The budget for the fiscal year 1931 contains an estimate of $118,360 for all authorized expenditures of the Federal Radio Commission, except the pay of the five Commissioners. That estimate was predicated on the then existing law, which provided that the Federal Radio Commission would function after December 5th, 1929, as an appellate body only.

"The act of December 18th, 1929, continues indefinitely all powers and authority vested in the Commission to carry on duties not contemplated when the budget for 1931 was submitted. This estimate, $206,640, is in addition to the estimate contained in the budget, $118,360, making the total of the estimates for all authorized expenditures of the Commission, except the salaries of the five Commissioners, for the fiscal year 1931, $325,000."

Canada Heard Arms Program Clearly

Montreal.

The broadcasting of the opening meeting of the Naval Arms Conference in London, including the address of His Majesty, the King, and of Secretary of State Stimson, the United States delegate, and Mr. Ralston, who spoke for Canada, and others who took part in the ceremony, was heard perfectly in all parts of Canada by radio audiences, according to E. A. Weir, director of the Canadian National Railways radio department.

The department, with its thirteen stations, took an active part in the broadcast across Canada from Moncton to Vancouver. Reports from CNRV, the most western station, Vancouver, British Columbia, indicated that reception at the Pacific Coast was as satisfactory as in the East.

The broadcast began at 6:08 a. m. Eastern Standard Time, when the King made his first public utterance since his illness. Coming on such an important occasion his remarks were heard with the greatest interest.

"There was a little fading," commented Mr. Weir, "but apart from this reception was perfect. As daylight increased the speakers were heard more and more definitely. Every word of Mr. Stimson could be clearly distinguished. The speeches of the British Prime Minister and of Mr. Tardieu also came through without interruption."

New Corporations

Doyle's Mount Kisco Radio Shop, Mount Kisco—Attys. Doyle & Anderson, Mount Kisco, N. Y.

Actual Radio Co.—Atty. L. W. Santaslere, 110 East 42nd St., New York, N. Y.

MAJESTIC CRIES MONOPOLY AND TURNS ON RCA

By B. J. GRIGSBY

I am president of the Grigsby-Grunow Company, of Chicago, manufacturers of Majestic radio receiving sets. During 1929, we produced approximately 1,000,000 sets at a retail selling price of $150,000,000, out of an estimated total of 3,900,000 sets produced in the United States, with a value of $490,000,000. Our output of sets was larger both in number and value than that of any other manufacturer in the United States, including the Radio Corporation of America.

The Grigsby-Grunow Company was organized in 1921 to make automobile accessories. In 1924, we entered the radio field, manufacturing loudspeakers, and radio battery eliminators. In 1927, our company was the largest manufacturer of such eliminators in the United States.

$5,302,879.15 Royalties

We are licensees under the receiving set patents of the Radio Corporation of America, the General Electric Company, the Westinghouse Company, and the American Telephone & Telegraph Company, sometimes known as the radio trust.

In the year and a half in which we have made radio sets, we have paid that monopoly $5,302,879.15 in royalties. If we had not been compelled to add this royalty to our manufacturing cost, the retail purchasers of Majestic sets would have been saved approximately $15,000,000.

We did not pay this royalty because we considered these patents worth such a royalty. We did not believe we needed these patents, and none of them had been adjudicated. But the radio combine had so terrorized the industry and had so intimidated the dealers and jobbers everywhere, that they were afraid to handle what they called "unlicensed" sets.

Our bankers said they would not finance us unless we took out a license. They said they would not finance a patent fight against such a monopoly and there was nothing left for us to do but to sign the license agreement. The merits of the patents were never examined by the bankers. The merits of the patents had nothing to do with the case.

Cabinets Now Omitted From Fee

Originally, this license contract called for a royalty of 7 1-2 per cent of our gross receipts, not only on the radio apparatus involved, but on the cabinets and even the packing cases in which we sold them. Of course, the RCA had not patent on either cabinets or packing cases, but it had the power to compel the payment of any royalties it pleased, and therefore put the royalty on the manufacturers' price of the complete set.

As a result, some of the manufacturers were not putting their sets in cabinets, and thus were saving this royalty. We built our huge sales on the economies effected by our large mass production. One of these economies arose from the fact that our company was perfectly integrated, and that we made everything, including our own cabinets, in one plant. We were the largest furniture manufacturers in the United States.

If the royalty on cabinets had been continued, it would have forced us out of the cabinet business, and therefore would have destroyed the economies of our modern method of production.

It was because we served notice on the radio trust that unless it changed its policy, we would manufacture our cabinets through a separate company, so that it would not be able to collect these royalties, that the Radio Corporation of America changed its policy and abandoned the royalty on cabinets.

Even with this deduction, however, no industry can long pay 7 1-2 per cent royalty to its competitor. The combine could sell its products and make a profit of 7 1-2 per cent, at a price that would represent only our cost, and therefore eventually bankrupt us. If there were merit in any of the combine's patents, we would have no objection to dealing with the individual companies that owned these patents, but we do protest that it is a violation of the anti-monopoly laws to compel us to deal with all of them as one group, and to take all of their patents, and to pay a royalty, not on the merit of the patent, but solely on the power of the combination to destroy us unless we surrender.

Saddled With Bankrupt's Debts

When we took our license in 1928, the Radio Corporation of America compelled us to buy the license of a bankrupt company, and we were compelled to assume the obligations of that bankrupt company, which protected the Radio Corporation against loss.

The patent situation in the radio industry is becoming intolerable. When the Radio Corporation fixed its royalty rate at 7 1-2 per cent it did so on the pretense that it had a complete monopoly of the radio patent situation and that its patents covered every part of the radio receiving set. This is not true. We are now paying royalties to three other patent owners, and have been sued by five additional companies, claiming infringement of seven patents. In no case has the Radio Corporation protected us against these patents or helped us in the suits which have been filed against us.

The patent licenses we were thus compelled to take out include one under the patents of the Radio Frequencies Laboratories on a circuit. We have also had to take out a license under the Lektophone patent. This is a patent on the loud speaker cone. When we manufactured our loudspeaker under the RCA patents we copied directly the 104A type of Radio Corporation speaker.

When the Lektophone Company charged us with infringement we tried to get some help from the Radio Corporation of America, but they refused to give it to us because they had taken out a personal license from the Lektophone Company and had thus acknowledged the validity of its patents.

But the radio combine did not take out a license to protect its licensees, and so we had to pay additional royalties to the Lektophone Company on the same speaker which we were making under the Radio Corporation of America patents.

Anomalous Litigation

Later, again on this same speaker, we were threatened by the Magnavox Company, who brought suit against us, but not against the Radio Corporation, although the construction of the speakers is identical.

We have also a license under the Lowell and Dunmore patents, which has recently been upheld in a suit against the RCA. Further, to show that the members of the radio combine, individually, or as a group, do not own patents covering even standard types of sets, we are also being sued at present by the following, in addition to the Magnavox suit mentioned: The Hazeltine Corporation (two patents), La Tour Corporation (two patents), Federal Telegraph Company (Kolster patent), Edelman and De Forest. Besides this, we have been threatened by at least a dozen owners of other patents.

Charges Monopoly Attempt

The distinction between the licensing policy of the radio combine and that of the other patent owners is that the combine is seeking to dominate the industry and create a monopoly, while the others are simply trying to collect revenue from their patents.

Until the Radio Corporation abandoned the tube clause, we had to buy tubes from that corporation for the initial equipment of our sets. As a set is useless without tubes, this meant that our largest competitor could cripple us at will by delivering tubes to our own dealers and failing to deliver them to us. Repeatedly, we found that we could not get enough tubes to equip our sets, while we were informed that dealers who sold Radio Corporation sets had plenty of them.

LICENSES HELD NO PROTECTION TO SET MAKERS

Pooling of Patents Called Necessary

Washington.

A radio patent pool, similar to the automobile patent pool, should be created, B. J. Grigsby, president of Grigsby-Grunow Company, makers of Majestic sets, told the Senate Committee on Interstate Commerce, to end monopoly. The committee hearing was on the Couzens bill to create a Federal commission on communications.

He testified that the patent situation in radio is fast becoming intolerable and that the patent pool was a necessary remedy.

Patents owned outside the RCA, said Mr. Grigsby, are "more important than those they have." He declared that the Lowell & Dunmore patent, for "plug-in" sockets for receiving sets is one of the most important in radio, and that, although still in adjudication, it has been decided by the lower courts against the RCA. He said he did not believe that the combination of RCA patents had contributed to the development of the industry.

[He also read to the committee a statement published in this page in full.—Editor.]

WMBG Wants WJSV Listed in Other State

Washington.

An effort to have WJSV, operated by the Independent Publishing Company of Mt. Vernon Hills, Va., accredited to the District of Columbia instead of to Virginia, was made by WMBG, of Richmond, Va., at a hearing before the Federal Radio Commission.

WMBG had applied for an increase of power from 100 watts to 500 watts, unlimited time. WMBG said the programs which are broadcast from WJSV originate in Washington, D. C., and not at Mt. Vernon Hills, Va., and therefore, under the provisions of the Davis amendment, should be charged against the quota of the District of Columbia.

NO BLANKETING BY HIGH POWER ON NEW AERIAL

Washington.

Scientific progress being made by radio engineers to relieve congestion in the broadcast band, where more than 600 stations are operating on only 90 channels, was outlined and discussed at a meeting of leading engineers with the Federal Radio Commission.

Synchronization, or the simultaneous operation of two or more stations on the same wavelength to conserve the limited number of frequencies, was the primary topic. Engineers of various radio research organizations presented views of its development, agreeing that notable progress has been made, although perfect results have not yet been attained.

Two methods designed to improve broadcasting reception were preesnted by representatives of the Westinghouse Electric and Manufacturing Company. One related to synchronization, and the second involved a new type of transmitting antenna system for increasing strength of local signals and at the same time minimizing distance signals, or the reverse.

Avoids Blanketing

Papers by Dr. Frank Conrad, assistant chief engineer of Westinghouse Company, and Walter C. Evans, superintendent of the Westinghouse radio operations departments, were presented on these subjects. Other engineers generally agreed that synchronization, at least by wire control, has bright prospects, but that the antenna system did not appear feasible.

Mr. Evans said that the new antenna system, now being used in short wave transmission experimentally, will make it possible for a cleared channel station to broadcast with high power without blanketing the surrounding area. Conversely, he said, the system also can be used so that a local station can send out a strong signal in its own territory without interfering with distant stations.

Dr. Conrad said that synchronization has the advantage of making it possible to increase the service area of a program furnished identically by two or more stations without utilizing more than one channel and at the same time reducing fading. He pointed out that Westinghouse has operated wire-synchronized stations since 1926.

Remedies Sought

Opening the discussions, Commissioner Charles McK. Saltzman, in charge of the Commission's engineering division, said the conference was called to ascertain what remedies were in sight for broadcasting. The Commission, he said, is having difficulty because of the limited number of channels and the constantly growing number of requests for changes in assignments.

Capt. Guy Hill, the Commission's acting chief engineer, said the main purpose was to attempt to work out means of minimizing interference in the broadcast band. There is no hope of taking care of more stations, he said.

Mr. Evans, in discussing the antenna system developed by Westinghouse, said the new system will be first installed at Saxonburg, Pa., for KDKA, according to 'The United States Daily."

When it is desired to have a station send out a strong local signal without distance transmission the antenna is built so that it radiates a powerful wave along the ground but does not send one into the air where it would be deflected to distant areas, the engineer explained. If the station is on a cleared channel it can be made to send out a strong sky wave with a small amount of ground wave, he said.

KDKA to Use Eight Aerials

At KDKA, it was explained further, this effect will be achieved with eight individual antennas set in 110-foot poles arranged in a circle 800 feet in diameter.

"The upward movement of the signals is compared to the action of a lawn sprinkler which sends its spray upward and outward so that it is distributed at a distance, but not immediately around the source," Mr. Evans explained.

Dr. J. Hoyt Taylor, Director of the Naval Research Laboratory, said there might be a benefit within an area of 50 miles, but that he was skeptical about long distance transmission.

Dr. J. H. Dellinger, chief of the radio division of the Bureau of Standards, declared the net gain of the system would be to improve the service within the service area of a particular station, but that it was problematical as to the long distance reception results.

Signals Improve 40%

Edward L. Nelson, engineer of Bell Laboratories, New York, said his company had experimented with new type antennas. It has made tests with a small balloon which raised a single wire antenna to about 1,000 feet, he said. The results showed that as far as the signal in the local area are concerned, it can be improved some 40 per cent.

The method of synchronization supported by the Westinghouse group is that of generating a frequency and supplyi-- it to one or more radio stations over either wire facilities or to be multiplied at the several stations sufficiently to be put out on the air as a carrier wave. Dr. Conrad said that methods which do not depend upon a wire or radio connection between the stations have not proved satisfactory.

Committee Appointed

Following the meeting a committee of five engineers was named by Commissioner Saltzman to analyze the views that had been expressed. The following were oppointed:

C. W. Horn, general engineer, National Broadcasting Co.; Dr. J. H. Dellinger, chief of radio division, Bureau of Standards; L. E. Whittemore, American Telephone and Telegraph Co.; John V. L. Hogan, consulting radio engineer of New York; and W. C. Evans, superintendent of radio operations, Westinghouse Electric and Manufacturing Co.

N. B. C. *Progressing On Synchronization*

Washington.

Merlin H. Aylesworth, president of the National Broadcasting Company, told tne Senate Interstate Commerce Commission his company is working on synchronization, or putting two or more stations on the same wave at the same time, without interference, due to identity of carrier frequency (no heterodyne) and geographical separation. He said:

"While it may not be the best business policy to say so at this time, our engineers are now and for a long time have been working toward synchronization in the hope that the present traffic jam on the air will eventually be relieved.

Last Summer I went to Europe with engineers to see what was being done there toward synchronization. I found that our own engineers are far ahead of any others with this task.

EQUALIZATION ZONES UNFAIR, SAY STATIONS

Washington.

Establishment of a permanent commission with full control of radio regulation, whether or not it may be vested with authority over other forms of communication, and elimination of the present "zone system" of distributing radio facilities were advocated by William S. Hedges, president of the National Association of Broadcasters.

Mr. Hedges laid before a Senate Committee resolutions adopted by his association regarding proposed legislation. He explained the association includes in its membership 147 stations. Mr. Hedges is director of WMAQ, Chicago, and radio editor of "The Chicago Daily News," which operates the station.

Five Recommendations

Five specific legislative recommendations were made by the witness. In addition to those relating to the creation of a permanent commission, and elimination of the "zone system," and Davis amendment, Mr. Hedges urged that broadcasting licenses be issued for a minimum period of one year instead of 90 days as at present; that administrative provisions of the existing law be clarified; and that Congress act with the least possible delay.

Unfairness Charged

In allocating radio facilities, Mr. Hedges said, it is unfair to charge particular stations to a particular zone or States, when they serve people in other zones or States as well. By eliminating the zone system "a more efficient use may be made of the very limited number of channels available for broadcasting."

It was urged by the witness that the service to radio listeners be made the sole basis for the distribution of radio facilities.

Aeronautic Committee on Radio Appointed

Washington.

Formation of a liaison committee on aeronautic radio research, to survey governmental and industrial research seeking to overcome obstacles to safety and reliability in air transportation, was announced by the Assistant Secretary of Commerce for Aeronautics, Clarence M. Young. The committee:

Harry H. Blee (chairman), Aeronautics Branch, Department of Commerce; Dr. J. H. Dellinger (secretary), Bureau of Standards, Department of Commerce; Lt. Comdr. D. B. Duncan, U. S. N., Bureau of Aeronautics, Navy Department; F. C. Hingsburg, airways division, Bureau of Lighthouses, Department of Commerce, or H. J. Walls, alternate; Herbert Hoover, Jr., Aeronautical Chamber of Commerce of America, or H. C. Leuteritz, alternate; Dr. Lewis M. Hull, Radio Manufacturers' Association; George W. Lewis, National Advisory Committee for Aeronautics; Capt. H. M. McClelland, Air Corps, War Department; F. M. Ryan, Institute of Radio Engineers; Wesley L. Smith, American Air Transport Association, and Ray Stearns, National Electrical Manufacturers' Association.

FORECASTS OF STATIC NEWEST LISTENER HELP

Washington.

Static, which spoils radio entertainment so frequently, is to be forecast and made known in the same manner as weather forecasts are now desseminated. When this service has been put into operation it will be possible for radio fans to know what kind of radio reception they may expect during a certain period.

This subject will be taken up at the Stockholm meeting of the section of terrestrial magnetism and electricity of the International Geodetic and Geophysical Society to be held next August, and a proposal will be made that daily reports of magnetic disturbances, which cause much static, be broadcast on short waves along with the regular weather forecasts and reports on seismic activities, according to an announcement by Dr. D. L. Hazard, assistant chief of the division of terrestrial magnetism and seismology of the United States Coast and Geodetic Survey.

Investigations on the relationships between magnetic storms and reception of radio waves have been made by Dr. G. W. Pickard, Newton Center, Mass., research associate in terrestrial magnetism of the Carnegie Institute, the Bureau of Standards, the Naval Research Laboratory, and the General Electric Company, and the conclusion is that fairly accurate forecasts of magnetic storms and their effects on radio reception can be made.

RCA and A. T. & T. Sue on Two Patents

Wilmington, Del.

Suit was begun against the Universal Wireless and also against the Detroit Radio Company by RCA and A. T. & T. for alleged patent infringements.

The bill states that two De Forest patents obtained prior to 1914 were adjudicated valid in the case of A. T. & T. against the Westinghouse Company and that the Radio Corporation has exclusive rights under each of the patents.

The Radio Corporation asks for damages and an injunction prohibiting use of the patents.

TRIAD LICENSED

Triad Mfg. Co., Pawtucket, R. I., tube maker, announces it has been licensed by R. C. A., G. E. and Westinghouse.

Italian Station Europe's Strongest

Rome.

At Santa Palombia, the largest and most powerful broadcasting station in Europe has been opened. The plant was installed by RCA, about 13 miles south of Rome. It is rated at 50-kw. output power and will use 100 per cent modulation, although there is provision for 200-kw. output. The wave is 441.8 meters.

DILL FORESEES WORLD TONGUE

By THOMAS F. DILL
United States Senator, State of Washington

The first basis of peace is acquaintance and understanding. Radio will make that possible as nothing else has ever done. Radio has the power to make us feel together, think together, and live together and act together. Radio transforms a human personality into an electrical force which penetrates water and air, walls and mountains as easily as light passes through glass. Today we begin to use it as a means of helping men and women all over the earth to understand one another better and thereby make all nations better friends.

When I think of Radio I think of the spirit of youth. Whatever it desires, it dares to try. This spirit of youth has brought radio to its present state of development and is already making it serve mankind beyond even the imaginations of the wisest radio engineers of a few years ago. What it will yet do for mankind nobody can foretell.

Radio binds together the inhabitants of the far places of the earth. The rancher on the plains, the working man in the city, the miner in the hills, the invalid on the sick bed, the mariner at sea, the pilot in the clouds—all are a part of the vast audience of radio in every land.

Radio will do more than anything else to give us a world language and it will be the American-English language. American broadcasting stations are the most numerous and the most powerful. American programs are the most interesting and entertaining.

Through American and English stations all the world soon can listen in, and all the civilized people of the world will come to know one another better day by day. As they know one another better, they will be less likely to hate one another.

CASH LOW, BUT KOLSTER HOPES TO 'COME BACK'

The Kolster Radio Corporation consented to a receivership in Newark, N. J., and announced a reorganization is expected to put the corporation on a paying basis.

Frederick J. Faulks, attorney, entered the consent. He said he had been called in only to advise the company in this matter. He said the company's assets were considerably in excess of liabilities, but because of overproduction it had been unable to raise cash to meet immediate obligations. He said he hoped the receivership would be of short duration and believed the company would soon be reorganized and again be on a money-making basis.

Three receivers were appointed: Harry J. Hendricks, Newark real estate man; Harry Meyers, president of the Lincoln National Bank of Passaic, N. J., and Ellery W. Stone, president of the Kolster corporation. A joint bond of $50,000 was ordered by the court.

The receivership was ordered on the petition of Morris H. Cohen on behalf of Jacob Meyer, as holder of 100 shares of stock. The contentions were that the company had sustained a $916,233 loss, that it was insolvent and that its assets were $2,000,000, exclusive of patent rights and accounts of doubtful value, while liabilities were $18,000,000 including capital stock liability.

Albert Schwartz, a Paterson lawyer, appearing as a stockholder, said that "somebody had rigged the market" in selling Kolster stock and asked that the receivers check up this angle. The court said he did not understand the term used, but presumed the receivers would attend to that feature.

China to Spend a Lot on Message Stations

Washington.

Expenditures of $3,000,000 for the construction of radio stations for the transmission of messages between China and America, and China and Europe, will be included in the proposed $10,000,000 telegraph loan which will be floated shortly by the Chinese government, according to a report from Trade Commissioner Frank S. Williams, made public by the Department of Commerce.

In order that the ministry of communications may terminate the special privileges hitherto granted to foreign companies the government will devote $4,000,000 to settle outstanding obligations to the Eastern Extension Telegraph Company and the Great Northern Telegraph Company, the report adds.

Supper Hour Feature to Simulate Banquet

What's what, but not who's who, will be set forth in the new series over WEAF and chain, sponsored by the American Radio Corporation, daily, except Saturdays and Sundays, for a half hour beginning 6:30 p. m. The company becomes the biggest time buyer in the United States—2½ hours a week.

Termed as a "banquet for radio listeners," the programs have been so planned that they may be heard while listeners are at the dinner table. Continuity and music is so designed as to create the illusion that the listener is at a banquet.

A feature of the half-hour programs will be the "radio reincarnation" of noted personalities on their birthdays. By means of brief dramatic sketches listeners will be taken into their imaginary homes. Vocal and instrumental offerings also will be woven into the programs.

A mystery will be injected into the series by the utilization of an incognito toastmaster. The names of the assisting artists will also be withheld at first in order to test the listeners' recognition of radio entertainers.

The series is said to represent a combination of radio features seldom attempted before in one period on the air.

Radio Permit Asked By Ford Motor Co.

Washington.

The Ford Motor Company, of Dearborn, Mich., filed with the Federal Radio Commission an application to establish an aeronautical radio service.

In its application, the company requested construction permits for the service, which would operate in the long wave band ranging from 278 to 500 kilocycles, with 1,000 watts power. The application was taken under advisement.

LATEST BOARD COUNSEL UNDER SENATE FIRE

Washington.

The rapid succession of counsel to the Federal Radio Commission, due to resignations, has started something among Senators. A lso, Senator Wheeler charges that appointments to positions under the Commission are for the fulfillment of political debts.

"The Commission," said Mr. Wheeler, who hails from Montana, addressing the Senate Commerce Committee, "has been made a political football by the Administration by use of appointive positions to pay political debts. I have been informed and believe they have appointed a man as attorney who has not had any experience in the Commission, and that now they are taking a couple of negroes from Ohio who have never had any experience in radio work at all and propose to put them on as assistant counsel simply for political reasons."

The attorney to whom Senator Wheeler referred is Colonel Thad H. Brown, recently appointed general counsel of the Commission.

Senator Dill, Democrat, of the State of Washington, said:

"The situation with regard to the attorneys of the Radio Commission is very bad. They have had three in a big case going to the Supreme Court. One attorney presented the matter to the District Court of Appeals, and he got out. Another attorney prepared the briefs in the case in the Supreme Court. Now he is out and a new attorney is in."

Col. Brown later denied that the appointment of two negroes as assistant counsel had been contemplated.

Both Senators Wheeling and Dill are Democrats.

Patents "Hamper" Police Radio Plans

Washington.

Even police departments of cities must respect patent rights of R. C. A. and associated companies, the Senate Committee on Interstate Commerce learned.

Lieut. Kenneth R. Cox, of the Chicago police department, said efforts to install a radio police system had been delayed because the city's law department advised that use of non-licensed equipment would render the city liable for damages.

Cox, a radio engineer, said he had pioneerel in police radio and had installed the system in Detroit. He said the RCA had prevented the Chicago department from building its own equipment on the ground that it would infringe RCA patents. Subsequently, he declared, contracts for the three transmitters were let to the Graybar Electric Company, subsidiary of the Western Electric, and for the receiving sets to be installed on "cruising" cars, let to RCA, the entire system to cost $117,500. "We could have built a far superior one for $48,600," he said.

Every large city in the country, and many foreign cities, have awakened to the benefits of police radio, Lieut. Cox declared. In Detroit, the first city to install a stystem of short wave crime detection, he said there has been a 54 per cent. decrease in burglaries and a 45.8 per cent. increase in convictions, attributable to radio. Both voice and code

Forum

More News—Yes? No?

I AGREE with Arthur Day, of Kentucky, that your radio magazine is one of the best of its kind in the country and also, as he says, that you are making a mistake in not printing more radio news.

The technicalities are for engineers, not for those that have never made radio technique a study.

I think that all of your writers are good.

FRANK A. ROGERS, Detroit, Mich.

* * *

Error in Diagram

I WISH to call your attention to an error in the pictorial diagram of the HB-44 of the Jan. 28th issue.

You will note that no voltage is applied to the shield-grid of the 224 detector; that is, the "G" terminal of socket V4 goes straight to one side of C6. The voltage lead going to the high side of R1 *crosses* this lead, but should connect to it. The accompanying schematic diagram was correct in this point.

T. C. RAYNES, Braman, Okla.

* * *

Wants Technical Stuff Out

I AM a subscriber for your magazine. As an operator of a broadcasting station I am at all times seeking constructive criticism.

Here is what I will suggest for you:

Cut out the technical educational part of your magazine. The time has passed when the public is interested in HOW TO BUILD A SET. The ready-built sets are better than anything that can be built by an amateur.

You have entirely too much advertising.

You don't have enough interesting reading matter for the public.

This is enough.

JOSEPH HENKIN,
KSOO, Sioux Falls, S. D.

A THOUGHT FOR THE WEEK

TAKE heart, radio dealers! It has been estimated five million sets will be sold during 1930. Where is the solemn-faced individual who announced some months ago that the radio market had reached the point of saturation? He's not at all popular with the optimists, who, Heaven bless them, are still with us.

WGY'S VICTORY FINAL ON LAST COURT'S ACTION

Washington.

The victory of WGY, Schenectady, N. Y., over the Federal Radio Commission, whereby WGY was given full tune on 790 kc by court order, despite the part time allotment under the reallocation, is regarded as final now, as the United States Supreme Court, after hearing the commission's counsel on the appeal, refused to hear counsel for WGY and the State of New York. Such refusal heretofore has been followed by a decision in favor of the party not required to be heard.

The General Electric Company in its briefs insisted that the court was without jurisdiction since the decision of the court of appeals was administrative and not judicial.

In this view it was joined by the briefs of the State of New York. The New York briefs also insisted that the public necessity, convenience and interest required that the former license of WGY be renewed due to the large pupulation which it catered to for radio entertainment.

The position was also taken in the WGY briefs that priority of time as against any subsequent stations gave WGY superiority of right to be free from interference caused by subsequently established stations and this, it was claimed, is a vested property right, akin to a trade mark. This particular contention the lower court overruled.

The action of the Supreme Court in declining to hear any arguments on the merits or to hear counsel for respondents is was stated at the Commission by its acting general counsel, Paul D. P. Spearman, established the court of appeals as the administrative agency, over the Commission.

WMAK LOSES POINT

Washington.

The Court of Appeals of the District of Columbia denied the petition of the WMAK Broadcasting System of Buffalo, N. Y., for a stay order to prevent the Federal Radio Commission from removing WMAK from its present channel in favor of the "Buffalo Evening News."

Squeals Put to Work; Produce Real Organ

Pittsburgh.

The heterodyne squeal familiar to all owners of radio receivers has been put to practical use in a new electrical organ, which has been developed by R. C. Hitchcock of the research laboratories of the Westinghouse Electric and Manufacturing Company. A concert played on this organ by Dr. Charles Heinroth went on the air recently over station KDKA.

The electric organ, which is about one-hundredth the size of a conventional pipe organ, produces clear musical tones of almost any quality desired. It is played on a keyboard similar to that of a pipe organ, and the keys control the pitch, or frequency of the squeal thus producing the tones.

The synthetic music produced in this manner has several advantages over other music. First, higher harmonics which may be disturbing to some ears may be eliminated completely, thus leaving the pleasant harmonic combinations which produce rich, deep, and resonant music. Second, each harmonic can be tuned separately so that the harmonic content may be of any desired composition of intensity. Third, the volume level of the music can be changed at will without changing the relative timbre.

The range of the new electric organ covers over three octaves, but it can be extended to any desired limit.

One of the practical advantages is that it can be built at a lower cost than any pipe organ and another is that it requires so little space that it can be put where no conventional organ could be placed. It is thought that it will find application in broadcasting studios throughout the world.

RADIO UNIVERSITY

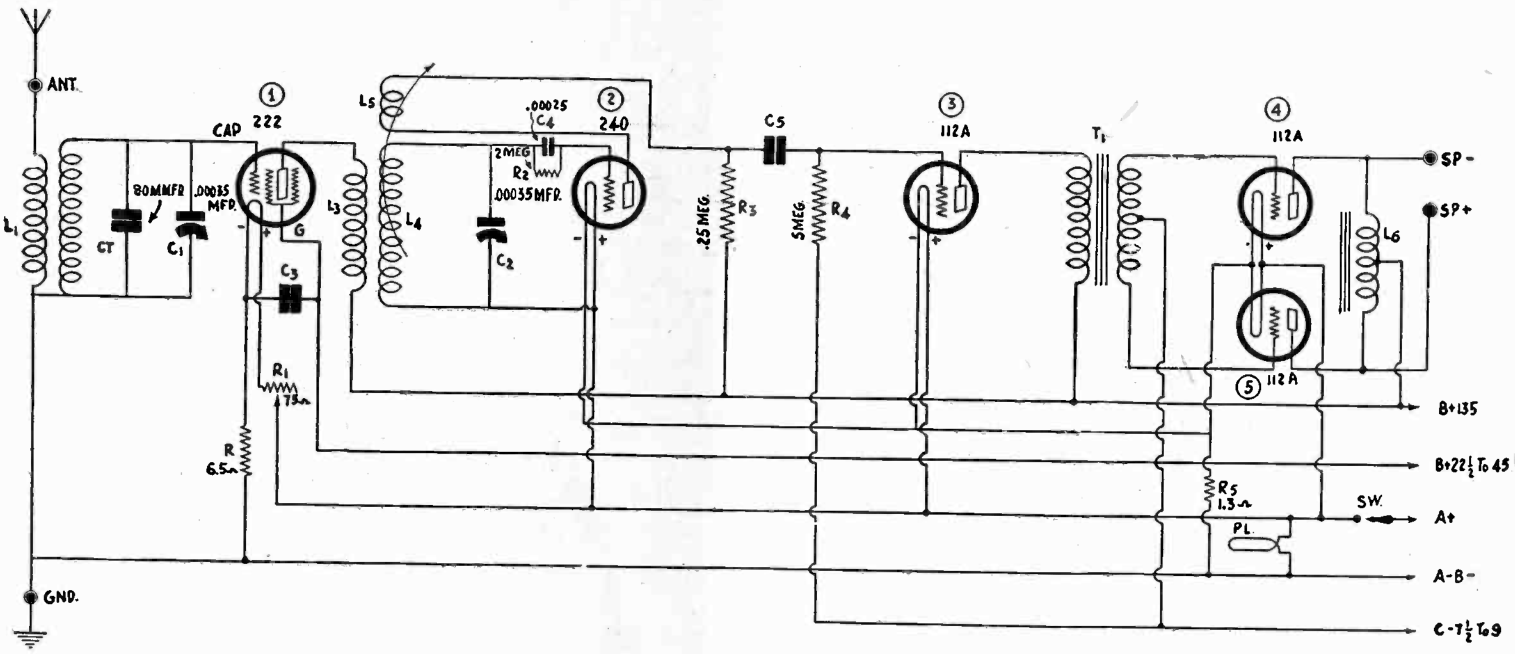


FIG. 826
FOR THE RECEPTION OF LOCAL STATION A FIVE-TUBE RECEIVER OF THE KIND ILLUSTRATED HERE IS EXCEPTIONALLY SUITABLE.

A FIVE-TUBE RECEIVER

PLEASE PUBLISH the diagram of a simple, regenerative receiver using DC tubes throughout and one screen grid tube in the first stage. A receiver capable of good quality quality is desirable. It does not have to be very sensitive because it is to be used for the reception of local stations only.—C. G. A.

Fig. 826 shows a circuit like that you request. If you tune the two circuits independently you do not need the trimmer condenser CT.

MODULATION HUM IN RECEIVER

WHENEVER I tune in a station there is a strong hum in the loudspeaker. I have tried everything to stop this hum, but have had no success at all. The hum is not very objectionable while the music is on, but becomes very objectionable during moments of silence in the station. What can be done in stopping the hum?—K. W. S.

This hum is directly due to the residual ripple in the plate current supplied to the radio frequency tubes. These tubes detect or act as modulators and therefore mix the ripple with the carrier frequency. Once the ripple has entered the carrier frequency as a modulation it is tuned in and amplified just as any other signal. Since the hum is due to the ripple and the detecting characteristic of the tubes, the remedy would be either to remove the ripple or to decrease the detecting efficiency of the amplifier tubes. The ripple may be reduced by increasing the filtering of the plate and screen currents supplied to the amplifier tubes, using either choke coils or condensers, or both. The detecting efficiency of the amplifier tubes may be reduced by operating the tubes with the proper grid, screen, and plate voltages. There is also a method of balancing out the hum, but this is rather complex and depends on the degree of modulation.

DISCUSSION ON B SUPPLY UNITS

CAN YOU REFER me to a book containing a discussion on B voltage supply units, including principles of rectification, filtering and voltage distribution?—A. D. S.

There is a chapter devoted to this subject in Audio Power Amplifiers by J. E. Anderson and Herman Bernard. There is no complete book devoted exclusively to the subject.

SEEING IN THE DARK

I HAVE SEEN references in radio papers to noctovision. I understand that it has some relation to television, but I don't know what. Will you please explain what it is and how it works?—J. J. N.

Noctovision is the phase of television in which infra-red radiation is used at the transmitting end instead of visual light. The object to be transmitted is scanned in the usual way with a beam of infra-red light, light which is just beyond the red end of the visual spectrum. A photo-electric cell which is exceptionally sensitive to such radiation is used for picking up the infra-red rays and converting them into electrical impulses. At the receiving end the electrical vibrations are converted into visual images in the usual way. Infra-red rays have the advantage of penetrating fog and smoke where visual light rays would be absorbed. At the transmitting end the object may be in complete darkness as far as the human eye can tell, yet it may be intensely illuminated as far as the photo-electric cell is concerned. Television could also be conducted with ultra-violet rays, rays just beyond the violet end of the visual spectrum. Most photo-electric cells are most sensitive at ultra-violet waves, but ordinary lenses will not transmit them. When television is conducted with these rays, lenses and the wall of the photo-electric cells must be made of quartz.

USE OF POWER TRANSFORMER

I HAVE BECOME interested in the Loftin-White amplifier and am wondering if the Polo transformer designed for full-wave rectification can be used in a half-wave rectifier so as to get the high voltage required for this amplifier.—B. L. O.

It can be so used. The center tap on the high-voltage winding is ignored and the two extreme terminals alone used. There is no filament winding for the 281 tube on this transformer so that if this tube is used a separate filament transformer giving a voltage of 7.5 volts must be provided. However, it is possible to use a 280 tube in a half-wave rectifier. The two plates are tied together and connected to one of the high-voltage terminals of the transformer, the other being connected to the filament of the rectifier. While this tube is not intended for such high voltage it will withstand it, unless it is slightly defective.

HEAVY LEADS NECESSARY

IN BUILDING a receiver in which there are many heater-type tubes connected to the same transformer winding would it be advisable to run a separate pair of leads from the heater terminals of each tube to the transformer rather than to use a common pair of leads? If there are any disadvantages of this arrangement, kindly point them out.—M. C. A.

The arrangement is very good because there will be less voltage drops in the leads. Not only is it advisable to use separate leads for each tube, but also to make each pair of heavy wire. The wires should be cut off at a suitable length and then joined. They can all be soldered to a pair of heavy terminal lugs. The leads from the transformer can also be terminated in a pair of binding posts made of No. 8 screws and nuts, or heavier. Twist or bunch the leads throughout and put the binding posts as close together as possible without short-circuiting.

HEAVY CURRENT IN POWER TUBE

I HAVE ASSEMBLED a Loftin-White amplifier and got it to working fine. I had to use meters, however, to effect the adjustment. During my testing I noticed that the current in the power tube ran up abnormally high when I first turned on the power, and then gradually settled down to the normal value. During this initial instability the amplifier did not work. Can you explain the phenomenon?—H. A. S.

The grid bias on the power tube is the direct current voltage drop in the coupling resistor ahead of the tube. When no current is flowing the bias on the power tube is positive and a heavy current flows in the plate circuit. Now as the power is first turned on the B supply and the power tube begin functioning almost instantly while the heater tubes requires a considerable time to heat up. During the heating-up period no current flows through the coupling resistor and consequently the bias on the power tube during this period is positive. Hence the heavy current. There are two reasons why the amplifier does not work during this period. The first is that the heater tube does not work at all and the second is that the power tube will not amplify while its grid is positive.

TUBES DE-AMPLIFY

I HAVE A MULTI-TUBE screen grid receiver with gang control of the condensers. The volume is not good at all. In fact, I can only get earphone detection. I have found that if I connect the antenna to the grid of the detector I get good reception. If I connect the antenna to the next preceding grid I get less. The farther ahead I put the antenna the less the volume and by the time the antenna is on the post provided for it I get only earphone volume on the loudest stations. Can you suggest a remedy for this condition?—B. D. J.

It may be that the tubes are bad, in which case the receiver would behave that way. But it is more likely that the trouble is lack of matching of the tuned circuits. Adjust the trimmer condensers on a low-wave station until the signal of this station is the strongest possible. Adjust the number of turns on the coils at a long-wave station until it comes in strongest. Possibly the coil adjustment should be done first or else the trimmer adjustment should be made both before and after the coil adjustment.

WHEN TUBES BURN OUT

THE TUBES IN MY receiver do not last very long, but burn out after a few days of operation. It is always the filament which gives out, yet the voltage is not over the rated value of 2.5 volts. What could cause this trouble?—J. J. S.

Possibly there is a short between the heater and the cathode. If there is a high voltage between these two elements, as there frequently is, the tubes would not last long. The short cannot be complete or the tube would burn out instantly. Test the tube out of the circuit for a possible short between the two elements, using a battery and a voltmeter. If the voltmeter shows a reading it indicates a connection between the heater and the cathode, which should not be. Use a voltage which is about the same, or higher than the voltage which may be expected across the elements in operation. If the test is carried out in the circuit a reading will be obtained even if there is no short, because the heater is usually connected somewhere so that there is a complete circuit.

VOLTAGES IMPORTANT

WHAT ARE the most important elements in the non-reactive circuits in which no stopping condensers are used between the tubes?—K. K. O.

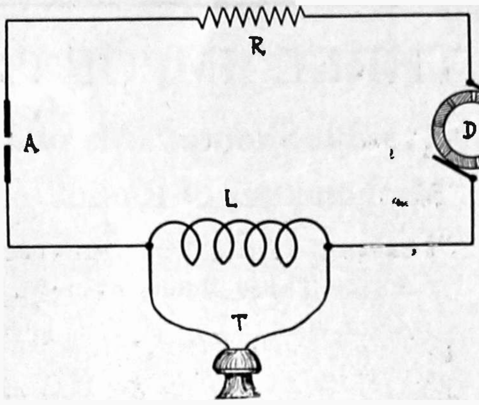
All elements are of equal importance, for the circuits will not work unless they are all there. We presume that you are referring to the so-called Loftin-White circuits. However, correct co-ordination of the voltages is extremely important. In adjusting these it is well to set the grid bias at a fixed value and then use the highest plate voltage that is permissible in view of the bias that must be applied to the power tube. The screen grid voltage should then be adjusted so that the first tube amplifies properly. Usually, the screen-grid voltage should be very much lower in a resistance coupled circuit than that ordinarily recommended.

DOES A SUPERHETERODYNE RADIATE?

I HAVE A SUPERHETERODYNE which works very well, but my neighbors complain that it oscillates and causes interference with their sets. Is this possible? If so, how can I prevent the radiation and still leave my set sensitive?—C. A. H.

It is not only possible that your superheterodyne radiates and interferes with your neighbor, but it is quite probable that it does. A superheterodyne must have an oscillator and any oscillator causes radiation. One way of preventing radiation from the receiver is to shield the receiver completely. If you have a loop for picking up signals, and if there is feed-back, shielding will not stop any of the radiation. Another way of preventing radiation is to put a stage of untuned radio frequency amplification ahead of the first tube.

FIG. 827
A simple diagram of a speaking arc. The voice current, or the voice modulated current from a radio receiver, is impressed in series with the arc circuit.



THE SPEAKING ARC

SOME TIME AGO you published something about a speaking arc as a kind of loudspeaker. Will you kindly publish a diagram of such a circuit now and suggest how it can be used for reproducing sound from a radio receiver?—H. A. B.

In Fig. 827 is the speaking arc circuit in its simplest form. D is a direct-current generator which supplies the current for the carbon arc A. L is a coupling inductance for impressing the sound from the microphone or the radio receiver on the arc circuit. Since the current required to maintain the arc is of the order of 15 amperes it is clear that the coil L must be wound with very heavy wire on a core large enough to prevent saturation. If the output of a radio receiver is impressed, L may be the secondary of a step-down transformer. The radio frequency current may also be impressed on the arc circuit, making the arc the detector. In that case L should be an air-core transformer or choke coil.

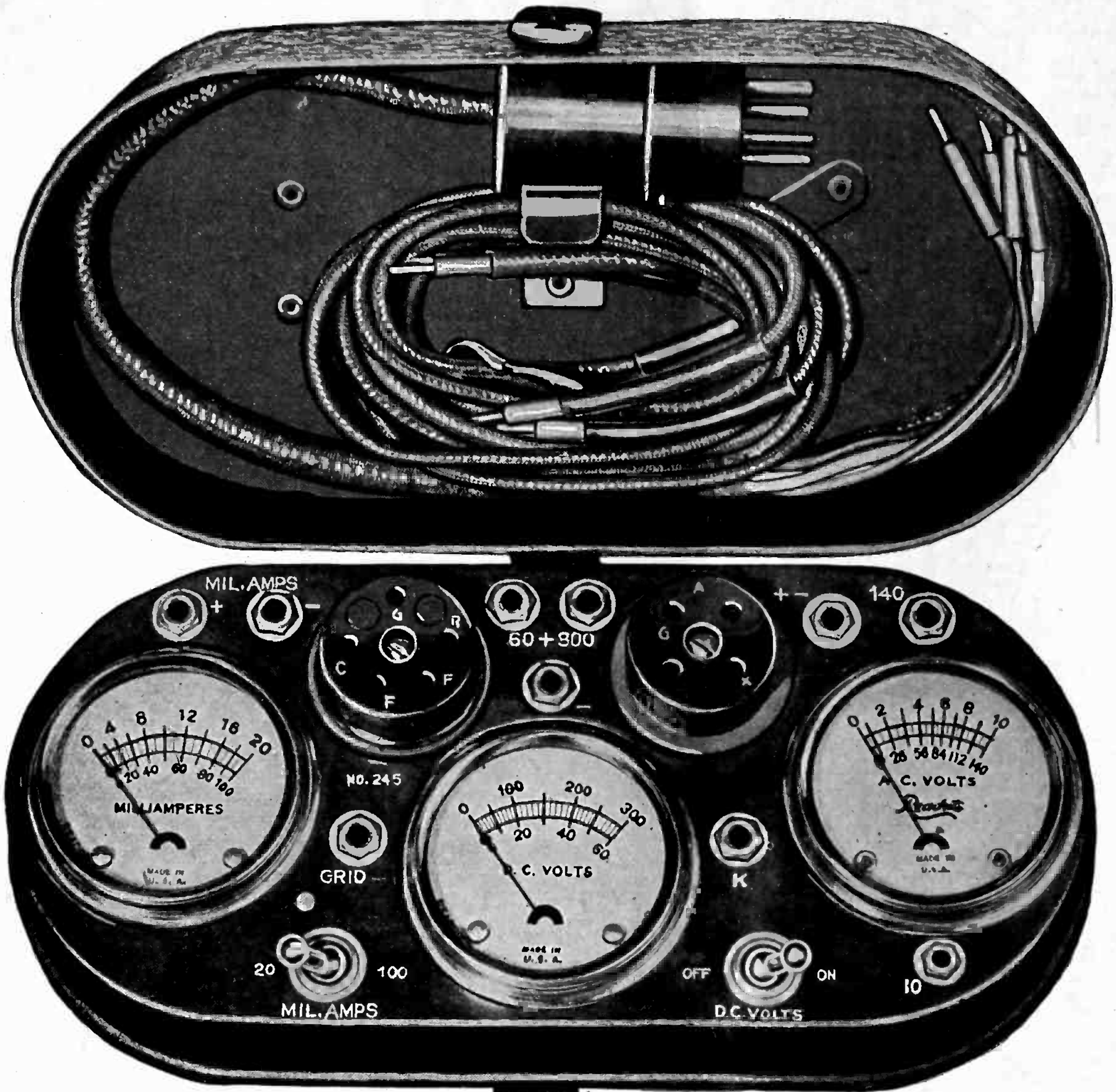
HOW TO REMOVE SQUEALS FROM SUPER

I WISH YOU would publish something on the causes and cures of repeat points and squealing in superheterodynes. I have looked through every issue of RADIO WORLD for two years back without finding a thing on the subject. It seems to me that this is an important subject and that it edserves discussion.—W. A. D.

Sure it is an important topic and that is the reason we discuss it periodically. We must have run articles at least twenty times during the last two years and a half. It is less than six months since a series of articles was run on the superheterodyne.

NEW J-245-X TROUBLE-SHOOTING JIFFY TESTER

Illumination Continuity and Polarity Tester FREE with Each Outfit!



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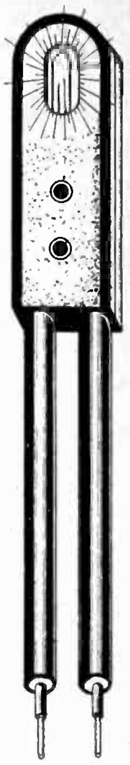
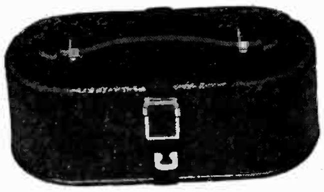
$15.82

Complete



Illumination Tester, Vest Pocket Size, Shows Shorts and Opens Visually, also polarity of DC line. A Neon lamp is built in.



The three-meter assembly, in the crackle-brown finish carrying case, with slip-on cover in place. The handle is genuine leather. The buckled strap holds the cover on.

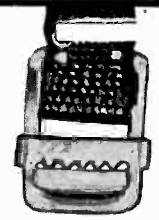
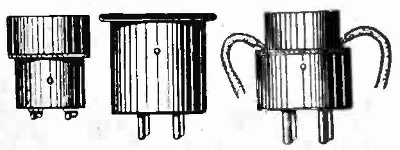


Illustration above is 2/3 scale.



J-111 Multiplier, upper left, with tip; below it, J-106 Multiplier with tip; plugs, left to right, J-19, conforms UV socket to UX plug; J-20, conforms UX tester socket to UV199 tube; J-24, to test Kellogg and old style Arcturus tubes.

Makes All Necessary Tests in a Jiffy and Simplifies Service Work!

WHEN servicing a radio set, power amplifier, speech amplifier or sound reproduction or recording equipment, the circuits and voltages are almost inaccessible, unless a plug-in tester is used.

The Jiffy 245-X plugs in and does everything you want done. It consists of:

(1)—The encased three-meter assembly, with 4-prong (UX) and 5-prong (UY) sockets built in; changeover switch built in, from 0-20 to 0-100 ma.; ten vari-colored jacks, five of them to receive the vari-colored tipped ends of the plug cable; grid push-button, that when pushed in connects grid direct to the cathode for 224 and 227 tubes, to note change in plate current, and thus shorts the signal input.

(2)—4-prong adapter for 5-prong plug of cable.
(3)—Screen grid cable for testing screen grid tubes.
(4)—Pair of Test Leads for individual use of meters.
(5)—J-106 Multiplier, to make 0-300 DC read 0-600.
(6)—J-111 Multiplier, to make 0-140 AC read 0-560.
(7)—Two jack tips to facilitate connection of multipliers to jacks in tester.
(8), (9), (10)—Three adapters so UV199 and Kellogg tubes may be tested.
(11)—Illumination Tester.

The illumination tester will disclose continuities and opens and also the polarity of DC house mains. It is as handy as a pencil and fits in your vest pocket. It works on voltages from 100 to 400. There are two electrodes in a Neon lamp in the top of the instrument. On AC both electrodes light. On DC only one lights, and that one is negative of the line, the light being on the same side as the lead. Hence the illuminator shows whether tested source is AC or DC, and if DC, which side is negative.

Even the output of the speaker cord will show a light.

Also, the device will test which fuses are blown in fused house lines, AC or DC. Besides it tests ignition of spark plugs of automobiles, boats and airplanes, also faulty or weak spark plugs.

Just flash on the illumination tester momentarily. It will last about 4,000 flashes.

THE new Jiffy Tester, J-245-X, is a complete servicing outfit. It consists of a three-meter assembly in a metal case, with slip-on cover and a cable plug. There are ten adapters. It is vital to have the complete outfit so you can meet any emergency.

With this outfit you plug the cable into a vacated socket of a receiver, putting the removed tube in the tester, and using the receiver's power for making these tests: plate current, up to 100 milliamperes; plate voltage up to 300 volts; filament or heater voltage (AC or DC), up to 10 volts.

Each meter may be used independently. One of the adapters—a pair of test leads, one red, the other black, with tip jack terminals—serves this purpose. Multiplier J-106 extends the range of the DC voltmeter to 600 volts, but this reading must be obtained independently, as must readings on the 0-60 scale of the DC voltmeter. Independent reading of the AC voltmeter for line of voltage is necessary; also to use 0-140 scale while Multiplier J-111 extends the AC scale to 560 volts for reading power transformer secondaries.

The other adapters permit the testing of special receiver tubes, so that tests may be made, in all, of 22 different tubes: 201A, 200A, UX199, UV199, 120, 240, 171, 171A, 112, 112A, 245, 224, 222, 228, 280, 281, 227, 226, 210, 250, Kellogg tubes and old style Arcturus tubes.

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☐ Please send me on 5-day money-back guaranty your J-245-X Jiffy Tester, complete, with all 10 adapters, and with illuminated Tester FREE with each order. Also send instruction sheet, tube data sheet and rectifier tube testing information.

☐ Enclosed please find $15.82 remittance. Ship at your expense. [Canadian must be P.O. or Express M.O.]

☐ Please ship C. O. D. @ $15.82 plus cartage and P.O. fee.

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Your Choice of These Nine Meters FREE!

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- ☐ 0-25 Milliamperes D.C. .... No. 325
- ☐ 0-50 Milliamperes D.C. .... No. 350
- ☐ 0-100 Milliamperes D.C. .... No. 390
- ☐ 0-300 Milliamperes D.C. .... No. 399
- ☐ 0-400 Milliamperes D.C. .... No. 394

Equip Yourself Now With Necessary Meters!

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

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

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RADIO WORLD

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LACAULT'S BOOK

GIVES YOU A FINE UNDERSTANDING OF the SUPER-HETERODYNE

R. E. LACAULT, E.E., I.R.E., who died recently, was one of the outstanding authorities on the Super-Heterodyne. He wrote a book, "Super-Heterodyne Construction and Operation," that explains in a non-technical manner the phenomena associated with a Super-Heterodyne. More, it gives a clear outline of the way such a receiver functions, and naturally gives the clues to solving virtually all the troubles that may arise in a Super.

So thoroughly did Lacault do his wrok that he covered associated topics, thus making his book a sidelight on radio in general, including advice on trouble-shooting.

Therefore the service man, the home experimenter, the custom set builder and the student will welcome this book.

It consists of 103 pages and includes 68 illustrations. It is bound in maroon buckram.

There are three valuable tables in the book, also. One classifies harmonics into groups, e.g., sound, radio, short waves, heat, light, chemical rays, X-rays and "unknown." Another is a trouble-shooting chart, classifying "trouble experienced" and "causes" and referring to the text for specific solutions. The third is a table for converting broadcast frequencies to wavelengths (accurate to .1 of a meter) or for converting the wavelength into frequency.

THE book begins with a comparison of alternating and direct current and proceeds to a discussion of the relation of wavelength to frequency. Then tuning is explained.

Condensers, coils, induction, vacuum tube operation and testing, earphones and speakers, rectification, oscillation, grid condenser action, modulation, grid bias detection, regeneration, beat notes, frequency changing, audio amplification, batteries, aerials, loops, wiring, sockets, and shielding are only some of the other important topics covered.

Besides, there is an entire chapter on the construction of a Super-Heterodyne receiver, with list of parts, front, top and rear views of set, front panel layout, shield dimensional drawings, schematic diagram of wiring and picture diagrams of the top and bottom views of the subpanel.

You Can Get This Book At Once!

You will want this book not only for present reading but also for future reference. It is authoritative and highly informative. Send for it now! It's free with each order for an eight weeks' subscription for RADIO WORLD. Present subscribers may renew under this offer. Their subscriptions will be extended eight weeks. Please use coupon.

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Gentlemen: Enclosed find $1.00. Please enter my subscription for RADIO WORLD for eight weeks at $1.00 and send me at once one copy of R. E. Lacault's "Super-Heterodyne Construction and Operation," FREE!

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[Check off parts you want. Each part is sold separately.]

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- ☐ T1—Push-pull input transformer 2.50
- ☐ CT—80 mfd. equalizer .... .35
- ☐ C1, C2—Two .00035 mfd. ext. shafts @ 98c 1.96
- ☐ C3, C5—Two .01 mfd. mica condensers .... .70
- ☐ R—One 6.5 ohm filament resistor .... .25
- ☐ R1, Sw—One 75 ohm switched rheostat ... .80
- ☐ R2, C4—2 meg. Lynch leak, grid clip condenser .... .51
- ☐ R3—One .25 meg. .... .30
- ☐ R4—One 5.0 meg. .... .30
- ☐ R5—One 1.3 ohm filament resistor .... .20
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- ☐ One socketed, self-bracketing metal subpanel, all holes drilled 3.50
- ☐ One National new modernistic drum dial with color wheel, pilot bracket, 6v. lamp, hardware, knob 3.13
- ☐ Two matched knobs for rheo. and tickler @ .18 .... .36
- ☐ Five vari-colored cable leads @ .07 ...... .35
- ☐ Metal link and insulated shaft .... .22
- ☐ One screen grid clip .... .06
- ☐ All parts (including blueprint) $21.89

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Component Parts for 245 Push-Pull Power Amplifier

(as described and specified by Herman Bernard)
Check off which parts you desire. All parts sold separately.

- ☐ C1—One .00025 mfd. mica condenser .... .21
- ☐ C2—One .01 mfd. mica fixed condenser .... .35
- ☐ C3—One Flechtheim 1 mfd. filter condenser, 1,000 volts DC continuous working voltage rating, 550 volts AC (root mean square) continuous voltage rating 1.76
- ☐ C4, C5, C6, C7—Four Mershon condensers in one copper casing, two of 8 mfd. and two of 18 mfd. with low bracket. Cat. Q2-8, 2-18B 5.15
- ☐ C8, C9, C10, C11, C12, C13, C14, 15, C16—Nine 1 mfd. bypass condensers, 200 volts DC continuous working voltage rating 4.50
- ☐ T1—One Polo Filament-Plate Supply transformer: 110 volt 50-60 cycle primary, 724 volt secondary center-tapped, 5 volt 2 amp. secondary center-tapped; 2.5 volt 3 ampere secondary center-tapped. and 2.5 volt 12 ampere secondary center-tapped. Cat. PFPS 7.50
- ☐ FC, PPOC—Two center-tapped chokes for high current one used as filter choke, other as push-pull output choke 7.42
- ☐ PPIT—One push-pull input transformer 3.41
- ☐ SW—One AC pendant through-switch, with 12-ft. AC cable and male plug 1.10
- ☐ F—One 2 ampere fuse, with holder .... .50
- ☐ CO—One convenience outlet (for dynamic speaker AC cable) .... .50
- ☐ PJ, PJS—Phonograph Jack with automatic switch and plug 1.42
- ☐ R1—One resistor, 0.1 meg. .... .30
- ☐ R2—One grid leak, 5.0 meg. .... .30
- ☐ R3—One multi-tap voltage divider, 50 watt rating; fourteen taps affording thirteen different voltages; 13,850 ohms 3.95
- ☐ Two resistor mountings.
- ☐ Roll of heavy insulated hookup wire for power work.
- ☐ Fifteen binding posts 1.50
- ☐ One 15x9 ½" cadmium plated steel subpanel, with self-bracketing flanges, one five-prong and three four-prong sockets built in; sockets marked to identify tubes that go in them; subpanel drilled and insulated where necessary; flat insulating washers; hardware 4.00
- ☐ All parts $43.57

Ferranti AF5CC push-pull input instead of above input transformer 9.60

[Note: For 40 cycles 110v. order Polo P40 FPS at $10; for 25 cycles 110v. order Polo P25 FPS at $1"

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Blueprint of the New One-Dial Push-Pull Battery Model SG DIAMOND

Full-sized picture diagram of the wiring, with list of parts. This 5-tube receiver is really superlative. It gives you screen grid radio frequency amplification and push-pull output, most economically.

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- Δ Three Tube Speaker—Operating Circuit, parts costing $11.10!
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The construction of these circuits, with a pictorial diagram as one of the illustrations, was described by Jack Tully, himself a schoolboy, in RADIO WORLD. See list below.

- ☐ Sept. 21st and 28th issues, One-Tube DX Set, by Jack Tully; two-part article.
- ☐ Oct. 5th, Three-Tube Single Dial Speaker Set, by Jack Tully.
- ☐ Oct. 12th, Two Stage Transformer, Coupled Audio Amplifier, by Jack Tully.
- ☐ Oct. 19th, Four-Tube DX Speaker Set, by Jack Tully.

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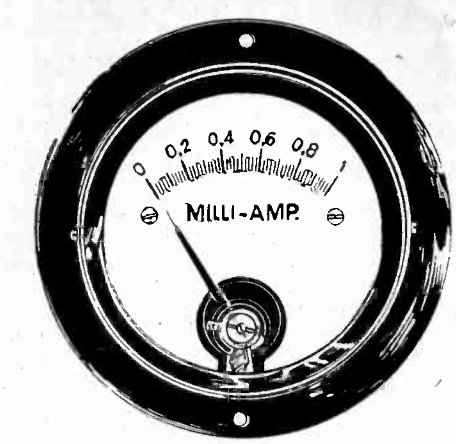
O-1 MA, $5.95



Here is a 0-1 milliammeter, accurate to plus or minus 1% clearly legible to two-one hundredths of a milliampere at any reading (20 microamperes). This expertly made precision instrument is offered at the lowest price so far for a 0-1 ma. Order Cat. FO-1 at $5.95. C. O. D. orders accepted.

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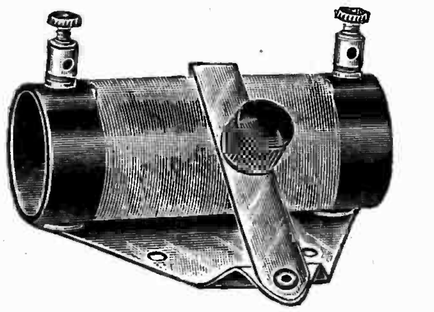

Remove aerial lead from set. Connect aerial instead to one of the binding posts of the Aerial Tuner. Connect the other binding post of the Aerial Tuner to antenna post of your set. Then move the lever of the Aerial Tuner until any weak station comes in loudest. The lever need not be moved for every different frequency tuned in. The Aerial Tuner acts as an antenna loading coil and puts the antenna's frequency at any frequency in the broadcast band that you desire to build up. Price, 85c.

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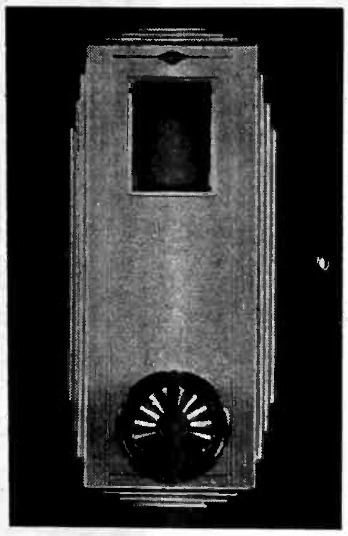

Modernize the appearance of your receiver by installing the brilliant new National dial, with color wheel built in, so that as you turn the dial knob one color after another floods the screen on which the dial numbers are read. On this screen the numbers are projected, so that you get the same dial reading from any position of the eye. This is just what DX hunters want—laboratory precision of dial reading.

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☐ Cat. HC6, National modernistic drum dial, with color wheel built in, pilot bracket, 6-volt pilot lamp for storage battery or A eliminator sets; hardware; instructions $3.13
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Latest Model National Velvet-B, Type 5580, in handsome crackle finish black metal casing, for use with sets up to and including six tubes. Input 105-120 volts AC, 50 to 60 cycles. Output, 180 volts maximum at 35 milliamperes. Three variable output intermediate voltages. (Det., RF, AF). Eliminator has excellent filter system to eliminate hum, including 30 henry choke and 18 mfd. Mershon condenser. No motorboating!
(Eliminator Licensed under patents of the Radio Corporation of America and associated companies.)

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Get a free blueprint of either circuit listed on the coupon below, by sending $1.00 for eight weeks' subscription for RADIO WORLD, or send $1.50 for 13 weeks' (quarter of a year) and get both blueprints free!

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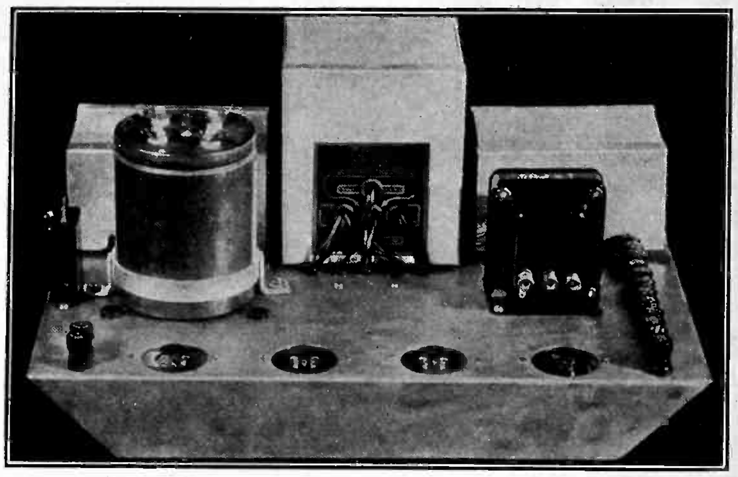
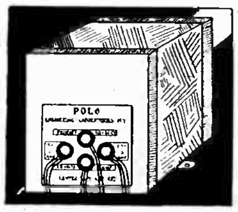
Power Amplifier Equipment



At left is illustrated a push-pull power amplifier, using a first stage of resistance coupled audio, 280 rectifier and two 245s in push-pull, as described in the November 2d issue of Radio World. Abounding volume and faithful tone reproduction are assured. The Polo Filament-Plate Supply, two Polo center-tapped audio chokes and a Multi-Tap Voltage Divider are used, with a Q 2-8, 2-18 Mershon condenser, an input push-pull audio transformer and auxiliary equipment. The total parts, including cadmium-plated steel subpanel, come to $43.57 net, the best power amplifier for that modest amount. Provision is made for phonograph pickup plug insertion. Thirteen output voltages are provided, including 300, 180, 75, 50 and an assortment of nine different voltages under 50 available for bias. All A, B and C voltages are provided for the power amplifier and for a tuner to be used with it employing 227, 224 or 228 tubes. Order Cat. PO-245-PA @ $43.57 net, for 50-60 cycles, 110 volts. [For 25 cycles order PO-245-PA-25 @ $48.57. For 40 cycles order PO-245 - PA - 40 @ $46.07.]

Subpanel alone, cat. SPO @ $3.50

Polo 245 Filament Plate Supply (less chokes) has four windings, all save primary center-tapped (red), is 4½" wide, 5" high, 4" front to back. Weight, 9 lbs. Filament windings, 2.5 v. at 12 amps., 2.5 v. at 3 amps. (for 245 filaments), 5 v. at 2 amps. for 280 rectifier, and 724 v. @ 80 m.a., center-tapped. Order Cat. PFPS @ $7.50.
[For 25 cycles order Cat. PFPS-25 @ $12.00.]
[For 40 cycles order Cat. PFPS-40 @ $10.00.]



Polo Filament Transformer Only, four windings, consists of 50-60 cycles 110 v. winding, 2½ v. at 12 amps., 2½ v. at 3 amps., 5 v. at 2 amps. All windings, save primary, are center-tapped (red). Size, 4⅝" high x 3¾" wide x 3" front to back. Weight, 6 lbs. Order Cat. PFT @ $4.25.
[For 25 cycles order PFT-25 @ $7.00; for 40 cycles order PFT-40 @ $6.25.]

By-pass Condensers

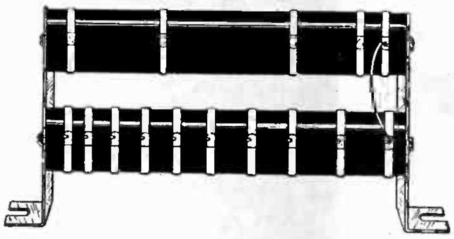
For by-passing B+ leads to ground or C minus from 200 v. post or less, where current is less than 10 m.a., 1 mfd. paper dielectric condensers are useful. Order LV-1 @ ....$0.50 ea.

Filter Condensers

For high voltage filtration next to the rectifier, use 1 or 2 mfd. The 2 mfd. makes the output voltage a little higher.
Order Cat. HV-1 (1,000 v. DC, 550 v. AC)...........$1.76
Order Cat. HV-2 (1,000 v. DC, 550 v. AC)...........$3.52

Filament-Plate-Choke Block

Same as Filament-Plate Supply, except that two 50 henry chokes are built in. Six windings: primary, 110 v., 50-60 cycles; 2.5 v. at 12 amps.; 2.5 v. at 3 amps.; 5 v. at 2 amps.; 724 v. at 80 m.a.; choke All AC windings center-tapped (red), except primary. Connect either end of a choke to one end of other choke for midsection. Order Cat. P-245-FPCH @ ..$10.00
[For 40 cycles order P-245 FPCH-40 @ $13.50.]
[For 25 cycles order P-245-FPCH-25 @ $14.50.]



Two rugged, expertly engineered wire-wound, enamelled resistors, mounted in series, one atop the other, with fourteen useful lugs, providing all necessary choice of voltages without the uncertainty of adjustable variable resistance.

The Multi-Tap Voltage Divider has a total resistance value of 13,850 ohms, in the following steps: 3,000, 4,500, 2,000, 800, 700, 600, 550, 500, 450, 400, 200, 100 and 50 ohms. With the zero voltage lug (at lower left) the total number of useful lugs is fourteen. The resistance stated are those between respective lugs and are to be added together to constitute 13,850 ohms total.

A conservative rating of the Multi-Tap Voltage Divider is 50 watts, continuous use. The unit is serviceable in all installations where the total current drain does not exceed 125 milliamperes.

Extreme care has been exercised in the manufacture of the Multi-Tap Voltage Divider. It is mounted on brackets insulated from the resistance wire that afford horizontal mounting of the unit on baseboards and subpanels.

There long has been a need for obtaining any necessary intermediate voltage, including all biasing voltages, from a Multi-Tap Voltage Divider, but each lug has to be put on individually by hand, and soldered, so that manufacturing difficulties have left the market barren of such a device until now.

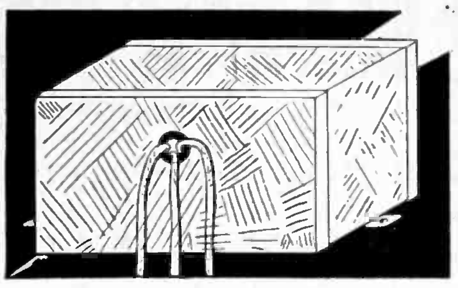
The Multi-Tap Voltage Divider is useful in all circuits, including push-pull and single-sided ones, where the current rating of 125 milliamperes is not seriously exceeded and the maximum voltage is not more than 400 volts. If good ventilation is provided, this rating may be exceeded 15 per cent.

The expertness of design and construction will be appreciated by those whose knowledge teaches them to appreciate parts finely made.

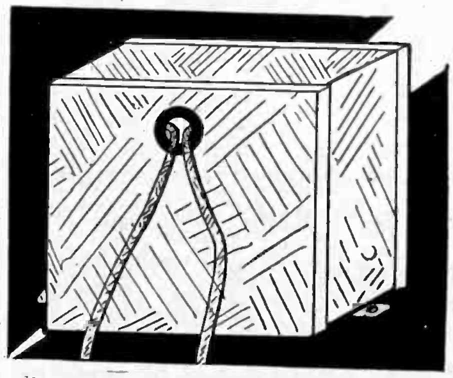
When the Multi-Tap Voltage Divider is placed across the filtered output of a B supply which serves a receiver, the voltages are in proportion to the current flowing through the various resistances. If a B supply feeds a receiver with two-stage audio amplifier, the last stage a single-sided 245, then the voltages would be 250 maximum for the power tube, 180, 135, 75, 50, 40, 35, 30, 25, 16, 10, 6 and 3. By making suitable connection of grid returns the lower voltages may be used for negative bias or even for positive voltage on the plates.

If push-pull is used, the current in the biasing section is almost doubled, so the midtap of the power tubes' filament winding would go to a lug about half way down.

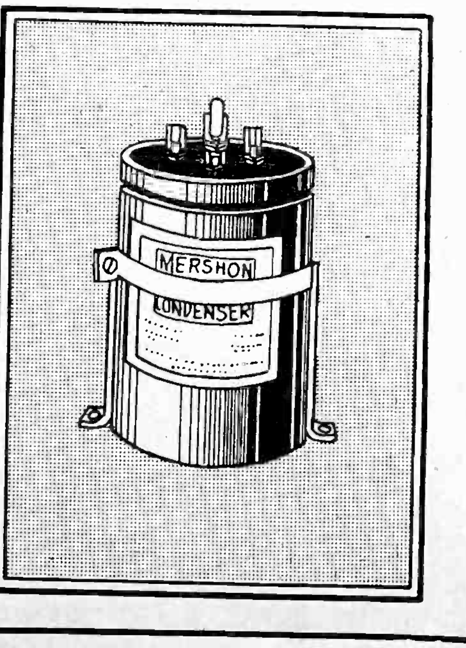
Order Cat. MTVD at $3.95.



Center-tapped double choke, 125 m.a. rating, 30 henrys in each section. Used for filtering B supply or for a push-pull output impedance, where speaker cords go directly to plates of tubes. Center tap is red. Order Cat. PDC @ $3.71.



Single 30 henry 100 m.a. choke for filtered output (where condenser is used additionally) or for added filtration of a B supply. Order Cat. PSC @ $2.50.



The Mershon electrolytic condenser, 415 volts DC, for filtering circuits of B supplies. Q 2-8, 2-18 has four capacities in one copper casing: two of 8 mfd. and two of 18 mfd. The copper case is negative. The smaller capacities are nearer the edge of the case. The vent cap should not be disturbed, and the electrolyte needs no refilling or replacement.

Mershon electrolytic condensers are instantly self-healing. Momentary voltages as high as 1,000 volts will cause no particular harm to the condenser unless the current is high enough to cause heating, or the high voltage is applied constantly over a long period.

High capacity is valuable especially for the last condenser of a filter section, and in by-passing, from intermediate B+ to ground or C+ to C−, for enabling a good audio amplifier to deliver true reproduction of low notes. Suitably large capacities also stop motor-boating.

Recent improvements in Mershons have reduced the leakage current to only 1.5 to 2 mils total per 10 mfd. at 300 volts, and less at lower voltages. This indicates a life of 20 years or more, barring heavy abuse.

In B supplies Mershons are always used "after" the rectifier tube or tubes, hence where the current is direct. They cannot be used on alternating current. Rated 415 v. DC.

The Mershon comes supplied with special mounting bracket. Order Q 2-8, 2-18 B @ $5.15

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Please ship at once the following:

Quantity	Cat. No.	Product	Price
☐	PO-245-PA	Power amp. parts, 50-60 c.	$43.57
☐	PO-245-PA-40	Same, 40 cycles	46.07
☐	PO-245-PA-25	Same, 25 cycles	48.57
☐	PFPS	Fil. plate supply, 50-60 c.	7.50
☐	PFPS-40	Same, 40 cycles	10.00
☐	PFPS-25	Same, 25 cycles	12.00
☐	PFT	Fil. trans., 50-60 c.	4.25
☐	PFT-40	Same, 40 cycles	6.25
☐	PFT-25	Same, 25 cycles	7.00
☐	P-245-FPCH	Power-filter block	10.00
☐	P-245-FPCH-40	Same for 40 cycles	13.50
☐	P-245-FPCH-25	Same for 25 cycles	14.50
☐	PSC	Single choke	2.50
☐	MTVD	Multi-tap volt. div.	3.95
☐	PDC	Double c.-t. choke	3.71
☐	Q2-8, 2-18B	Mershon with bracket	5.15
☐	LV-1	200 v., 1 mfd. by-pass cond.	.50
☐	HV-1	1,000 v., 1 mfd. filter cond.	1.76
☐	HV-2	1,000 v., 2 mfd. filter cond.	3.52
☐	SPO	Subpanel	3.50

☐ Enclosed please find check—money order—for the above. [Note: Canadian remittance must be by postal or express money order.]

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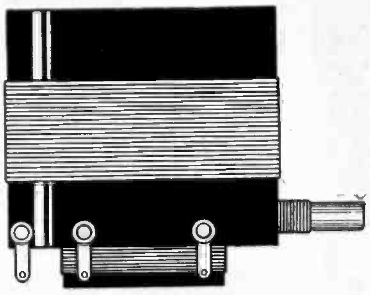

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FOR .0005 MFD. CONDENSER

Moving primary and fixed secondary, for antenna coupling. Serves as volume control. Cat. No. VA3 for .00035 mfd. $0.90

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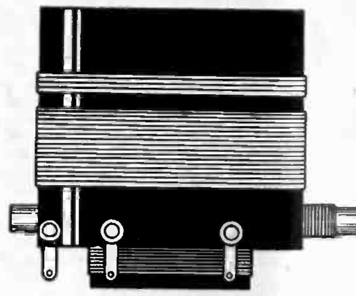
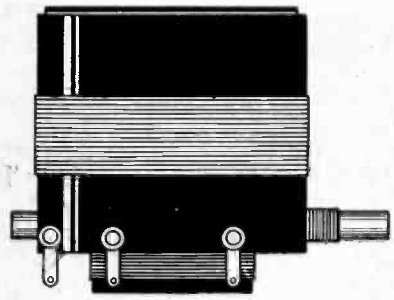


Cat. No. BT5A—$1.35
FOR .0005 MFD. CONDENSERS

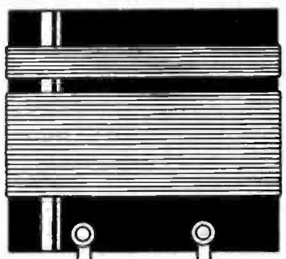
Bernard Tuner BT5A for .0005 mfd. for antenna coupling, the primary being fixed and the secondary tuned. This coil is used as input to the first screen grid radio frequency tube. Secondary has moving coil.
Cat. No. BT3A for .00035 mfd. ..$1.35

Bernard Tuner BT5B for .0005 mfd. for working out of a screen grid tube, tuned primary, untuned secondary. Primary has moving coil.
Cat. BT3B for .00035 mfd. ..$1.35



Cat. No. BT5B—$1.35
FOR .0005 MFD. CONDENSER

SG TRANSFORMER



Cat. No. SGS5—$0.60
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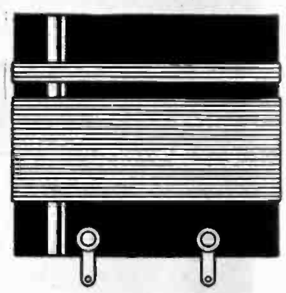
Interstage radio frequency transformer, to work out of a screen grid tube, primary untuned.
Cat. No. SGS3 for .00035 mfd. $0.65



Cat. No. RF5—$0.60
FOR .0005 MFD. CONDENSER

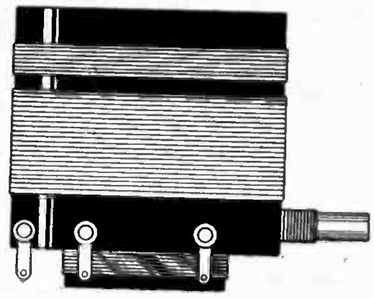
DIAMOND PAIR

Cat. No. RF5—$0.60
FOR .0005 MFD. CONDENSER

Antenna coil for any standard circuit, and one of the two coils constituting the Diamond Pair.
Cat. No. RF3 for .00035. $0.65

Cat. No. SGT5—$0.85
FOR .0005 MFD. CONDENSER

Interstage 3-circuit coil for any hookup where an untuned primary is in the plate circuit of a screen grid tube.
SGT3 for .00035 mfd...$0.90

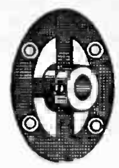


Cat. No. SGT5—$0.85
FOR .0005 MFD. CONDENSER

Order the Diamond Pair, Cat. DP5 for .0005 mfd. at $1.45

Order the Diamond Pair, Cat. DP3 for .00035 mfd. at $1.55

[Note: These same coils are for AC or battery circuit.]



FL4 $0.30
Flexible insulated coupler for uniting coil or condenser shafts
Order Cat. FL4 at $0.30
Equalizing condenser, 80 mmfd., for connection across any tuning condenser where ganging is resorted to, or for equalizing independently tuned circuits to make dials track.
Order Cat. EQ80 at $0.35

STANDARD TUNER

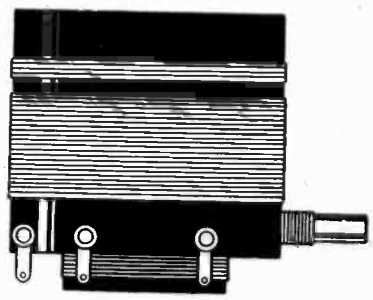
The standard three-circuit tuner is used with primary in the plate circuit of any RF tube, AC or battery type, excepting only screen grid tube.
For .0005 mfd. order T5 at $0.85
For .00035 order Cat. T3 at $0.90

All coils have 2½" diameter, except the shielded coil, which is wound on 1¾".

The coils are wound by machine on a bakelite form, and the tuned windings have identical inductance for a given capacity condenser, i. e., .0005 mfd. or .00035 mfd. Full coverage of the wave band is assured.

All coils with a moving coil have single hole panel mounting fixture. All others have base mounting provision. The coils should be used with connection lugs at bottom, to shorten leads.

Only the Bernard Tuners have a shaft extending from rear. This feature is necesary so that physical coupling to tuning condenser shaft may be accomplished by the insulated link.



Screen Grid Coil Company,
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☐ Cat. No. .... at $ ....
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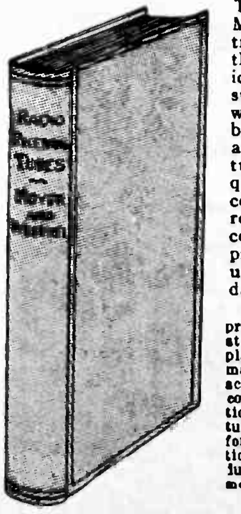

"RADIO RECEIVING TUBES," by James A. Moyer and John F. Wostrel, first edition just off the press. No radio service man, experimenter or student of radio should be without this authoritative book on the principles and applications of vacuum tubes. It answers all your questions relating to receiving, amplifying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

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

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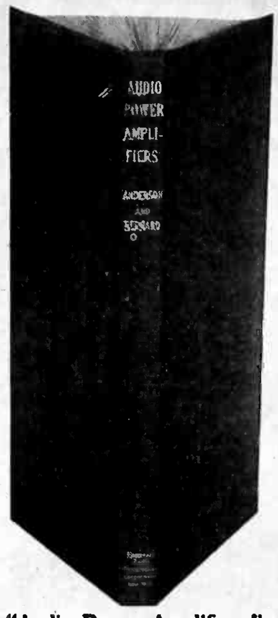

"Audio Power Amplifiers," 193 pages, 147 Illustrations; Maroon Cloth Bound Cover, Lettering in gold. Price, $3.50.

"AUDIO POWER AMPLIFIERS"

By J. E. ANDERSON and HERMAN BERNARD

The First and Only Book on This Important Subject—Just Out

IN radio receivers, separate audio amplifiers, talking movies, public address systems and the like, the power amplifier stands out as of predominating importance, therefore a full and authentic knowledge of these systems is imperative to every technician. "Audio Power Amplifiers" is the book that presents this subject thoroughly. The authors are

J. E. Anderson, M.A., former instructor in physics, University of Wisconsin, former Western Electric engineer, and for the last three years technical editor of "Radio World."

Herman Bernard, LL.B., managing editor of "Radio World."

They have gathered together the far-flung branches of their chosen subject, treated them judiciously and authoritatively, and produced a volume that will clear up the mysteries that have perplexed many.

What are the essentials to the reproduction of true tone values?

What coupling media should be used? What tubes? How should voltages be adjusted?

These are only four out of 1,400 questions raised and solved in "Audio Power Amplifiers."

The book begins with an elementary exposition of the historical development and circuit constitution of audio amplifiers and sources of powering them. From this simple start it quickly proceeds to a well-considered exposition of circuit laws, including Ohm's laws and Kirchhoff's laws. The determination of resistance values to produce required voltages is carefully expounded. All types of power amplifiers are used as examples: AC, DC, battery operated and composite. But the book treats of AC power amplifiers most generously, due to the superior importance of such power amplifiers commercially.

Rectification theory and practice in all the applied branches, grid bias methods and effects, push-pull principles, power detection, reproduction of recordings and methods of measurements and testing are set forth. And besides there is a chapter on the subject of motorboating, with which one of the authors is probably better familiar than any other textbook author. Then, too, there is a chapter on tubes, with essential curves and a full list of tables of tube data. Every tube that will be used in an audio amplifier—therefore virtually all tubes—is clearly diagnosed, classified and tabulated! These data on tubes should be at every radio engineer's hand.

"Audio Power Amplifiers" is a book for those who know something about radio. It is not for novices—not by a mile. But the engineers of manufacturers of radio receivers, power amplifiers, sound installations in theatres, public address systems and phonograph pickups will welcome this book. Engineers—even chief engineers—of the Bell Telephone Laboratories, Radio Corporation of America, Westinghouse Electric & Mfg. Co., Western Electric, Photophone, Vitaphone and the like needn't be afraid they won't learn something from this little book.

Table of Contents

The book consists of 193 pages in type the size used in printing these words, known as 8 point, and therefore a great deal of text is contained in these 193 pages, and the book is small enough to be carried conveniently in the side pocket of a sack coat. It was purposely printed that way because busy engineers and other experimenters will want to consult this precious volume while riding in conveyances, as well as when in the laboratory, and compactness was therefore desirable.

The edition is strictly limited to 1,000, and the publishers recognize that the field of distribution is necessarily small, hence the price is $3.50. Those to whom such a volume is of any value would not be without it at any price.

The device of presenting no more information or greater number of illustrations, but of using larger type, and thicker and often cheaper paper, to present a bulkier appearance, was purposely avoided. The paper is finest super stock and the size of the page is 5 x 8".

What Is Not As Well As What Is

SOMETIMES it is more important to expose a fallacy than merely to state the fact. A crop of technical weeds has grown into the garden of audio amplification, and the authors have gone to the pains of exposing these.

The book "Audio Power Amplifiers" is free from traditional errors, except in citing them as fallacious conclusions. Each attack on a fallacy is abundantly supported by proof of the REAL facts.

As an example, take the theory that motorboating is due to grid blocking. The authors say: "Many explanations for this oscillatory condition (motorboating) have been made, some of which are wholly untenable. One of these is that the oscillation is due to blocking of the grids of the amplifiers . . . If blocking of the grid were the cause of the phenomenon, the wave form of the oscillation would be very irregular, but an oscillograph shows that it is very nearly of a sinusoidal form."

Then follows an exposition of motorboating, and oscillation at other frequencies, with expressions for predetermining the instability or stability of audio circuits.

Detailed Exposition of Chapter Contents

Chapter I. General Principles, analyzes the four types of power amplifiers, AC, DC, battery-operated and composite, illustrates them in functional blocks and schematic diagrams, and treats each branch in clear textual exposition. Audio coupling media are illustrated and discussed as to form and performance: transformer, resistance-resistance, impedance-impedance, impedance-resistance, resistance-autotransformer, autotransformer-resistance and non-reactive. Push-pull forms are illustrated, also speaker coupling devices. Simple audio ampifiers are illustrated and analyzed. Methods of connection for best results are stressed.

Chapter II. Circuit Laws, expounds and applies Ohm's laws and their special form known as Kirchhoff's laws. Direction of current flow in tube circuits is revealed in connection with the application of these laws to several circuits, including a DC 110-volt A, B and C supply, and series and parallel filaments in general. Special diagrams are published for Ohm's and Kirchhoff's laws.

Chapter III. Principles of Rectification, expounds the vacuum tube, both filament and gaseous types, electrolytic and contact rectifiers, and explains why and how they work. Full-wave and half-wave rectification are treated, with current flow and voltage derivation analysis. Regulation curves for the 280 tube are given. Voltage division, filtration and stabilization are fully illustrated and dissected.

Chapter IV. Practical Voltage Adjustments, gives the experimental use of the theoretical knowledge previously imparted. Determination of resistance values is carefully revealed.

Chapter V. Methods of Obtaining Grid Bias, enumerates, shows and compares them.

Chapter VI. Principles of Push-Pull Amplifier, defines the push-pull relationship, with keys to the attainment of desired electrical symmetry.

Chapter VII, Oscillation in Audio Amplifiers, deals with motorboating and oscillation at higher audio frequencies, explaining why it is present, stating remedies and giving expressions for predetermination of regions of instability. The trouble is definitely assigned to the feedback through common impedance of load reactors and B supply, and in some special instances to the load's relationship to the C bias derivation as well. The feedback is shown as negative or positive and the results stated.

Chapter VIII, Characteristics of Tubes, tells how to run curves on tubes, how to build and use a vacuum tube voltmeter, discusses hum in tubes with AC on the filament or heater, and presents families of curves, plate voltage—plate current, for the 240, 220, 201A, 112A, 171A, 227 and 245, with load lines. Also, plate-screen current characteristics of the 224, at five different control grid biases, at platevoltages 0-250. Then Table I gives the Average Characteristics of Amplifier and Detector Tubes 220, 200A, 201A, 112A, 171A, 222, 240, 226, 227, 224, 245, 210 and 250, stating use, filament voltage, current, and resistance, Det. B volts, Amplifier B volts, grid bias for amplification and detector, plate current, plate AC resistance, mutual conductance, mu, maximum undistorted power output, physical size. There is a composite table (II) of characteristics of Rectifier and Voltage Regulator Tubes, and individual tables, giving grid voltage, plate current characteristics over full useful voltage ranges for the 220, 201A, 112A, 171A, 222, 240, 227, 245 and 224.

Chapter IX, Reproduction of Recordings, states coupling methods and shows circuits for best connections.

Chapter X, Power Detection, explains what it is, when it should be used, and how to use it. A rectifying detector, designed by one of the authors, is expounded also.

Chapter XI, Practical Power Amplifier, gives AC circuits and shows the design of a sound reproduction system for theatres. A page is devoted to power amplifier symbols.

Chapter XII, Measurements and Testing, discloses methods of qualitative and quantitative analysis of power amplifier performance. A scale illustrates the audio frequencies in comparison with the ranges of voice and musical instruments. A beat note oscillator is described. Thirteen causes of hum, with remedies, are stated, also the estimation of power required for output and preliminary tubes.

You may safely order "Audio Power Amplifiers," either enclosing your remittance or ordering the book mailed C.O.D. Examine it for five days. If you are not completely satisfied with it for any reason, or for no reason, send it back in five days with a letter asking for a refund. A check refunding the purchase price will be sent to you immediately. We can not send the book on approval, without payment before receipt, so please do not ask us to do so.

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