RADIO DESIGN

OFFICIAL ORGAN OF THE RADIO INTERNATIONAL GUILD

In this issue

The A. C. "Super-Wasp", the only light-socket short-wave receiver ever developed—The Grimes 110 volt D. C. "New Yorker"—The Pilot Twin "Screen-Grid 8"

Articles by David Grimes, Robert S. Kruse, John Geloso, Robert Hertzberg, Zeh Bouck and Alfred A. Ghirardi

Volume 2 FALL ISSUE — 1929 Number 3

Price, 15 Cents

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Vol. 2
No. 3

Fall
1929

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RADIO DESIGN MAGAZINE

Is Published By

RADIO DESIGN PUBLISHING CO., INC., 103 Broadway, Brooklyn, N. Y.

RADIO DESIGN Magazine is published quarterly, or four times during the year. The subscription price for the four issues is 50 cents for the United States and all other countries of the world. Checks and money orders should be drawn to the order of Radio Design Publishing Company, Inc.; U. S. coin as well as U. S. stamps accepted. Remittances for foreign subscriptions should be made by international postal money order. Subscriptions are always started with the current issue unless otherwise ordered. Single copies of current and back numbers 15 cents each. The contents of this magazine may be reprinted by other publications if full credit is given. The editors will be glad to cooperate by supplying illustrations.

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The Pilot
A.C. SUPER-WASP

The First Short-Wave Receiver that Works Successfully on Alternating Current; Additional Features are Tuned Screen-Grid Stage, Double Shielding and 14-500 Meter Wavelength Range

by DAVID GRIMES

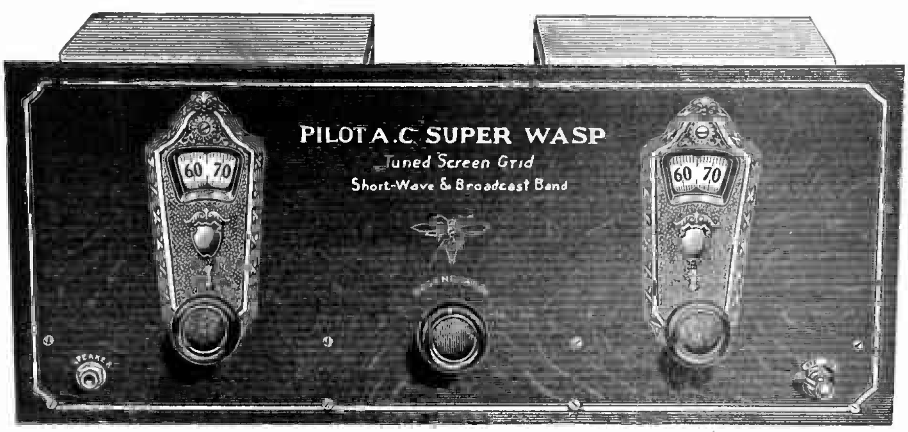
THE usual procedure in describing a new circuit is to delve at once into the various peculiar ramifications of that particular hook-up. We have decided to adopt a slightly different method of approach for the A.C. Super-Wasp, because the laboratory development of this unique arrangement has been most romantic. More than half the interest of the story would be lost if we were to confine ourselves solely to the technical description, without taking you with us over the path of progress which was so persistently pursued for almost a year. Accordingly, our narrative starts with the successful completion of the battery-operated Super-Wasp; for no sooner was this task accomplished than the laboratory facilities were concentrated on its complete electrification on A.C. circuits.

Now in view of the satisfactory electrification of other types of receivers, the problem confronting us seemed rather simple. It didn't take very long, however, to completely disillusion us on this point. The A.C. operation of broadcast sets was an entirely different proposition than that presented by the multi-range Super-Wasp. It was one thing to design a receiver that was commercially humless in loud speaker performance and quite another to find a circuit combination that would permit the use of telephone receivers.

WAVELENGTH DIFFICULTIES

Then, again, a few circuit experiences were sufficient for quelling the hum in any one receiving band; but the difficulties of the problem were considerably multiplied by the necessity for the Super-Wasp to properly perform over a multiplicity of wavelengths. Circuit combinations that were absolutely noiseless on the broadcast range were impossible on the shorter waves. And last, but not least, the regenerative detector of the Super-Wasp added a particularly knotty problem, as hums that were not noticeable on straight detection became veritable Niagaras when the regeneration control was brought near the sensitive point.

So you see, the job we had cut out before us was a mean one and well destined



Front panel view of a completed A.C. Super-Wasp.

No more batteries! At last you can enjoy the thrills of short-wave reception with all the conveniences of full lamp-socket operation

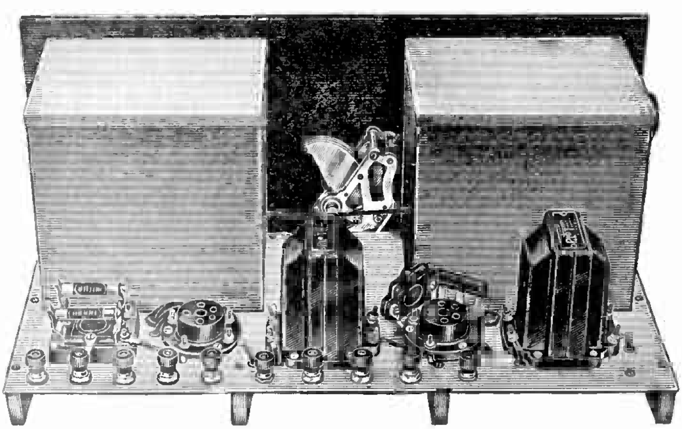
to consume the year that was finally devoted to it. Well, naturally our first consideration was to see what troublesome requirements of the Super-Wasp could be eliminated; thus placing the set in the category of solvable circuits. Could the headphone operation be relegated to the discard and could we insist solely on loud speaker hook-ups? We just placed ourselves in the position of the short-wave fan and tried operating the battery Super-Wasp for a few nights on loud speaker only. It was emphatically decided that earphones were a necessity as far as the rest of the household was concerned. We enjoyed the loud speaker but the family did not! Telephone receiver operation must be retained and the hum level reduced accordingly.

A DETERMINATION

Next, we certainly could not confine the performance of the set to one set wave band. One of the real features of the Super-Wasp was its efficient operation on all of the accepted channels. No! The hum must be conquered on each and every group of tuning coils at present used in the receiver. And as regards the third predicament, it would be useless to consider the set at all if it could not be made to regenerate, for CW reception would be impossible without that feature. Hence the hum must be positively eradicated on any regenerating action. Our requirements are clear cut enough! There is no mistaking to be done. We must produce the first successful A.C. regenerative, short wave, headphone receiver in existence!

Well, let's get into our story. We found that there were in general two classes of "hums". The first class was what we termed a "residual hum" because it could be heard in the headphones at all positions of the tuning dials. It was arising from the audio circuit. The second class was what we choose to term "tunable hums". This latter class was very numerous and could be brought in on several places on all of the coils. All of these could be tuned in or out by operating the tuning dials. They appeared to have definite wave lengths.

We set about to eliminate the residual hum as a starter. It was fairly easy to trace it right down to the detector tube. It was a pure question of 60 cycle induction caused by the construction of the tube itself. It was also present in the two audio tubes, but the succeeding amplification was, of course, not as great as the total following the detector. Hence it was not as noticeable from these latter sources. Anyway, a study of the design of the tube was started. Meanwhile, during the progress of this tube study, a re-design of the entire audio circuit was undertaken. It was obvious that too much audio gain was undesirable for other reasons than A.C. hum amplification. Microphonic detector noises are always an annoyance resulting from excessive audio amplification. Incidentally,



Back view of an assembled A.C. Super-Wasp, with shield cans in place.

two stages of transformer coupled audio amplification are not as good for tone quality as more recent combinations of resistance and transformer coupling.

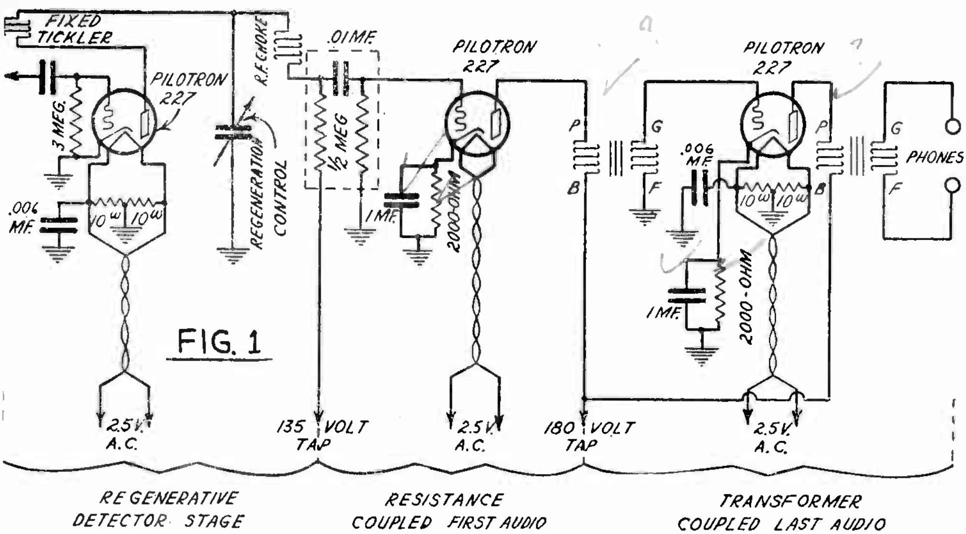
TONE QUALITY

It was felt that with the ever increasing number of short wave broadcasting stations, the question of good tone quality would shortly become a paramount issue. Consequently, we took the bull by the horns and incorporated a modern audio amplifying system. This is illustrated in Figure 1. It consists of a detector working directly into a high resistance-high capacity coupling unit, onto the grid of the first audio tube. This audio stage is then coupled to the last audio tube thru a standard transformer with the primary phase arranged for negative howl tendency. A tube with the standard electrical amplification characteristics of the 227 is used in all three positions. Other features of this tube are entirely different, as will be subsequently shown. The use of this first resistance stage reduced the residual hum much more than the reduction in audio amplification explained. It was found that a net gain in hum reduction resulted from the use of the resistance coupling in the first stage. The resistance units did not act like A.C. pick up coils, as did the transformer windings in this location.

You may wonder why, in our effort to obtain good tone quality, we did not employ a power tube in the last audio stage. The 227 type was deliberately retained. You see, power tubes are operated on raw A.C. filaments. This is quite all right on loud speaker sets, but if you want to know just how much hum is really present with such a tube, listen to the output of a standard broadcast set with a pair of phones. If we are to use phones on this short wave set of ours, we simply cannot tolerate a raw A.C. filament tube, even in the last stage. Hence it is ruled out. Furthermore, by installing an output transformer in the plate of this tube to connect it to the reproducing unit, the impedances may be approximately matched so that the tone quality is not particularly compromised in spite of this 227 type in the last stage.

TUBE TROUBLES

Our tube research laboratory by this time had a report ready for us. The substance of this report is shown in Figure 3. **It developed** that the hum was caused by an unbalanced field created by the filament. The standard 227 tube has a straight filament run thru the center of the heated cathode. It is apparent that at one instant the bottom of the filament will be positive while the top is negative, shortly followed by a reversal of the heating current which makes the bottom of the filament negative with the top positive. The electronic field within the cathode is thus rapidly twisted back and forth during each alternation of the heating current. A noticeable hum results. Now the construction shown in the Pilotron 227 is purposely designed to avoid this very thing. The heating filament is doubled back on itself within the cathode cylinder after the fashion of a hairpin. In this arrangement, the electronic field is neutralized at every point and no upheavals take place on the reversals of the heating current. The Pilotron 227 is a very quiet tube and has been specially designed for the A.C. Super-Wasp for use in the detector and audio stages.



The audio system of the A.C. Super-Wasp.

Two other things also contributed to the total amount of hum which were entirely separate and distinct from the hairpin filament assembly. There have been and are several makes of special tubes which employ the doubled filament mounting, but the results from these were somewhat disappointing. Other hum sources there were that were annoying even tho they were of less intensity. These were found to be located in an insulating sleeve that was in-

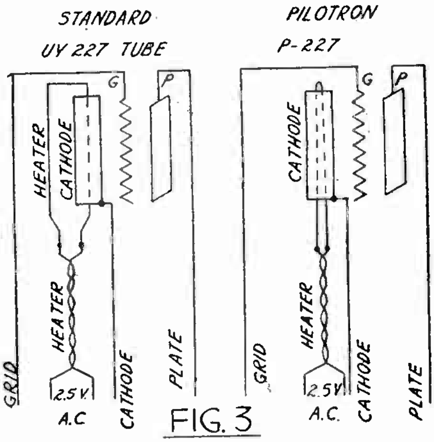


FIG. 3

The difference between the P-227 and ordinary tubes.

corporated to hold the filament in place and in the amount of residual gas still remaining in the tube. The P-227 Pilotron was accordingly built with a high degree of vacuum and the insulating sleeve was omitted. Correct mounting of the elements makes this sleeve unnecessary anyway.

TUNABLE HUMS

The above precautions killed the A.C. residual hum or, at least, reduced it to a negligible minimum. The tunable hums next came under surveillance and these were the most exasperating puzzles. But, like most complicated problems, they were confusing only because they were resulting from many different causes. Each hum and its cause was finally found to be a very simple function, and the remedy in each case has been as simple. To confine ourselves to the problem at hand, we studied the hums with the antenna entirely disconnected from the set. This removed some of the disturbances which were coming in from the ether. This class of disturbance, and sometimes hum, is beyond our power to solve. Such effects would be as noticeable on any other type of set. These hums must not be confused with those arising in the set. *If there is ever any doubt in your mind as to the source of a hum, merely remove the antenna. Its marked reduction or disappearance will prove it to be of external origin, falling within the incurable class.*

TUBE CAPACITY TROUBLESOME

But by far the greater number of our hums continued to persist, even after we had removed the antenna. These obviously existed in the receiver itself and, as such, fell under the curable classification. Those on the red and orange coils, within the wavelength bands of 14 to 50 meters, were the strongest. They must have arisen from some high frequency oscillation in the set modulated by the 60 cycle current. Some combination of inductance and capacity was acting as a transmitting circuit. This was finally found to be actually true. One of these circuits is shown in Figure 4. The capacity of the oscillating system is the internal capacity of the cathode-heater combination. The inductance is that of the leads combined with that of the center-tapped resistance. This resistance unit actually has enough inductance to be troublesome at the very short waves. The cure consists in merely adding a capacity across one side of this center-tapped "inductance" so as to kill the resonant combination.

There were two of these cathode-heater oscillating circuits. One was in the last audio tube and the other was in the detector. The latter seems reasonable enough, but one would never think to look at the last audio tube as a possible source of short-wave radio-frequency disturbance. Nevertheless, there it was and it was the strongest of the two, due to the higher plate and grid voltages employed. These apparently acted as shock exciters of the oscillatory circuits—the shocks taking place on every half wave of the 60 cycle current. This effect is shown in Figure 5. A casual glance at the audio circuit of the A.C. Super-Wasp will reveal these .006 mf. by-passing condenser across the mid-tap resistors in both the detector and last audio

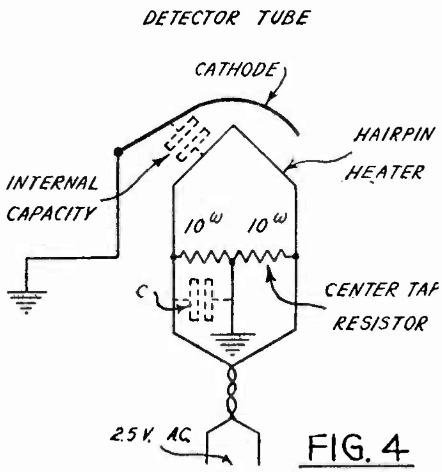


FIG. 4

Killing the hum by means of a by-pass condenser, C.

circuits. Of course, removing these center-tapped resistors entirely will open up these oscillating circuits and the hums on the lower wave length coils will cease. In fact, it was this that first led to their discovery. But, removing the resistors only cures one trouble to bring in another. The residual hum greatly increases in the straight audio system when these center-tapped grounds are removed. They must remain and the high frequency oscillation must be killed by the by-passing method.

USING R.F. CHOKES

With these two culprits put away, there still remained other sources of hums, the latter occurring on the higher wave length coils, up in the green and blue range. These were obviously caused by similar circuits except with higher inductances and capacities, so that the wavelengths were longer. As a further clue to their cause, they did not occur until the plate and grid connections were made for the screen grid tube. They existed in these leads and were obviated by the insertion of the .2 mf. by-passing condensers and the small chokes. The chokes are commercial, cylindrically wound, resistors; but their main function in the plate and screen grid leads is a choking one. They are indicated on the sketches as 450 ohm resistors. These are shown in Figure 6.

There is one other point of special mention that should not be overlooked. Many of you are already familiar with the "squawking" of the ordinary regenerative receiver at the very point of oscillation. It is most annoying, not only because of the racket, but because that particular point is the one at which signals are most likely to be heard. This was given considerable attention in the A.C. design and, as a result, it has been completely subdued. The high resistance in the plate circuit of the detector accounts for this. There appears to be a highly critical condition existing in the grid circuit at the starting point of oscillation. Just as the grid tends to change from the slight positive bias, which it normally has, to the negative value which the rectification gives it, it undergoes an oscil-

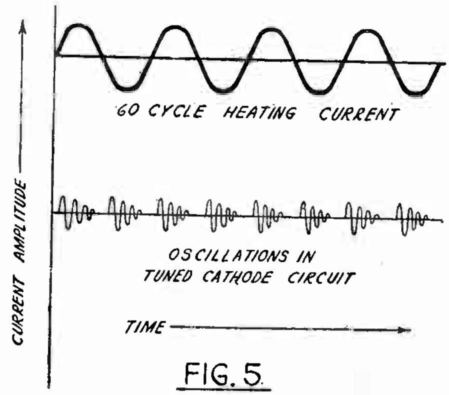


FIG. 5

How the 60-cycle current causes oscillation.

latory condition which causes a bad "squawk" when the plate voltage is fed thru a transformer. But when the plate potential is supplied thru a high resistance, such as the .5 megohm shown in Figure 2, the effective plate voltage drops when this condition occurs and this decline immediately stops the oscillation or "squawk". The result is that the new A.C. Super-Wasp goes into R.F. oscillation in a very smooth manner, permitting perfect regeneration on even the weakest stations.

Figure 7 gives the overall circuit layout of the complete set, including the Pilot K-111 "A" and "B" pack. This is shown intact because it is quite necessary to operate the receiver on a given "B" eliminator to insure the proper plate voltages. The success or failure, particularly of a

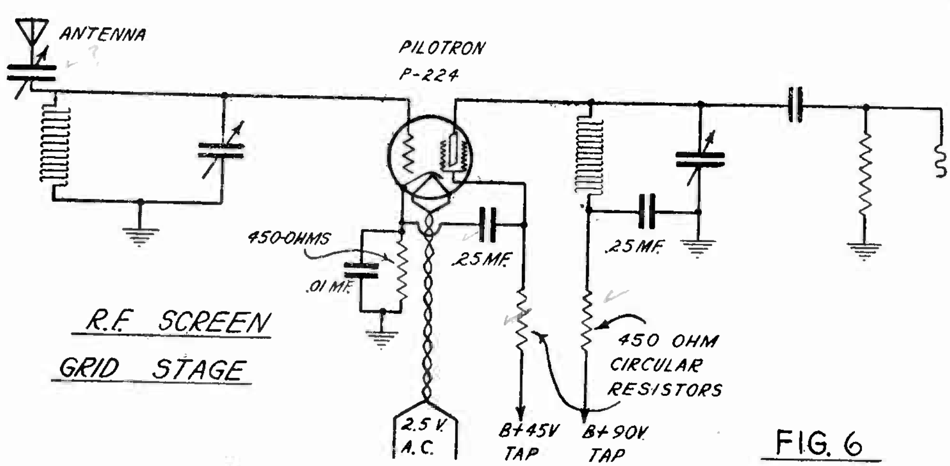


FIG. 6

How 450-ohm circular wound resistors are used as R.F. chokes.

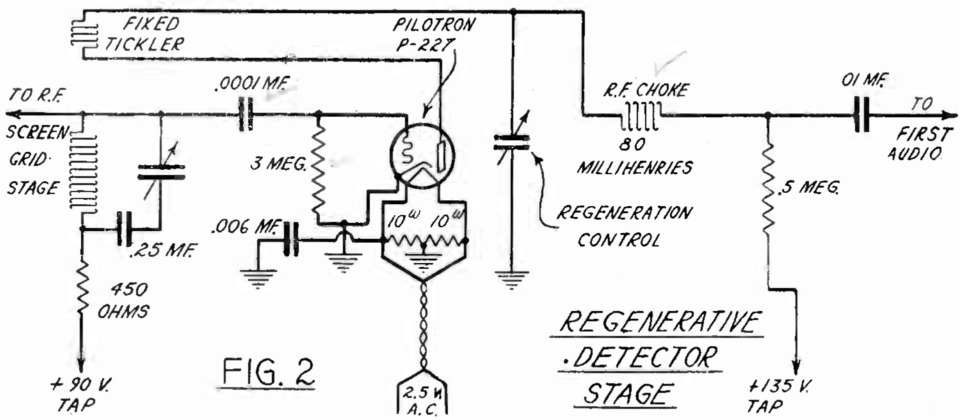


FIG. 2

Details of the detector circuit of the A.C. Super-Wasp.

regenerative receiver, depends largely on the correct plate potentials. For instance, too much voltage on the detector will make the oscillation uncontrollable, while too little will stop it altogether. The taps have been worked out so that no audio or radio feedback is present in the eliminator. Any other combination may cause trouble.

No stress has been placed on the rest of the A.C. circuit, as the connections are entirely conventional. There is nothing unusual in the methods for obtaining "C" bias by means of a voltage drop in the minus "B" lead to each tube where the bias is required. The resistance is by-passed by a large condenser so that no fluctuating feed-back will occur. Sometimes a common bias can be employed by two tubes which operate under like conditions, such as the two audio stages shown in the diagram. This has not been found feasible for this circuit and is not recommended.

Like its famous predecessor, the A.C. "Super-Wasp" is marketed in kit form, all the necessary parts being supplied. The front panel and the sub-panel are drilled with all the holes, so the constructor need only tighten up several dozen small nuts and bolts to assemble the kit into a working radio receiver.

The kit includes the following parts:

1—No. 699 Front panel
1—No. 698 Sub-panel
1 pair—No. 600 shield cans, with covers
4—No. 37 metal shelf brackets
2—No. 1282-L vernier dials
1—No. 46 lever type snap switch
2—No. 1611 variable condensers (with No. 1259W knobs)

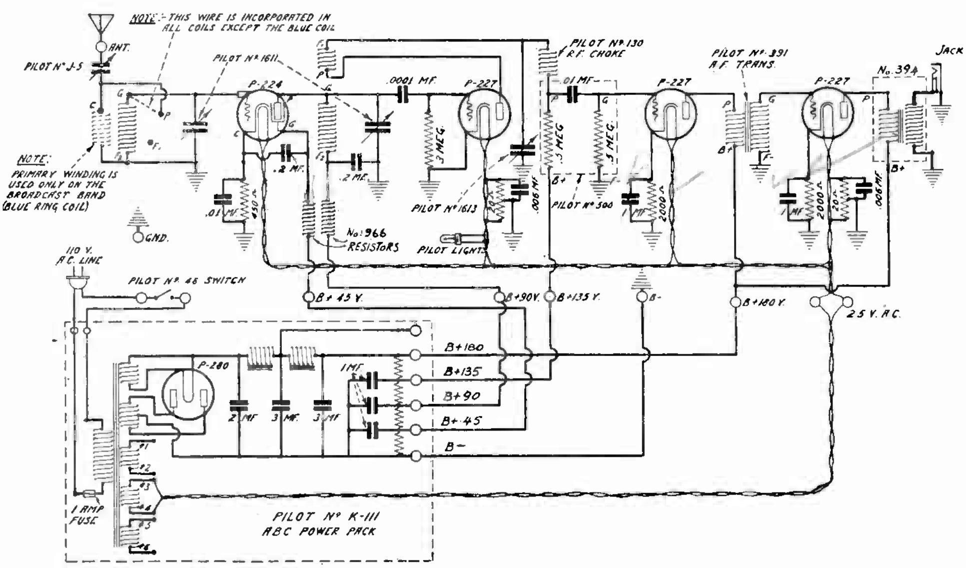
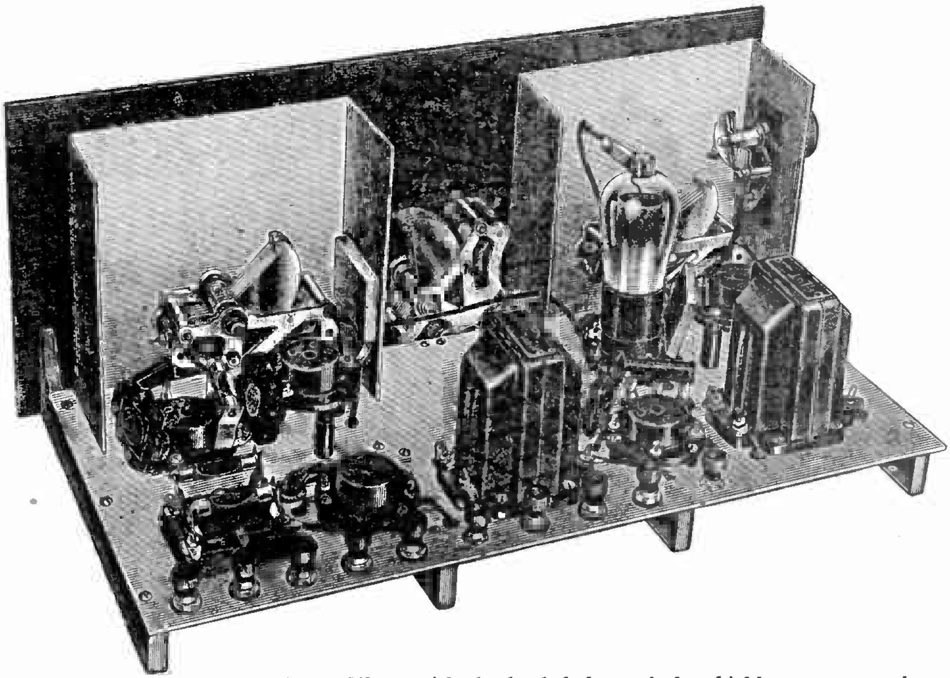


Fig. 7: The complete wiring diagram of the A.C. Super-Wasp.



Back view of an A.C. Super-Wasp with the back halves of the shield cans removed.

1—No. 1613 variable condenser (with No. 1259W knob)
1—No. J-5 midget condenser (with No. 1259W knob)
1—No. 59 condenser (.01 mf.)
1—No. 50B fixed condenser (.0001 mf.)
2—No. 58 condensers (.006 mf.)
2—No. 801 by-pass condensers (1. mf.)
2—No. 805 condensers (.2 mf.)
1—No. 500 Resistoblock
1—No. 391 audio transformer
1—No. 395 output transformer
1—No. 130 R.F. choke coil
3—No. 966 resistances (450 ohms)
2—No. 958 resistances (200 ohms)
2—No. 354 center-tapped resistances (20 ohms)
10—No. 29 blank binding posts
1—No. 20 "ANT" binding post
2—No. 752 grid leaks (.5 megohm)
1—No. 758 grid leak (3 megohms)
2—sets of plug in coils; No. 601A, antenna coils; 601D, detector coils
1—No. 697 Hardware package, which includes all nuts, bolts, washers, soldering lugs, special fixtures, connection wire, etc.

DETAILED ASSEMBLY INSTRUCTIONS

The parts of the A.C. Super-Wasp are laid out in such a manner that the connections are very short and direct—an important feature in any short-wave receiver. If you assemble the set in the proper order, you will find the job an easy and interesting one, and you will have no trouble to look for later. Therefore, read the following instructions carefully before starting on your kit. If you rush right into the work you'll encounter difficulty in making certain of the parts fit.

As with any other kit, the first thing to do is to remove all the parts from their boxes. Get all the paper and cardboard out of the way and line up the instruments on the table. Identify each part and study the drawings to determine just where it belongs. Put aside the two boxes of plug-in coils, one of the shield can covers, and the two back halves of the shield cans—the sections that do not have a large hole in the front section. Pour the various nuts, bolts, washers, lugs and other incidental hardware into one of the can covers, so that they will not be spilling all over the place.

To start, mount the shelf brackets to the extreme ends of the sub-panel. Face the curved ends of the brackets toward the long edge of the sub-panel that has a rectangular opening cut in the center. Use the very short oval-head screws for this purpose. Now mount one of the 450-ohm resistors and the R.F. choke coil to the side of another of the brackets, in the positions shown in the under view of the receiver (page 13). Mount another 450-ohm resistance on the side of the fourth bracket, and then screw both brackets to the sub-panel, using three screws apiece. You can spot the proper holes in the sub-panel by merely sliding the brackets along until you can look thru both the sub-panel and the edge of the brackets. Have the soldering lugs of the resistors point outward.

MOUNTING THE RESISTORS

The sub-panel now has four strong feet to stand on, and you can proceed with the mounting of the other parts. First line up the two 2000-ohm resistors between the two center brackets. Use one screw to hold the overlapping feet of the resistors, in the center of the sub-panel. Put a lug under this screw, as shown in the under view. Put lugs under the binding posts of the two 1. mf. by-pass condensers, and mount the latter by passing screws through their feet, along the edge of the rectangular cut-out.

Get the binding posts out of the way by mounting them along the back edge. The "B"— and "*gnd*" posts are not insulated, but merely connect with the aluminum. The others are insulated by means of double hard rubber washers. One section of the latter is placed over the large binding post hole on the top of the sub-panel, the other on the underside. The screw of the binding post is simply passed through and tightened on the underside. Of course, put soldering lugs under all the screws.

Turn the sub-panel top side up, and mount the socket for the screen grid tube by means of three screws. Note that the screw marked "C" (between the F posts) holds, on the underside of the sub-panel, one end of a 450-ohm resistor. Now mount the socket for the antenna coil by raising it above the sub-panel with three of the one-inch hard rubber bushings and passing long screws through the holes. One of these long screws, marked "B" holds the other end of the 450-ohm resistor. You will have to spread the feet of this resistor to make them fit the screws; this is easy, as the metal is thin.

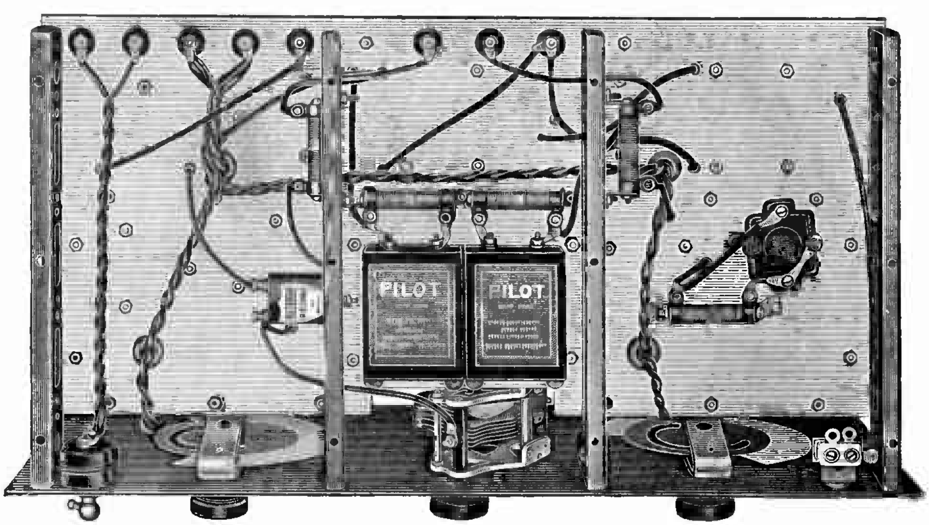
Another of the long screws, marked "A", passes through the .01 mf. condenser, which is spaced away from the underside of the sub-panel by a hexagonal spacer. Take one of the double-end lugs supplied with the 1 mf. by-pass condensers and bridge it between screw "A" and one terminal of the condenser, putting an additional soldering lug under the latter terminal.

In mounting the two sockets, study the drawing carefully to determine the correct placement to the binding posts.

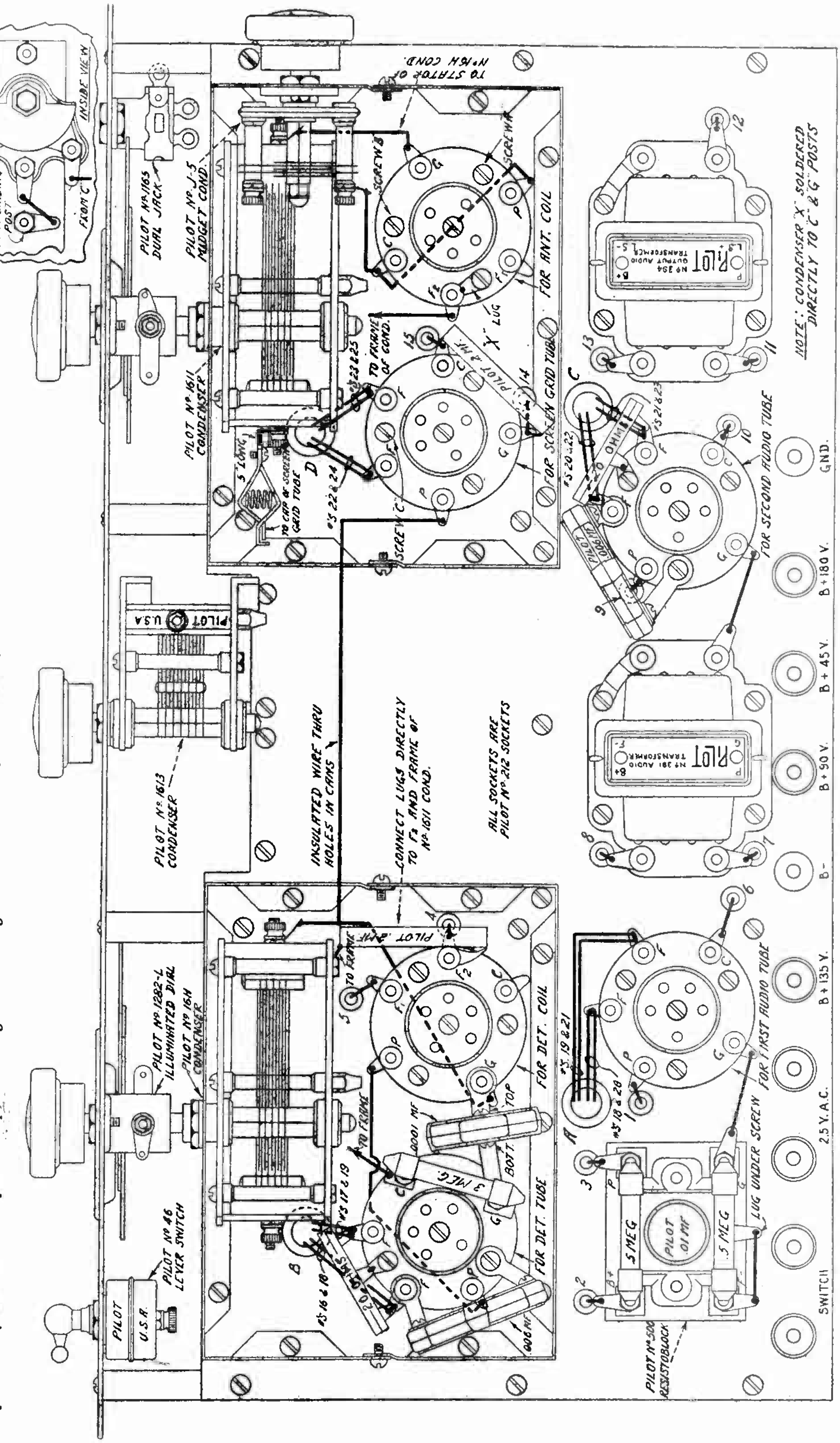
Now shift to the left side of the sub-panel and mount another pair of sockets in a similar manner, elevating the coil receptacle by means of the three remaining hard rubber studs. The screws holding the coil socket in this case do not hold anything else. However, the detector tube socket supports a .006 mf. condenser. This is held in a vertical position by means of two double-end straps (which you will find in the hardware package). Screw one end of each lug under one condenser screw, and bend the other ends so that one will fit under an F post on the socket and the other under a screw passing through the socket near the P post. Put a soldering lug under the screw passing between the two F posts; you'll need it later.

The .0001 mf. condenser is supported between the G posts of the two sockets in a similar manner, by means of two more double-end lugs. These lugs also act as connectors. While fastening the bottom

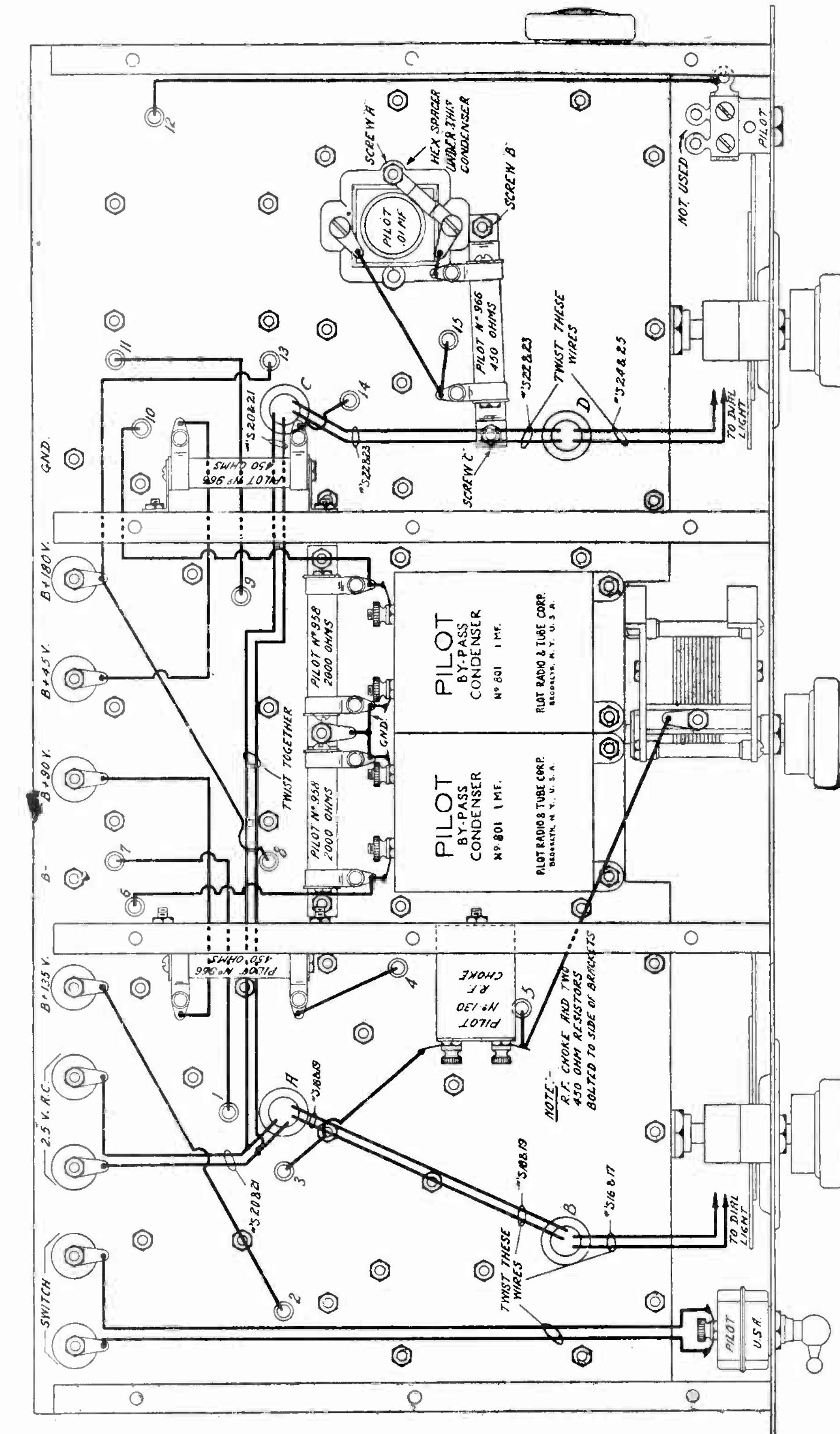
(*Continued on page* 14)



Under view of the A.C. Super-Wasp.



Top view of the A.C. Super-Wasp, showing the wiring and the exact placement of the parts.



Bottom view, showing the resistors and the condensers and the connections to them.

lug to the G posts of the detector tube socket, fasten one of the grid leak clips to this post at the same time. Put the other clip on the C post. The 3 megohm leak will just clear the detector tube if the clips are bent over a little.

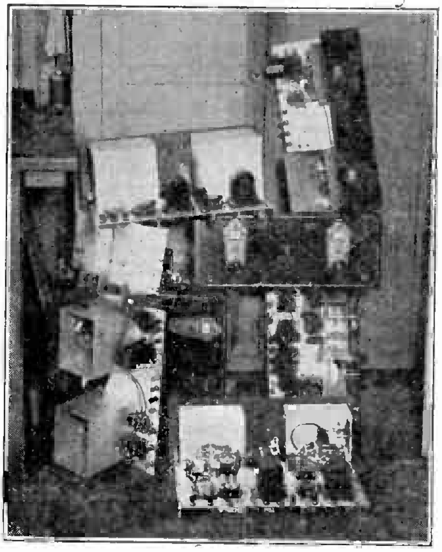
Special note: use lock washers under all nuts, throughout the receiver.

The rest of the assembly work on the sub-panel is easy. Place the Resistoblock, the two remaining tube sockets, and the two transformers. Note that the socket for the second audio tube supports a .006 mf. condenser in exactly the same fashion as the socket for the detector tube. Likewise, a lug is needed under the screw between the F posts.

In mounting the No. 391 transformer, bridge the F— post to the nearby mounting screw by means of another of the thin double-end lugs furnished with the 1 mf. by-pass condensers. Do the same with the LS— post of the No. 394 output transformer.

Even though you haven't even touched the front panel and the shield cans, you can do most of the wiring right now, with those parts out of the way. Do the filaments first. Start with the socket for the screen grid tube, and through hole D run out two pairs of twisted wires from the F posts. Cut wires 24 and 25 about 10 inches long, and leave them alone; they will connect later with the dial light. Run the other pair, numbered 22 and 23, through hole C, up to the socket for the second audio tube, and bring out another pair from these same posts; the second pair is marked 20 and 21. At the same time, solder the outside lugs of a 20-ohm center-tapped resistance to the F posts of this socket, and the center lug to the lug between the posts.

Bring wires 20 and 21 up through hole A, to the socket for the first audio tube, and also bridge them to the binding posts marked "2.5 volts A.C." Bring another pair (marked 18 and 19) out from this socket and up through hole B, to the detector tube socket. Bring a last pair of wires from hole A (numbers 16 and 17), cut 10 inches long, and leave it hanging; this is for the other dial light. Solder the other center-tapped resistance to the F posts of the detector tube socket as shown.



Some of the experimental A.C. Super-Wasps piled up in a corner of the Pilot laboratory. These sets were rebuilt as often as six times.

Study the picture diagram and do as much more of the wiring as you can. The whole audio system can be wired with the front panel still off, and part of the radio.

In the kit you will find two special .2 mf. condensers in paper containers. Take one and solder its lugs directly to the G and C posts of the socket for the screen grid tube. This condenser is marked "X" in the drawing.

Now take the front panel, and on it mount the snap switch, the phone jack, the No. 1613 condenser and the two dials. In mounting the dials, put washers behind the back of the panel, to keep the scale and the back edge of the panel plate separated. Also discard the slotted back pieces supplied with the dials, as they are not needed. Leave the dials a bit loose; you will fasten them permanently afterward.

Proceeding to the shield cans, take the can section that has an insulating strip riveted to one side. Mount the J-5 midget condenser in the upper hole, and the "ANT" binding post in the other. Slide the shield along the edge of the sub-panel until you can slip screws through the holes in the mounting feet, and tighten them down.

Now take one of the No. 1611 variable condensers, fasten a lug under the right hand stator binding post and another over the threaded stud on the back of the frame. Cut a piece of flexible wire five inches long, connect one end to the left hand stator binding post and the other to the Mueller snap clip supplied in the hardware package. Mount the condenser in the large hole in the center of the shield, using the single large hex nut.

Repeat this assembly operation with the other shield and the other No. 1611 condenser, omitting the flexible wire. Take the second .2 mf. fixed condenser, fasten one lug under the F2 post of the detector coil socket, and the other lug under the screw that holds the right side of the No. 1611 condenser frame together.

Now place the front panel against the brackets and slip the studs of the two dials over the protruding condenser shafts. Using the brown colored screws, fasten the panel to the brackets first and tighten the dials afterward.

MORE AMPLIFICATION

Because the P-227 A.C. screen-grid tube has a higher amplification factor than the D.C. tube, the A.C. Super-Wasp is even more sensitive than the now-famous battery model, thousands of which have been built during the past few months. During one of the preliminary trials on the A.C. set, the following stations were tuned in ON THE LOUD SPEAKER during the course of three hours of alternate listening and experimenting: G5SW, Chelmsford, England (signing off with the midnight bells of Big Ben, the famous London clock); PCJ, Eindhoven, Holland (audible fifty feet from the speaker); W6XN, Oakland, California, (relaying an N.B.C. chain program; CJRX, Winnipeg, Canada; and KDKA (W8XK), Pittsburgh, Pa., (also relaying a chain program). This test was made at Yorktown Heights, N. Y.

The battery operated Super-Wasp has brought in short-wave stations from all over the world for its many satisfied owners. The A.C. Super-Wasp will bring in these stations louder and better.

Build an A.C. Super-Wasp and enjoy the thrills of the short-waves with all the conveniences of lamp-socket operation!

You can now finish the wiring of the set. With all the wiring in, slip the back halves of the shield cans in place, and screw the cans together. If you find yourself dropping the screws that go through the feet of the can, hook the end of a piece of wire and hold the screws in it as you push them through the holes with a screw-driver. To fasten the sides of the shields, use the very shortest round head screws in the hardware collection. You are now ready to "go on the air".

THE ACCESSORIES

You need a power pack and four Pilotrons—the new Pilot tubes. The A.C. Super-Wasp is designed to work particularly with the Pilot K-111 power pack, which is small, compact, and inexpensive. The binding post markings on the receiver correspond to the markings on the terminal plate of the K-111, although the actual plate voltages delivered by the latter are higher than the figures marked. This is due to the fact that the whole A.C. Super-Wasp draws very little current, hence the "B" output voltages are higher than they would be with a six or seven tube set, for which the K-111 will deliver its rated voltages. This is no disadvantage; quite the contrary, it is a fortunate circumstance, as the filtering action of the choke coils is better with the lighter current drain.

The B+ 90 post, for instance, actually develops about 135 or 140 volts (depending on line conditions) and the 45 volt post about 50 volts. This is a good combination for the screen grid tube. (Note that the plate voltage for the screen grid tube flows through the detector plug-in coil.) The B+ 180 post delivers about 200, which is not excessive because the 2000-ohm biasing resistors automatically control the plate current of the audio tubes. The B+ 135 gives about 180 volts. This sounds like a dangerous amount of voltage for the detector tube, but the tube actually receives far less than this because of the use of a .5 megohm plate resistor.

In regard to tubes, we wish to emphasize the fact that no ordinary 227's will work in the A.C. Super-Wasp. Pilot engineers, under the supervision of John Geloso, were forced to develop a special tube, and unless you use the new P-227's, you cannot expect anything more than a loud growl out of the receiver. Use a P-224 A.C. screen-grid tube in the left hand can, and P-227's in the other three positions, and you will enjoy all the thrills of short-wave reception with all the conveniences of full A.C. operation.

The plug-in coils are used in pairs to cover any one wave band. The wavelength ranges are approximately as follows:

Red coils: 14 to 27 meters; orange, 26 to 50; yellow, 50 to 100; green, 100 to 200; blue, 200 to 500 meters.

The red, orange, yellow and green antenna coils consist of a single winding, while the blue has a primary at the top of the form. All the detector coils have two windings, a grid coil and a tickler. After changing from one set of coils to another, always replace the tops of the shield cans.

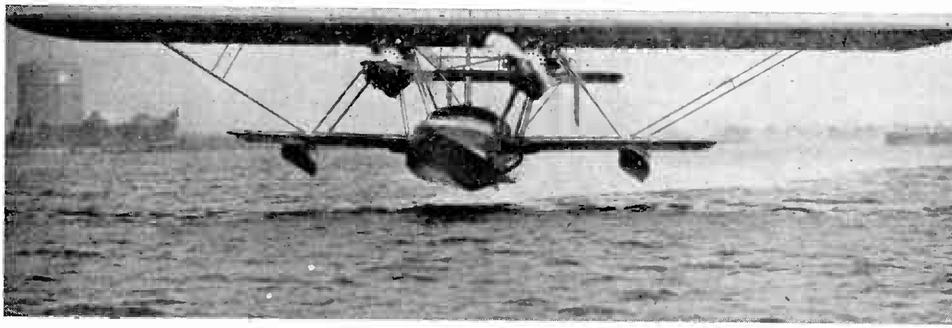
The operation of the A.C. Super-Wasp is even more simple than the battery model. There is one less control, as the heating currents are furnished directly from the transformer windings. The filament rheostat has been eliminated. The left hand tuning dial, or antenna control, usually tunes just a little lower than the right hand condenser. This is due to the antenna effect and somewhat to the difference in tubes in the two circuit positions. However, the left hand control is somewhat broad, so signals may still be received even tho the dials are not at their exact tuning position.

An aerial totalling between 30 and 50 feet in length is satisfactory for both short and regular broadcast wave reception, while the ground may be a connection to a steam or water pipe. Little need be said about the operation of the set on the broadcast

(Continued on page 28)

RADIO HAILED AS NEW BOON TO COMMERCIAL FLYING

by ZEH BOUCK



An exceptionally good photo of a Sikorsky amphibian taking off from the surface of Lake Erie in a cloud of spray. Radio plays an important part in the navigation of a deluxe air cruiser of this kind.

HERBERT HOOVER, JR., in a recent radio address, outlined imaginatively but soundly the close connection that will necessarily prevail between radio and safe commercial flying. Had his proposition required proof, it would have been adequately upheld by the serious consideration given to radio in the design and operation of the majority of ships exhibited in Cleveland during the National Air Races, held between August 24th and September 2nd.

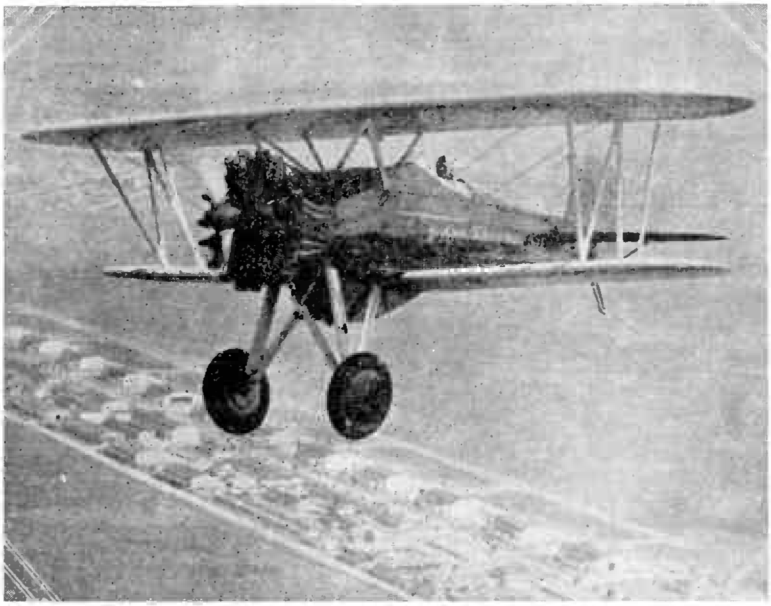
RECEIVERS ESSENTIAL ON ALMOST ALL SHIPS

The utility of the radio receiver in cross country flight has been so well established in various prominent experimental trips—the last being the record breaking flight of Captain Hawks—that such apparatus is part of the standard equipment on all planes operated by the large transport companies, carrying express and mail. Every ship flown by the N.A.T.—National Air Transport—operating southern and western lines out of Cleveland, is equipped with receivers working on the existing and contemplated airplane beacon and weather broadcasting wavelengths between eight hundred and one thousand meters. The principal utility of these receivers at present is the reception of the weather reports that are sent out every hour on the hour by high powered radio telephone broadcasting stations located at the prominent air terminals. For instance, there are three broadcasts available to pilots on the Cleveland-New York run, programs being broadcast from Hadley Field, N. J., Bellefonte, Pa., and Cleveland, Ohio. The pilot is never out of communication distance from all of these points, and is kept accurately informed as to the weather conditions before him. These receivers are also used for the reception of both aural and visual directional signals, the former by means of a variation in signal peculiarity which warns the pilot when he is off his course and the latter through the vibrating reed device described in detail in the Spring issue of RADIO DESIGN.

The significant fact is that air lane operators have at least realized that these radio services are now functioning effectively—that they are not merely interesting experiments suggestive of future possibilities—and will add immediately to the efficiency and safety of any air route at a relatively low cost to the operator. As a result, practically all airplanes on production schedules for 1930 incorporate various features essential or desirable from the standpoint of radio operation. All adjacent metallic parts in the structure of the plane are bonded—that is, electrically connected. This is done for two reasons: first, to insure the use of every available bit of metal in the counterpoise of the antenna system; and second, to prevent the interference that would be occasioned by the rubbing together of metal parts, not electrically common, in the antenna field.

NEW IGNITION SHIELDING

Manufacturers of ignition apparatus have developed shielded equipment which effectively reduces the noises set up by this system. The flying laboratory of the Pilot Radio and Tube Corporation is at present experimenting with a new and radically different type of shielded spark plug that



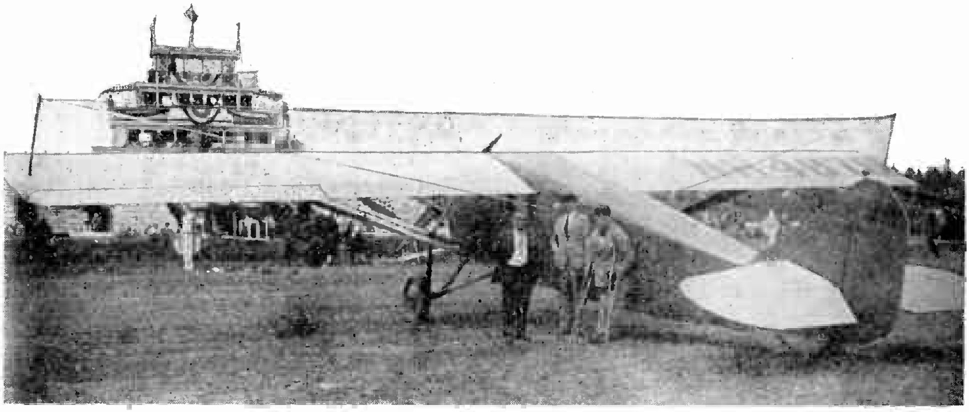
Even small single-seater planes, like this new Boeing pursuit ship, will soon carry compact beacon receivers, without which night or fog flying is dangerous or impossible.

practically eliminates interference from this source on receivers of even the high gain essential for long distance beacon reception. However, it is not sufficient to shield the sparks plugs only. The magnetos, the switch and the entire ignition system must be shielded to approach anything like satisfactory quietness.

The manufacturers of planes designed for mail and express services supply with their planes, at slight additional cost, a six to ten foot vertical pole antenna necessary for beacon reception and equally effective for general weather broadcasts.

LITTLE WORK DONE ON TRANSMITTERS

To date the attention of the majority of designers has been directed toward the development of radio receiving apparatus, transmitting sets having received little attention outside of experimental equipment. However, the large transport passenger carrying ships are being equipped for transmitting on the aeronautical waves between eight hundred and one thousand meters. The necessity for transmitting equipment, which is necessarily heavy, and which, for reliable communication over reasonable distances requires antenna and



The Pilot flying radio laboratory on the field at Cleveland during the national air races. Notice the aerial wire strung between the wing tips and terminating at the sides just behind the cabin. Mr. Bouck is at the extreme right.

power installations that materially reduce the speed of the plane, has been considerably reduced by scheduling frequent weather broadcasts. The principal function of the transmitter would be to request weather information and for directional purposes, both of which operations are satisfactorily taken care of by the much lighter and more easily operated receiving sets. Transmitters on the large transport jobs will be used for reporting positions and for establishing communication between passengers and land points exactly as wireless is used on board ships at sea.

RADIO AT THE RACES

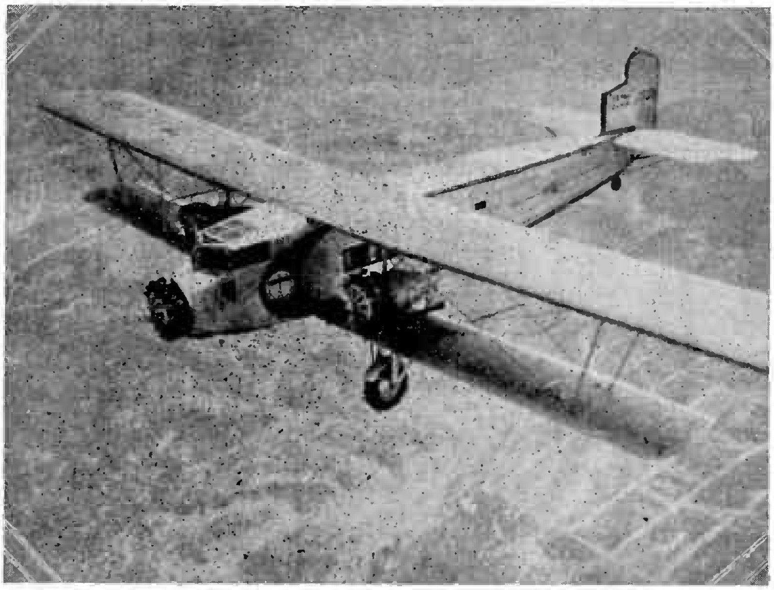
Some interesting possibilities in the way of airplane radio were suggested during the races held simultaneously with the air show at Cleveland. All races were monitored by amateur radio, seven and a half watt transmitters being installed on each of the pylons (guide posts). The five mile closed course included three pylons and the ten mile course four pylons. The home pylon was equipped with three receivers, each of which was tuned to one of the other pylons. Each receiver was outputted to a loudspeaker, making it possible to monitor the returns from each pylon at all times. The receivers at the individual pylons were tuned to the central transmitter located at the home pylon. Judges were located at all pylons.

The transmission was effected by radiophone on the eighty meter band under amateur call letters. The installations were designed and manned by the Cleveland Wireless Association and the Cleveland Amateur Radio Association.

The object in controlling the races in this manner was to keep a constant check on the movements of the racing planes, making it possible to disqualify any plane immediately following the cutting of a short corner, and consequently the announcement of the winner immediately following the finish.

PILOT PLANE BROADCASTS RACES

An interesting demonstration of radio communication between plane and ground was staged by the Pilot flying laboratory during the races and as a part of the broadcast program WHK, the official race broadcasting station. A daily rebroadcasting program was maintained during the races, an announcer going aloft in the plane and describing the various events over the short wave transmitter, W2XBQ, with which the ship is equipped. The short wave signals were picked up on the ground, amplified, and put over land wires to the control room of the station. At the same time the amplified signals were outputted to the public address system before the grand stands. Two-way conversation was maintained at all times between the ground and the flying laboratory, to which both radio listeners and the audience watching the races gave a most attentive ear. The ship was put through various maneuvers in front of the grand stand while an announcer on board the plane described exactly what was being done.



In some of the new ships of the air, like this monster Boeing 18-seater, both pilots and passengers will be able to talk to the ground as easily as they can telephone from one office to another. No longer will the plane be out of touch with sources of valuable information.

Some

Radio Questions and their Answers

A variety of subjects are covered by these queries from readers; the answers, by Alfred A. Ghirardi, contain much useful information.

COILS FOR SCREEN-GRID TESTS

1. I have several R.F. coils which were designed for use in sets employing three-electrode tubes of the 201-A, 226 or 227 type. Can I use these coils in a screen-grid set satisfactorily?

Answer: Coils designed for use with three-electrode tubes generally do not work well with screen-grid tubes. In order to obtain a large amount of amplification from screen-grid tubes the impedance of the plate load must be made very high to effectively match the very high plate impedance of the screen-grid tube. This means that if ordinary R.F. coils with tuned secondaries are used, they must have a greater number of turns of wire on the primaries than in the case when three-electrode tubes are used, otherwise only a small proportion of the high amplification which the screen-grid tube is capable of producing will be obtained. It is best to use R.F. coils designed especially for use with screen-grid tubes.

ONE DIAL K-106 RECEIVER

2. Can I build the K-106 receiver as a single control set, using a three-gang condenser for tuning the radio-frequency stages?

Answer: The K-106 receiver was designed as a two-dial control receiver and we advise you to build it exactly as shown in the official diagrams. If you attempt to build this set as a one dial receiver you will find it very difficult to keep the R.F. stages exactly in tune over the entire wavelength range.

A.F. TRANSFORMER MARKINGS

3. What do the markings P, B+, G, and F— on the terminals of audio-frequency transformers indicate? Please publish a diagram showing how the windings are connected to these terminals.

Answer: The markings on audio-transformer terminals were devised to indicate where each terminal is to be connected. Thus, as shown in Fig. 1, "P" goes to the plate of the preceeding tube, B+ goes to the B+ terminal of either the "B" battery or "B" power unit, "G" goes to the grid of the following tube, and F— goes to either the filament minus terminal (in battery operated sets) or to the "C" biasing resistor in A.C. sets.

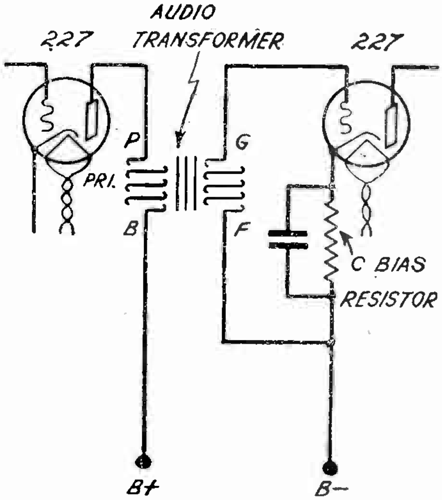


FIG. 1

Fig. 1: How the connections of a typical amplifier run to the terminals on an A.F. transformer.

DYNAMIC vs. CONE SPEAKER

4. I have a five tube tuned R.F. receiver. What type of loud speaker shall I use with it, a dynamic or a cone speaker? Is it true that dynamic speakers are the best kind?

Answer: The dynamic speaker, when operated with a proper baffle and receiving set, is considered to be about the best type of speaker available at the present time. It will give better reproduction than most other types of speakers, especially when great volume is desired. If you have a set which is capable of producing good volume and undistorted amplification, we advise you to use a good dynamic speaker with it. If the set does not produce much volume a good cone speaker will work just as well. Also remember that all dynamic speakers are not good ones.

USING THE NEW 245 POWER TUBE

5. Kindly explain how to connect a simple 245 power tube in the last audio stage of a receiver?

Answer: To properly understand the circuit using the 245 power tube, one should be familiar with the general characteristics of the tube. These are as follows: Maximum plate voltage 250 volts, "C" bias voltage —50 volts when 250 volts plate potential is used and —30 volts when 180 volts plate potential is used. Filament voltage 2.5 volts and 1.5 amperes.

Fig. 2 shows the connections for a 245 power tube in the last audio stage of a re-

ceiver. The filament is energized from a 2.5 volt source of alternating current. This is usually furnished by a separate step-down transformer operating from the 110 volt, 60 cycle, A.C. lighting line or from a 2.5 volt winding on the filament heating transformer in the set. The filament of the 245 tube should not be operated from the same winding as a 227 or 224 detector but should have an independent filament winding. With a common winding troublesome feed-back occurs.

The center-tapped resistor "R" should have a resistance of 20 ohms, and should be connected as near to the filament terminals of the tube as possible. The proper "C" bias is obtained by resistance R1, connected as shown. This should have a value of 1500 ohms when 250 volts is used on the plate of the tube. The "C" bias resistor is by-passed by a 1 mf. fixed condenser C. The grid return is connected to the "B—" and thus the bias is obtained by the plate current drop through resistor R1.

It should be remembered that the total voltage available from the "B" power unit will have to be 300 volts in order to allow 250 volts for the plate potential and 50 volts for the "C" bias potential. When a plate potential of 180 volts and C bias potential of —30 volts are used, the total "B" voltage necessary is 210 volts.

Either the choke coil-condenser output coupler (as shown) or an output transformer may be used to couple the power tube to the loud speaker.

It is recommended that the maximum plate voltage of 250 volts be used with this tube whenever possible, as then the full benefits of the tube will be obtained. Under these conditions it is able to handle 1600 milliwatts of power without distortion.

245 TUBES IN PUSH-PULL

6. Kindly publish a diagram showing the connections for two 245 tubes in push-pull, in the output stage of an audio amplifier.

Answer: Fig. 3 shows the connections for a 245 push-pull audio stage. Note that "C" bias resistor has a value of 750 ohms when a plate potential of 250 volts is used, as this resistance now carries the sum of the plate currents of both tubes. A push-pull output transformer is used between the 245 tubes and the speaker.

TESTING FOR TUBE DISTORTION

7. Kindly explain a simple way to test an amplifier tube in a set to find out whether the "B" and "C" voltages are correct, in other words, to detect tube distortion.

Answer: Tube distortion can easily be detected by connecting a D.C. milliammeter having the proper range (depending on the plate current of the tube to be tested) in the plate circuit of the tube, as shown in Fig. 4. When the set is playing at full volume the needle of the milliammeter should not deflect more than 10 per cent of its reading when particularly loud notes or sounds are received. If the needle deflects downward when a loud note is received, the "C" bias voltage should be raised or the plate voltage lowered. If the needle kicks upwards the plate voltage should be increased or the grid bias reduced. If the needle swings both up and down from its neutral position it indicates that the signal voltage capacity of the tube is being exceeded;

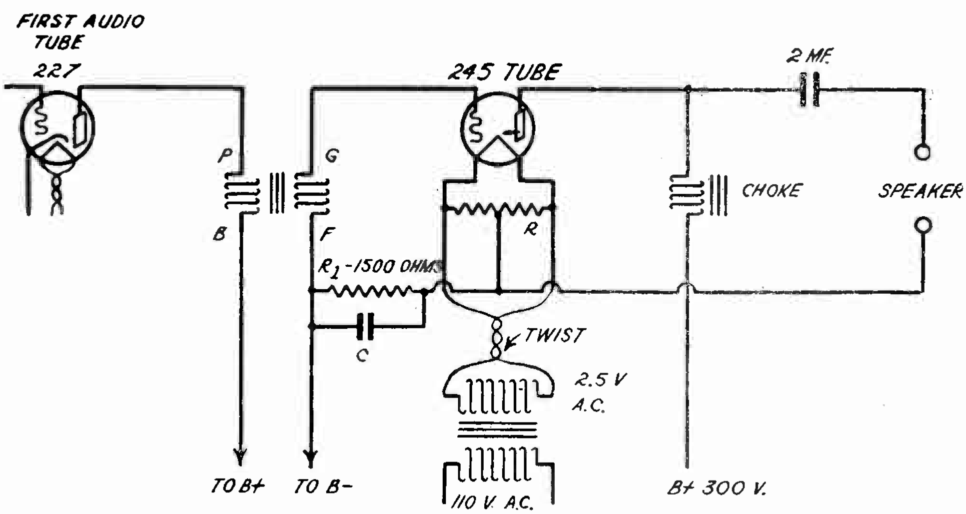


FIG. 2

Fig. 2: How a single 245 tube is used in the output stage of an audio amplifier. The center-tapped resistor should have a resistance of 20 ohms.

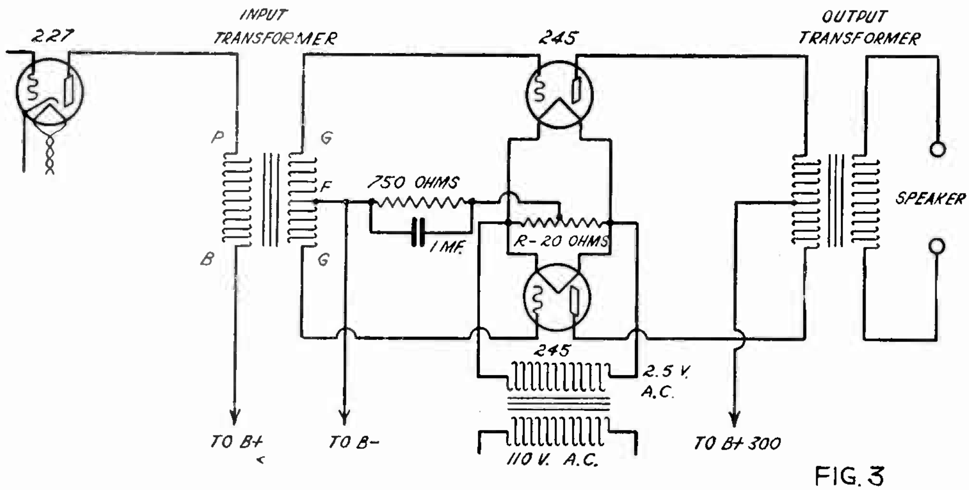


FIG. 3

Fig. 3: A push-pull stage using 245's. The biasing resistor now has a resistance of 750 ohms, but the 20-ohm center-tapped resistance remains the same.

i.e., the tube is being overloaded. In this case either use two tubes in push-pull, or a tube which has a larger handling capacity.

The plate current of small tubes like the 227 is less than 10 milliamperes, so an 0-10 milliammeter may be used. For 171-A and 245 power tubes, the current is about 20 and 30 milliamperes, respectively, so an 0-50 milliammeter is necessary. This larger size may also be used for the smaller tubes, of course.

HOWLING IN A SET

8. Why does my set hum and howl when the loud speaker is placed on or near the cabinet and play clearly when the speaker is removed to the other side of the room?

Answer: This action is due to the fact that your receiver contains one or more "microphonic" tubes. The sound vibrations produced by the speaker vibrate the whole set and the tubes in it. (You can feel this by placing your hand on the cabinet while the set is playing loudly). This vibration makes the grid, the plate, and the filament in the microphonic tube vibrate and so the relative distance between these three elements changes rapidly. This makes the plate current of the tube vary in exact accordance with the spacing changes (see Radio Physics Course in Vol. 2, No. 2 of Radio Design*) and this variation is amplified and fed through to the loud speaker, where it is reproduced as a loud hum or a howl.*

Detector tubes are usually the most sensitive to microphonics. A microphonic tube can usually be made to function properly by placing a heavy object on it to damp the vibrations. "Howl arresters" made of rubber or lead are sold for this purpose. Another remedy is to employ tubes which have their elements firmly supported and braced to prevent or at least reduce vibration. Also, the loud speaker can be placed a few feet from the set so that the sound vibrations do not act on it directly.

TRACING CAUSE OF NOISY RECEPTION

9. Reception of stations with my set is always accompanied by noises. Can you tell me how I can locate the cause and remedy it?

Answer: The noises you speak of may originate in your radio equipment or may originate somewhere outside and come by way of the aerial or ground circuit. To determine their origin operate the set so that the noises come in loudly. Now disconnect both the aerial and the ground. If the noises still continue it indicates that they originate somewhere in your receiver. In the former case, there is nothing you can do to cure the trouble unless you can trace it to its source. Elevator motors and switches, X-Ray and violet ray machines and other kinds of electrical machines are known to generate radio interference, which can easily be eliminated by the use of simple filter devices. The superintendents of apartment houses are usually glad to cooperate in tracing down noises of this kind.

Check up on your aerial and ground connections to find out if there is a loose or defective connection somewhere. All joints should be soldered.

If the noises originate in your equipment you will have to test and examine all parts for the trouble. Noises may be caused by loose connections, defective tubes, old "B" batteries or rectifier tubes, defective condensers, etc.

ELIMINATING TRANSFORMER HUM

10. The power transformer in my "B" eliminator hums so loudly that I can hear it several feet away. How can I remedy this?

Answer: The hum is due to vibration of the laminations of the steel core due to changes in the magnetism caused by the 60-cycle alternating current. Vibration can be reduced or eliminated in several ways. The exact method *it is best to employ depends upon the mechanical arrangement of the parts in the eliminator and how easily you can get at them. One way is to pour molten paraffin around the laminations so that it runs between them and fills up any spaces. Another way is to clamp the laminations together tightly by means of flat iron pieces held together by bolts. Sometimes it is possible to reduce the vibration by inserting thin strips of cardboard or paper between the laminations if they are very loose.*

"B" POWER PACK ON THE "LITTLE PAL"

11. Can I operate my three-tube "Little Pal" receiver with a "B" power pack instead of "B" batteries?

Answer: You can operate the Little Pal with any good "B" power unit capable of supplying at least 90 volts.

SPREADING TUNING ON SHORT-WAVE SETS

12. How can I spread out the tuning on my short-wave set, so that the short-wave bands come in all over the dial? I am using A Pilot .00016 mf. tuning condenser.

Answer: One very good way to spread out the tuning on your short-wave receiver is to remove all of the rotor plates except the center one from your tuning condenser. This will give you a condenser with its full set of stator plates but only one rotor plate. Now connect a Pilot No. J-23 (.0001 mf.) midget condenser across the altered tuning condenser. The midget should be mounted on the front panel or anywhere within convenient reach. The midget condenser is now used for rough tuning to the various wavebands and the altered condenser is used for the actual fine tuning within any waveband.

The Super-Wasp detector tuning stage may be "revamped" in this way. The J-23 condenser may be mounted on the left side of the shield can, on an insulating strip. It is not necessary to revise the antenna stage, as it tunes a trifle more broadly than the detector stage and may be left set while the actual selecting of signals is done with the detector condenser. Of course, the revamped set is more or less useless now on the 200-500 meter band, as the small condenser is too small to give any selectivity on these waves.

AUDIO OSCILLATION IN PUSH-PULL AMPLIFIER

13. I built a push-pull amplifier and there is a steady whistle in the set. I have traced it to the push-pull stage. How can I eliminate this?

Answer: The whistle is caused by audio feed back in the push-pull stage. This results in oscillation, with the resulting whistle. This can sometmes be eliminated by connecting by-pass condensers of at least 2 mf. capacity between the "B—" and "B+" amplifier terminals, or across the "C" bias resistor.

Another very effective method is to connect a variable resistance R in the grid return circuit, as shown in Fig. 5. A Pilot Resistograd works very well in this connection, as it can be varied to give the minimum amount of resistance necessary to prevent oscillation. This is really the grid suppressor method of oscillation prevention so commonly used in R.F. amplifiers, but by connecting the grid suppressor resistance in the grid return circuit, as shown, only one resistor is required for both tubes.

DYNAMIC SPEAKER FIELDS

14. I notice there are dynamic speakers for either A.C. or D.C. What is the difference between them?

Answer: The field windings of all dynamic speakers require direct current for their excitation. In D.C. models, the D.C. house supply (or battery current) is lead directly to the fields. In A.C. models, the current is rectified before being applied to the windings. A chemical rectifier or a 280 tube is usually used for the purpose. The necessity for the rectifier is what makes A.C. speakers more expensive than D.C. models.

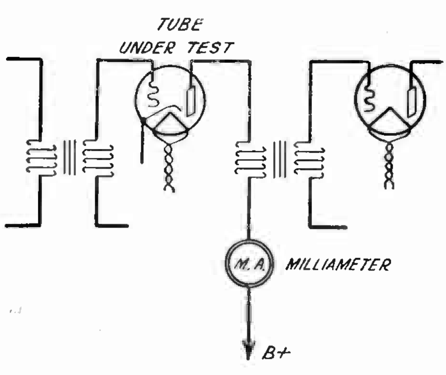


FIG. 4

Fig. 4: How amplifier distortion can be detected by means of a plate milliammeter.

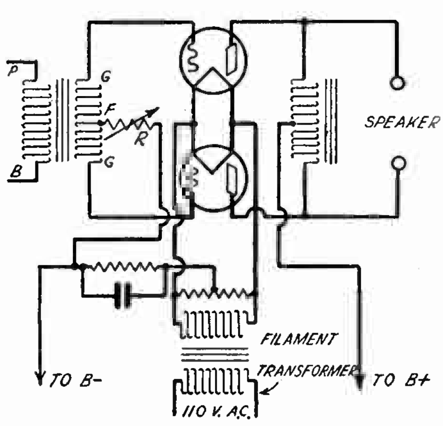


FIG. 5

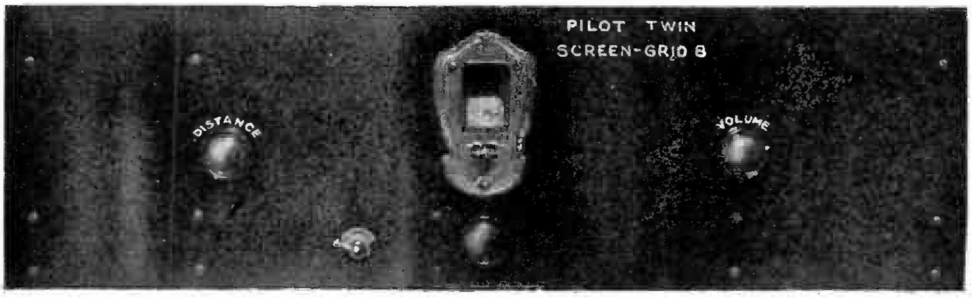
Fig. 5: How a variable grid resistor, R, is used to suppress audio howling.

The

Pilot Twin "Screen-Grid 8"

A single dial receiver using special coils to give a high degree of selectivity; Screen-grid tubes in both R.F. and detector positions, with two 245's in push-pull audio system. Parts supplied in kit form.

by **JOHN GELOSO**



Simplicity marks the appearance of the Screen-Grid 8 front panel.

DURING the past several months the A.C. screen-grid tube has achieved an extraordinary popularity, which it well deserves because of its high amplification and general stability in tuned R.F. circuits of proper design. Many owners of tuned R.F. sets using ordinary 227's have attempted to substitute 224's for the latter, and have been very much disappointed with the results. Their usual complaint is that the screen-grid tubes ruined the selectivity and caused half a dozen local stations to come in together.

This fault is not the tube's, but must be charged to the original receiver, which simply was never designed to take advantage of the high amplification afforded by the 224. The main weakness in these T.R.F. sets lies in the coils, which most radio constructors never suspect.

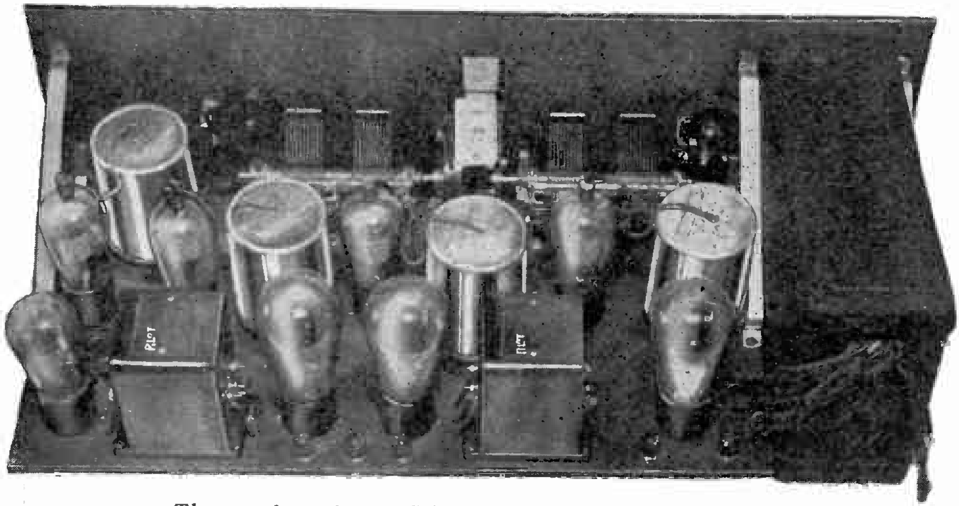
SCREEN-GRID DETECTOR

To meet the demand for a good circuit that can be built into a home constructed receiver, Radio Design presents herewith the Pilot Twin Screen-Grid 8, in which the necessary features of selectivity and sensitivity have been incorporated. Supplied in complete kit form to save the constructor the job of drilling his own panels, this set represents the latest developments in circuit design. Not only does it use the screen-grid tube in the R.F. positions, but also in the detector, where it offers distinct advantages over the usual 227 used for the purpose. The audio amplifier uses two 245's in push-pull, which is acknowledged to be the best amplifier arrangement known today for volume, tone quality and stability. All necessary power for the set is supplied by a Pilot K-112 power pack, which is built right into the set to make the outfit entirely self-contained.

The use of the screen-grid detector should be especially noted. Most screen-grid detector arrangements that have appeared during the past several months have been decidedly cranky in operation, and Radio Design has refrained from publishing any hook-ups of this nature. However, the circuit used in the Screen-Grid 8 is as stable as it is simple, and will cause no trouble. It is more sensitive than ordinary detectors and can handle signals of much greater strength. This latter feature is especially important, as the preceding radio-frequency amplifier does some real amplifying, and delivers signals that would choke up any other detector circuit.

THE CIRCUIT DETAILS

There are three stages of tuned R.F., controlled by a single dial working two double variable condensers. The new Twin Coupler PT2 and PT3 screen-grid coils, which are the secret of the whole set are used between tubes. The actual coils are enclosed in round aluminum cans, the bottoms of which are fitted with prongs to fit in standard tube sockets. The PT2, which is the antenna coupler, has a pri-



The completed Screen-Grid 8 with tubes and coils in place.

mary consisting of only six turns, with a center tap. The PT3's, used in the interstage positions, have larger primaries wound directly over the secondaries to give close coupling. Close coupling in a T.R.F. set using 227's is undesirable, as it causes oscillation and all the troubles that go with it; but in a screen-grid set it can be used to advantage because the screen-grid tubes do not appreciably couple the associated plate and grid tuning circuits.

The PT2 has a five-prong base, and may thus be distinguished from the PT3's, which have four-prong bases. Both types have a flexible wire coming out of the top, for connection to the cap of the screen-grid tube. The four coils are sold as a combination, bearing the catalog number 230.

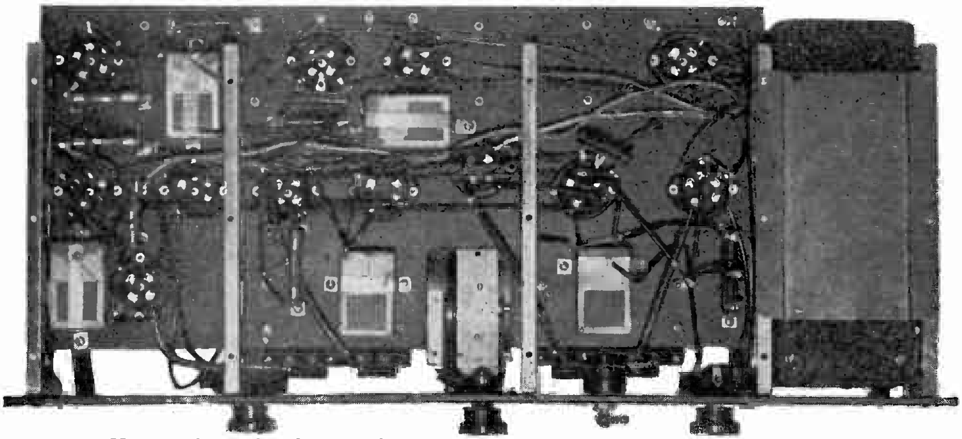
The front panel of the Pilot Twin Screen-Grid 8 is made of walnut finish bakelite, neatly engraved. In these days of steel case receivers, it is refreshing to note that a good bakelite panel is still a beautiful thing. The set, when completed, may be fitted in any standard cabinet or console with a 7 by 24 inch opening.

The sub-panel, of black bakelite, is securely braced to the front panel by means of four sub-panel brackets and by two additional brackets on the top side. It is cut several inches shorter than the front panel, to accommodate the K-112 power pack on the end. The latter unit is rigidly supported by two more sub-panel brackets, between which is screwed a metal shelf on which the power pack itself rests.

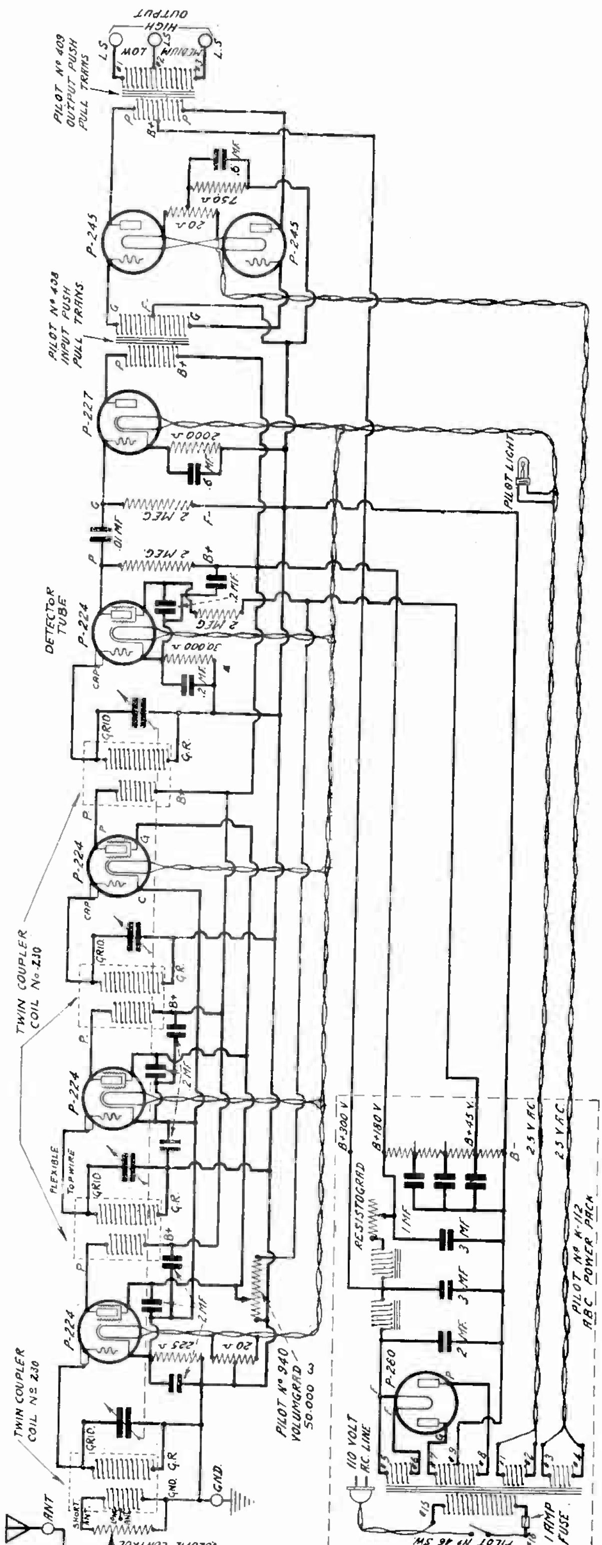
THE PARTS USED

The Pilot Twin Screen-Grid 8 uses the following parts, which may be purchased as a complete kit:

1—Drilled and engraved front panel
1—Drilled sub-panel



Under view, showing special by-pass condensers held down by clamps.



Complete wiring diagram of the Pilot Twin Screen-Grid 8.

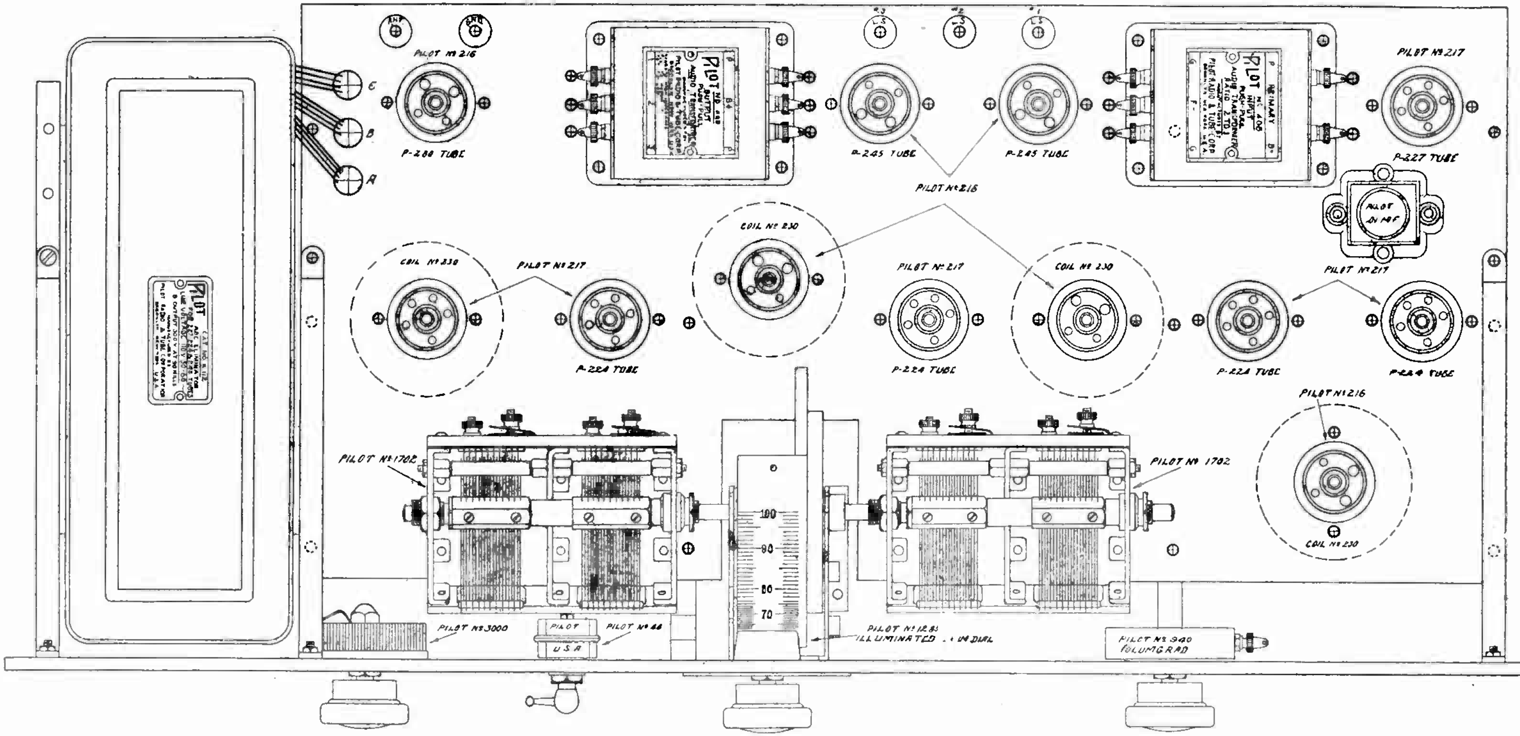
5—Sub-panel brackets and 2 additional bracing arms
1—K-112 power pack (completely assembled and wired)
1—No. 1285 vernier drum dial
2—No. 1702 double variable condensers
1—3000-ohm wire wound potentiometer
1—50,000 ohm Volumgrad
1—No. 46 snap switch
6—four-prong tube sockets, sub-panel mounting type
6—five-prong sockets, sub-panel mounting type
1—set of No. 230 coils (including one PT2 and three PT3)
1—No. 408 input push-pull transormer
1—No. 409 push-pull output transformer
2—20-ohm center-tapped resistances
1—each of the following fixed resistors: 225 ohms, 30,000 ohms, 2000 ohms, 750 ohms
3—grid leaks, 2 megohms each
1—.01 mf. fixed condenser
3—No. 806 special three section fixed condensers, .2 mf. per section
2—by-pass condensers, .6 mf. (same size case as No. 806)
5—Binding posts: "ANT", "GND", and three of "LS"

Incidental hardware, nuts, bolts, washers, soldering lugs, wire, insulating tubing, etc.

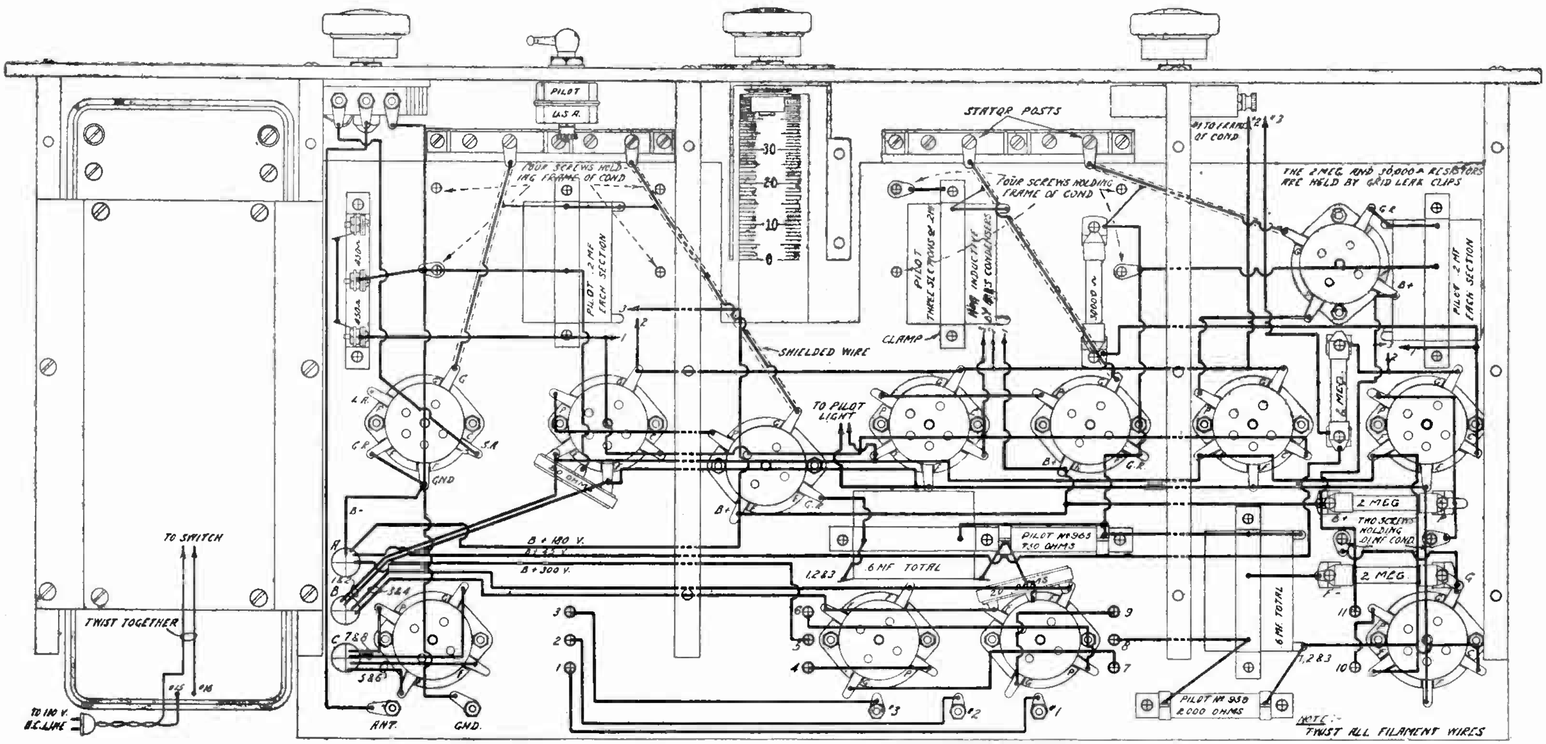
ASSEMBLY INSTRUCTIONS

In assembling the Screen-Grid 8, first screw four of the sub-panel brackets to the sub-panel. Now take the front panel and mount the vernier dial, the switch, the potentiometer and the Volumgrad. Slide the panel up against the feet of the brackets and screw it in place. Also mount the two side brackets that run from the ends of the sub-panel to the back of the front panel. Slide the double variable condensers into the sides of the dials, and screw them fast. You can easily locate all the screw holes when you place the instruments on the panels.

(*Continued on page* 28)



Top view of the Pilot Twin Screen-Grid 8, showing positions of parts. The three holes A, B, C, in the upper left corner of the sub-panel, carry the wires from the K-112 power pack to the underside. The dotted circles around the tube sockets indicate the PT2 and PT3 plug-in coils, which were designed especially for screen-grid circuits.



Bottom view of the Screen-Grid 8. Don't let this mass of wiring frighten you; when you start with the filament circuits and work gradually from tube to tube, you'll find the job quite easy. The wires on the power pack (on the left) marked "To Switch", run to the snap switch on the front panel.

How to make the A.C. Super-Wasp

by DAVID GRIMES

(*Continued from page* 15)

band, as it works very smoothly. As there are only two tuned stages, the selectivity naturally will not be as great as it is with complex broadcast receivers employing five or six, but it will be sufficient. You will be able to separate local stations without trouble, and will obtain loud signals of good quality. The selectivity is determined to a great extent by the setting of the midget condenser. If you live near a number of powerful stations, you will set this condenser to a low value. If you live in the country, you can short circuit it altogether.

On the short-waves, the setting of the midget condenser is of great importance. In general, it must be lowered as you go down in wavelength, although a single setting will hold for any one set of coils. The only thing to do is to experiment.

In hunting for short-wave broadcasting stations, remember that the tuning is going to be very sharp, and you will skip right by many powerful stations if you do not proceed carefully. If you start listening some evening after 8.00 p.m., plug in the yellow ring coils first, as you can practice tuning by getting W8XK, the 63-meter short-wave transmitter of KDKA, which is an old stand-by. Set the right hand dial at about 20, the left at about 25, and turn up the regeneration condenser until you hear the tell-tale rushing sound indicative of regeneration. Move the dials up or down a degree at a time until you hear a loud whistle. Tune in the whistle as loud as you can, and then start backing down the regeneration condenser. Juggle the tuning dials back and forth a trifle at the same time, and eventually you will be able to clear the whistle and hear the voice or music. If the signals are very weak, you may have to "zero beat" them. This is the operation of throwing the detector into oscillation, obtaining the whistle, and then tuning the set so carefully that the voice comes through just as the whistle disappears. It will reappear if the detector condenser is turned either up or down. Zero-beating is a very effective method of bringing in weak broadcasting stations, although it requires some experience in tuning. You will be able to master the trick after a few evenings.

GETTING THE FOREIGN STATIONS

In going after foreign broadcasting stations, you must bear in mind the time differences between the United States and the other countries of the world. Station G5SW, in Chelmsford, England, for instance, signs off at 7.00 p.m. Eastern Standard Time, it then being midnight in London. Thousands of short-wave set owners tune in this station regularly week days, and use its programs as dinner music. Station PCJ, in Holland, the star short-wave performer, is likely to be heard almost any time, as it puts on special programs for different countries of the world. It usually starts at about 10.30 p.m. Eastern time, and comes in with fine loud speaker strength.

The Pilot Twin "Screen-Grid 8"

by JOHN GELOSO

(*Continued from page* 25)

In doing the wiring, start with the filament circuit, and proceed with the rest of the hook-up. Do all the wiring before mounting the K-112 power pack in place; if you mount the pack first you will find the set heavy and rather difficult to manipulate. Simply leave the wires long, and cut them to size later.

The first, second and fourth screen-grid tubes are by-passed by the three-section condensers. The common terminal of each of these condensers goes to the cathode of the respective tube, while the others go to plate, screen-grid and biasing resistor.

The operation of the Pilot Twin Screen-Grid 8 is quite simple. The coils are quite evenly matched, but it is a good idea to experiment with the little balancing condensers on the double tuning condensers to make sure the circuits are in complete resonance all over the scale. Different lengths of aerials will have little detuning effect on the first R.F. stage, as the coupling is so loose.

THE United States has three exact geographical centers. I can prove that by the people of three towns in Kansas. Each town is in the exact center altho they are about 50 miles apart. The argument has been going on for about 60 years with the utmost good nature, all three towns being just a bit worried for fear someone will settle the question and make the losing towns feel badly, besides spoiling the fun of arguing.

The American sense of humor is also operating normally elsewhere and nearly a score of folks have written me to share a laugh at their own expense—which is both good humor and good sportsmanship. In each case the joke is that a Wasp or Super-Wasp which was originally suspected of being empty has later produced signals from all points between New York and Newark—the long way around. This is a sort of public "thank you" for the letters, altho I wish I hadn't raised the subject in the first place because some day there might be a Super-Wasp which really did not work. What could I say then?

One of the letters is from Mr. Fred S. Beach, Chief Draftsman of the Engineering Department of the Northwestern Electric Company at Portland, Oregon. Using the plain detector-and-two-audio Wasp, he has at several times secured loud speaker reception of a station at Moscow, Russia and also of the station RA97 at Khabarovsk, Siberia. Confirmation was secured in both cases. Concerning this confirmation there is an interesting point explained by Mr. Beach as follows.

"I wrote to the Soviet Government at Moscow, addressing my letter to Radio Station RA97, Moscow, Union of Soviet Socialist Republics. There is a Soviet regulation in regard to addressing any mail to any Russian city; the words 'Union of Soviet Socialist Republics' must be used in full or letters will be returned unopened to their senders. I mention this as other fans should know it."

If this keeps up English G5SW will begin demanding that American letters be translated into English.

KEEPING THE R.F. OUT OF THE AUDIO SYSTEM

MOST of us are only too familiar with the mushy quality and the thin high squeals that come from R.F. in the audio system. Usually we have tried to cure the condition by use of the circuit shown in Fig. 1A. This answered the days of "B" batteries and low-power detection, but it is not at all satisfactory in these days of A-B supplies, high-gain R.F. systems and short-wave broadcasting—for this is another one of the things which has to be treated more carefully at short waves than at long.

The idea, if any, of the circuit is that the choke is to stand across the road and sternly warn back any R.F. which dares to come out of the detector plate. Since some will none the less run past the barricade, we provide a detour around the audio transformer in the shape of the condenser C. A more analytic way of putting it is that the R.F. plate voltage is divided between two things placed in series. The first of these (the choke) has a high reactance and most of the drop takes place across it, while the second (the condenser) has a low reactance and therefore the drop across it is small.

All true, but why doesn't the thing work?

Clearly we have not completed the R.F. problem by simply allowing the first condenser beyond the tickler must be variable, as shown in Fig. 2A, if this type of control is to be used, consequently we cannot depend on it for a great deal of by-

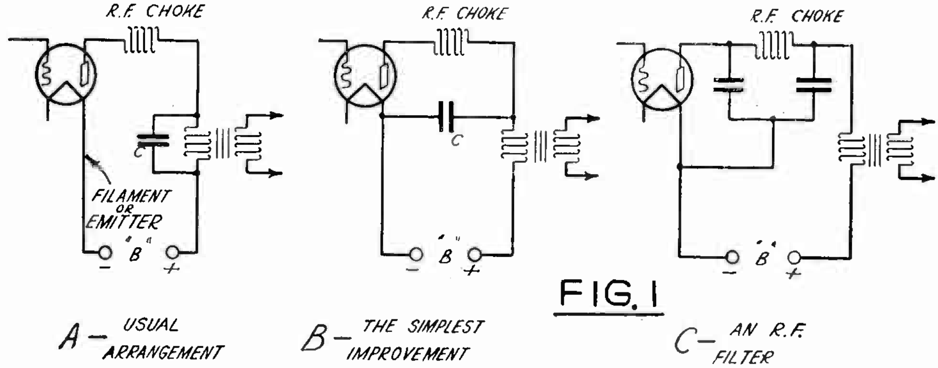


Fig. 1: The R.F. choking system and how it can be improved.

R.F. to flow past the transformer primary unless we also show it the way home to the filament, which is not done in Fig. 1A. In this circuit the R.F. is marooned on the transformer primary and asked to go home by any route it can find, whereupon it wanders off thru the A-B supply and the inter-winding capacity of the transformer, turning up at several very inconvenient places in the system.

The first and most obvious improvement is shown at B, where the condenser has been shifted so as to complete the R.F. path back to the filament. This improves the effectiveness of the system greatly. At short waves, or in receivers using high-level detection and only one audio stage, it is well to carry the filter idea further and to use a scheme such as shown in Fig. 1C, which is simply a stage of "pi" filter of the low-pass variety. It is some scores of times as effective as circuit B and some hundreds of times as good as that of A. None of the condensers should run materially above .0002, else they will tend to destroy some of the higher audio notes.

The regenerative detector, as usual, offers a special case, especially if condenser control of regeneration is to be used. The passing action. We may accordingly take refuge in such an arrangement as shown in Fig. 2B, where the filter of Fig. 1A follows the variable condenser with a resistance between. The resistance is preferred to another choke on the double grounds that it is cheaper and less likely to encounter troublesome tuning by the variable condenser. If the combination is not willing to oscillate easily we may need to exchange the position of the choke and resistor, putting up with such tuning as may take place. (The tuning referred to is NOT the usual one of an effect on the grid-circuit tuning, but is instead one having to do with series resonance of the regeneration condenser and the choke, causing the tube to go abruptly in and out of oscillation as the condenser is varied.)

The arrangement being a bit complex, we may resort to the further modification shown in Fig. 2C. This is rather completely wrong but does not work nearly as badly as one might think. The only precaution here is that the resistor must not be made too large, else there will take place the effect which is mentioned later under the heading of "A Hum Cure".

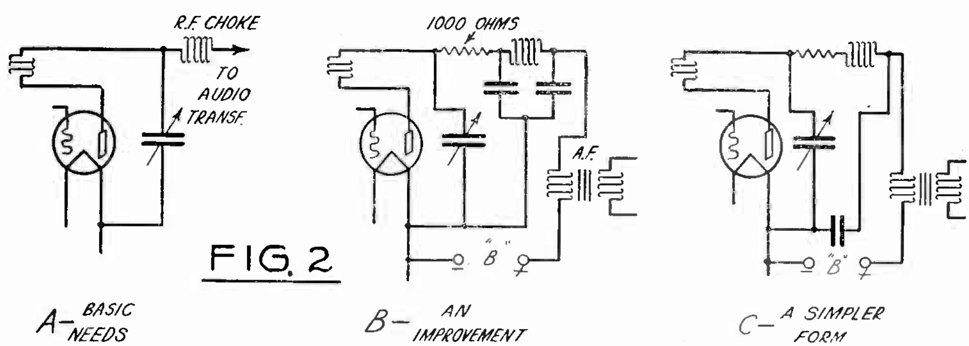


Fig. 2: R.F. choking systems for the regenerative detector.

If regeneration is controlled by a variable resistance, the troubles of the designer are smaller. He may then use the circuit of Fig. 3 with some confidence that nothing violent will take place.

A HUM CURE

A PARTICULARLY neat suggestion has come to me from L. W. Hatry, whom I have quoted before. It is that an objectionable hum can be reduced materially by simply making the audio system poorer at the low frequencies in the extremely simple manner shown in **Fig. 3**. The effect will take place especially in transformers which are initially a bit weak at that end and therefore is most useful when applied to sets whose makers have already fudged the audio system a bit to reduce hum which they did not keep out otherwise.

The action is as follows: At medium and high frequencies the transformer primary offers a very high impedance and the drop across the resistor is not important, and therefore has little effect. At low frequencies the transformer impedance drops off but that of the resistor stays the same and therefore more and more of the voltage appears across the resistor, which does not pass it on. The proper value of the resistor is found by trial for the particular set. A value of 25,000 ohms seems a good starter for the cases I have tried the suggestion on. Naturally the resistor causes some drop in plate voltage, but the intention is to introduce it early in the audio system where plate currents are small, plate voltages not large and the drop therefore unimportant, or else easily made up by shifting to a higher tap on the the power supply.

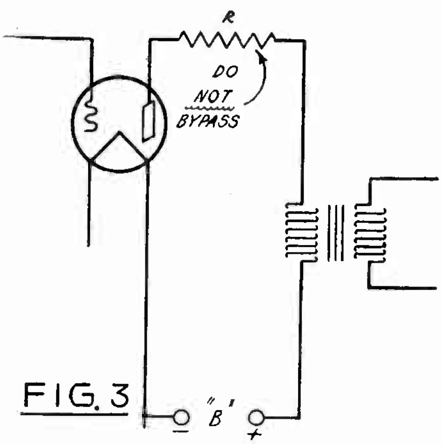


Fig. 3: A simple hum cure.

SUPER-REGENERATION THAT ISN'T WANTED

EVERY little while someone tries to use *226* or *227* tubes in the Wasp or the Super-Wasp and is greatly disgusted at the horrible roar that results. Having tried the same thing with every vacuum tube since the original DeForest tennis ball audion and having only just found out what to do about it, I am inclined to be sympathetic.

First of all, a tube such as the *226* is pretty hopeless for short-wave regenerative work. That's a flat statement and I am not going to argue it since even the broadcast set designers are going more and more to the *227*. The *227* also will be found to produce a strong hum when the regeneration is run up and examination shows this hum to have a number of components of which two important ones are transfer of a 60 cycle voltage from filament to cathode by capacity effect and by leakage. The first effect is important mainly where the wave form of the line is exceedingly bad and the voltage introduced is really more likely to be a harmonic of sixty cycles or else simply irregular disturbances. This can be minimized by feeding the detector filament from a separate transformer of somewhat special construction.

The matter stands differently with any leakage between filament and cathode. This is built into the tube and can't be gotten out. The only cure is to use a tube with the least amount of the best grade of solid insulation between these two elements. Some of the best known tubes are very terrible for this use tho probably quite o. k. for their normal use.

However, we spoke of super-regeneration and have not introduced it. You will recall that the limit of the regenerative amplification is reached when the tube slides into oscillation. This effect is not instantaneous and if we could keep pushing the tube back and forth "across the edge of regeneration" we would get exceedingly great amlification for an instant at each traverse. Armstrong did this by introducing an extra grid voltage which would bob the grid up and down several thousand times a second and thus secure several thousand of these brief instants of extreme amplification. The extreme amplification took place all right but the squealing of the "variation voltage" was too much for the broadcast listener, who declined absolutely to adopt the circuit.

A very similar effect takes place when a very small 60 cycle voltage wanders into the system by such accidental routes as have been mentioned. Small as they are, they are entirely sufficient to drag the tube toward and from the region of great amplification and thereby to produce some of the terrific super-regenerative effect. Great amplification follows—mainly of the 60 cycle growl. This is something not encountered in broadcast receivers, since their design is made as nearly non-regenerative as possible.

WHY THE REGENERATION?

I have no more enthusiasm about regenerative amplification than have the designers of receivers working in the ordinary 200 to 545 meter broadcast bands. In their case regeneration could be and was gotten rid of by placing it with additional stages of tuned R.F. amplification. The change took an astonishing amount of time, that is to say, astonishing until one studies the difficulty of devising means for manufacturing groups of tuned circuits which will work in each of 100,000 sets. It has in fact not been found generally possible to do this, since the best of condensers and coils vary somewhat. They are simply made very well and then are assorted into groups which are very closely alike, a final adjustment being made by some adjustable capacity device in the set. All this is done simply to tune across the region of 200 to 545 meters.

The short-wave receiver is expected as a matter of course to tune over the whole enormous territory from 14 to 550 meters. The thing cannot be done with one set of coils and therefore we have such arrangements as that of the Super-Wasp which employs five detector coils and five antenna coils. Thus it is automatically five times as hard to make all the coils alike as would be the case for one of the older broadcast receivers using one stage of R.F. For each stage of R.F. which is added we must supply five more coils and regeneration is equal to something between one and two stages. It is therefore not altogether unreasonable to use regeneration in place of another dozen coils. Not until there exists a public demand for a high priced short-wave receiver will be practical to make the change.

"UNTUNED R.F."

So called "untuned r.f." stages are usually tuned as to either their input or their output circuits and one had perhaps better call them "semi-tuned". It has been frequently suggested that there be added to the Super-Wasp a stage of "fixed tune"

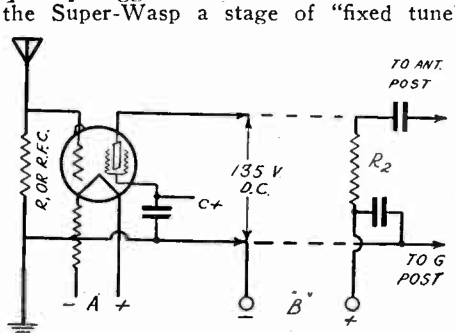


FIG. 4 A FIG. 4 B

Fig. 4A and 4B: Two possible ways of coupling another R.F. stage to the Super-Wasp.

(so called) radio-frequency amplification of the type shown in Fig. 4A. This would certainly have the advantage of removing most of the tuning effect of the antenna and allowing the two dials to run more nearly together. Perhaps we had better say that these advantages could be secured if it were possible to come upon a satisfactory method of coupling the stage to the existing one of the Super-Wasp.

The choice of this coupling is not easy. If we feed the plate of the tube thru a tuned circuit and couple it to the present antenna and ground terminals thru a condenser we have avoided circuit changes in the set, but have added a tuning condenser at an undesirable point where it does not help the selectivity greatly and is quite certain to cause the first tuned cir-

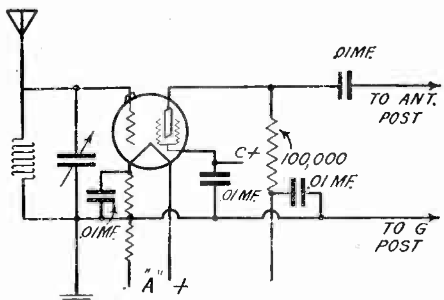


FIG. 4 C

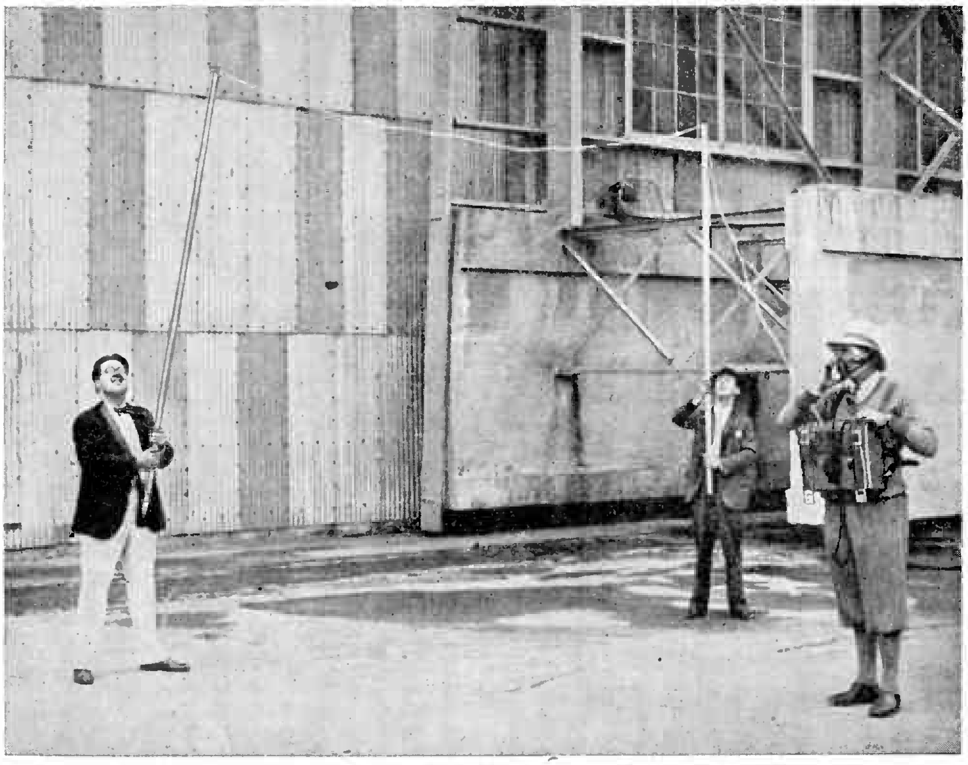
Fig. 4C: A more satisfactory way of adding the extra R.F. tube.

cuit inside the set to misalign very badly. If we feed the plate of the tube to a resistance and capacity couple it to the set terminals, as suggested in 4B, we have a somewhat more workable combination altho a very high plate voltage will be necessary. Suppose for instance that R2 has a resistance of 500,000 ohms to match the plate resistance of the tube and that the tube is to operate normally drawing about 1.5 milliamperes with 135 volts across the plate and filament. To cause 1½ mills to flow thru a resistance of 500,000 ohms requires 750 volts. This is in *addition* to the 135 which we are to deliver at the tube, so that we need a "B" supply of 885 volts!!! We may compromise by lowering the resistance to 100,000 ohms so that we need but 150 plus 135 or 285 volts, which is not impossible. The amplification would drop off in about the ratio of 3 to 1, but that cannot be avoided to any great extent.

However, of what good is the stage to us? It has introduced additional amplification but has added no selectivity whatever and therefore has all the practical effect of having very greatly decreased the selectivity. This holds true no matter whether a resistance or a choke is used in the antenna circuit. The resistance is

(*Continued on page* 75)

Broadcasting the Arrival of the *Graf Zeppelin*



G. W. Johnstone and W. B. Miller (left to right) carrying the aerial. Floyd Gibbons (extreme right) with the portable broadcaster.

WHEN the Graf Zeppelin arrived at Lakehurst, N. J., on Sunday, August 4th, the National Broadcasting Company made use of a unique portable short-wave transmitter in broadcasting a detailed description of the event to the millions of people comprising its listening audience. Floyd Gibbons, noted war correspondent, who acted as announcer, walked around the grounds at the hangar with the whole transmitter strapped to his chest, while two assistants, holding a short aerial, followed him step by step.

The signals from the portable station were picked up by a short-wave receiver located near the dirigible hangar. From this receiver they were transferred to a specially engineered telephone line, which conveyed them to the N. B. C. main control room at 711 Fifth Avenue. From this point they were distributed to the N. B. C. chain stations in the same manner as any other broadcast material.

The portable transmitter was designed by R. M. Morris, N. B. C. development engineer, and was originally intended for use by parachute jumpers in describing their sensations as they floated earthward after a leap from a plane. It weighs only 24 pounds complete and is fourteen inches wide, four inches deep and eleven inches high. The case is made of light wood, enclosed in a canvas bag for protection against the weather. The power rating is 500 milliwatts, or one-half watt. The outfit is credited with a range of one mile under adverse conditions and approximately ten miles under favorable conditions. During the Lakehurst broadcast, which was very successful, a wavelength of 127 meters was used. The best wavelength for any particular location is determined by experiment on the ground itself.

To allow the announcer free use of his hands, the microphone is fitted into a small harness which straps around his face. The "mike" is placed close to his mouth, to exclude outside noise.

The Author

DAVID GRIMES

AS this is the first of what I hope will be a long series of articles for RADIO DESIGN, it is naturally rather difficult for me to decide just what you experimenters wish to hear about most. After we have run along for a little while, your letters will reveal a lot and then these little ramblings will probably be more pertinent. Meanwhile, you will just have to be patient and allow me to exercise my writer's prerogative to set forth those things which are hobbies with me. Here's hoping that they will be interesting to you, also.

There are a great number of subjects which are discussed every day in the laboratory in connection with radio receiver design. You see, the concoction of radio circuits is not so much a matter of luck, anymore,—or shall we say, "blind luck". In the days when my Inverse Duplex was at the height of its popularity, one merely had to throw condensers and coils together in a haphazard manner and a new circuit was born! This was almost literally true. Little of the fundamental theory of radio was known by the experimenter at large. Many supposedly "different" circuits were technical equivalents. But who cared?

Now, a great deal of this "hurrah" has gone, we hope, forever. Most of the modern circuits constitute real contributions to the Art; they are the results of long weeks and months of research in well-equipped laboratories. Naturally, there has sprung up among these laboratory technicians a new sort of language—a special nomenclature—coined words to express definite engineering functions. These expressions are nothing less than verbal shorthand. They save lots of time when one engineer talks with another. But here is the unfortunate part of the whole business. The great number of experimenters have been left out in the cold, so to speak. They have suddenly found their favorite radio magazine offering less and less technical information; the pages are filled with service and other trade data; and such engineering "dope" that is presented is filled with the new technical lingo which only serves to confuse. Such a situation!

Because of this condition of affairs, I have taken up a new hobby,—to me, the most interesting in the world. I have started to devote my journalistic endeavors to simple analyses and explanations of the underlying principles involved in present radio experimentations. There isn't much difference between the experimenter in the professional laboratory and the experimenter out in the field. The former earns his livelihood at it—the latter, his pleasure. Both are intensely interested in the technique and both crave information. But, naturally, the professional investigator, who spends his business hours at the work, will uncover the greatest number of new facts. It is unfortunate for you, in the field, that the feable dribblings of scientific truth, that finally ooze out to where you are eagerly waiting, should be so obscured by laboratory shorthand as to be almost uninterpretable. It is this predicament that I hope to solve. I will attempt to act as a humble interpreter.

VOLTAGE AMPLIFICATION

Perhaps one of the most confusing terms extensively used is "voltage amplification". This has been brought up time and again in a never ending flow of questions by mail. It is all very well to rate the efficiency of a given radio receiver, but to do so in terms of voltage amplification, or any other term not generally understood, only invites misrepresentation and fraud on the part of the unscrupulous manufacturer. Horsepower, in the case of the motor car, gives at least some rough indication of the strength of the mechanism—even tho there are horses and horses! But radio sets must be rated somehow and the engineers seem to be bent on the voltage amplification system. Extensive newspaper advertisements, intended to fa-

—who will be a regular contributor to Radio Design, *explains the meaning of* voltage amplification *in language you can understand*

vorably influence the public at large, have recently appeared with almost the sole sales appeal based on "voltage amplification", "overall amplification", and "amplification per stage". It's being done in all of the best regulated families; so I guess we will just have to translate "ad" language into common sense.

Voltage amplification, in its simplest form, exists in the tube itself. Most of you are, no doubt, somewhat familiar with the theory of vacuum tubes. The heated filament merely liberates a supply of electrons which is drawn to the plate by the positive potential of the "B" source. This stream of electrons is passed thru a wire screening on its way to the plate. This screening is the grid. A positive potential placed on the screening will suck the electrons thru to the plate at a much more rapid rate. In other words, the plate current will be increased. Quite the reverse is true when a negative potential is placed on the grid. This negative voltage repels the electrons and tends to prohibit their passage thru the screen. This obviously reduces the plate current.

Now, if various voltages placed on the grid merely produce changes in the plate current, where does voltage amplification enter into the picture? It would appear on the surface that volts are not amplified at all! Furthermore, it would be absurd to refer to the tube action as current amplification because current is not required, or used, in the grid circuit. It is potential at this point that affects the electron stream. The question is well taken and is a good one. Just where does any amplification of voltage take place in a tube when it is well known that the voltage variations in the grid affect the plate current?

Well, here is how it is. Let us assume, for the moment, that the grid potential is kept at some steady value. Then, the plate current, or flow of electrons, will depend (within certain limits) on the attracting power of the plate. This is regulated by the amount of positive potential placed thereon. An increase will draw the electrons from the filament a little more rapidly—the plate current will increase. Decreasing the positive potential on the plate will cause the stream of electrons to slow up and the plate current will appear to fall off. Hence, the plate current MAY be affected by changes in the plate voltage. But the ordinary way to affect the plate current is thru the attraction and repulsion action of the variable potentials on the grid. Since either system will affect the flow of plate current, it is easy to see that some relation can be built up between them.

Now follow me closely at this point, for herein lies the whole explanation. Suppose that one volt positive potential on the grid of the tube increased the plate current by one milliampere. Now, obviously, the same plate current could have been increased the same one milliampere by boosting the plate potential instead of the grid voltage. But it takes a considerable increase in plate potential to affect the plate current to the same extent as that caused by a relatively small increase in grid voltage. In the standard 201-A and 112-A tubes, this ratio between grid and plate voltage for an equal effect on plate current is about eight. It requires EIGHT times the number of volts in the plate circuit to affect the plate current to the same extent as that accomplished by the grid. In other words, the voltage amplification of the 201-A and 112-A tubes is EIGHT. That's fairly simple, isn't it? So, while we generally think of the voltage on the grid as affecting the plate current, it is better to think of the voltage on the grid as producing an increased effective voltage in the plate circuit—which, in turn, increases the plate current.

By means of the curves shown in Figures 1 and 2, the voltage amplification of the tube may be calculated. Of course, these curves are different for each type of tube; but, given the tube without knowing the voltage amplification factor, the data for these curves are easily obtainable by means of a few batteries and a milliammeter. The voltage amplification factor may then be figured out as described below. Figure 1 shows the changes in plate current with

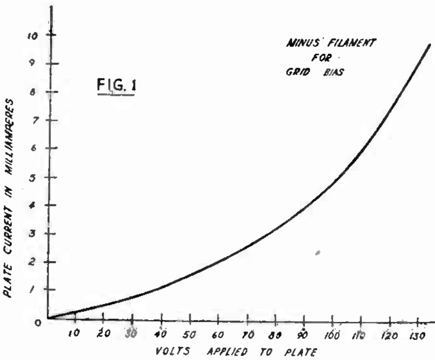


Fig. 1: Typical plate voltage-plate current curve.

changes in plate voltages. This curve is not usually given in vacuum tube discussions because it does not actually represent the action of the tube under operating conditions, where the grid voltage is varied and the plate voltage is left constant. The grid was returned to negative filament. Figure 2 shows the conventional vacuum tube curve. The horizontal distances indicate the variations in grid potentials, while the vertical spaces represent the plate current changes resulting from the grid voltage changes. The plate potential was kept at 100 volts.

The data necessary for plotting the curve in Figure 1 is obtained by means of the circuit and apparatus presented in Figure 3. The apparatus consists only of the tube to be investigated, the necessary source of energy for heating the filament, a milliammeter, and a "B" battery that has convenient taps at, say, every 22½ volts. Connect up the circuit as shown in Figure 3 with the milliammeter in the plate circuit—its positive end connected to the positive side of the "B" battery and the negative end fastened to the plate of the tube. Start off with the "B" battery at zero. The meter should read zero. Next, connect the "B" battery tap to the 22½ volt section. The meter should read a small amount of current. Record the plate current for each increased tap on the "B" battery and you have your curve and a good idea of the necessary increases in plate voltage for increases in plate current.

The data for the curve in Figure 2 may next be obtained as shown in Figure 4. Here the apparatus and hook-up is practically the same as that given in Figure 3. The "B" battery is now left at some fixed value such as that used under normal operating conditions. The potentials on the grid are then varied by means of a tapped "C" battery. The changes in plate current are read and recorded—resulting in the curve of Figure 2. This gives you a very good idea of the changes in plate current resulting from the variations in grid voltages.

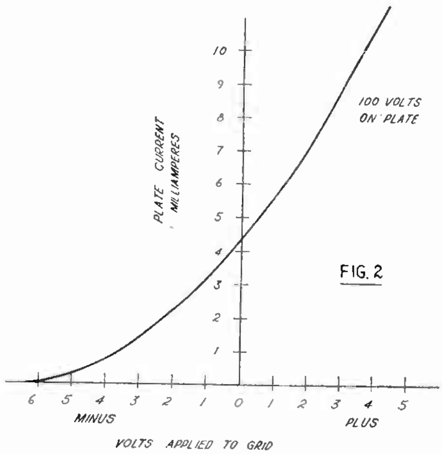


Fig. 2: Typical grid voltage-plate current curve.

Assume, now, that we decide to increase the grid voltage in Figure 2 from zero to plus 1½ volts. This will increase the plate current from the value OX to a value represented by the line 1Y. This action is illustrated in Figure 5. We will have increased the plate current by the amount ZY. With this value of ZY, we go over to the curve in Figure 6 and lay off this vertical distance along the line PZ. The distance OP is the normal operating plate voltage which was used on the plate when the data for the curve in Figure 2 was obtained. The normal plate current PZ flows when the normal plate voltage OP is applied. Upon increasing the grid voltage to 1½ volts plus, as just described, the plate current is increased to the value PY, or the amount SV on the curve. This new value of plate current is the same as that resulting from increasing the plate voltage to the value OC, by the amount PS. The ratio of PS, in Figure 6, to O1, in Figure 5, is the voltage amplification of the tube. If this ratio works out to be

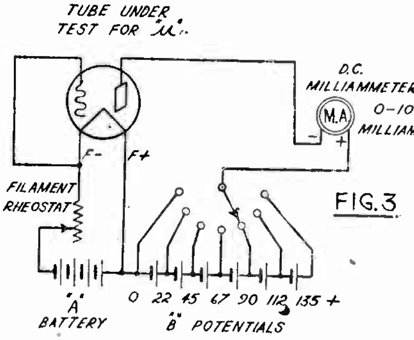


Fig. 3: Circuit used in obtaining data shown in Fig. 1.

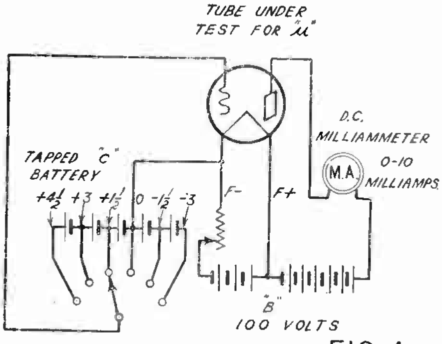


Fig. 4: Circuit used in obtaining data shown in Fig. 2.

8, the voltage amplification factor is 8. If it works out to be 30, the amplification factor is 30. In the curves shown, the ratio is 18 to 1½ or a "mu" of 12.

VALUES VARY WIDELY

Different types of tubes have different voltage amplification factors and one has but to run one's eye over the list of amplification factors of the various tubes on the market to realize that the range is astonishingly wide. A list of the better known types is herewith presented below, in the order of their amplification factors.

171-A	3.0
120	3.3
250	3.8
WD-11	6.6
WD-12	6.6
201-A	8.0
112-A	8.0
210	8.0
226	8.2
227	9.0
200-A	20.0
240	30.0
222	300.0

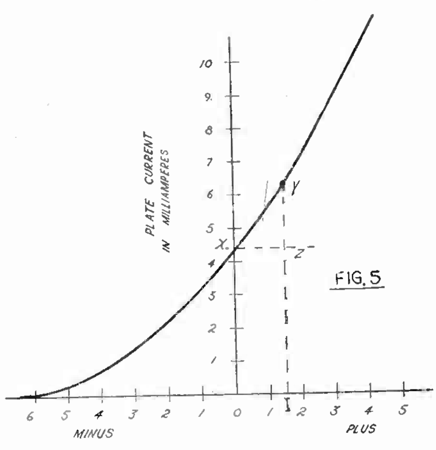
No doubt, you are wondering about the whys and wherefores of such a tremendous variation that would carry the amplification of a tube all the way from three to three hundred, depending on its design. I am going to be rather cruel and let you wonder for a few minutes. I like to write technical articles along the lines employed by the writers of fiction. They often take the reader into the plot up to a certain point—to just the part where the interest is the most intense, or the details of the story have demanded considerable concentration. Then, as a sort of rest, other threads of the story are picked up and gradually woven into place until all the supposed ramifications fit into the complete whole. We have had enough of the determination of amplification factors for the moment.

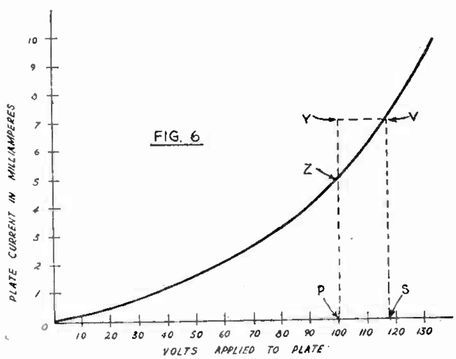
The term "amplification factor" is used to such an extent in all this sort of work that we get awfully tired saying the cumbersome combination over and over again. Hence, a nickname has been coined for it. It is called "mu" for short and is often written even shorter in the form of "u". That is one of the many nicknames which go to make up the engineer's language. From now on, I will use merely "mu" in referring to amplification factors. It is so much easier to write on this misspelling typewriter of mine and takes up less room on the paper.

A.C. ONLY CONSIDERED

In most all of our radio design work, we will be concerned with vacuum tubes only in connection with alternating current of some form. Radio sets employ tubes as amplifiers of high-frequency alternating currents known as radio waves. Tubes are also used to amplify the low-frequency alternating currents encountered in the audio circuits after the detector. Some tubes are utilized as rectifiers of the 60-cycle power current, while others function as rectifiers of the radio waves. The first are called rectifiers and the second, detectors. Under any circumstance, we will always be considering the applied voltages on the grid resulting from some form of alternating current. In other words, the grid voltages, with which we will be concerned in making a study of the "mu" of the tube, will always be alternating voltages.

To still further simplify their calculations, the professional experimenters prefer to draw the schematic diagram of a vacuum tube as shown in Figure 7. Here the grid is replaced by a small alternating current generator right in the plate circuit. The voltage of this schematic generator is the voltage of the alternating current wave on the grid multiplied by the





Figs. 5 and 6. Curves illustrating significance of "amplification factor".

"mu" of the tube. This stunt has reduced the complicated circuit of the tube to a simple series plate circuit with an effective alternating current generator representing the effect of the grid control on the plate current. The voltage of this make-believe generator would be high with a high "mu" tube and low with a low "mu" tube.

The object of the transformer, in either a radio or audio circuit, is to take as much of the voltage of this theoretical alternating current generator as possible and step it up for use on the succeeding grid circuit, where the stepped-up voltage is once more

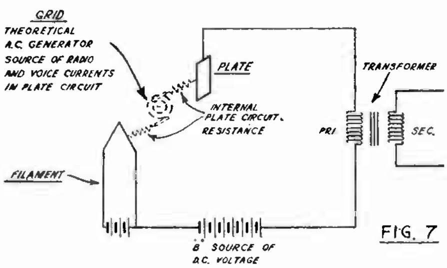


Fig. 7: Simple way of representing the three-element vacuum tube.

amplified by the "mu" of the succeeding tube. It is obvious that the entire amplification system of a radio set, including both radio and audio circuits and including both coupling transformers and the tubes themselves, is exclusively a voltage step-up device. The transformers contribute their share as well as the tubes. Figure 8 is offered with the hope of making this point clearer.

It would seem, then, that the tubes should have as high a "mu" as possible and the transformers should be built with an absolute maximum step up ratio—that is, if any sort of efficiency were desired. Yet, in spite of this reasoning, as many of the old timers know, the modern tendency has been toward lower ratio transformers, especially in the audio circuits. When broadcasting first became popular back in 1922, the transformers made by the Radio Corporation of America had a ratio of ten to one. Just imagine it! And now we are inclined to shoot anyone who even mentions a six to one ratio. This apparent reduction in voltage step-up in the transformers has been the result of deliberate design. Efficiency has been sacrificed at some frequencies for a net gain at others.

EFFECT OF PRIMARY

A careful study of Figure 9 will show that the primary of the transformer connecting to the plate circuit of the tube must present anything but a short circuit, or even a moderate load for that matter. If the primary draws any appreciable current at all, the full voltage of the theoretical alternating current generator in the tube will not reach the transformer, but will be partially consumed in overcoming the resistance in the plate circuit. If, on the other hand, the primary presents practically an open circuit to the tube, the full voltage will reach it as there will be little or no current flowing to cause a voltage drop in the plate resistance. It is highly desirable that the greatest possible voltage reach the primary because it is this primary voltage that is stepped-up in the secondary (depending upon the ratio of the secondary and primary turns) for use on the next grid.

Well, now, how are we to avoid the primary of the transformer forming any appreciable load on the plate of the tube? Just simply winding lots of turns on a rather large iron core. This is particularly necessary if we would have any bass note amplification, because the reactance of the primary coil decreases greatly as the lower notes are approached. This means that a primary consisting of a moderate number of turns would have sufficient reactance to appear as an open circuit at the higher frequencies, but would so markedly diminish at the low frequencies as to form a considerable load on the tube. Thus, with such a moderate-size primary, the full voltage of the theoretical generator would come thru on the high notes, but the low notes would be largely absorbed in the resistance of the plate circuit because the low notes would be accompanied by cur-

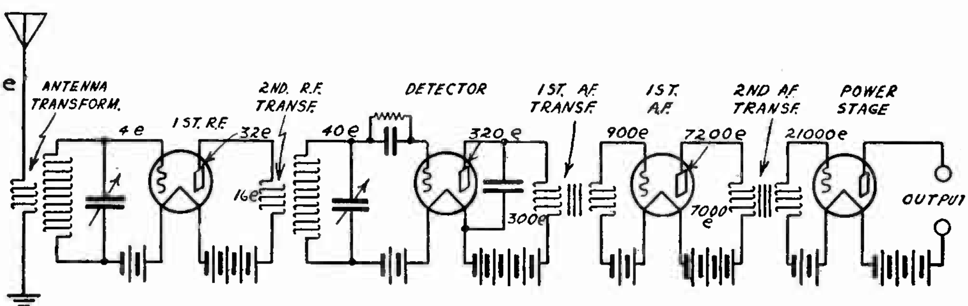


FIG. 8

Fig. 8: How the amplification builds up in a typical radio receiver.

rent flow caused by the relatively low reactance of the primary at the lower frequencies. No! If we want good voltage amplification over all of the frequencies, we must employ such a large primary that

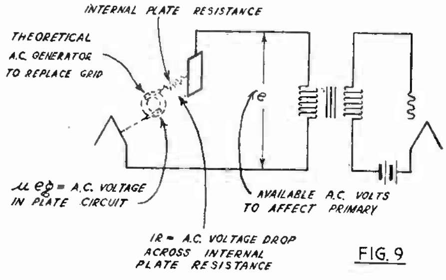


Fig. 9: Showing ***importance of high*** *impedance primary.*

its reactance will be practically an open circuit on the plate of the tube at the lowest notes encountered. Now, that's simple, isn't it?

So, modern transformers have lots of primary turns wound on fairly large iron cores. But this very large primary means

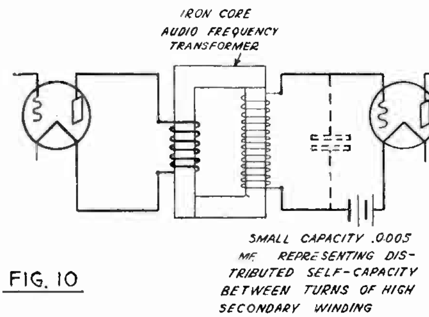


Fig. 10: The capacity ***effect of the*** *transformer secondary is represented by the dotted condenser.*

that, if we still desire high ratio transformers, we must correspondingly increase the number of secondary turns, and therein lies the difficulty. As the number of turns in the secondary increases, the self capacity of the secondary coil increases. Figure 10 attempts to show this visually. This self capacity acts just like a small condenser placed across the secondary terminals and you all know what that does! The high notes are short circuited and reach the grid of the succeeding tube with greatly reduced strength. Thus, while we have brought in the base notes by increasing our primary turns, we have lost the high notes thru the self capacity of the excessive number of secondary turns that are necessary, if we are to attempt to retain the high ratios formerly used. Answer:—for the sake of over-all quality, we must employ high primary, low ratio transformers. Doesn't that sound like the specifications for a modern transformer? It does! There are certainly no questions about that, are there?

TRANSFORMER CHARACTERISTICS

Before finishing this point on voltage amplification as it applies to transformers, I wish you would glance over Figure 11. Curve A shows the voltage amplification of the old style ten-to-one transformer over the musical range of frequencies. It will be noted that it is extremely poor on the lower notes—not because of its ratio, as that should make it better, if anything; but because of its very small primary. On the other hand, it is exceptionally good at the high notes, greatly exceeding the efficiency of the modern low ratio type. Curve B shows the modern transformer. There is no comparison at the low notes; while at the high notes, the present transformers are only about two-thirds down in efficiency. Curve B gives much better all around amplification on all notes and consequently less distortion. Of course, it is unfortunate that we are not able to design a transformer that gives the peak amplification of Curve A at all the frequencies needed. We admit that we have compromised for the sake of quality.

This transformer compromise has more or less put the problem of efficiency up to the tube designers. And quite naturally one might ask why tubes could not be made that gave greater "mu". This is exactly what has happened and this takes us back onto our main plot again. A mere glance at the table of tube "mu"s previously shown will disclose a most interesting fact. Leaving out, for the moment, the first three tubes in the list as they are power tubes and fall under a different classification which will be taken up at a later time, it is very apparent that there has been a decided tendency to increase the tube "mu". As one reads down the list starting at the low "mu" and ending up at the bottom with the high "mu" tubes, it is easily seen that the old type

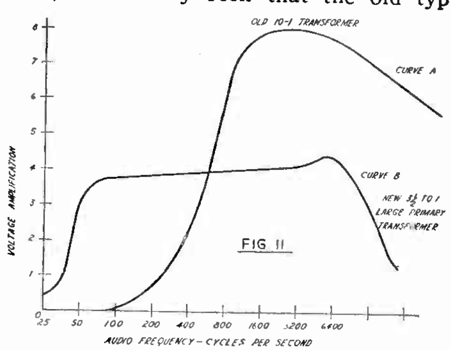


Fig. 11: Frequency response characteristics of two different transformers.

tubes head the list and that the latest tubes fall at the bottom. Every new tube put out has had a little higher "mu" than its predecessor.

But this line of procedure, also, has struck its snags. There are very definite limits in this direction. Mother Nature always seems to place obstacles in otherwise easy paths of progress. I guess it is intended by the Creator that we should encounter obstacles; for, in overcoming them, we continue to learn more about the

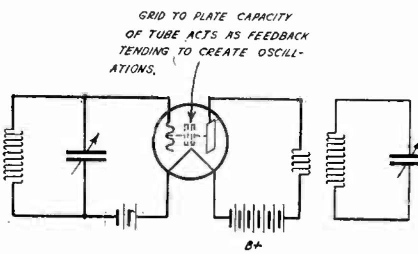


FIG. 12

Fig. 12: The capacity effect of the grid and plate elements are represented by the dotted condenser.

Creation. For instance, as soon as we increase the "mu" of a tube, we cannot help increasing the plate resistance. This is bad as it forces us to consider the design of even better primaries; so that even less current will be drawn thru the increased plate resistance. If we are going to even attempt to take advantage of the increased amplification of the tube, we must see that most of the increased voltage of the theoretical A.C. generator reaches the primary in the plate circuit. The increased plate resistance makes it imperative that the primary draw less current than before This would call for much larger primaries and resulting larger secondaries with the increasing detrimental self capacity. In fact, the primaries, themselves, would have to be so large that self capacity in them would adversely affect the higher frequencies. This has ruled the higher "mu" tube out of the picture, as far as the transformer coupling circuit is concerned. As a result the most modern audio A.C. tube, the 227 tube, has a "mu" of only NINE. This represents some improvement over the 6.6 in the old WD-12 tubes, but we cannot look for much better than this in a tube for use with transformers.

Really only one high "mu" tube was put on the market prior to the famous screen-grid era. This tube was the 240 type. It has a voltage amplification of 30. For the reasons just above mentioned, it was not at all satisfactory for audio transformer coupling. Its use, as far as audio circuits were concerned, was entirely limited to resistance coupling. High "mu" tubes also require less permanent grid bias for a given plate voltage than the low "mu" tubes. This limits their use to the stages of amplification where the A.C. voltages on the grid are so low that the permanent bias is not overcome by the impressed signal. You see, the grid of an amplifier must never run plus in operation if distortionless amplification is expected. Hence, small permanent grid biases mean a very definite limit to the strength of signal that can be passed thru the tube before distortion takes place. This confines the high "mu" tube to at least the first audio stage, even when resistance coupling is employed. In other words, the ordinary high "mu" tube is no good as an audio amplifier.

R.F. AMPLIFICATION

The next engineering efforts were concentrated on improvements in radio-frequency amplification. The same fundamental principles apply here as in the case of audio design. The only difference in the former case is that the energy is amplified at one frequency at a time as the particular carrier wave is tuned in. Each carrier frequency is tuned in as desired and amplified thru the various tuned stages by means of tuned transformer coupling. The fact that the transformers are tuned and that they are used for stepping up very high frequencies makes very little difference in our technical considerations. The objects sought are exactly the same. We are trying to boost up the exceedingly small voltage received on the antenna to such a degree that the signal can be efficiently detected without the use of supercritical circuits.

The incoming signal in the R.F. circuits undergoes voltage amplification by means of both the tubes and the tuned transformers in the same manner as that already discussed in the case of the audio energy. You would naturally expect that the same tactics have been used in the attempts to increase the R.F. amplification. Well, they have! First, the transformers were studied in an effort to raise the voltage amplification at this point to

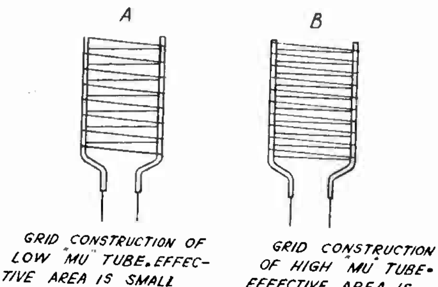


FIG. 13

Fig. 13: Relative fineness of grids of high and low "mu" tubes.

the maximum. The turn ratio between primary and secondary in the early coils was increased by employing a small primary and a large secondary. Now the size of the secondary is limited by the old bugaboo of self capacity. If the secondary coil is made too large, the self capacity of the coil prevents the high frequencies (shortest broadcast waves) from passing thru—even after tuning is attempted. You will recall that the self capacity of the audio secondary on a large coil prevented the high frequency voice currents from being properly amplified. Experience has taught the engineers that best results may be had from a secondary that requires a .00035 mf. condenser for tuning the broadcast band. Thus we are limited in the size of our secondary.

EFFECT OF PRIMARY SIZE

Of course the turn ratio can be improved by decreasing the size of the primary. This was actually done with some of the first coils used in broadcast reception. Let us see what happens under these conditions. We must go back to the same explanations which I previously offered in the case of audio transformer coupling. You will recall that the signal voltages on the grid may be replaced by a theoretical A.C. generator at that point in the plate circuit. This is also true in the radio-frequency circuits. Now the radio transformer primary works on the same theory as the audio primary. It must virtually present an open circuit condition to the plate circuit of the tube. Otherwise, it will draw some current and the full voltage of the theoretical A.C. generator in the plate circuit will not be available because of the voltage drop thru the plate resistance of the tube caused by this very current flow. The turn ratio of the transformer cannot, therefore, be increased by reducing the size of the primary. We have reached very definite limits in regard to the transformer.

Following right along the lines of least resistance, the next attempt to increase the voltage amplification in the R.F. circuits was in the tube itself. Tubes having a higher "mu", similar to those tried in the audio circuits, were subjected to extensive

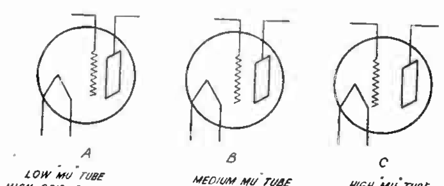


FIG. 14

Fig. 14: Relative positions of the elements in tubes of different amplification factors.

tests. The 240 type was put thru its paces. It was terrible at the broadcast frequencies, but not exactly for the same reason as in the case of the audio circuits. You will recall in the latter case that the higher plate resistance called for a higher primary to prevent any appreciable plate current from dropping the audio frequency energy and that it was not feasible to wind higher audio primaries. In the radio circuits, higher primaries were satisfactorily wound, but another factor upset the calculations.

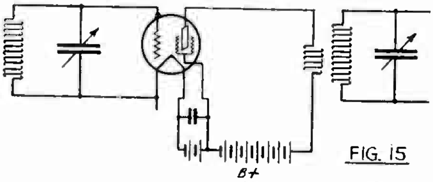


FIG. 15

Fig. 15: R.F. circuit using screen-grid tube. The voltage for the screen element is obtained by tapping the "B" battery.

This was regeneration and tendency to oscillate.

OSCILLATORY ACTION

As a matter of fact, radio primaries cannot be wound as high as they otherwise should because of this oscillatory effect. As soon as the primary approaches that point where it is really an effective choke in the plate circuit and consequently draws no current, the tube will oscillate. Some of the high plate A.C. voltage, obtained in the external plate circuit by means of the efficient primary, starts to find its way back to the grid circuit thru the capacity between the grid and plate elements right in the tube. This feed back action is directly proportional to the capacity between plate and grid, other factors being equal. See Figure 12. Now it is an unfortunate dilemma in which we find ourselves because a high "mu" tube, such as the 240, is high "mu" on account of an effectively large grid. See Figure 13. This means increased grid-plate capacity and an increased tendency toward oscillation. This increased oscillatory effect more than offsets the gain otherwise obtainable from the conventional high "mu" tube. The 240 type of tube is no good for radio-frequency amplification at broadcast frequencies.

Yet, there was one ray of sunshine still left in this picture. The radio primaries could be increased to match a high "mu" tube if such a tube could be built that did not have an increased tendency toward oscillation. This was really the serious start of the screen grid tube. A prodigous effort was exerted in this direction. Just how could the control action of the grid be increased without increasing the capacity between the grid and the plate? If the number of wires in the grid were increased, the control of the gird could be increased; but this would increase the effective size of the grid and the resulting plate-grid capacity would be larger. That system is out of the question. However, another possibility is still available. With a given size of grid, its control over the electron stream increases as it is placed nearer the source of the stream. Thus, without increasing the size of the grid, the "mu" of the tube may be increased by placing the grid near the filament and away from the plate.

This action can be made perfectly clear by carrying the conditions to the extreme. Suppose that the grid was located right at the plate. It should be apparent that a given voltage applied to the grid would affect the electron stream to the same extent that the same amount of voltage would, when applied to the plate; because both the grid and plate are at the same point in the stream. Now, move the grid on down toward the source of the electron stream. This action is analogous to that when one moves one's hand toward a source of light. At a considerable distance from the light, the hand has little or no effect and casts practically no shadow. But as the hand is brought closer to the light, the shadow becomes more noticeable until finally it may obscure the whole beam. This is exactly what has been done in the case of the screen grid tube. A relatively small grid has been placed quite near the filament and away from the plate. The "mu" of this type of construction is very high and at the same time, the inter-electrode capacity between the grid and plate was not only not increased, but actually diminished—by virtue of the smaller grid and increased distance between the grid and plate. See Figure 14 in this connection.

Then, to really cap the climax and do a good job, a screen was built into the space between the control grid and the plate. The purpose of this screen was to effectively ground any remaining capacity between the control grid and plate. All remnants of internal feedback were thus eliminated. Then, in order to avoid any detrimental action to the electron stream, the screen grid was given a potential about equal to the stream potential at the point in which the screen was inserted. This is shown in Figure 15. Simple, isn't it?

Do you wonder that the screen grid radio amplifier tube ushered in a new era in radio set design? It wasn't a haphazard "happenstance"—it was a sure and inevitable development; it made possible voltage amplification that was only dreamed of before. I look forward to more and more wonderful radio frequency circuits. Perhaps some of you amateur experimenters in the field will be responsible for many of them. I hope you will be and if this little ramble of mine has aided you ever so slightly on your way, I will feel amply repaid. Why don't you drop me a line, so that I may know of your progress?

Sydney to Seattle on the *Super-Wasp*

9733 Arrowsmith Ave.,
Seattle, Washington,
July 23, 1929.

Mr. Robert S. Kruse,
c/o Pilot Radio & Tube Corp.,
Brooklyn, N. Y.

Dear Sir:

I have had my Pilot Super-Wasp about six weeks now and since that time have been enjoying the short waves better than I have ever been able to with several different short-wave outfits before.

Have enjoyed a football game direct from 2ME Sydney, Australia. Held them fine for about an hour. Expect verification of this soon. Also this is the only outfit that gets WGY, KDKA, WLW and until recently, CJRX consistently. Right now KGO is coming in on the orange coils, 80 on the right hand dial.

Super-Wasp owners can't use an ordinary map. They need a globe to locate their stations.

In Radio News, I think it was April or May, 1929, some mention is made of the advantages of a screen-grid tube in the detector socket of a short wave receiver. If you have any definite data on how to install a screen grid tube as a detector in the Super-Wasp I would appreciate receipt of directions to do it. It would save me a lot of experimenting.

Very truly yours,

W. L. Butler.

John Geloso

JOHN GELOSO

Technical Consultant, Radio Design

offers a few

Helpful Hints

CONNECTING AMMETERS AND VOLTMETERS

AMMETERS measure the amount of current flowing through an electric circuit. Voltmeters measure the pressure, or the force that is pushing that current through. Ammeters, regardless of the amounts they are designed to measure, are always connected in *series* with the other devices in the circuit. Voltmeters are always connected *across* the circuit. If you remember these few simple facts you will never have trouble with these measuring instruments.

If by accident or through ignorance you connect an ammeter *across* the circuit, and leave it that way for more than a second or two, pull out your handkerchief and prepare to weep tears, for the delicate "works" of the instrument will now be a smoldering mass. If you're lucky, and discover your mistake quickly, you might merely bend the indicating needle around the backstop, and that won't be quite so bad.

Fortunately, you can't hurt a voltmeter by connecting it in the wrong place. If you hook it in series with the line, its high resistance will simply make the circuit inoperative, without causing any ill effects.

SHUT THE JUICE OFF FIRST!

THE innocent appearance of "B" power packs is very misleading. Even the smallest packs develop 200 or so volts when in actual service in connection with a receiver, and as much as 300 volts (and sometimes more) on open circuit. That's a lot of voltage in any language.

Before making any repairs or adjustments, ***turn the juice off first***. Also take a piece of wire in ***one hand*** and brush it between the minus and the highest voltage plus terminals, to discharge the filter condensers. The latter hold their charges for a considerable time after the primary circuit has been opened, and are the cause of many a mysterious but not serious shock.

A favorite trick of laboratory workers is to charge a number of filter condensers, put them back in the stock closet, and wait for a victim. The unexpectedness of the wallop through the fingers usually hurts more than the actual shock.

ESTHETICS AND ACOUSTICS

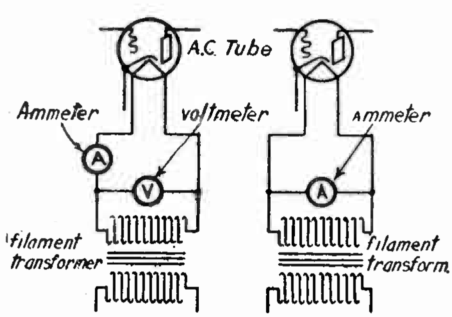
ONE of the advantages of having the loud speaker removed from the radio receiver itself is that you can try it in different positions, to obtain the best reproduction. Sometimes the same placement of the radio set that produces the most decorative effect (as far as the furnishings are concerned) produces the worst acoustical effect. Many a high-priced and otherwise high-quality receiver sounds pretty punk for this reason.

Smooth walls and uncarpeted floors cause echos, as do uncurtained windows. Keep the speaker as far as possible from the place where you sit while listening, and keep the volume down so that the announcer's voice sounds just as loud as that of a person standing next to the instrument. Under these conditions the background noises are least noticeable and voice and music sounds most natural.

WHEN NOISE ANNOYS

DID you ever sit in the front row of a theatre that boasted of a thirty- or sixty- or hundred-piece orchestra? If you have you know how uncomfortable you felt and how unmusical the music sounded, simply because the sound enveloped you with such volume.

When you sit down in front of a radio receiver you actually are putting yourself in the front row, but you have the advantage of a volume control. If you really want to enjoy your set and retain the friendship of your neighbors, keep the volume down to a reasonable level. If you want to blow the windows out use a shot gun; it's less violent.



THE RIGHT WAY *THE WRONG WAY*

How to connect measuring instruments.

The

Radio Physics Course

FOR HIGH SCHOOL STUDENTS

BY ALFRED A. GHIRARDI

Chapter 6

THE VACUUM TUBE DETECTOR

Two-Electrode Detector — Three-Electrode Detector — Grid Bias Method — Power Detectors — Grid Condenser Method — Grid Leak and Condenser — Comparison of Two Methods.

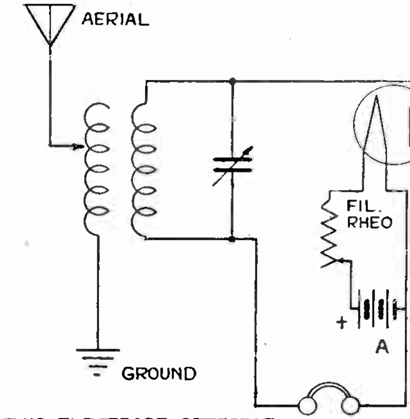
67. **TWO-ELECTRODE TUBE DETECTOR:** In Fig. 35 (Chapter 4), the use of a crystal detector for broadcast receiving was explained. Its many limitations led to its discard in favor of the vacuum tube detector. The two electrode tube was used for many years, being known commercially as the "Diode". The circuit. Fig. 42, was essentially the same as the crystal detector receiving circuit of Fig. 35, except that the two-electrode tube with its filament heating battery was substituted for the crystal detector. At the present time two-electrode tubes find little use except as rectifiers in power supply units. The three-electrode and four-electrode (screen-grid) tubes have supplanted them entirely for amplification and detection.

68. **THREE ELECTRODE DETECTOR:** The three-electrode vacuum tube can be made to act as a detector by any one of three main methods. The first is by keeping the average grid potential excessively *negative* with respect to the filament by means of a grid or "C" battery (having its positive terminal connected to the negative leg of the filament, and its negative terminal connected to the grid circuit). The second method is by maintaining the grid potential excessively *positive* by means of a battery or other means. The third method is by using a grid condenser and grid leak.

69. **GRID BIAS METHOD:** The first of these is variously known as the "power detection", "plate rectification", "grid bias", or "C" battery method and the manner in which it is accomplished can be most easily explained by reference to the grid voltage-plate current characteristic curve of the vacuum tube, Fig. 43B. The plate current depends on the difference of potential maintained between the filament and plate. As there is an IR drop between various points in the filament, these different points are at different potentials. Therefore some one point in the filament must be taken as the reference point from which all differences of potential must be measured. It has become almost standard practice to refer all voltages to the negative terminal of the filament as a reference point. Thus if the grid potential of a vacuum tube whose filament is operated on direct current is considered, it is understood that zero grid potential means the grid return lead is connected to the negative end of the filament.

Consider a three-electrode tube connected in a receiving set as shown in Fig. 43A. The tuning circuit consists of the inductance L_1, L_2 and the variable condenser C. The filament of the tube is heated by the "A" battery and the plate circuit is energized by the "B" battery, which maintains a positive potential on the plate. The grid is connected to the filament through the inductance and the "C" battery and the potentiometer P.

A potentiometer consists of a high resistance which is connected across a battery or other source of e. m. f. One terminal of this resistance is then positive and the other one negative, while at various points across the resistance we find all potentials between these two extremes. If a contact is arranged to slide across the resistance, we can give this sliding contact any desired intermediate potential. Thus if we connect the wire which connects the grid to the filament, (grid return lead) to this slider, it is possible



TWO ELECTRODE DETECTOR
Figure 42

to impart any desired potential, within the limit of the "C" battery, to the grid. This imparting of a certain mean potential to the grid of a vacuum tube is called "biasing", and we often revert to biasing or "C" potentials to attain certain advantages in other applications of the vacuum tube. The biasing battery is called a "C" battery.

By sliding the movable contact of the potentiometer of Fig. 43A, it is possible

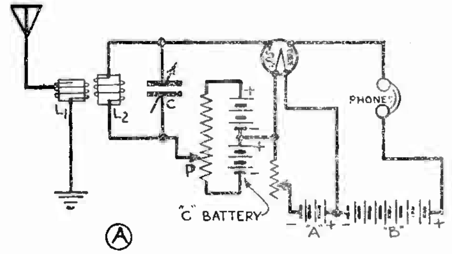


Fig. 43A: Three-electrode tube in detector circuit with potentiometer control of grid bias.

to accurately adjust the grid potential to such a value that when no signal is being received, the operating point of the tube is some point E on the lower bend of the tube characteristic curve of Fig. 43B. Now if a signal is received by the antenna, a high-frequency alternating e. m. f. will be set up across the coil and the plates of the condenser C. This is impressed between the grid and filament of the tube, producing at every cycle approximately equal and opposite plus and minus variations (+ and —) of the steady grid potential E. This is represented by the lower curve, drawn as a simple wave for sake of simplicity. From the way the characteristic curve bends, it is easy to see that if the grid potential increases "A" volts + (right) the plate current increases a larger amount (C) than it decreases (B) when the grid potential decreases "A" volts — (left). The "B" variations have been practically eliminated and due to this cutting off of the lower portion of the wave we have rectification and the tube acts as a detector. The sharper the bend of the curve the more perfectly the "B" variations will be eliminated and so the more perfect the detection.

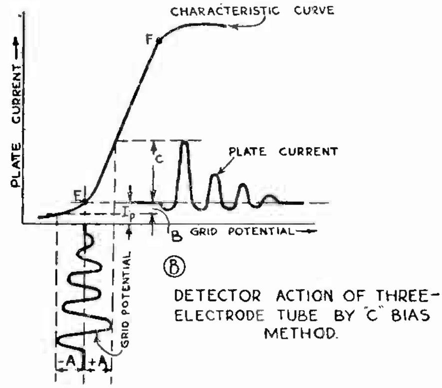


Fig. 43B: Detector action with the tube operating on the bend of the characteristic curve.

Considering this signal voltage variation, the grid potential, the plate current and the final motion of the phone diaphragm are shown in Fig. 43 C, D, and E. Notice that with this method of detection, the effect of every cycle of the signal voltage is to produce a large increase and a small decrease in the plate current, as shown by the middle curve; and that the resulting movement of the diaphragm follows the wave form or envelope of the received modulated radio-frequency potential due

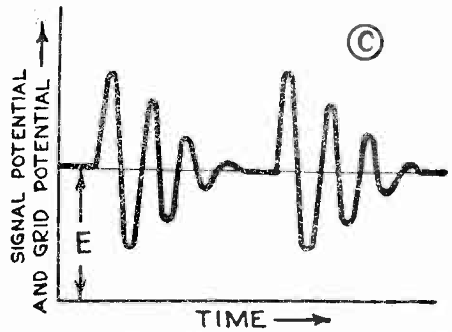


Fig. 43C: The signal voltage impressed on the grid of the grid-bias detector.

to the inertia of the diaphragm and the inductance and capacity of the windings in the phones, as explained in Chapter 4.

It is evident that the operation of the tube about the point F on the upper bend of the curve by putting a positive voltage or bias on the grid is similar to that on the lower bend, with the exception that at every cycle the incoming signal produces a large decrease and small increase of plate current. However, in practice the operation around the lower bend is preferable and used most, since the steady plate cur-

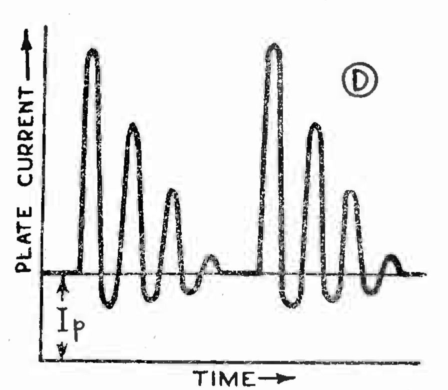


Fig. 43D: Plate current variations in tube operating as grid bias detector.

rent "I" flowing in the plate circuit at all times is much smaller than in the case of the upper bend, so the current drawn from the "B" batteries (or other "B" power

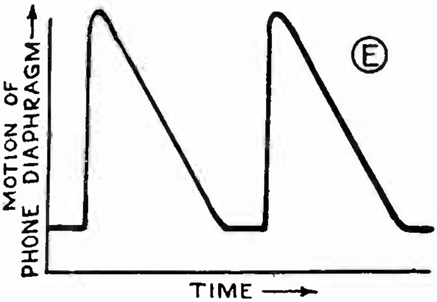


Fig. 43E: Final motion of receiver diaphragm.

supply unit) is not so great and their useful life is lengthened. With the modern UX-201A type of vacuum tube, the upper bend of the curve occurs at comparatively high positive grid voltages (with ordinary plate voltage of about 45). When using the lower bend and 45 volts on the plate, the negative "C" battery bias voltage necessary for detection is around —4 volts. Another reason for not using the upper bend is that when the grid is made positive a current flows in the grid circuit. This is objectionable, as will be seen later.

With ordinary UX-201A tubes it is usually possible to eliminate the potentiometer by using a standard 4½ volt "C" battery which has a tap at each of its three cells. The "C" bias can then be adjusted in steps of 1.5 volts, which is usually sufficiently close.

70. POWER DETECTORS: The modern tendency in sensitive receiving sets is toward the use of so called "power detectors". These usually take the form of "C" bias detectors in which a relatively high plate potential and negative "C" bias voltage is used on the detector. Detectors of this type are preceeded by a large amount of R.F. amplification to cause a relatively large signal voltage to be built up in the grid circuit of the detector. To prevent distortion, the maximum R.F. grid voltage swing must be within the straight portion of the plate current grid-voltage characteristic of the tube. The "power detector" is capable of handling a relatively large signal voltage without distortion. Power detectors will be discussed again in connection with electric receivers.

71. GRID CONDENSER METHOD: The grid condenser, or grid current rectification method of operating the three-electrode tube as a detector, is shown in Fig. 44A. This is based upon the fact that the grid can act more or less in the same manner as the plate and attract electrons itself as soon as it becomes positive with respect to the filament. The circuit is the same as that of Fig. 43A, except that there is no "C" battery in the grid circuit. A condenser "C" is connected in series with the grid, and the grid return is brought to the positive side of the filament. (The detecting action of the ordinary UX-201A type tube is better when a positive grid return is used than when a negative return is employed. This is due to the shape of the grid current—grid potential curve. Special detector tubes like the UX-200A type work best with a negative grid return).

With this circuit when no signal is being received, a steady plate current Ip flows from the plate to the filament and back through the phones, depending on the voltage of the plate and the temperature of the filament. If the grid return is to the positive side of the filament, the normal grid potential is at E, Fig. 44B, (slightly positive).

When a signal is received by the antenna, an alternating e. m. f. is set up across the coil and the plates of the condenser "C". This alternately charges the grid positively and negatively through the grid condenser "C". During a positive half cycle, the grid attracts some of the electrons from the filament (acting just like a plate). During the next half cycle, when the grid potential becomes negative, the electrons on the grid cannot escape because they are trapped on the insulated part of the circuit comprising the grid and the one plate of the grid condenser. On the next positive half cycle more electrons are attracted to the grid, which are also trapped so they cannot escape from the grid during the succeeding negative half wave. In this way, more and more electrons are trapped on the grid. The latter builds up a negative potential, and the high-frequency potential variations on the grid vary around a mean grid potential which becomes more and more negative, Fig. 44E. This reduces the plate current, and if the grid were perfectly insulated from the rest of the circuit, the action, if continued long enough, would finally reduce the plate current to a low value and

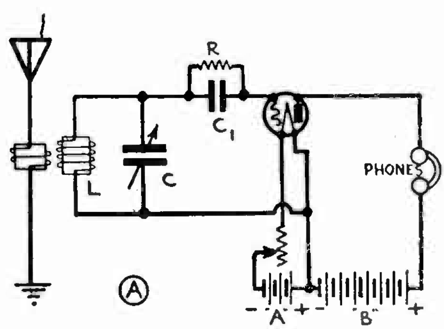


Fig. 44A: Circuit of grid leak and condenser detector.

the tube would be choked or stopped. To prevent this, after a wave train has been received it is necessary to remove the accumulated negative charge from the grid in order to restore it to the initial condition for the arrival of the next wave train.

If the tube insulation between the grid and filament is not perfect or if there is appreciable gas in the tube (as in soft tubes) the charge will automatically leak off through it. If the tube is well insulated and has a high vacuum, an artificial leakage path must be provided from the grid to the filament. This must be so proportioned that the electrons cannot leak off through the path to any appreciable extent in the extremely short time between a positive and negative wave of the incoming signal, but so the electrons do leak off in the time necessary to complete a wave train, as shown in Fig. 44E.

This can be done by connecting a high resistance R, from 1 to 10 megohms (1 megohm equals one million ohms), known as a "grid leak", either across the grid condenser "C" as shown in Fig. 44A, or directly between the grid and the filament as shown in Fig. 44C. The latter method has a special advantage in present day single control receivers, as we will see later.

The result is that if the incoming signal potential wave is shown in Fig. 44D, the grid potential follows the variations in its amplitude, Fig. 44E. The plate current varies in the same way, Fig. 44F, and this flowing through the phones energizes the electro-magnets resulting in the final movement of the diaphragm as shown in Fig. 44G. This produces sound waves which are practically a duplicate of these impressed on the carrier wave at the broadcasting station.

72. GRID LEAK AND CONDENSER: With present day vacuum tubes used for broadcast receiving, a grid condenser of about 0.00025 to 0.0005 mf. is satisfactory. The best grid leak resistance value is from about 0.5 to 10 megohms, depending on the particular circuit used and on the reception conditions. In any

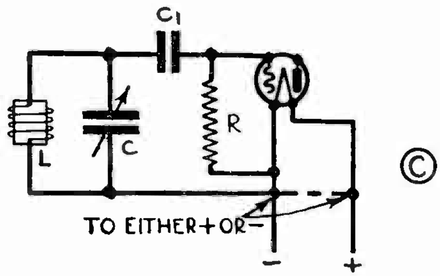


Fig. 44C: The grid leak may be connected from grid to filament, as shown, instead of across the grid condenser.

case, it must have a low enough resistance to allow the accumulated negative charge on the grid to leak off during the interval between the wave trains. Its resistance must be high enough to prevent the charge from leaking off the grid too rapidly, in

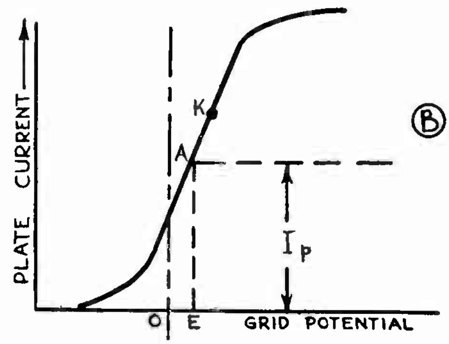


Fig. 44B: Point A is the operating point of a grid condenser and leak detector when positive return of the grid lead (?) is used.

which case there would be only a small change of plate current produced and the signal strength as heard in the phones would be reduced. For receiving comparatively strong signals from nearby broadcasting stations, leaks of 1 to 3 megoms give best results, since they allow the comparatively strong signals from nearby broadcasting stations to leak off at the proper rate. For weak signals, such as on long distance reception, a tube is much more senstive if the higher resistance grid leaks are used. In either case, if a grid leak having too high a resistance is used it will result in excessive accumulation of negative charge on the grid, blocking the action of the tube, or making the signals sound mushy. This is usually accompanied by a characteristic "cluck-cluck-cluck" sound in the phones or loud speaker as the charge leaks off at intervals through the insulation between the tube elements.

High grade grid leaks having permanent and accurate values of resistance should be used. A grid leak whose resistance varies will cause crackling and frying noises. The resistance element is usually enclosed in a glass tube with metal end caps for connection and is designed to snap into metal clips furnished on the grid condensers.

A consideration of the theory of condenser reactance and the vacuum tube shows that for the higher audio frequencies and their harmonics there is considerable by-passing thru the grid condenser due to the lowered impedance, and therefore a given signal strength causes less change in grid voltage than at the low frequencies. It is thus important to make the grid condenser as small as possible without offering an appreciable reactance to radio frequency.

Capacities lower than about .0002 mf. decreases the amplitude of the radio frequency potential impressed on the grid and therefore decrease the signal volume, while higher capacities cause a decrease in output on account of audio frequency by-passing. The best capacity tends to decrease as the frequency increases. Short-wave receivers usually employ small grid condensers of the order of .0001 mf.

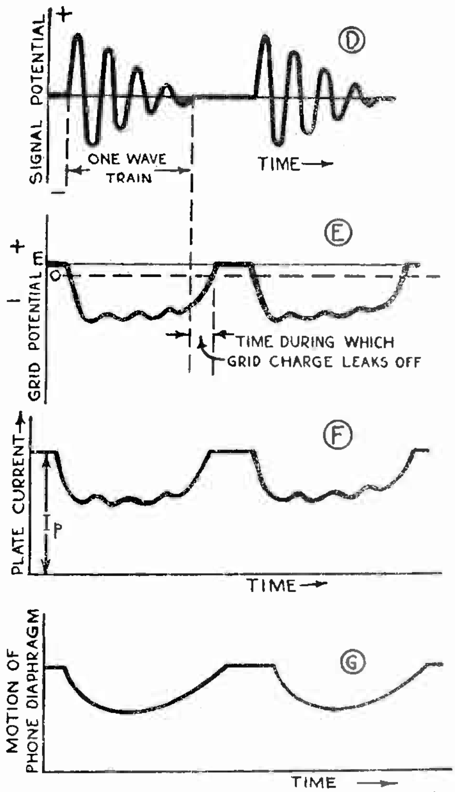


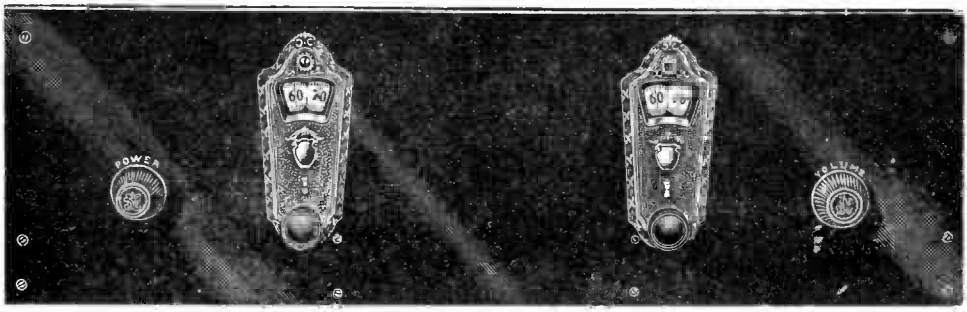
Fig. 44, D, E, F, G: Curves illustrating behavior of grid condenser and leak detector.

73. COMPARISON OF TWO METHODS: It is important to remember that in the grid leak and condenser method of detection the less the strength of the incoming waves the greater the plate current, and vice versa. In the "C" battery method, using a negative "C" bias voltage, the less the strength of the wave, the less the plate current. The former method is supposed to be the most sensitive because the effects of the little individual waves of the wave train are accumulative and therefore tend to produce an appreciable change in plate current, and since the tube is operated on the straight portion of its characteristic curve, there is some amplifying action in addition.

A disadvantage of this method is the frequency distortion due to the varying reactance of the grid leak and condenser with frequency changes. The "C" battery method, while less sensitive, is entirely absent from frequent distortion and is able to handle much greater signal strength without distortion, since it makes the full straight portion of the characteristic curve available. This characteristic makes it particularly suited to present day radio receivers located near powerful broadcasting stations, where great detector sensitivity is not required since multiple stages of tuned radio frequency amplifiers are used, but greater detector signal handling capacity is necessary.

In the grid condenser method of detection, the tube operates as a detector at practically any point on its characteristic curve.

In most present day receivers, which have considerable R.F. amplification, the detector is operated on the "C" bias method.



Front panel view of the D.C. New Yorker.

The Grimes
110-Volt "D. C. New Yorker"

Do you live in a direct-current district? If you do this set is the answer to your wish for a really good broadcast receiver that will work economically from the lamp socket.

by DAVID GRIMES

THERE is no need to emphasize that the modern tendency in radio invention and design has been toward the complete electrification of all types of receivers. First, the costly and short-lived "B" batteries were replaced by satisfactory rectifying apparatus called "B" eliminators. Then, most of the "C" batteries found their way into the discard and, now, the messy acid storage battery has been relegated to oblivion by the heater-cathode tube. But the most natural and yet the strangest thing has occurred during this transitional period. The electrification of receivers for operation on alternating current circuits—the hardest nut to crack—has been solved first. Little or nothing has been done toward the electrification of receivers on direct-current power lines.

Of course, all positive statements have some exceptions and it would not be fair to some commercial companies and to many amateurs who live in D.C. districts if the above were not somewhat qualified. It is quite true that several complete D.C. sets have recently been brought on the market and for some years experimenters have been building their own to their entire satisfaction. But most of these have been woefully deficient in either tone quality, volume, freedom from line noise, or cost of either installation or operation or both. Many otherwise inexcusable abortions have been tolerated simply because the receiver was electrified D.C. operated. That seemed to be the standard excuse for everything bad. The purpose of this article is to describe the results of a thorough investigation covering this entire subject, results which have definitely established for all time the fact that excellent reproduction can be obtained on an 110 volt D.C. power line operated electric set without any of the aforementioned drawbacks or other alibis.

THE PROBLEMS INVOLVED

The writer has incorporated the findings of his investigations into a complete broadcast receiver, which has been named the 110-volt "D.C. New Yorker" because it finds a particular field in the large section of New York that is supplied with direct current. Before describing the set itself, which is of simple construction, let us go over the technical problems involved, as these are more complicated.

It may appear to you, at first glance, that the easiest of all problems would be the D.C. electrification of radio receivers. "Isn't the D.C. line quiet like a battery or a good 'B' eliminator?" you ask. "Didn't we use to have satisfactory battery sets which operated on but 90 volts of 'B' supply?" you query. The answer to both questions is NO with capital letters. In all of my laboratory experience, I have never found a more knotty problem or one which defied solution for so long. The entire A.C. problem is very simple in comparison because any plate voltages desired are available thru the step-up action of a transformer and any filament currents are obtainable thru the step-down action. But in this D.C. puzzle, transformers do not function and we have to accept conditions as we find them, always bearing in mind among other things, economy.

TWO MAIN PROBLEMS

One would conclude from the above that the elimination of line noise and the reproduction of good quality on only about 100 volts of plate potential are the two real considerations. This assumption is correct and our design from the very start must be controlled by these two factors. Attempts in the past to eliminate this line noise have been made thru the installation of elaborate filters. Some D.C. sets incorporate both filament and "B" circuit filters. These not only add to the cost considerably, but reduce still further the already too small voltage available for plate supply.

Before proceeding with the elimination of this line noise, it is best that you understand its nature and character. It is caused by the brushes rubbing on the commutator at the D.C. generator itself. It is called brush hum or commutator ripple. It is quite strong, not only due to its inherent energy but to its pitch, which is around 500 cycles—the note at which the average ear is most sensitive. It is loudest on the outlets near the power house and decreases very rapidly as the more remote outlets are tested. The capacity of the feeder lines helps to by-pass this high-frequency racket. Hence, the noise will obviously be greater in some localities than in others. Any hum elimination device must take this into account. Fortunately, the proper solution for the worst condition is also the cure for the more favorable location.

THE "A" SUPPLY

The complete supply for the filament circuit of the "D.C. New Yorker" is shown in Figure 1. Here the several filaments in the various stages are connected in a series-parallel arrangement. The first two R.F. stages are connected across each other. The detector and first audio tube are so connected and the last audio stage, which is a push-pull combination, has the two filaments arranged in multiple. Each of the three groups is connected in series with the others and with a 60 watt lamp in the positive end of the line and a ten ohm variable rheostat in the negative end of the line. This is all there is to the entire filament hook-up. There is certainly nothing complicated here and no expensive filters!

It is impractical and expensive to attempt to operate all the filaments in parallel, such as is customary in a battery receiver. This would call for a current drain for the six tubes of one and one-half amperes. The series voltage-dropping lamp would have to be around 150 watts. It is obvious that this is a real load on the meter as compared with the 60 watts in the receiver discussed herewith. Furthermore, it is necessary to incorporate some additional voltage drop in the minus end of the circuit to act as the negative "C" bias for the various stages. These voltage drops might just as well be furnished by the filaments of tubes in other stages, such as is shown in Figures 2 and 3. The next natural question pertains to running all of the filaments in series for still further reduced current drain. As the filaments would only draw one-quarter ampere, the resistance lamp would only have to be a twenty-five watt light. Also, the filament voltage drops across each tube would act as the negative "C" bias for the adjacent tube located in the positive lead.

Well, the trouble with complete series

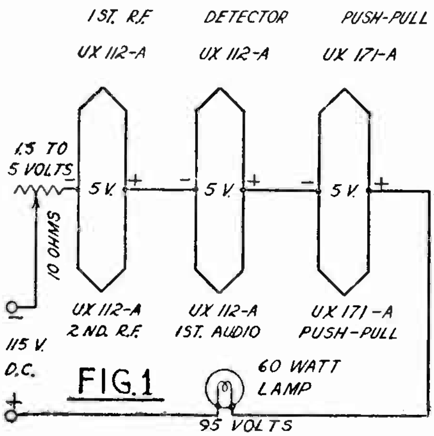


FIG.1

Fig. 1: The filament circuit of the D.C. New Yorker.

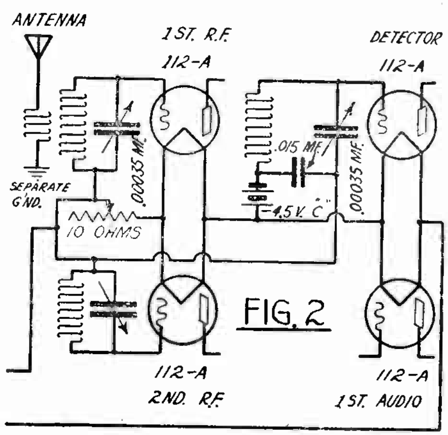


FIG. 2

Fig. 2: How the grid biasing voltages are obtained.

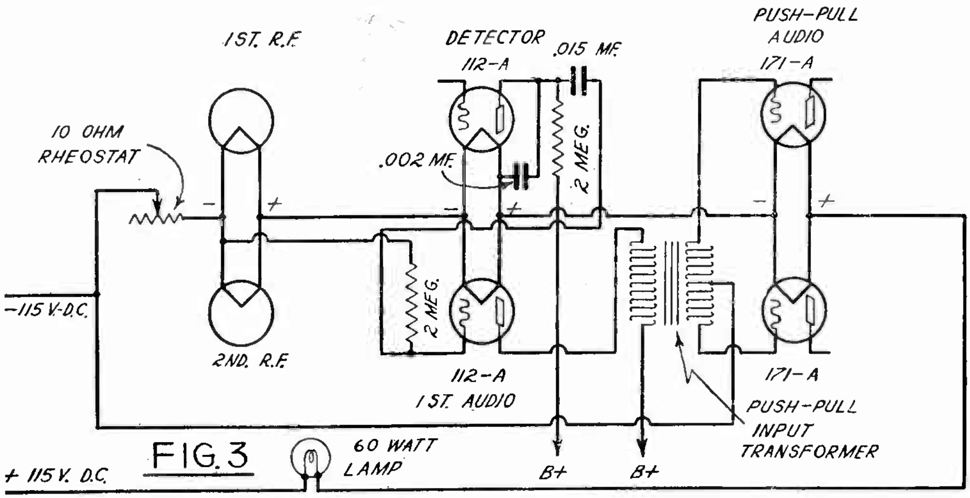


Fig. 3: How the biases for all the tubes are obtained.

filaments is that each filament connected in series subtracts that much voltage from the total available for the plate supply. The six tubes reduce the line voltage by 30 volts—dropping the 115 volt source down to a mere 85 volts. This is the last straw that breaks the camel's back. There is absolutely no need to run any more tubes in series than that required for the maximum negative "C" bias on the power tubes. This amount of voltage has to be taken from the plate supply. The best all around compromise is that presented in Figure 1. By placing the power tubes at the positive end of the filament string, the filaments of the other tubes can be utilized for the negative bias. Maximum plate voltage with minimum current drain is possible with this scheme. Complete parallel operation of filaments consumes too much current. Complete series operation of filaments consumes too much voltage. The series-parallel arrangement is the only proper answer.

SELECTING THE TUBES

The filaments have long been recognized as a source of noise when operating on power line connections. The first alternating current attempts employed filament rectifiers and filters with the hope of supplying the filaments with a fairly quiet flow of current. The apparatus was bulky, troublesome, and excessively expensive. The hot cathode tube was the solution to all this foolishness. It made the A.C. set practical. But this is not the solution for our D.C. set. The current required for the heaters on the hot cathode tubes is prohibitive for D.C. work. The noise conditions for us are much less severe, but the hot cathode tube offers a clue. It is the time required for this tube to heat and cool that makes it free from noises in the heater current. Why not use some type of battery tube that draws less current but still has some heating lag—sufficient to overcome the noise conditions encountered in the D.C. power mains? The 112-A is just such a tube. It requires from one to three seconds to heat up and cool off. It eliminates all noise from this source.

THE "C" BIASES

Now that we have the "A" circuit designed, we are ready for the "C" potentials. Figures 2 and 3 should be consulted. The correct grid bias for both the first and second R.F. stages is furnished by the variable 10 ohm rheostat connected in the negative filament of these tubes. The bias may be regulated as the resistance varies the potential from zero to five volts. For best results on distance, the grid bias should be about 1½ volts, but for best quality on loud, local stations the bias should be set at the maximum value of five volts. This is because this resistance also furnishes part of the bias for the power stage, as explained later on.

The bias solution for the detector has not been so simple. The least little noise in the grid of the detector is amplified many times by the succeeding audio stages. All attempts to electrify this grid bias have resulted in disappointment. Under some conditions, a bias obtained by connecting the grid return across the filaments of the R.F. stages is sufficiently free from noise to be satisfactory. This occurs in locations far removed from the D.C. power house, where the capacity of the power lines acts as a filter. Of course, a grid leak system of detection would not require a bias here as the grid is returned directly to the positive end of the filament. But a grid leak system will not handle large

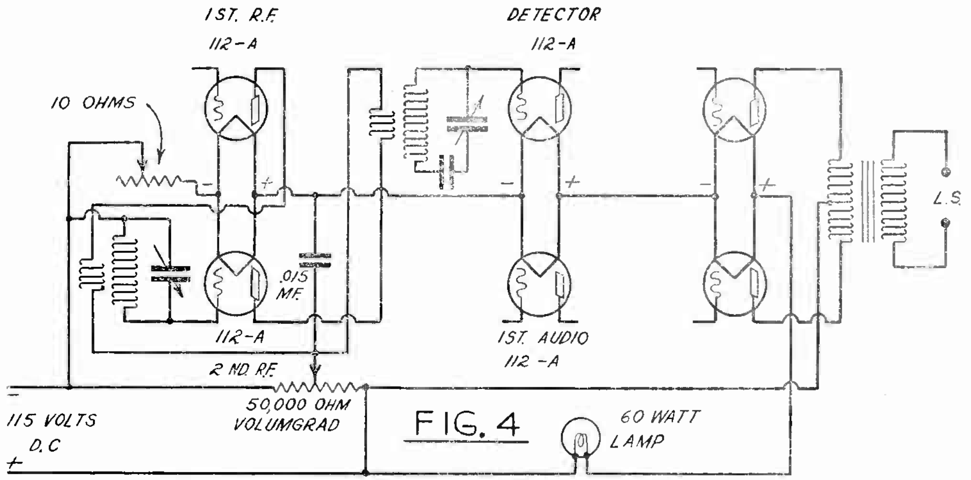


Fig. 4: Further development of the circuit that eventually grew into the D.C. New Yorker.

enough energies to properly amplify the bass notes without choking. The grid leak system of detection is more or less a thing of the past. No! The "C" bias system must be employed and the only practical solution at present lies in the installation of a dry "C" battery for this purpose. Such a battery should last for at least a year and should not be a source of annoyance. The second and third tuning condensers are ganged, which accounts for the connection running between the two rotor shafts of these units. The .015 mf. fixed condenser shown in the detector grid circuit permits this ganging without confusing the separate sources of "C" bias used on the two tubes.

The grid bias on the first audio stage is easily obtained by merely connecting the return back to the negative side of the R.F. stages. Apparently, no noise difficulties are encountered here as the amplification is not sufficient to make it noticeable. This places about five volts on this grid. The grid return from the push-pull stage is even more simple. The lead is run to the minus end of the power line circuit. This gives the voltage drop across the detector-audio combination, the R.F. stages, and the 10 ohm variable resistance.

THE PLATE SUPPLY

The plate supply for the two R.F. stages is taken directly off the positive end of the power line thru a potentiometer. This permits a smooth regulation of the voltage for the purpose of volume and regeneration control. The potentiometer is connected across the line. It should be about 50,000 ohms. The actual resistance of this unit is by-passed by the .015 mf. fixed condenser so that only the variation in plate potential affects the volume, rather than any loss effect caused by the resistance itself which would broaden the tuning. There is no need for a filter in the R.F. plate supply. Noises here do not seem to affect the reception. The circuit connections are shown in Figure 4. This diagram also shows the plate supply for the last audio push-pull stage as this requires no filter either. In this latter case, it is just a question of insufficient amplification. The lead is run directly back to the positive power line.

The only filtering necessary on the whole layout is that presented in Figure 5. Extensive tests showed that it was absolutely necessary to filter the plate supply of the detector and first audio tubes. Any line noise in either of the stages receives enough amplification to make the hum objectionable. But the filter is a very simple one. The entire contraption consists of one 30 henry choke coil and a 2 mf. condenser. The choke coil may be a very inexpensive one as the current drain thru it is small. Only the plate current for the first audio tube flows thru it; the detector plate really has no current because of the "C" bias and the high plate resistor. A cheap filter condenser is in order also because the line voltage across it is less than 100 volts.

GENERAL REMARKS AND PRECAUTIONS

We are now prepared for a discussion on the overall circuit. The segregated diagrams in the previous figures have served their purpose in clarifying certain points. Now we are set for some of the D.C. peculiarities. In the first place, it is imperative that a separate ground connection be used for the antenna circuit. This is indicated in the diagram. There must be absolutely no ground connected to any other part of the circuit. Fireworks galore will result if this is not followed to the letter. The trouble lies in the fact that the power lines are grounded at the power house—sometimes on one side of the line and sometimes on the other side of the line. There is no way of telling this without a test. The best answer is to avoid all trouble by the separate ground and then you do not care anything about the power house ground.

LAMP USED AS RESISTOR

The size of the resistance lamp is also a special problem. Fortunately, the ordinary electric "Mazda" lamp is satisfactory, so you may try the several sizes to determine the proper one. For the average location, the 60-watt lamp will give the proper voltages on the filament. This is where the line voltage ranges between 110 and 120 volts. This gives about 5 volts on the filament. If the location is near the power house, the voltage will often run as high as 125 to 135 volts. This calls for a higher resistance lamp to cut the voltage down to the proper filament value. A 50-watt lamp is recommended for this condition. Then, we have discovered a third location, usually at a considerable distance from the power plant, where the line voltage gets down as low as 100 to 110 volts. The cure in this case is the installation of a 75-watt lamp. This you will have to determine for yourself. If you have no voltmeter, you can judge by a very simple experiment. The filaments require about 1½ second to heat up under the proper voltage. Merely tune the set onto a program and turn it off and on and measure the time required for it to start performing after the switch has been connected. If it starts up immediately, the lamp has too high a wattage. If it takes too long to start the lamp is too small and should be increased.

One other fact should be emphasized before turning you loose. In the ordinary A.C. electric receiver with which you are undoubtedly familiar, it makes no difference which way the electric plug is inserted in the wall receptacle. The set plays equally well. But this is not so with the D.C. receiver. While no damage will result if the plug is inserted in the wrong way, there will be no operation. The tubes will light but the plate voltage will be negative instead of positive. The remedy lies in removing the plug and inserting it in the opposite direction.

A FEW PRECAUTIONS

Extreme care should be exercised whenever the switch is turned on. Remember that you have the whole powerhouse behind you if you short circuit anything. Better remove the wall plug before attempting to do anything. This applies particularly to the removal of any tubes from their sockets. Do not remove any tubes from their sockets while the power is turned on. If you do, you will blow the other tube in the couple or multiple connection as all of the filament current is then forced thru this one tube, while it divided equally thru two tubes before.

Don't let these simple precautions discourage you, however. Every set has certain factors that will bear watching. The most encouraging part of the whole D.C. field is that the voltages are such that

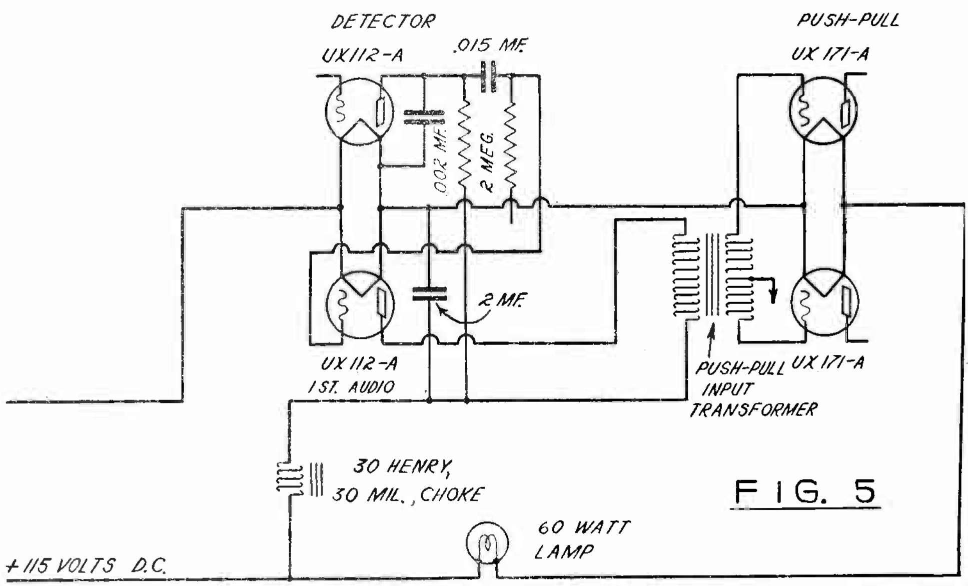
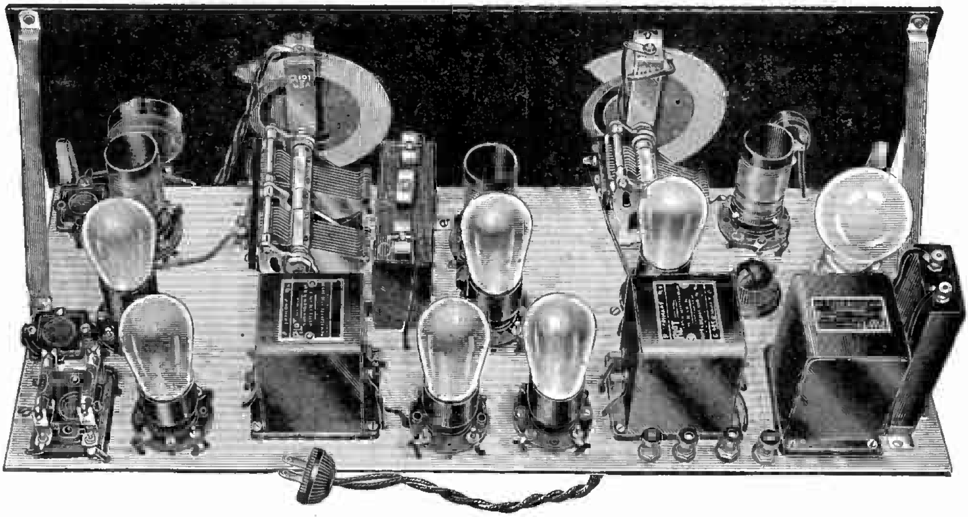


FIG. 5

Fig. 5: A single 30-henry choke is all that is needed for the filter system of the D.C. New Yorker.

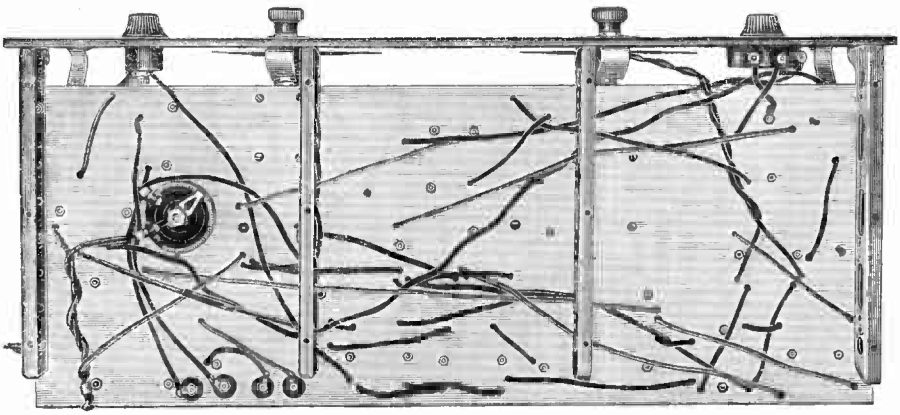


How the Grimes D.C. New Yorker looks when completely assembled and wired.

one cannot possibly receive a serious shock and this is a real problem in working on A.C. sets where the step-up transformers run the voltages to 300 and over. In the case of full-wave rectification, the A.C. voltage runs over 600 volts. From this angle, the D.C. receiver is almost child's play.

As the "D.C. New Yorker" is supplied in complete kit form, with the front and sub-panels already drilled with all the necessary holes, the work of assembling a set is quite easy. The accompanying drawings show the exact locations of all the instruments and also of all the wires. The parts used in the set are as follows:

1—No. 1617 variable condenser
1—No. 1617-2 variable condenser
2—No. 1282 illuminated vernier dials
9—No. 214 four-prong sockets
1—No. 176 plug-in coil
2—No. 176A plug-in coils (These are the same as the regular No. 176 except that the primary has 12 turns instead of 24).
1—No. 940 Volumgrad
1—No. 500 Resistoblock
2—No. 750 grid leaks
1—No. 408 push-pull input transformer
1—No. 409 push pull output transformer
1—No. 377 "B" eliminator choke coil
2—No. 19 binding posts
1—No. 20 " "
1—No. 21 " "
1—No. 32 " "
1—No. 44 snap switch
3—No. 37 metal brackets
1—No. 9000 condenser clamp
1—No. 9302 fixed condenser
2—No. 59 fixed condensers
1—No. 54 fixed condenser



Under view of the sub-panel. The wiring looks complicated, but it can be done very easily.

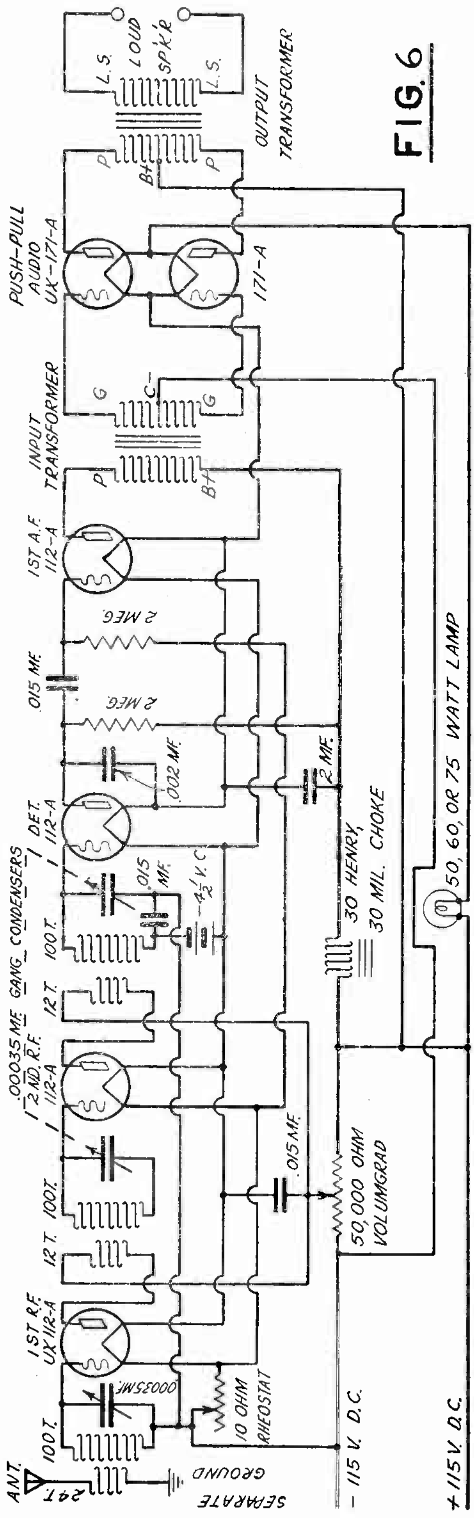


FIG. 6

1—Drilled and engraved front panel, walnut finish bakelite, 7½ by 24
1—No. 910 rheostat
1—Standard lamp socket inches
1—Drilled sub-panel, black bakelite, 8 by 24 inches
1—Hardware package, containing necessary mounting screws, nuts, washers, wire, etc.

The placement of parts shown in the accompanying woodcuts on page 54 is slightly different from the layout shown in the picture wiring diagrams on pages 56 and 57, as the arrangement was improved a little after the woodcuts were made. The panels are drilled in accordance with the picture wiring diagrams, so study the latter for the exact placement of the various instruments.

THE R.F. COILS

Six of the No. 214 sockets, which fasten to the sub-panel by means of their terminal screws, hold the tubes; the other three hold the No. 176 and 176A R.F. coils, which plug into them. The 176A are like the 176 except that instead of having 24 turns on the primary, they have only 12. This smaller number is necessary to prevent the 112A tubes from oscillating beyond control. (The coils were originally designed for 210A's).

If you do not buy a kit, and obtain the 176 coils separately, simply unwind half the primaries of two of them, and use them as 176-A's.

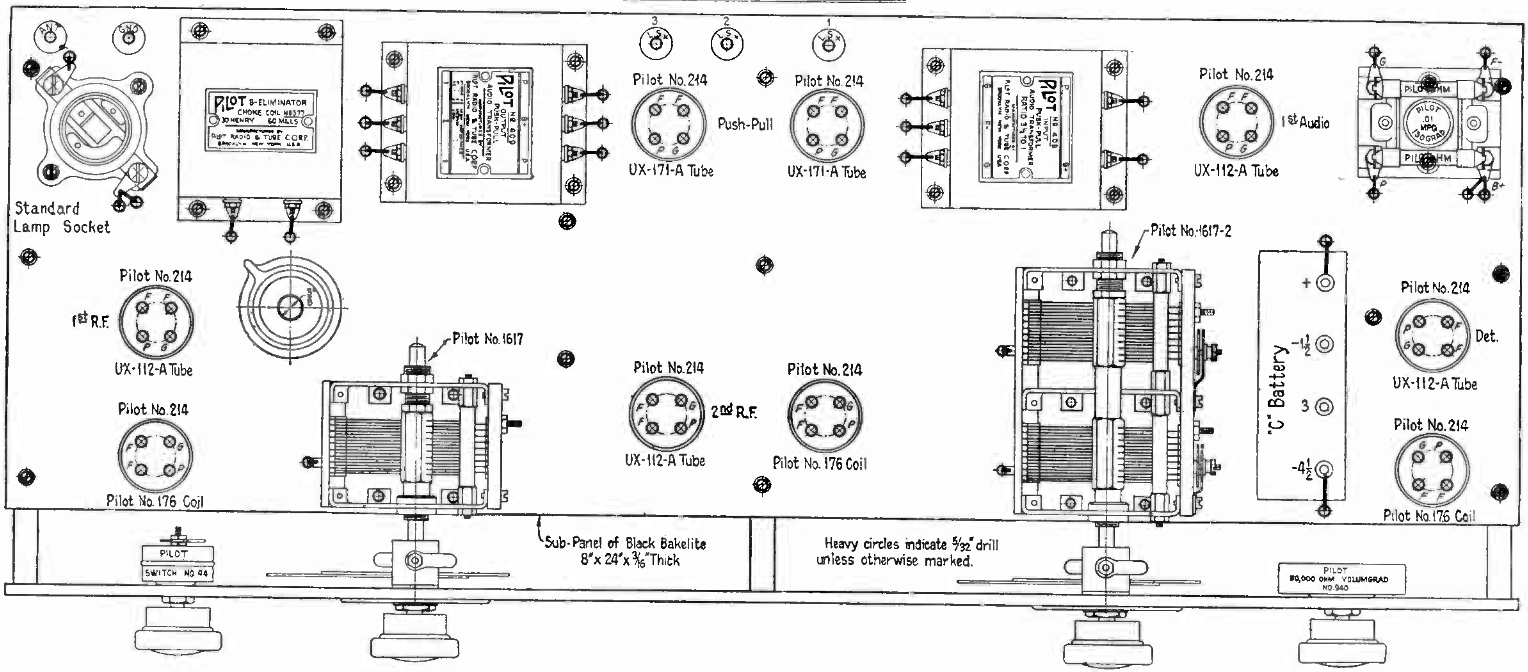
In putting the set together, first mount the three brackets to the front panel, to give the latter a support. Put the switch, the two dials, and the Volumgrad on the panel, but do not tighten the dial screws permanently yet.

Now screw the sub-panel to the three brackets, and mount the lamp socket, the tubes sockets, the Resistoblock, the binding posts and the rheostat. Now take the single 1617 condenser and slip its shaft into the bushing of the left dial. You will notice that the mounting feet of the condenser go right over four holes in the sub-panel. Put screws through these holes to secure the condenser, tighten the set screw in the dial bushing, and then finally tighten the screw and the nut of the dial. Push the screws up through the bottom of the sub-panel.

Mount the 1617-2 double condenser in the same way. Use a long screw in one of the holes nearest the edge of the sub-panel, and pass it through one of the .01 mf. condensers to hold it against the sub-panel. Put a lug under the head of this screw, and connect it directly to either of

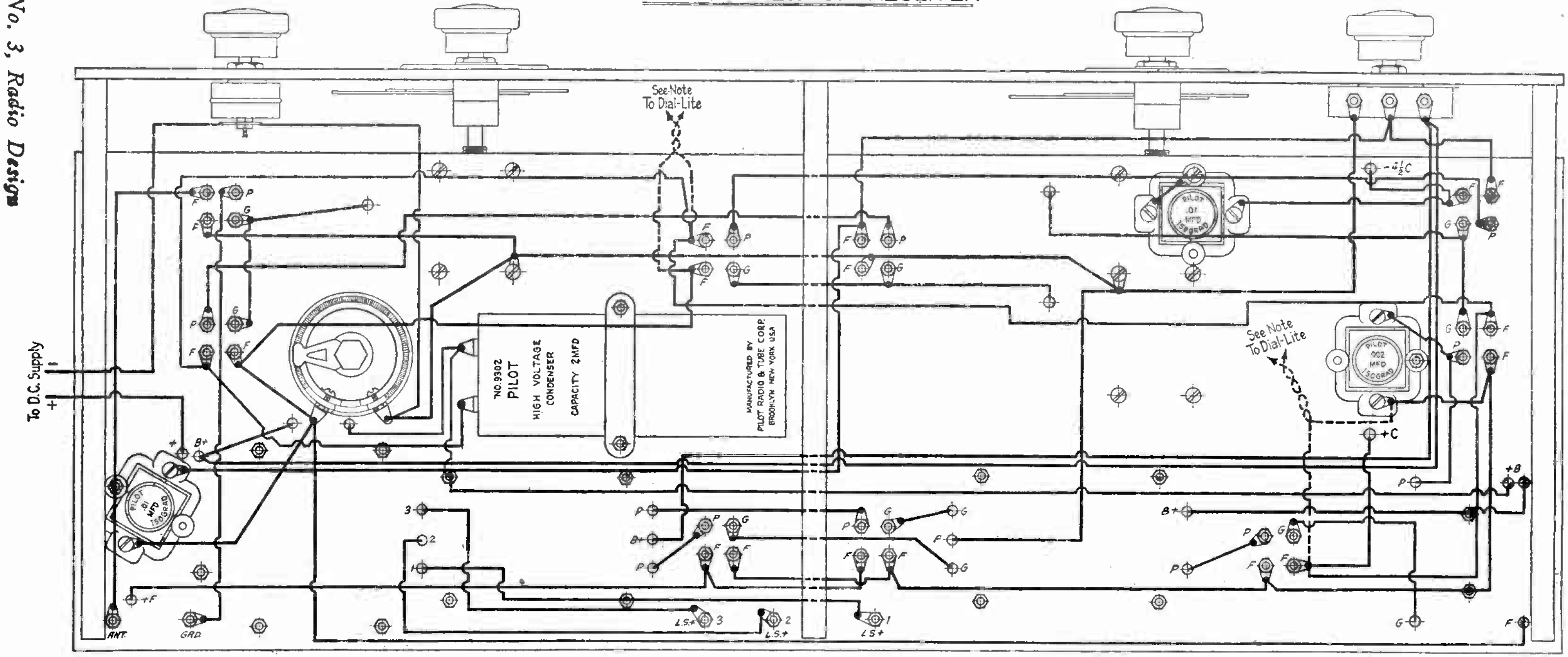
(*Continued on page* 58)

TOP VIEW OF RECEIVER



Top view of the Grimes 110-volt D.C. New Yorker, showing the exact placement of the parts on the front panel and the sub-panel. The panels as furnished with the K-118 kit are already drilled with all the necessary holes; the front panel, in addition, is neatly engraved with the name of the receiver.

BOTTOM VIEW OF RECEIVER



NOTE:- Installation of Dial-Lites reduces operating efficiency somewhat.

Bottom view of the D.C. New Yorker, showing all the wiring. The .01 mf. fixed condenser under the right hand dial is held by one of the screws passing up through the mounting feet of the double variable condenser. The .01 mf. condenser in the lower left corner is held by the same screw that holds the lamp socket.

the terminals of the condenser, to ground the latter. Incidentally, note that the other .01 condenser is held by one of the screws that fastens the lamp socket in the upper left corner of the sub-panel. The .002 mf. condenser is held by a separate screw just the left of the socket for the detector tube.

FINISHING THE JOB

To finish the assembly work, mount the audio transformers, the choke coil, and the large 2. mf. condenser. The latter lies flat against the underside of the sub-panel, and is held by a flat clamp (catalog number 9000). The "C" battery (which is not supplied with the kit) is not mounted in any particular fashion, but merely rests on the sub-panel to the right of the double condenser.

Because of the absence of the usual complicated power pack, the wiring of the "D.C. New Yorker" is quite easy. Do the filaments first, as they involve the most work; the rest of the connections are then simple. The wires on the left marked "to D.C. Supply" should be a length of twisted lamp cord, fitted with a plug for insertion in the lamp socket or wall outlet.

It is recommended that you leave out the dial lights, and get along with unilluminated dials. Putting the dials lights in shunt with the tubes unbalances the series-parallel circuit and reduces the operating efficiency of the receiver.

The usual aerial and ground are needed. Any type of magnetic or dynamic loud speaker may be used, three output posts being provided. Try different combinations of two posts at a time, and use whichever works best with your particular speaker. You can fit the set into any kind of a cabinet, depending on how much you or your clients want to spend.

If you live in a D.C. district, you can probably sell a number of "D.C. New Yorkers" to neighbors who now have to struggle with inadequate battery receivers. Make one yourself, let your prospective customers hear it, and you'll get enough orders to keep you busy for weeks.

Some Unusually Interesting Short-Wave Reception

723 Seven Oaks Ave.,
West Kildonan,
Winnipeg, Manitoba,
Canada.

Editor,
"Radio Design,"
Brooklyn, N. Y.
Dear Sir:

Received Radio Design the other day and find it quite interesting. It's too bad you don't publish it oftener, that's all. Anyway, my friend (E. Geere) and myself are quite enthusiastic over short waves. Every Saturday night we sit up and try our luck. We have an old "junk box" receiver with two stages (one Pilot).

On June 23rd, Sunday morning 3 A. M. Central Standard Time, we tuned in 3LO, Melbourne, Australia, and had it quite clear for an hour, when they quit. Well, this sure got us tickled. Next Sunday morning (June 30th, 6 A. M. Central Standard Time), we tuned in 2ME, Sydney, Australia. For two hours my friend listened with phones and I listened to a Temple Air Chrome loud speaker. They were having a talk with CJA, Drummondville, Quebec, Canada.

On Sunday morning (July 7th) we tuned in on CJA Drummondville, Quebec, calling 2ME Sidney, Australia. This gave us the tip that 2ME was on again. Inside of half a minute we tuned in 2ME on the loud speaker. Old Ed (that's my slogan for my companion on these nightly vigils) is "nuts" on short waves, and knows them too. Well, he suggested grounding the opposite end of the aerial, as this is supposed to be good for short-wave work. It was terribly stormy up here during the time of reception, so at first I thought he was crazy. Anyway, I grabbed the length of 28 gauge D.C.C. wire, fastened it on the opposite end of the aerial and the other end on an old chisel and stuck it in the ground. When I got in, reception was as clear as a bell, and the signals were loud enough to be heard 30 feet away clearly. We could hear every word that 2ME said. When I get my confirmation, I will mail it to you. Think it's darn good, don't you?

Well, after my short-wave friend showed me all that in three nights, I got nuts over short waves too, let me tell you. The following week I went down and bought two Pilot push-pull transformers and am quite satisfied with them. I am quite finicky over the audio end as that is the most interesting end of the whole works to me. Well, I hope you'll find this quite interesting, anyway.

Hoping to hear from you soon, I remain,

Yours most sincerely,

Louis W. Burwell.

ALFRED A. GHIRARDI

Tells the Why's and Wherefore's of

Push-Pull Amplification

Alfred A. Ghirardi

WHAT is a push-pull amplifier; why is it used; what are its advantages; can a push-pull audio stage be used in any set? These and many other questions regarding the increasingly popular push-pull connection are received daily by the editors. The purpose of this article is to clear up some of the apparent mysteries regarding the operation and use of this form of amplification and to present the theory of its operation for those thousands of students, service men and set builders who want to know "how and why".

During the coming season the push-pull connection of the power tubes of radio receivers promises to be an almost standard item in radio receiver design, and practically every up-to-date powerful set will employ it. While many people are hearing of it for the first time, it is not really a new invention. Way back in 1915 the circuit arrangement was developed by E. H. Colpitts, who assigned it to the Western Electric Company. It has been used practically continuously by that organization in telephone and radio work since that time. The introduction of the 171A and more recently the 245 power tubes has brought this form of aamplification to the fore in the radio receiving set field, so that push-pull is now a common word in the nomenclature of the radio-wise.

WHY PUSH-PULL?

When a large amount of volume is required from a radio set or loud speaker, the set must amplify the signal sufficiently to produce the required signal energy to be delivered to the speaker. This is a matter of designing a number of amplifier stages with the proper gain per stage, etc., and will not be considered here. The last audio stage in the audio amplifier must handle the comparatively large amount of power delivered to the speaker—*and should handle it without distorting the signal frequency or voltage variations in any way.* Large power tubes such as the 210 and 250 tubes can be used to handle this power, but the use of these tubes results in increased cost and complication of the "B" supply unit since they require high plate voltages and draw large plate currents.

One solution to this problem is to use two smaller power tubes connected in the popular push-pull fashion, as shown in Fig. 4. This combination has a greater undistorted power handling capacity than that of one tube alone. The push-pull connection also prevents second harmonic distortion, as will be explained later. It may be said then, that it has become popular because by its use two small tubes can be made to handle as much power without distortion or overloading as one larger tube.

The use of the smaller tubes reduces the cost of the "B" power supply unit, because they operate with lower plate voltage and plate current drain. The reliability and the maintenance cost are also reduced since the filter condensers, insulation, etc., are less liable to break down in "B" power units designed for 180 and 250 volts (for 171 and 245 tubes) than in units designed to operate at 450 volts or more (210 and 250 tubes).

ELIMINATES SECOND HARMONIC DISTORTION

When a vacuum tube is working with a low plate impedance (such as the primary of a transformer, a choke coil, etc.) in its plate circuit, its grid voltage-plate current characteristic curve Fig. 2 (see Chapt. 5, Radio Physics Course, in Summer issue) is slightly curved instead of straight, as is usually assumed for simplicity (the theoretical straight characteristic curve is shown in Fig. 1). The curve of Fig. 2 is sometimes referred to as the dynamic characteristic curve of the tube. This is especially true of an output tube in an audio amplifier, where the tube is feeding into a low impedance load, usually the output choke, output transformer, or the loud speaker. The curved characteristic causes the output of the tube to be distorted, that is, the current variations in the place circuit (curve C D, Fig. 2) are not exact reproductions of the grid voltage variations (curve A B, Fig. 2).

Thus, in Fig. 2, if the signal voltage applied to the grid varies about the steady normal value E, the increase a b in plate current due to the decrease c d in negative grid potential is greater than the decrease a f in the current caused by an equal increase e c in the negative grid potential. This gives rise to the lop-sided curve C D and distortion. By a mathematical series known as Fouriers Series, this distorted wave form (curve C D of Fig. 2) can be resolved into several components of various frequencies. (This discussion is too mathematical to be presented here). One of these is the fundamental frequency (curve E F, Fig. 3-A) which indicates that at least the pitch of the original note will be preserved. The other frequencies are the second harmonic (curve G H) and others which are so weak as to be relatively unimportant.

HARMONIC DISTORTION

These frequencies, which were not present in the original tone, are added to those that were present, and distortion occurs in the reproduction, making the reproduced sounds different from the original sounds. Thus, if a pure undistorted 100 cycle note were applied to the grid of a vacuum tube, we would find that in the output there would appear a strong 100 cycle note and in addition some weaker notes of 200 cycles, 300 cycles, 400 cycles and so on. The weaker these "harmonic" frequencies are, the less is the distortion.

This form of distortion is known as frequency distortion and can also be caused by improper design of audo transformers, or when the transformer is worked near the magnetic saturation point or bend of the magnetic curve. As will be shown, a properly designed and operated push-pull amplifier overcomes these sources of distortion, and permits of about three times the undistorted power output that is possible with a single tube of the same type and operated at the same voltages.

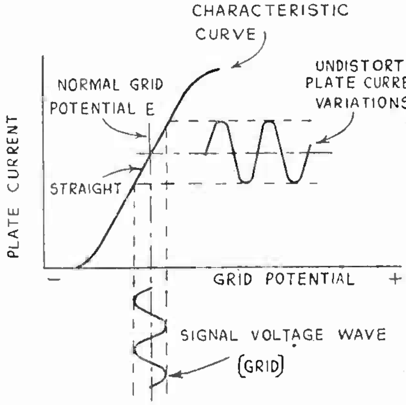


Fig. 1: Theoretical distortionless amplification with straight characteristic curve.

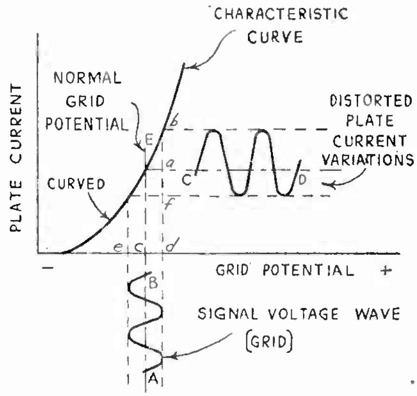


Fig. 2: How the vacuum tube actually operates. Note how the curved characteristic causes distortion.

HOW PUSH-PULL WORKS

Fig. 4 shows a circuit diagram for a conventional stage of push-pull amplification. The input transformer T has the usual primary winding but the secondary is tapped at the center point. The secondary has a greater number of turns than the primary, thus providing a step up in voltage (usually 2 or 3 to 1). The two outside terminals go to the grids of the tubes. The center tap goes to the negative terminal of the "C" bias voltage supply (in this case a "C" battery). As each half of the secondary is connected to a separate tube, the induced signal voltage in the secondary of the transformer T is divided, each tube receiving an input grid voltage equal to only half the signal voltage. This point is important for it means that two tubes in push-pull can handle twice as much input signal voltage, without operating on the bend of the characteristic curve, as one of these tubes alone can.

Suppose that at a certain instant the voltage induced in the secondary of transformer T is such that the grid of the top tube "A" is positive with reference to the center-tap of the transformer secondary, and the center tap is equally positive with reference to the grid of the lower tube "B". (This does not mean that the grid is "positive" with reference to its filament, for in this event distortion would be produced due to the flow of grid current. The "C" battery takes care of this. (It merely means that the grid is more positive, or less negative than the center tap). There will then be an increase in current through the plate circuit of tube "A" and a decrease in plate current through tube "B". The output of each tube is passed through half the winding of an output choke L (or half the primary winding of an output transformer T as in Fig. 5). This is wound with a center tap so that an increasing current in the upper half of the winding produces the same effect as a decreasing current in the lower half. Therefore, the effect in the output device, of the two tubes, is additive. Hence the name "push-pull".

If the two tubes are exactly similar and operating at the same filament, grid and plate voltages, their direct plate currents will be equal, and since they flow in opposite directions in the split winding, as shown by the dotted arrows in Fig. 4, the magnetic fields due to the *steady normal plate current* will cancel each other. This prevents core saturation in the output unit. Furthermore, with balance conditions, no fluctuating audio signal current flows down through the B+ power line into the output resistance or choke impedance of a "B" eliminator or "B" batteries. This reduces the possibility of instability due to feed-back from the power tubes to the detector or first audio tube, and also reduces the possibility of "motorboating".

ELIMINATING HARMONICS

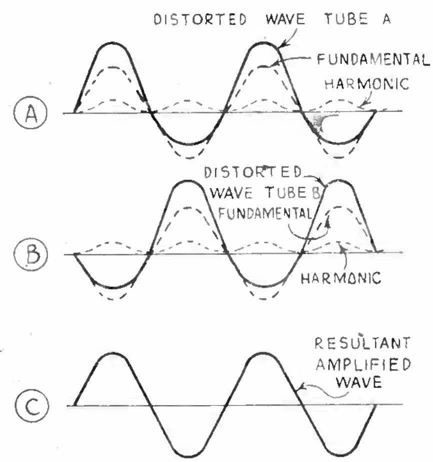
Since the signal potentials on the grids of the two tubes are 180 degrees out of phase, (one is always positive or negative with respect to the other), the fundamental plate currents in the two plate circuits differ by 180 degrees, as shown by the solid arrows in Fig. 4 and the dotted curves "E F" and J K in Fig. 3-A and Fig. 3-B. Curve E F in Fig. 3-A is the fundamental wave in tube "A" and G H is the harmonic. These two combined together give the distorted wave form C D. Curve J K in Fig. 3-B is the fundamental wave in tube "B" and G H is the harmonic. These two combined together give the distorted wave form L M from tube "B". The harmonics are in phase, as shown by dotted curves G H in Fig. 3-A and Fig. 3-B. These undesirable harmonics also happen to be represented by the dotted arrows in Fig. 4, for the instant considered. It will be evident by referring to these current directions at any instant that in the output unit (whether it be a choke coil or a transformer) the fundamentals (which are 180 degrees out of phase with each other in the tube) add together, since an increasing current through the upper half of the winding produces the same effect as a decreasing current in the lower half. For the same reason, the harmonics (which are in phase with each other) neutralize each other in the output unit and the resultant output to the loud speaker is an amplified reproduction of the fundamental wave only. It is evident from the foregoing that true push-pull action can only be obtained when the two tubes have identically the same characteristics (matched tubes).

OUTPUT UNITS

The output unit in a push-pull amplifier may be either a choke coil, as in Fig. 4, or a transformer, as in Fig. 5. When a choke coil is used, with well matched tubes, (passing the same plate current) the ends of the winding E and F are substantially the same D.C. potential, for there will be the same potential drop from the common center tap to E and F. For this reason the speaker can be connected across these points without danger of any damaging direct current flowing through the windings. This eliminates the necessity for any blocking condensers between the choke and the speaker. However, fixed condensers C_1 and C_2 of two to four mf. capacity are sometimes connected in the speaker circuit in order to insulate the speaker terminals from the high plate voltage to prevent severe shock if they are touched by a person whose body is grounded. This is especially advisable when the larger power tubes such as the 210 or 250 types are employed, as the voltages then are above 300 volts.

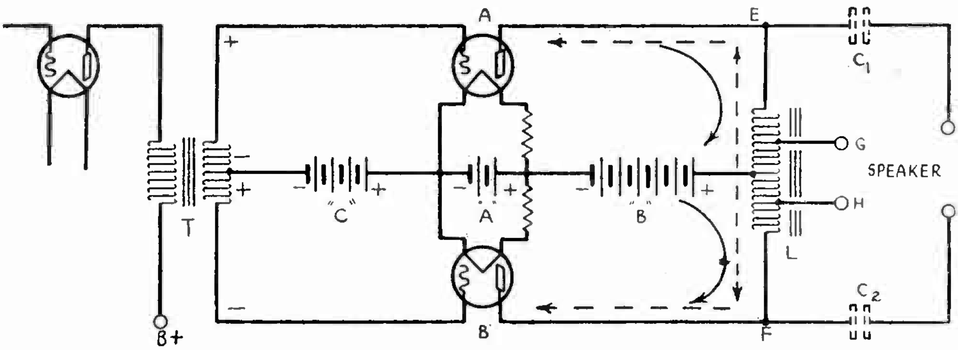
Some push-pull output impedances are made with two taps. In Fig. 4 points G and H are at the same D.C. potential when placed equally distant from the center tap. They may be used for speaker connection when a step-down ratio is required for the best operation of low-impedance speakers.

The use of an output transformer (Fig. 5) with push-pull amplifiers is becoming increasingly popular because it is possible to obtain a better impedance match between the tubes and the speaker by proper design. This is especially important when using



SECOND HARMONIC DISTORTION CORRECTION BY PUSH-PULL AMPLIF

Fig. 3: How harmonics are eliminated in a push-pull amplifier.



PUSH—PULL AMPLIFIER

Fig. 4: A typical push-pull amplifier circuit.

low-impedance speakers, especially dynamic speakers. The secondary can be provided with taps for obtaining the best impedance match with any particular speaker. The illustration shows two of the latest push-pull units developed by the Pilot Radio & Tube Corporation. One is a 2 to 1 ratio push-pull input transformer, No. 408, and the other is a push-pull output transformer, No. 409. The output transformer is tapped, providing output impedances of 1500, 2500 and 4000 ohms respectively. It may thus be matched to almost any speaker or combination of speakers.

FREEDOM FROM A.C. HUM

If the tubes in a push-pull amplifier are matched, and the center taps placed correctly on the input transformer and output device, there are no audio currents in the "C" minus or "B" minus leads, and consequently any electrical disturbance in the filament circuit (such as alternating current) does not enter into the amplification process. This makes alternating current operation of the filaments without hum easy.

If the tubes in a push-pull amplifier are not even nearly matched, or the transformer center taps are not located correctly, the voice currents do not neutralize each other and the filament circuit will no longer be isolated, thus allowing feedback through the inter-electrode capacity of the tubes to occur. This condition manifests itself usually as a strong amplification of the higher audio frequencies, and if the unbalanced condition is great, the audio tubes will oscillate, producing a steady howl or a high-pitched whistle.

Oscillation in push-pull amplifiers can generally be readily prevented by connecting a choke coil (such as the primary of an old audio transformer) or a resistance of about 50,000 ohms in the grid return circuit, marked "X" in Fig. 5. No by-pass condenser should be placed across it. This is really the grid suppressor method similar to the grid suppressor scheme used on R.F. amplifiers. The use of this choke or resistance will not affect the quality, as this circuit does not have to carry any audio frequency currents. Connecting a regular 30 henry choke in the "B"+ lead from the center tap of the output deuce to the "B"+ terminal of the plate supply will also aid in suppressing oscillation and stopping the whistle.

A push-pull amplifier can be tested for oscillation either by listening for the howl or whistle, or by connecting a low reading milliammeter in the "C"— leg at point X in Fig. 5 in order to determine whether any current is flowing in the grid circuit. Under normal conditions there should be no deflection of the needle. However, if the circuit is oscillating, several milliamperes of current may be found to flow in the grid circuit. Then the remedy described above should be applied.

A rough test to determine whether both tubes in a push-pull amplifier are operating properly can be made by operating the set loudly with both push-pull tubes in their sockets, and then removing one of the tubes. If the quality of reproduction becomes poor it indicates that the tube taken out is at least fairly good. If no charge is noticeable in the reproduction it indicates that the tubes are not matched. A new tube should then be tried. Now replace this tube and remove the other tube from its socket for the same test. The tubes should only be removed from the sockets for a few seconds, to avoid damaging the remaining tube due to the decreased "C" bias voltage caused by the lowered plate current flowing through the "C" bias resistor.

WHEN TO USE PUSH-PULL

It is evident from this that the answer to the question of whether to use push-pull amplification in a particular set, and just what tubes to employ in the power stage, depends on several factors. Push-pull amplification is not a cure-all for all set ills. It has definite limits and purposes.

First of all it should be remembered that while a properly operated push-pull stage eliminates the harmonics produced in that stage, it does not eliminate the harmonics or distortion produced in other stages. Thus, in a two stage audio amplifier with a single tube for the first stage and a push-pull output stage, the push-pull output stage does not correct any distortion appearing in the previous stages. However, the harmonic distortion produced in a high quality first stage (provided the tube is not overloaded) is so small as to be negligible in its effects on the final output.

DOUBLED PLATE CURRENT

It must also be remembered that since the plate circuits of the two push-pull tubes are in parallel, the total plate current drain is double that taken by each tube. This factor is sometimes overlooked and the socket power device used with a set having a single output tube may be seriously overloaded if push-pull amplification is incorporated in the set. Naturally trouble would result. This fact must be considered also when substituting larger size power tubes in a set. For instance, suppose a five-tube set using one 171-A power tube draws a total plate current of 40 milliamperes. The 171-A tube alone takes 20 milliamperes. Now suppose the 171-A tube is replaced by a push-pull output stage using 245 tubes. Each 245 tube takes a plate current of 32 milliamperes. Therefore, the push-pull output stage requires 32 x 2 = 64 milliamperes. The entire set then requires 64 + 20 = 84 milliamperes. This is more than twice the plate current drain the "B" eliminator was called upon to supply before, and it may exceed its rating.

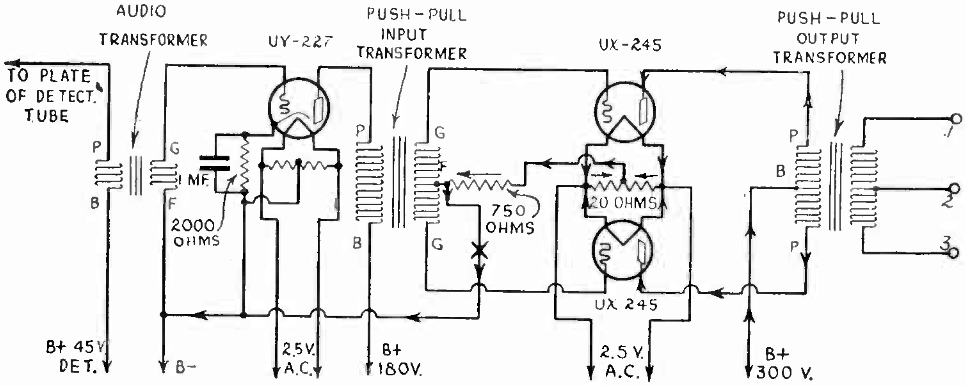
Therefore, the current rating of the "B" supply device should be ascertained before adding push-pull amplification to a set, which formerly used a single power tube in the output. If it will be exceeded under the new conditions, an eliminator with larger current output should be employed.

Another point to be remembered is that one of the main advantages of the push-pull connection is the increased power output handling capacity provided by the two tubes, over that provided by a single tube. If a set is to be operated so that the volume required from it under normal requirements will never exceed the undistorted power output rating of the single power output tube, it is needless to change that particular set to use larger power tubes or push-pull amplification. The improvement noticeable after the change will be very slight. However, if the single tube were being overloaded, the use of a push-pull stage would greatly improve results, for the undistorted power output handling capacity of two tubes in push-pull is nearly three times that of a single tube of the same size.

The speaker in a set should also be considered. It should be able to handle the full output of the push-pull output stage without rattling. Unless it is able to do this, the full possibilities of the set will be reduced by the speaker.

USE OF LARGER POWER TUBES

A question which often arises in the mind of the radio novice is just what power tube to use in a set. It is just as foolish to use a power tube five times as large as necessary as it is to use one which will overload on loud signals. The table below gives the undistorted power outputs of various power tubes operated singly, at various plate voltages. For two tubes in push-pull the undistorted power output capacity is about three times the values shown here for a simple tube.



AUDIO AMPLIFIER WITH PUSH-PULL STAGE

Fig. 5: A complete audio amplifier with a push-pull output stage.

UNDISTORTED POWER OUTPUT IN MILLIWATTS

Plate Voltage	112A Tube	171A Tube	245 Tube	210 Tube	250 Tube
90	30	130			
135	195	330			
180	300	710	750	145	
250			1600	340	900
400				950	3250
450				1540	4650

The question of which power tube to use is often determined by the fact that a certain plate voltage is available and the best power tube to be used in this case must be determined. Thus, from the table it can be seen that if a plate voltage of say only 90 volts is available, the 171 should be used. If 250 volts are available, the 245 tube should be used. This has a greater handling capacity at this particular plate voltage than even a 250 tube.

The next question is one of plate voltage and plate current drain. The larger power tubes require high plate voltages and drain heavy plate currents. For undistorted output the 171A tube should be operated with 180 volts on the plate and the 245 tube should have 250 volts. The 171A tube requires a 40 volt "C" bias at this plate voltage and the 245 tube requires about 50 volts. Thus, the total voltage output of the "B" supply device operating the 171A tube should be 180 + 40 or 220 volts, while the voltage of that for 245 tubes should be 250 + 50 or 300 volts.

If a set is employing 171A tubes with an eliminator furnishing a maximum of 220 volts, this same eliminator will hardly be entirely satisfactory for operating 245 tubes in push-pull, as its maximum voltage output with the large current drain imposed by the 245 tubes in push-pull will be entirely inadequate for the proper operation of these tubes. Also, due to the increased current drain on the eliminator, the filtering action of the chokes will be reduced due to the decrease in effective inductance. This will increase the ripple in the plate current and the hum from the set. The "B" eliminator then, should be designed to furnish the required amount of current at the proper voltage, without overloading.

If a new set is being built, or an existing set is to be brought up-to-date, an output stage with two 245 tubes connected in push-pull should be employed with a power supply unit capable of furnishing the correct voltages for the tubes. Two of these tubes will handle, without distortion, all the power one could possibly desire for a home.

The following table contains suggested tube arrangements for handling various power outputs without distortion. This has been arranged with a consideration for cost of parts with tubes, cost of power equipment, etc.

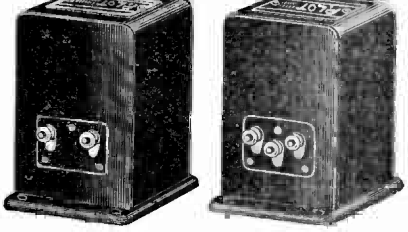
Milliwatts Output	Best Arrangement
500 or less	One 171A at 180 volts.
500 to 1000	171A's in push-pull at 135 volts or one 245 with 200 volts plate.
1000 to 1500	Single 245 at 250 volts.
1500 to 2000	171A's in push-pull at 180 volts.
2000 to 5000	245 tubes in push-pull.
5000 - up	250 tubes in push-pull.

PRACTICAL AMPLIFIER

The Pilot K-113, described in this issue, is an excellent example of a modern high-quality push-pull amplifier. Harmonic distortion in the first stage is eliminated by the use of resistance coupling instead of a transformer. The push-pull stage uses two 245's, and provides enough volume for small theatres, soft-drink parlors and other public places. For the home, it can easily be turned down without losing its natural tone quality.

SUMMARY

From consideration of the facts presented in this article, the reasons for the great popularity which push-pull audio amplification is now enjoying will become evident. The elimination of second harmonic distortion, the greater permissable signal grid voltage swing and undistorted power output handling capacity provided, as well as the reduction of hum with A.C. operation, are the important factors considered. These features have made this form of amplification very popular for the second stage, especially on powerful receivers which deliver great volume. The effective plate resistance of the push-pull combination is equal to twice that of a single tube. The allowable input voltage is twice that for a single tube.



The new Pilot push-pull transformers. Left, No. 408 input unit; right, No. 409 output unit, with tapped secondary.

RADIO INTERNATIONAL GUILD INC.

Announcing the formation of a world-wide fraternal radio organization to which every radio experimenter, serviceman and custom set builder should belong.

by ALBERT L. RUDICK,

Executive Secretary, Radio International Guild

IT has been conceded by leading educators and public-spirited citizens generally that the radio era has ushered in golden opportunities for self-education. It has done more to make a nation of scientifically trained men and women than any other single factor or industry. Persons who never before knew the fundamentals of electricity first mastered them through their interest in radio.

We have recently had a very illuminating and encouraging example of the influence for self-education and personal advancement that the scientific interest in radio can produce. Nearly everyone in the United States, yes, almost in the entire world, has heard of Wilbur B. Huston, the sixteen-year-old youth who won the Thomas A. Edison Scholarship from among forty-nine contestants, each representing a state in the Union and the District of Columbia—and all of whom were selected after exhaustive tests in their own states to determine their eligibility to take part in the national contest.

A RADIO FAN AT 10

Huston first showed a scientific bent at the age of ten, when, after persistent urging, his father purchased for him the various component parts with which to build a radio set. According to his father the boy turned out a very good receiving set.

There is little doubt that the primary scientific research engendered by the previously dormant capabilities that were aroused through the wonders of radio in this boy's mind were in a large measure responsible for the ultimate fund of knowledge imbibed by him in the succeeding years. It was this knowledge that finally resulted in his remarkable achievement of winning a contest that racked the brains of eminent university professors and scholars throughout the land who endeavored to answer the questions at the request of newspapers and periodicals.

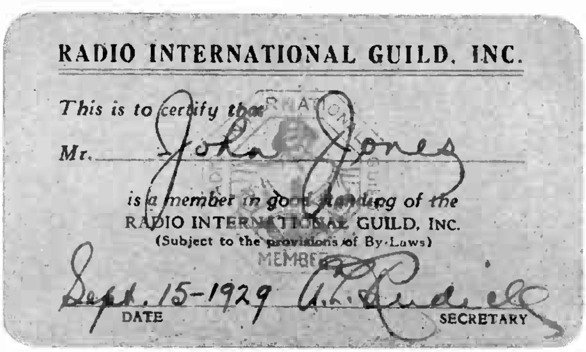
REASON FOR THE GUILD

It is the desire to encourage this fundamental influence for self-education that caused the Radio International Guild to come into being. It is the purpose of the Guild to be of active, substantial and pecuniary assistance to all radio enthusiasts, experimenters and custom set builders, so that the influence for scientific education in the home will be perpetuated.

The Pilot Radio & Tube Corporation, of Brooklyn, New York, has consented to underwrite the expenses of the Radio International Guild for the first year as its contribution to the advancement of radio. After the first year it is confidently expected that the membership dues will carry the organization along without further assistance.

The Radio International Guild is an organization by means of which the radio experimenter, the custom set builder and all others interested in the advancement of radio and allied sciences can join hands to effectively further their progress. It is a corporation organized in 1929 under the laws of the State of New York.

The aims and objects of the Radio International Guild are: To encourage individual experimentation in radio to the end that new devices may issue from the home labora-


RADIO INTERNATIONAL GUILD, INC.
This is to certify that
Mr. John Jones
is a member in good standing of the
RADIO INTERNATIONAL GUILD, INC.
(Subject to the provisions of By-Laws)
Sept. 15-1929 A. L. Rudick
DATE SECRETARY

A reproduction of the membership card issued to all members of the Guild.

tory and attic work-shop. Substantial prizes will be awarded by the Guild for outstanding work of this character. The Guild calls attention to the fact that many of the outstanding inventions of the past have come as a result of the individual experimenter's work, rather than from the laboratories of huge industrial and manufacturing corporations.

HELPING THE RADIO MAN

To provide a place to which members may bring new developments of their own invention, receive advice of a competent engineering staff and directions as to the securing of patents.

To bind together radio experimenters and enthusiasts not only in the United States, but throughout the world in a common cause, thus promoting international amity and goodwill.

The Guild recognizes that science knows no limitations and that the progress of any art is dependent, in a large measure, upon the free interchange of information among independent workers, no matter how far separated their domiciles may be.

The Guild will cooperate with technical and trade schools and will aim to encourage all students of the radio sciences.

A library of radio knowledge will be established consisting of text books, publications and periodicals so arranged as to be available for members use.

The Guild will aim to provide an organization by means of which members of the radio public and of the industry may make themselves heard in legislative halls and in the leading forums of radio thought and advancement.

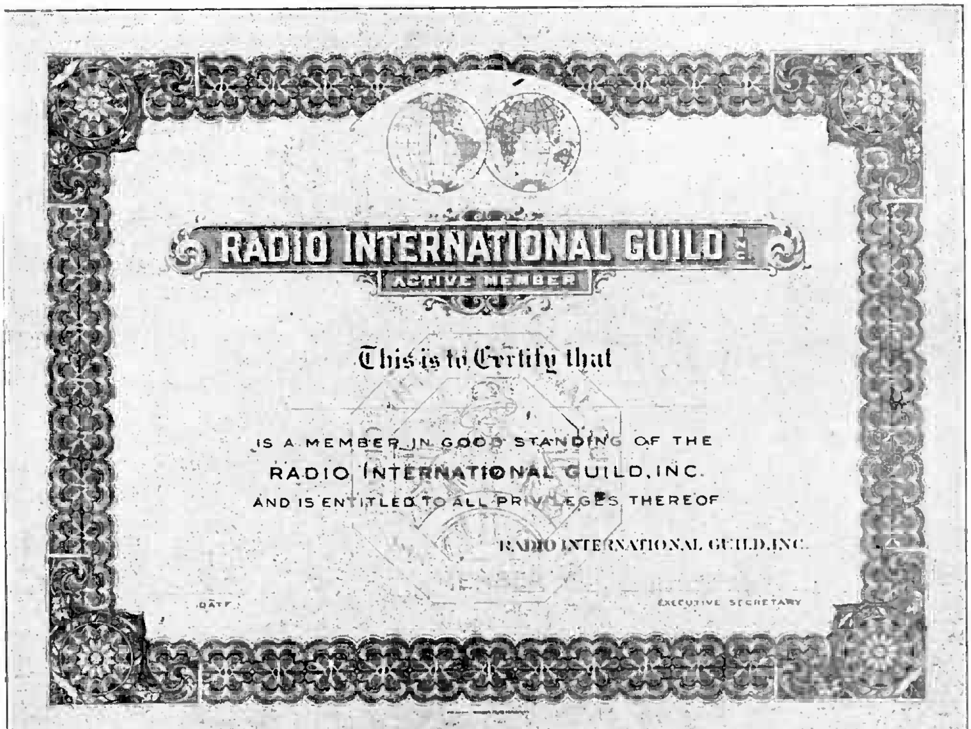
The membership of the Radio Interna- legislation intended to advance radio and allied sciences. It will combat all legislation and propaganda which it does not deem to be in the best interests of radio. It will aim to correct any abuses which may appear in the industry.

It will act as a clearing house for radio information and will transmit authentic news of new devices and developments to the public press and other publicity mediums and to its members.

TWO CLASSES OF MEMBERSHIP

The membership of hte Radio International Guild is divided into two classes. Class One is for *Active Members*, which includes radio engineers, experimenters, custom set builders and the radio public. Class Two consists of dealers and merchants engaged in the radio business and they will be known as *Trade Members*.

The annual dues for active members are fifty cents per year. The annual dues for



A reproduction of the membership certificate issued to all members of the Guild. It is 8½ by 11 inches, and is handsomely engraved. You will be proud to have one on your wall.

trade members are one dollar per year. There will positively be no assessments or levies against the members other than the annual dues.

Radio Design is the official organ of the Radio International Guild. It aims to present, four times each year, all the latest developments of radio and is edited by competent radio engineers — practical men who work out their problems in the laboratory.

Radio Design is issued to all members of the Radio International Guild, whether active or trade members, as a part of their membership in the Guild. It is also available to the general public and is sold through radio dealers everywhere. All subscribers to Radio Design automatically become members of the Radio International Guild and every member of the Radio International Guild is therefore a subscriber to Radio Design.

Wilbur B. Huston, the 16-year old winner of the Edison contest, was a radio fan at the age of 10.

The Guild will supply its members with suitable certificates testifying to their membership and will also present them with appropriate insignia to be worn in the coat lapel. Identification cards will also be provided. These aids for the mutual recognition of members will prove of infinite value. To the trade members of the Guild, in addition, will be furnished appropriate window transparencies showing that they are members of the Guild, so that the patronage of the active members might be properly directed to them. The Guild will maintain offices at 325 Berry St., Brooklyn, N. Y., and will operate as an independent unit under the control of its own officers.

Why You Should Join The RADIO INTERNATIONAL GUILD

If you are a regular reader of Radio Design you will want to become a member of Radio International Guild. This very fact alone will be sufficient reason, for, if Radio Design interests you, then the Radio International Guild supplies the link that will make you feel like one of the members of a great big family with kindred interests and brotherly consideration for one another. Radio International Guild will encourage free-lance research, particularly among non-professionals who labor at leisure on their pet hobby.

All you need do to become a member of the Radio International Guild is to become a regular subscriber to Radio Design. If you are already a subscriber renew your subscription for another year and you become a member of the Guild. All members will be supplied with a certificate, an identification card and pin free of charge. The cost of a year's subscription to Radio Design is only fifty cents and that is all you have to pay to secure the magazine, the Guild membership and all that goes with it.

For information and a copy of the constitution of the Guild, write to Albert L. Rudick, Executive Secretary, Radio International Guild, 325 Berry Street, Brooklyn, New York.

How To Make And Use The—

by

E. Manuel

The K-113 in use with a phonograph and a microphone for entertainment purposes.

TO meet the increasing demand for an audio amplifier that can be used with radio receivers for high-quality reproduction in the home and for general radio, phonograph and sound motion-picture reproduction in small halls, theatres and other public places, the Pilot company has brought out the K-113 power amplifier, which will appeal to every radio builder because of its electrical efficiency, its mechanical simplicity and its low cost. Using two 245 tubes in push-pull, preceded by a stage of resistance coupling, it provides great volume of signals without distortion, and is capable of operating several powerful dynamic speakers. It is not too powerful for the home, as it can be turned down to a whisper without losing its natural tone quality.

PARTS IN KIT FORM

The parts for the K-113 are supplied in complete kit form, and can be assembled and wired in an evening. They mount on a strong base-panel of formed aluminum, accurately drilled with all the necessary holes for the mounting screws. The completed instrument possesses a real commercial air, and has none of the "breadboard" appearance that characterizes so many home-built amplifiers. When assembled it is only 16 inches long, 9¾ inches deep and about 8 inches high and it therefore can be fitted very comfortably and conveniently in the record compartment of old-style phonographs or in the bottom of console cabinets.

The K-113 uses five tubes altogether, in the circuit shown on page 71. You will notice that the first tube, a 227, has no input device attached to it, although it is resistance coupled to the second tube, also a 227. Clips for a grid leak are provided on the base-panel, so that a grid leak may be inserted if the builder wants to add another stage of resistance coupling to the outfit. No transformer or other coupling device is provided because most radio builders prefer to use some pet system of their own. If the amplifier is used for public address work, the microphone modulation transformer will be connected to the input posts; if a phonograph pick-up is employed, it may be coupled direct, or through any special transformer supplied with the instrument.

TAPPED OUTPUT TRANSFORMER

The second 227 is followed by the push-pull stage, which uses the new Pilot No. 408 and 409 transformers. The secondary of the No. 409 output transformer is tapped, so that the amplifier will work to best advantage with loud speakers of either low or high impedance.

All filament, grid and plate power for the tubes in the K-113 is supplied by a Pilot K-112 power pack, which fits on a shelf along the rear edge of the base-panel. As the K-112 is supplied in a neat steel can, wired and all ready for use, the builder is saved three-quarters of the work usually involved in the assembly of a 245 power amplifier. The amplifier is fully self-contained and will work entirely independently of the radio receiver.

The following parts are included in the K-113 kit:

1	No.	K-112	ABC Power Pack in can.
1	"	780	Aluminum Base Panel
1	"	781	Aluminum Base Cover
1	"	408	Input Push-Pull Transformer
1	"	409	Output Push-Pull Transformer
1	"	500	Resistoblock
3	"	216	Sockets
2	"	217	Sockets
4	"	801	1 mf. By-pass Condensers
2	"	958	Resistor—2000 ohm
1	"	965	Resistor—750 ohm
2	"	354	Center-Tapped Resistance—20 ohm

K-113 PUSH-PULL AMPLIFIER for 245 TUBES

Bring your set up to date by adding this inexpensive, easily-assembled amplifier to it; parts supplied in kit form

5 " 29 Blank Binding Posts
1 " 21 "Gnd" Binding Post
1 " 752 .5 megohm grid Leak
1 " 750 .1 megohm grid Leak
1 " 770 Resistochoke
1 " 782 Hardware for Pack consists of: 13 Binding Post Insulators; 4 Rubber Bushings; 9 Black Oval head ⅛" Screws; 5 Nickel Plated Round Head 2-⅛" Screws; 2 Condenser Mounting Straps 2⅛"; 3 Nickel Plated Round Head 1" Screws; 2 Fuse Clips; 7 N.P.R.H. Screws ¼"; 20 Solderings Lugs; 40 Hex Nuts; 30 Lock Washers; 4 Round Head Screws ⅝"; 26 Ft. Black Rubber covered wire; 8 Ft. Blue Rubber covered wire.

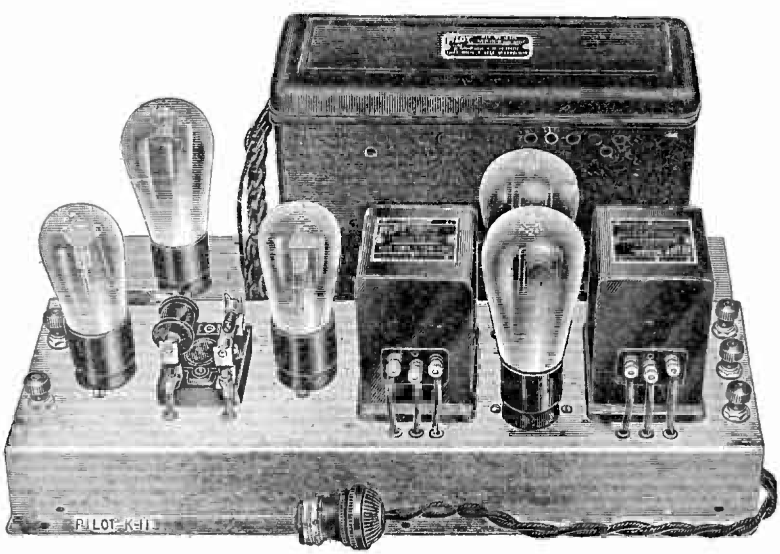
The accessories needed for the amplifier itself are two P-227 tubes, two P-245's (power amplifiers) and one P-280 (full wave rectifier). No one-off switch is provided, as in most cases the amplfier will be controlled by the switch on the radio receiver. The cord from the K-112 is simply spliced into the switch circuit.

If you are still using an old amplifier with 226 or 171A tubes, or, as a service man, have customers who want their receivers brought up to date, by all means buy a K-113. It provides a cheap and easy means of turning two- or three-year old outfits into 1930 model musical instruments.

To describe in detail the manner in which the K-113 is put together, let us assume that you have bought a kit and are ready to start on it. The only tools you need are a screwdriver, a pair of taper-nose pliers, a Spintite wrench to fit the small nuts used throughout in the amplifier, and a soldering iron.

STARTING THE ASSEMBLY

Take all the parts out of their boxes, and study them for ten minutes or so to acquaint yourself with their markings. Compare them with the drawings, to get an idea of how they are supposed to fit. Start the assembly by mounting the five tube sockets, with the machine screws going in through the top of the base-panel. Note from the bottom view of the base-panel



A K-113 amplifier fully assembled and wired and with the tubes in place. The outfit presents a fine factory-built appearance.

that soldering lugs are fastened under some of the nuts that tighten these screws. There is one on the bottom screw of the first socket in the upper left corner; one under each of the screws of the next socket; and one under the right hand screw of the bottom socket for the 245 tube. By putting these lugs on now you'll save the trouble later of loosening the screws.

Next mount the six binding posts and the fuse clips for the grid leak. The F— and ground posts (on the left) simply make contact with the aluminum, no wires being connected to them. All the other posts and the clips are insulated from the base-panel by means of hard rubber washers. Put soldering lugs under all the fastening nuts. Of course, do not forget to put lock washers under all nuts, throughout the amplifier.

The next operation involves the Resistoblock, which simply requires two mounting screws.

MOUNTING THE TRANSFORMERS

Before mounting the push-pull transformers, you must install the by-pass condensers on the underside of the base-panel, as the screws for these will be covered later by the transformers. After putting soldering lugs on all their terminals, place one 1 mf. condenser on top of another, and clamp the two down in the center of the base-panel, between the sockets for the second 227 and the two 245 tubes. Long screws and a flat clamp for the purpose are provided in the kit. Have the binding posts face to the left. Mount the other two 1 mf. condensers in exactly the same manner to the right of the 245 sockets.

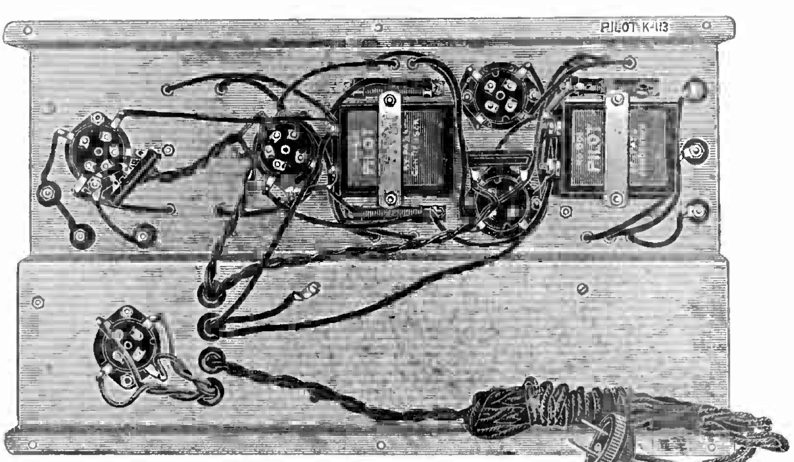
With this finished you can put the transformers in place. Note from the picture diagrams that the No. 408 is placed with its three secondary posts facing the front edge of the base-panel, while the No. 409 is twisted the other way. The same screws that pass through the corners of the No. 408 transformers hold, on the underside of the base-panel, two 2000-ohm fixed resistances, which provide the bias for the two 227 amplifier tubes. These resistors flank the sides of the two 1 mf. condensers, which act as by-passes across them.

The two front screws of the No. 409 transformer hold, on the underside, a 750 ohm resistance, which gives the bias for the two 245 tubes.

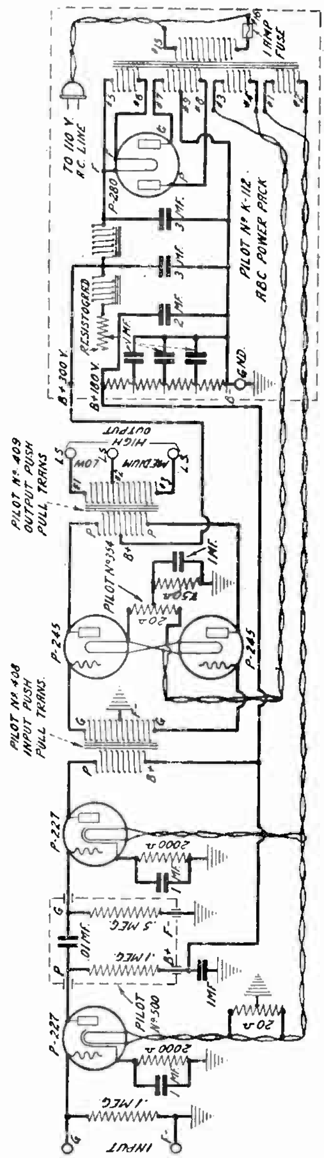
The only other thing to mount is the K-112 power pack, which rests on the low shelf of the formed base-panel. In one of its ends there is a large opening, through which the connection wires are passed; face this end to the left, that is, toward the four-prong socket for the 280 rectifier tube. Mount this unit by passing four screws up into its bottom from the underside of the base-panel. Put a lug under the screw in the upper left corner. Do not fail to include lock washers under the heads of these screws, as they support the weight of the power pack. Remove the cover of the can, to expose the terminal plate. Force the soft rubber bushings into the four large holes between the 280 socket and the end of the K-112, and you are ready to start the wiring.

THE WIRING

Start with the rectifier tube socket, and run the filament and plate wires through hole A. The filament runs to the posts on the K-112 terminal plate marked 5 and 6; the G and P connections to 7 and 8. Posts 5 and 6 supply 5 volts, 7 and 8 the high voltage for the plate circuits. Twist the filament wires together.



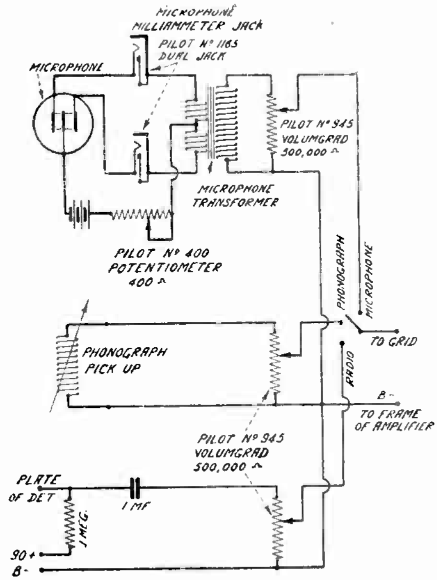
The underside of a completed K-113 amplifier. Note how short and direct the connections are.



The complete schematic wiring of the K-113 push-pull amplifier. The section at the right, within the dotted lines, shows the connections inside the K-112 power pack, which is supplied completely assembled and ***wired except*** *for the rectifier. The list of parts at the extreme right should read: "1—No. 750 grid leak—.1 meg" instead of "2—No. 750 grid leaks—.1 meg." Also, there should be added the item "1—No. 770 Resistochoke—.1 meg."*

LIST OF PILOT PARTS

No.	DESCRIPTION
1 - K-112	A B C Power Pack.
1 - 780	Aluminum Sub-Panel.
1 - 781	Aluminum Base.
1 - 408	Input Push-pull Transformer.
1 - 409	Output Push-pull Transformer.
1 - 500	Resistoblock.
3 - 216	Sockets.
2 - 217	Sockets.
4 - 801	By-pass Condensers - 1 Mf.
2 - 958	Resistors - 8000 ohm.
1 - 965	Resistor - 750 Ohm.
2 - 354	Center Tapped Resistances - 20 ohm
5 - 29	Blank Binding Posts.
1 - 21	Ground Binding Post.
1 - 752	Grid Leak - .5 Meg.
2 - 750	Grid Leaks - .1 Meg.
1 - 782	Package of Hardware: (13 Binding Post Insulators; Rubber Bushings; Wire; Solder; Lugs; Fuse Clips; Screws; Hex Nuts; Washers etc.)



How the K-113 may be used with microphone, radio, or phonograph input. A simple 3-point switch is used for changing over.

Next do the filaments of the 227's and 245's. Run twisted wires from the terminals marked 1 and 2 on the power pack to the 227's, and from 3 and 4 to the 245's. Solder one of the 20-ohm center-tapped resistances directly to the lugs on the socket on the extreme left, and the other to the lugs on the bottom socket for the 245. The two pairs of wires go through hole D.

The "B" leads are brought down through hole C. The "B"— post of the K-112, marked 9 on the terminal plate, is grounded to the lug just to the right of the hole D. The "B"+ 300 and 180 run to the Resistoblock and the input transformer, and to the output transformer.

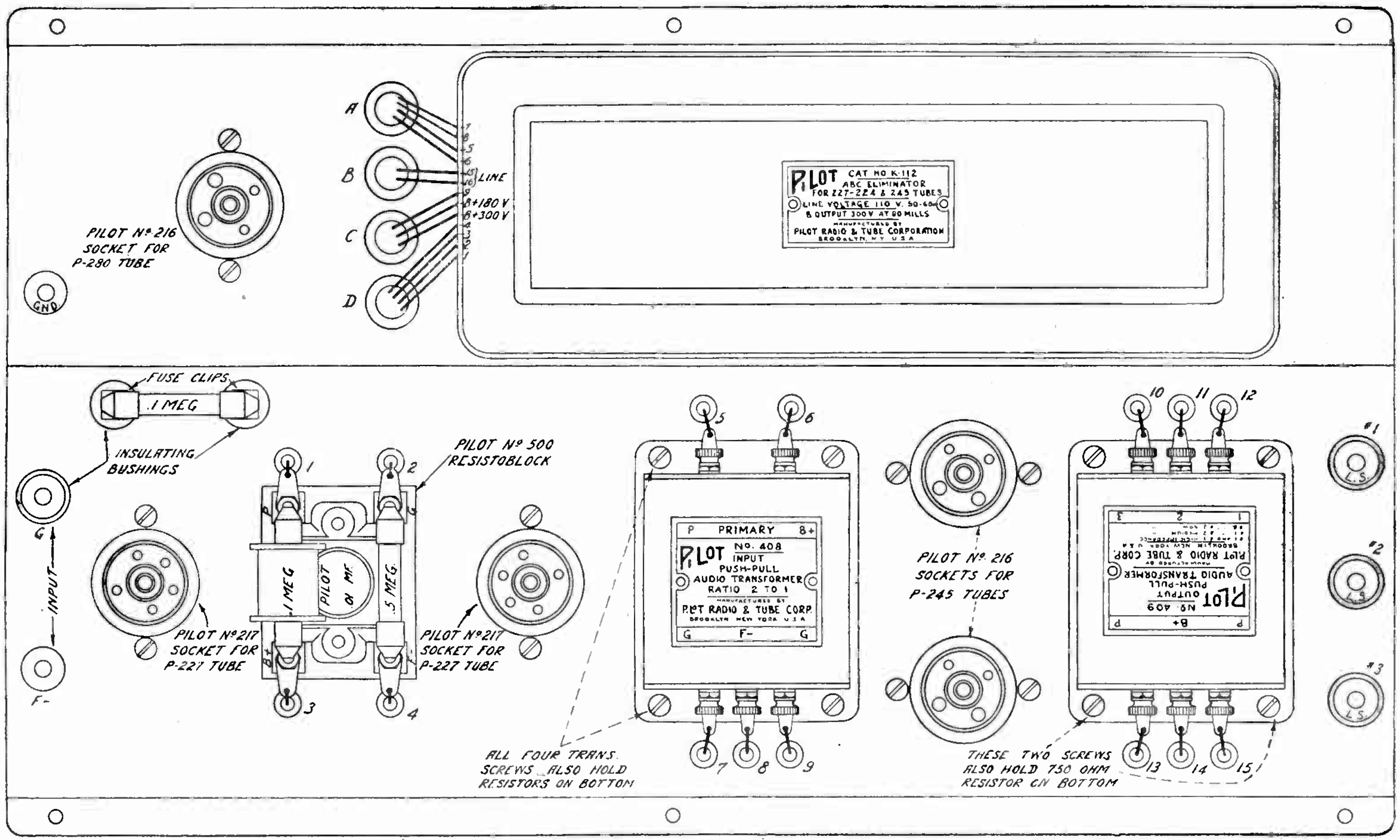
The other connections between the various parts are clearly indicated in the picture diagrams on pages 72 and 73. Solder them all carefully with a clean hot iron and rosin-core solder.

Be careful not to confuse the connections from the four 1 mf. by-pass condensers. The two lower posts of each pair are connected together and to the aluminum base, but the upper ones are separated and lead to the biasing resistors and to the Resistochoke.

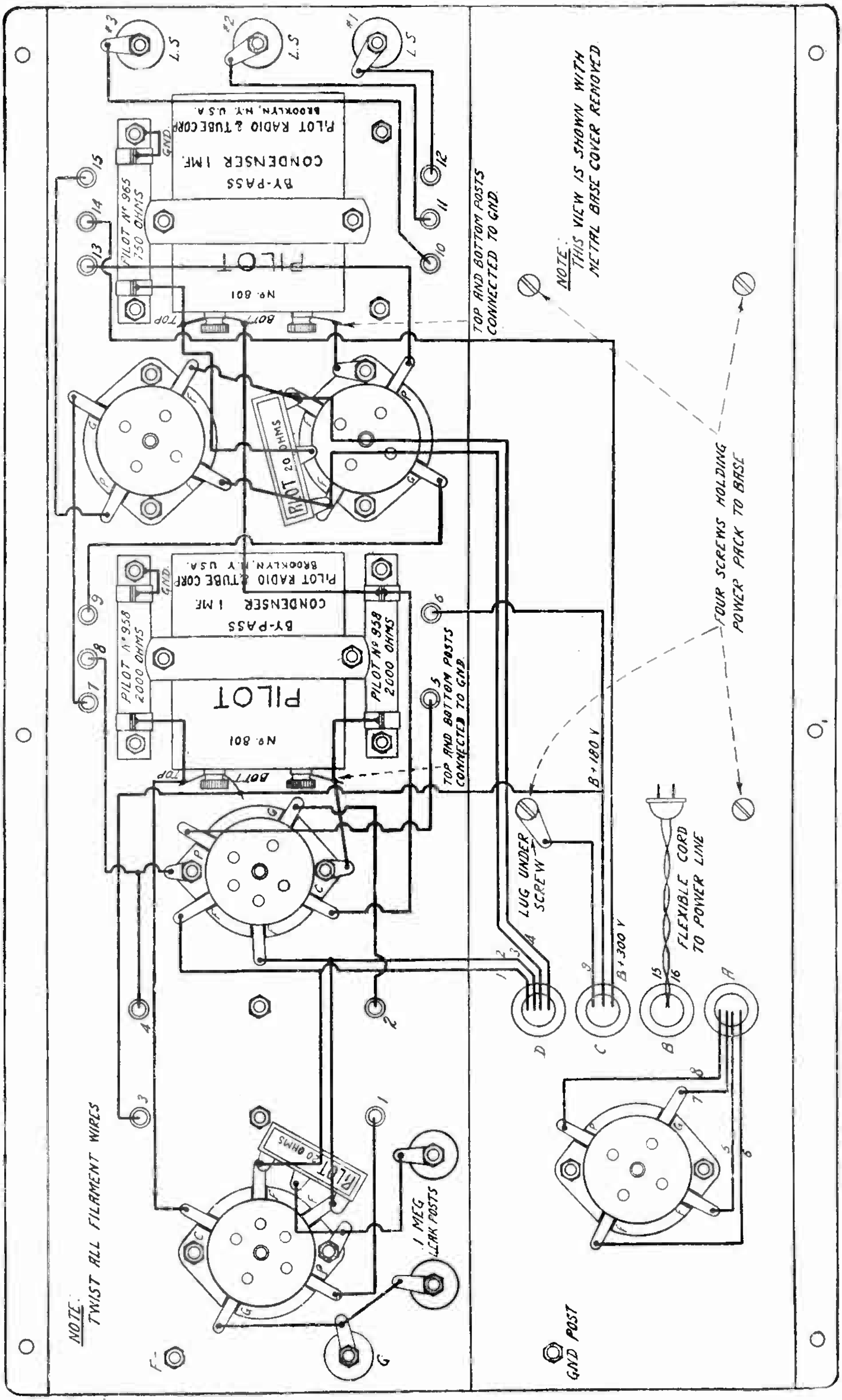
To make their identification easy, you will notice that holes which pass wires through the aluminum are marked with corresponding numbers in the top and bottom views. However, the numbers next to the wires coming through the large holes A, B, C and D correspond to the markings on the K-112 terminal plate.

The last wires to be connected are the 110-volt cords, which run through hole B

(*Continued on page* 80)



Top view of the K-113 amplifier reduced to scale. Study this carefully for the placement of the parts. Where a wire disappears through a numbered hole in the base-panel, it reappears in the bottom view (shown below) with the same hole marked with the same number. Note that the Resistoblock holds the .1 megohm Resistochoke in its left pair of clips.



What you see when you turn the amplifier over to rest on the side of the K-112 power pack. Study all the little notations before doing any assembling, and you will save yourself work later. Twist together the filament wires, 1 and 2, and also 3 and 4, coming out of hole D. Nothing is connected to the F— and "Grid" posts; they contact merely with the aluminum base-panel.

Radio Helps Explorer in the Jungle

Dr. and Mrs. Herbert S. Dickey. Mrs. Dickey was the first white woman to enter the land of the head hunters in South America.

WHEN Dr. Herbert S. Dickey, explorer of world-wide renown, left New York this Spring on his eighth expedition into the wilds of South America, he took with him a complete Super-Wasp receiver, a donation of the Pilot Radio & Tube Corporation. It was his intention to use the set for the reception of radio time signals, by means of which he could check his chronometers and thus be able to determine accurately his position in uncharted territory. His purpose on this expedition was to map the source of the mysterious Orinoco River, in Venezuela, and to study the Indians inhabiting the territory.

As companions on his hazardous journey Dr. Dickey had Sidney F. Tyler, Jr., who acted as his assistant, and Charles F. Polsten, as radio operator and navigator. They were the only white men in the original party, which also included a number of Indians. Later they picked up an itinerant Spaniard named Felix Cardona, an ex-sailor who had been prospecting unsuccessfully for diamonds in the vicinity of the Orinoco. Dr. Dickey returned to New York on August 15th, and through his kindness we are able to describe some of his experiences with the radio set in the jungles.

Leaving New York on the steamer "Dominica" of the Furness-Trinidad Line, the party reached the Port of Spain, Trinidad, off the northern end of South America. Here it boarded the steamer "Delta", which took the explorers 300 miles up the Orinoco River to Ciudad Bolivar, from which the actual expedition started. While in this city Dr. Dickey wrote the following letter, which is self-explanatory:

Dickey Orinoco Expedition.
c/o American Vice Consul,
Ciudad Bolivar, Venezuela.

Pilot Radio & Tube Corporation,
Brooklyn, N. Y.

Dear Sirs:

In thanking you for your gift of a Pilot Super-Wasp to my expedition, I wish to state that this set has given us the greatest satisfaction. We assembled it shortly after arriving at this place and have been enjoying programs from all over the United States since that time.

Your apparatus will not only be of incalculable value to us in getting time for our observations, but will also prove a very welcome addition to our scant means of entertainment when we are in the wilds of the Upper Orinoco.

Reiterating my thanks, I am,
Sincerely yours,
Herbert Spencer Dickey.

The Super-Wasp itself was carried in a double box. The inner one was a misfit radio cabinet picked up by Mr. Polsten on Cortlandt Street, New York's "Radio Row", just before sailing. This was in turn supported inside a packing case fitted with hinges. For "A" supply, fifty dry cells of standard No. 6 size were taken, as the weight of a storage battery and a charging generator made these more desirable accessories impracticable. A group of four batteries at a time was used, and then simply discarded after the cells became exhausted. A set of cells gave an average of 25 hours service. A bank of heavy-duty Burgess "B" batteries furnished the plate current. Three pairs of earphones, one for each member of the party, were carried.

For an antenna, Mr. Polsten used two lengths of flexible insulated wire, one length as aerial and the other as counterpoise. The aerial wire was thrown over trees and bushes and the counterpoise simply stretched on the ground, whenever a stop was made.

MUSIC IN THE WILDERNESS

Although Mr. Polsten is an experienced radio operator, he made no attempt to copy any of the hundreds of radio-telegraph stations he heard, as Dr. Dickey and Mr. Tyler wanted to hear voice and music, which they could understand. The set proved its efficiency on the short waves by bringing in stations like PCJ, in Holland, 5SW, in England, and the short-wave transmitters of KDKA and WGY in our own United States. Although the static was terrible most of the time, the signals came through loud and clear, and frequently with loud speaker strength.

Needless to say, the men were delighted, as they were kept in close contact with civilization although they were many miles from the nearest settlement. The cheery voices of the announcers and the pleasant strains of the music did much to relieve the discomfort of the drenched and insect-infested camps that were made along the turbulent Orinoco.

Traveling in a sailboat equipped with an outboard motor, Dr. Dickey and his companions managed to reach a point 1200 miles up the river from Ciudad Bolivar in the time of one and a half months. On July 11 the motor broke down, and the expedition was forced to turn back because it could not obtain Indians to row the craft against the current. One of those perennial South American revolutions had flared up during the course of the trip, and the natives were so frightened by the disturbance that they took to hiding or were conscripted into what passes for military service. As the white men were sick from fever, they could not battle the rapids themselves and they had no choice but to return, although they probably could have reached their goal in another week.

On July 20, while encamped along the river, the intrepid explorers experienced one of their greatest thrills; they heard a radio program from KDKA addressed especially to them. For a time before the transmission started the static was so bad that it threatened to ruin all reception, but it cleared miraculously and allowed the malaria-stricken men to hear messages from their own homes.

The expedition finally drifted into Ciudad Bolivar on July 28, and its members left shortly for New York. Dr. Dickey, who has spent 28 years in the tropics, plans to return soon, to accomplish his mission.

SET CONQUERS STATIC

Mr. Polsten visited the Pilot plant to express the thanks of the expedition for the Super-Wasp. He was loud in his praise of the receiver, saying that of all the radio sets he knew of in Venezuela, it was the only one that worked through the static. This is no faint praise, for the static that abounds in the tropics is the most horrible in the world. It seems to permeate the whole atmosphere, and normally drowns out the strongest signals.

Naturally, we are quite proud about the way the Super-Wasp performed under such adverse conditions. Its operation is a credit to its design and efficiency.

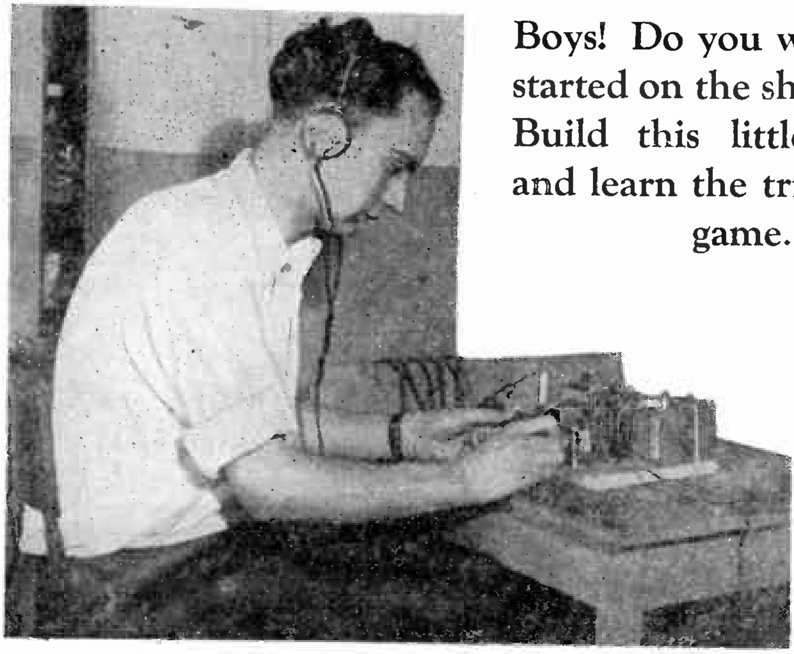
Short Wave Jottings, *by Robert S. Kruse*

(*Continued from page* 32)

bad because it introduces 60 cycle hum as well as R.F. This is frequently serious enough to cause modulation of the incoming signal. The R.F. choke is bad because its response at different wavelengths is not even.

Altogether the more satisfactory scheme is to use a tuned input as shown in Fig. 4C, which also gives the constants. The resistances in the filament circuit are the usual biasing resistances employed with the 222 and are found in convenient form in the Pilot No. 961 resistor.

As usual, the diagram does not show everything and unless the stage is shielded thoroughly its main effect will be to trigger the whole set into oscillation. Indeed both this stage and the main set must be *more carefully* treated than the set alone, since the overall gain is higher. If you have ample patience the addition will amuse you.



Boys! Do you want to get started on the short waves? Build this little receiver and learn the tricks of the game.

The "Workshop Special" is small, but it works. This boy built one and enjoys it greatly.

THE "Workshop Special" is a simple, inexpensive little short-wave receiver that can be thrown together with odd parts such as are found in every experimenter's workshop junk box. Although it does not approach the famous Super-Wasp in general efficiency, it makes a very fine little set for the school boy who has little money to spend or for the man who would like to try his hand at short-wave reception but doesn't want to invest in a larger receiver. It works quite satisfactorily on small dry cells, and the whole outfit, including batteries, fits on a board the size of an ordinary letterhead, 8½ by 11 inches.

COSTS LITTLE

Even if you have to go out and buy all the parts, you will still receive change from a ten dollar bill, and that takes in tubes, batteries, earphones and everything. You can surely pick up odd sockets and some kind of an audio transformer from among your friends or you may have them kicking around in your own junk collection. You can assemble, wire and have the set working in two hours, and I guarantee you'll get a barrel of fun out of it.

If you are a transmitting amateur, you'll find the "Workshop Special" a dandy monitor. Being small and compact, you can keep it out of the way of your other apparatus.

The "Workshop Special" is the simplest and most elementary form of short-wave receiver, and is well suited as a construction exercise in school shops. Since so many boys from the age of 12 up have a natural interest in radio, manual training teachers will find them quite enthusiastic about making a little set like this.

In constructing the receiver shown in the accompanying illustrations, the writer used Pilot parts throughout, because these are cheap and can be obtained everywhere. Check off the parts you have on hand, and borrow or buy the others.

THE PARTS USED

The following parts (or their equivalent) are needed: Wood baseboard 8½ by 11 inches, any thickness (½ or ¾ inch preferred).

1—Pilot J-13 and 1 J-23 midget condensers.
1—No. 920 rheostat (20 ohms).
1—No. 413 audio transformer. (Any transformer at all will do).
1—No. 217 five-prong socket. (For the plug in coils).
2—No. 216 four-prong sockets. (For the tubes).
3—No. 185 blank coils forms.
1—.0001 mf. grid condenser, with grid leak clips.
2—4½-volt "C" batteries.
2—Small size 22½-volt "B" batteries.
2—UX-199 tubes.
1—Pair earphones.

The layout of the parts is exceedingly simple, and is made clear in the illustrations on pages 78 and 79. The first thing to do is to make three little L-shaped brackets out of brass, about two inches high, one inch wide, and with the foot an inch long. These are used to support the midget condensers and the rheostat along the long edge of the baseboard. The J-13 midget, which is used as the tuning condenser, is

The "WORKSHOP SPECIAL"

Made of Odd Parts Picked Out of the Junk Box, this unique "Breadboard" set brings in Europe on two dry-cell tubes

by Robert Hertzberg

at the right end, the rheostat at the left, and the J-23 in the center. The J-23 is the regeneration control. It isn't necessary to provide the condensers with scales, as you can easily see the plates. However, if you want to fix up little scales of white cardboard, you can fasten them under the same nuts that hold the condensers to the brackets.

The five-prong socket is mounted just behind the J-13 midget, with its P and G terminals facing the latter. A lttle behind and to the left of this socket mount one of the four-prong receptacles, also with its P and G posts facing the front edge of the baseboard. Proceed with the audio transformer and the socket, with their posts facing as shown in the picture diagram.

The grid condenser stands upright between the first two sockets, being held in that position by the short wires connecting it to the P post on the five-prong socket and the G post on the four-prong.

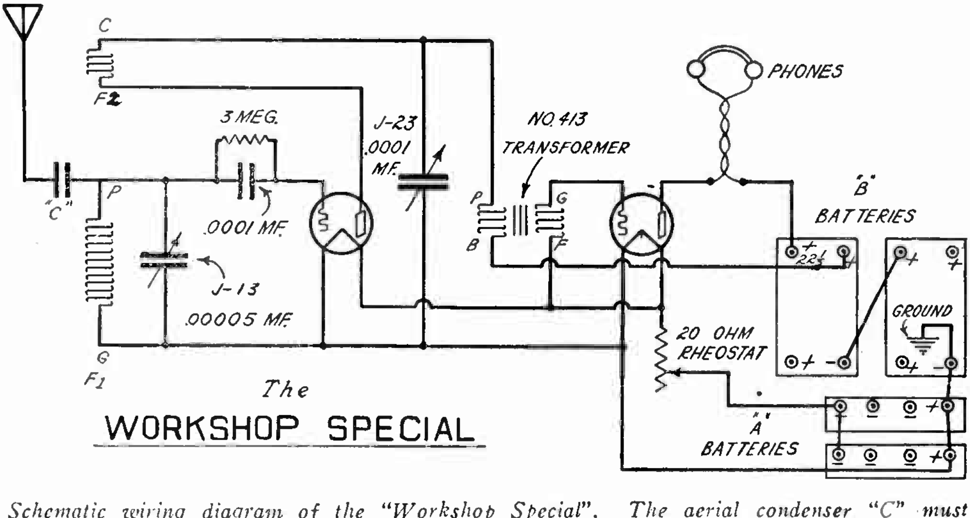
The "A" and "B" batteries fit along the back edge of the baseboard. Leave them off until you have finished the wiring. Then you can simply tie them down with cord, which is perfectly satisfactory, or you can devise clamps for them.

The wiring is easy, as there is so little to be done. Notice that there are no binding posts, all the battery wires being brought right up to the battery terminals. The wire from the rheostat that goes to the "A"— is fitted with a clip, as is the one from the "B"+ post of the audio transformer. These clips make a switch unnecessary; to shut off the set really completely, so there will be no possibility of running the batteries down, merely unhook the clips from the battery terminals and snap them on the cord that ties the batteries down. The rheostat, in its off position, also shuts the set off.

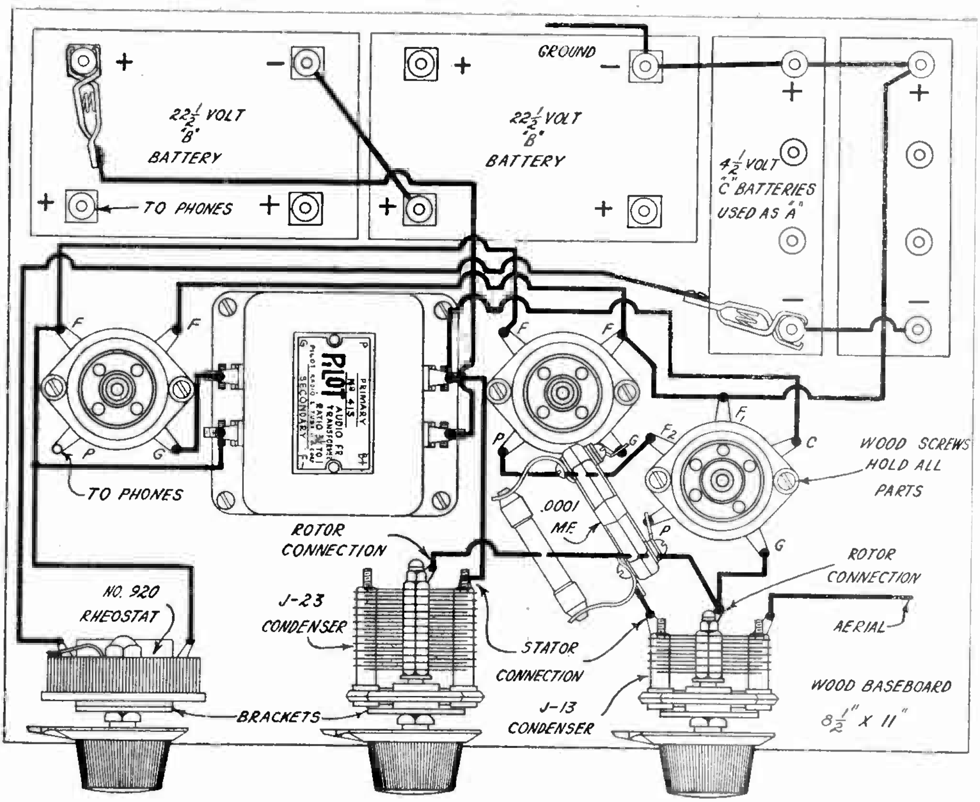
Put clips on the earphone cords also. Snap one directly on the P terminal of the amplified tube socket and the other on the "B"+ post on the extreme left, and you're ready to listen.

WINDING THE COILS

The winding of the three plug-in coils will take only a few minutes. Each form has a grid coil and a tickler, connected to the pins in the base as shown in the sketch on page 80. For the wire, you can use any size larger than No. 28 and smaller than No. 16. No. 24 is a handy size, as a lot of



Schematic wiring diagram of the "Workshop Special". The aerial condenser "C" must be of very low capacity; see text for details.



Picturing wiring diagram of the "Workshop Special". Simply clip the earphones to the P post on the socket on the left and to the plus post of the second "B" battery.

this wire is used for broadcast coils. If you don't want to buy a spool of new wire (you need only a few yards) strip an old R.F. transformer.

Coil A, which tunes from about 18 to 29 meters, has 6½ turns on the grid coil and 4 on the tickler. Coil B, which tunes from 29 to 43 meters, has 10 grid and 7 tickler. Coil C, which covers 43 to 68 meters, has 17 on the grid winding and 7 on the tickler. The direction of winding is unimportant, but whichever direction is adopted must be followed for the two windings of each coil.

You will notice that the bottom end of the grid coil connects to two pins, numbers 1 and 2. This is done merely to shorten the wires from the five-prong socket to the tube socket and to the condensers. In the schematic diagram the ends of the coils are marked with the letters that appear on the terminals of the five-prong socket, as it is to these terminals that the actual connections in the set are made. In the sketch showing the coil construction, the ends of the wires are marked with the numbers molded into the base of the plug-in forms. Pin number 1 corresponds to G on the socket, 2 and 3 to F1 and F2 (see picture diagram), 4 to P and 5 to C. This sounds complicated, but when you look at the coils and sockets it will all be very plain.

These three coils cover all the important short-wave channels, taking in thousands of telegraph and all the short-wave broadcasting stations of the world. It can be made to tune higher by means of additional coils, but there really is nothing much to listen for above 70 meters except a lot of telegraph signals. The three coils make a good starter; if you want to do more ether exploring you can wind larger coils.

SMALL AERIAL CONDENSER

To operate the "Workshop Special" you must observe a few simple precautions. First of all, you don't need much of an aerial. If you already have one up and can use it without disturbing the regular broadcast receiver to which it is attached, you must couple it to the grid of the detector tube through a very small condenser. No factory-made condenser is small enough. and we can't recommend a specific size because it will depend on the particular aerial being used.

A trick that is both simple and effective is to connect a piece of insulated wire about a foot long to the stator plates of the J-13 condenser, and to merely twist the aerial lead around it once or twice without making an actual conductive connection. With the tubes turned on, you can tell when you have too many twists by the fact that the set will refuse to oscillate. Start out with no aerial but the one foot length, and make sure you get good oscillation with all three coils. Incidentally, you will be surprised at the number of telegraph stations and carrier-wave whistles that you can pick up with just this short wire alone. The writer, who lives in upper New York City, actually heard a program from G5SW, England, with a piece of wire only three feet long hanging off the edge of a kitchen table. Of course, the voice and music was weak, but it was England all right.

IT RECEIVED EUROPE!

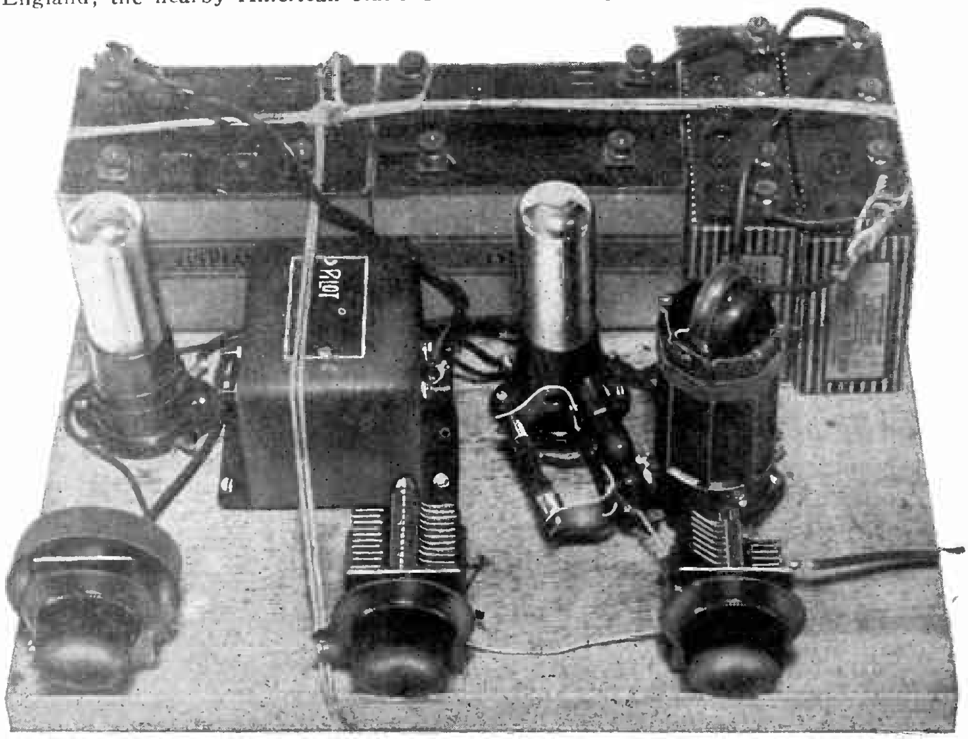
A piece of lamp cord twenty feet long, just dangling from a fourth floor window, produced as good results as an 85-foot aerial running twenty feet higher to the roof. In connecting it to the set, the writer merely bent the end of the wire and hooked it around another wire fastened to the stator of the J-13 condenser. The wires were not connected; the slight capacity effect alone was enough to transfer the high-frequency energy from the aerial to the set.

This arrangement brought in PCJ, Holland; W6XN, Oakland, California; G5SW, England; the nearby American stations in **Pittsburgh** and Schenectady (all broadcasting voice and music), and amateur and commercial telegraph stations by the hundreds, from all over the world. It is trickly work "fishing" for them, but they can be received.

All the usual rules about regeneration control and zero-beating must be observed in the operation of the "Workshop Special". (See detailed articles in Spring and Summer issues of Radio Design). The set is working best when, with the J-13 at maximum capacity (plates all in) with any one coil in the coil socket, it goes nicely into oscillation when the J-23 condenser is turned to full capacity. If the set "plops" into regeneration with the J-23 only partly in, remove a turn at a time from the tickler until the aforementioned operation is obtained. If it oscillates on the high wavelength end of the coil, it will work without trouble as the tuning condenser is turned down.

The detector plate voltage is a matter of experiment. Most small size 22½-volt "B" batteries have two or three taps on them, so you can try voltages from 4 up to the full 45 of the two batteries in series. The filament rheostat is not critical. As the "A" batteries wear out, it is advanced to keep the tubes at the right voltage.

The grid leak likewise is something that must be played with. The writer found



The simple construction of the "Workshop Special" is made plain in this picture. Note how the batteries are tied down by cord.

that 4 megohms was about right for three different 199's. If the leak is too high, the set will explode into a loud growl on the point of oscillation, instead of sliding gently into the soft hushing noise characteristic of regeneration.

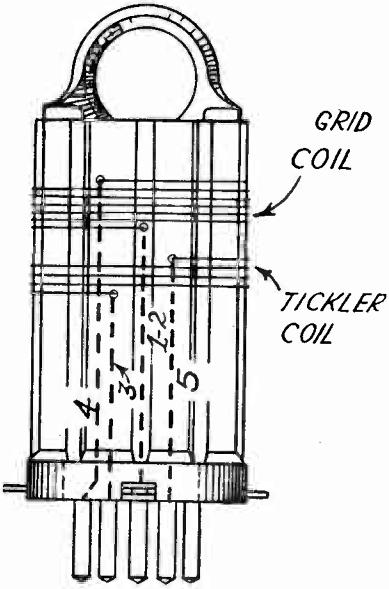
Unfortunately, most of the short-wave broadcastng stations of the world transmit on an experimental basis, and it is impossible to obtain a reliable schedule of their activities. However, the following table will be of some assistance when you are "fishing" around:

Coil A, 18 to 29 meters: with the J-13 condenser about three-quarters in look for stations G5SW, Chelmsford, England, 25½ meters; and CJRX, Winnipeg, Canada, just a fraction of a degree below. Condenser about all in, 2ME, Sydney, Australia, 28½ meters. Condenser near zero, PCL, Kootwijk, Holland, 18 meters; and the transatlantic radio telephones in New Jersey and in London.

Coil B, 29 to 43 meters: condenser about half way in, PCJ, Eindhoven, Holland, 31½ meters (this is the best of the short-wave stations); 3LO, Melbourne, Australia, 31½ meters; NRH, Costa Rica, Central America, about 30 meters, (a little 7½-watt station that reaches everywhere); W2XAF, Schenectady, N. Y., 31 meters; W6XN, Oakland, California.

Coil C, 43 to 68 meters: near the top of the condenser, W8XK, Pittsburgh, Pa., 62½ meters (very reliable in the U. S.); W2XE, New York, 58 meters.

There is one important thing you must be cautioned about: don't expect to bring in Europe the first night you listen. The short waves are decidedly tricky, and you can run by stations a dozen times without knowing it. If you exercise a little patience and play with the set frequently, you will soon learn the tricks. It seems incredible that a little instrument like this can bring in stations thousands of miles away, but it certainly does.



NO. 185 COIL FORM

Details of the plug-in coils.

The K-113 Push-Pull Amplifier for 245 Tubes

(*Continued from page* 71)

and connect to the line terminals on the K-112, marked 15 and 16. Pull the cord out to the right or left, as you prefer, and then finish the whole amplifier by screwing on the flat aluminum base.

A special .1 megohm fixed resistance was designed for use in the resistance-coupled stage of the K-113 amplifier. This is known as the Resistochoke, and fits in the left pair of clips of the Resistoblock. Being wound with wire, it will withstand the plate current of the 227 without changing in any way. It is far superior to ordinary grid leaks for the purpose, as the latter soon disintergrate and become very noisy.

The operation of the K-113 is very simple, as there is nothing to turn or adjust. You simply connect it up, and if the tubes are good the voice or music will pour right out of the loud speaker.

Any kind of a speaker may be used, although a good dynamic will give the best all-round results. You can connect it to the output transformer in three different ways; to posts 1 and 2, 1 and 3 and 2 and 3. Try all three combinations for fifteen or twenty minutes each and use whichever one seems to sound best.

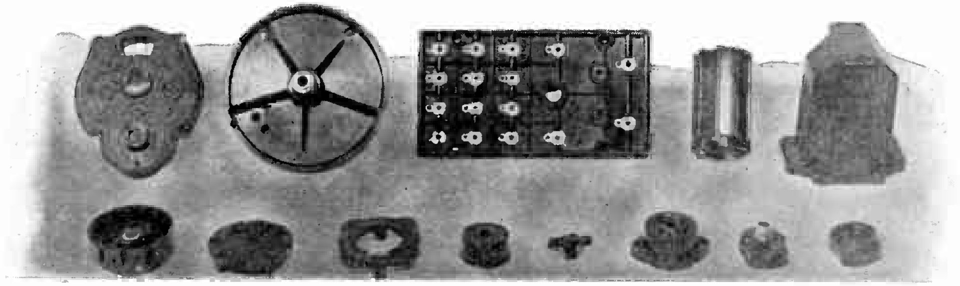
To use the K-113 with a radio receiver, it is best to make the first 227 a resistance-coupled tube by connecting an external blocking condenser of any size between .01 and .1 mf. between the G post and the plate of the detector tube, with a .1 megohm plate resistor to feed plate voltage to the detector. A 500,000 ohm Volumgrad may be connected as a volume control, as shown on page 71.

This diagram also shows how a simple three-point switch may be used to switch the amplifier from the radio set to phonograph pick-up or to a microphone, if all three systems are to be used. A two-point switch will serve if only the radio set and the phonograph pick-up are used, as they would be in the ideal combination for the home. For public address work in small theatres, dances halls, soft-drink parlors, etc., the microphone is very desirable for the purpose of making announcements.

How Bakelite Radio Parts are Molded

No. 3 of a series of trips through the Largest Radio Parts Plant in the World

by ALFRED A. GHIRARDI



A group of Pilot parts molded of solid Bakelite. Top row (left to right): art dial, drum dial, terminal plate, coil form, transformer case. Bottom row: Volumgrad form, socket parts, and snap switch.

TO the average American, the sight of Bakelite in one form or another is a common, everyday experience. It is used for shaving brush handles, coffee percolator tops, pipe stems, fountain pens, telephone receiver and transmitter cases, in radio receivers and for thousands of other purposes. The processes by which this versatile material is made into useful articles are not complicated, but nevertheless very few people are familiar with them. It is the purpose of this article to explain in simple language how the hundreds of different Bakelite molded parts used in Pilot radio apparatus are made in the world's largest radio parts plant. Every Bakelite molded part is made right in the plant, in keeping with the Pilot policy of producing every part under one roof under the constant supervision of trained engineers.

For those readers interested in the "how" and "why" of things we will first explain just what Bakelite is and the reasons for the various manufacturing processes.

WHAT BAKELITE IS

Bakelite, an American product, was invented by Dr. L. H. Baekland in 1907 after exhaustive research. The principal ingredients used in its manufacture are phenol (commonly called carbolic acid) and formaldehyde. Phenol is obtained from coal tar and formaldehyde is made from wood alcohol. Under certain well defined conditions these two odoriferous materials combine chemically to form a solid, resin-like substance differing in every way from the ill-smelling liquids from which it is made, a substance that is odorless and tasteless, and possessing altogether different chemical and physical characteristics. This resinoid is the starting point for all Bakelite products.

Molding material is prepared by mixing the original Bakelite resin with various filling ingredients, such as wood flour, asbestos, etc. Suitable coloring pigments are employed to produce various color effects. Thus in the Pilot factory black Bakelite is used for sockets, coil forms, dial drums, etc.; mahogany or walnut for dials and knobs; and yellow, red, green, orange and blue Bakelite for the handles on short-wave coils.

The filling ingredients are mixed with the Bakelite resin and ground together for hours. The resulting powder is then run between hot rolls, causing the wood-flour to be thoroughly impregnated by the molten resinoid. Sheets of material resulting from this operation are ground to a powder which is then sifted and thoroughly mixed to insure uniformity. This powder constitutes the molding material ready for the market, and it is in this form that the Pilot company receives the raw Bakelite in steel drums from the Bakelite Corporation.

MAKING THE PRE-MOLDS

The first step in the Bakelite molding department of the Pilot plant is shown in the photograph, Fig. 1. Rather than use the old-fashioned method of pouring the powder into each mold separately, practically all parts are made from preformed "pills", "biscuits" or "pre-molds" of compressed Bakelite powder of the ex-

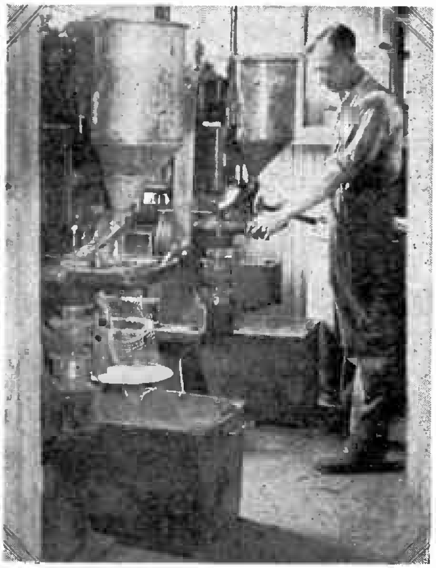


Fig. 1: Pre-mold machines which prepare the Bakelite for the molding presses.

act weight required for the object to be molded. These are made by the pre-mold machines pictured in Fig. 1. They consist of a metal hopper containing the Bakelite powder and a mold of the size and shape best suited for the particular object. The machine is motor driven and automatic in its operation. Several machines require only one operator to fill the powder hoppers and remove the pre-molds when the receptacles are full. The correct quantity of powder is put into the mold and then it is compressed to a self supporting "biscuit" or pre-mold. By using these pre-molds the Pilot company has eliminated waste due to defective parts caused by either too much or too little Bakelite powder. Each pre-mold contains the exact amount of powder required for the object.

The next stop is the actual molding. The pre-molds of compressed powder are put into the lower half of a heated mold. The molds are made of hardened steel and are mounted in powerful presses. Provision is made for heating the molds to the exact temperature of 350 degrees Fahrenheit, required for the chemical change which the Bakelite undergoes.

The press forces the two halves of the mold together and as the temperature rises the resinoid binder first melts, while the steadily increasing pressure forces the plastic mass into every crevice of the mold cavity. Only a few minutes are required at a pressure of 2,000 pounds per square inch to cause the resinoid to be transformed into its permanent, strong, infusible, insoluble state.

The pre-mold has been transformed into a solid mass as a result of the chemical reaction produced by the combined heat and pressure. We thus have the peculiar phenomenon of a material solidifying or "freezing" by as much heat that initially softened it.

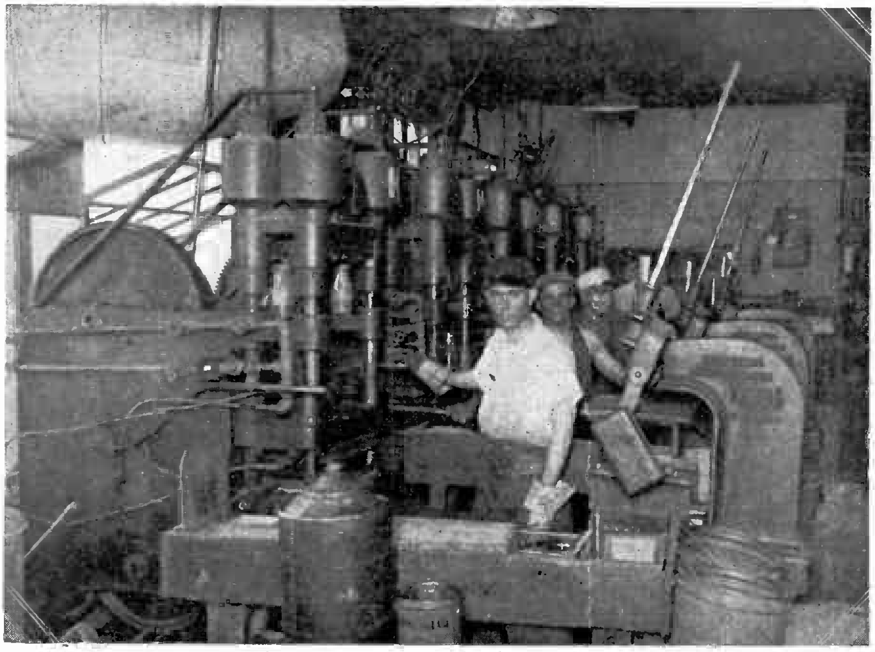


Fig. 2: A battery of five Terkelson mechanical Bakelite molding presses.

The molded parts as they come from the molding machines are examined by inspectors and defective parts are immediately destroyed. Some parts require slight finishing, but most of them are ready for assembly when they come from the presses. The parts leave the hardened and polished molds exact and accurate in their dimensions and faithfully mirror the lustre of the mold surface. Even the minute markings and graduation on dials are produced in the molding operation as accurately as though machined.

MULTIPLE CAVITY MOLDS

In line with the idea of quantity production of high grade parts at low cost which prevails throughout every department of the Pilot plant, Bakelite parts are not molded one at a time. Practically all the molds are made with multiple cavities, so that many parts are molded during each operation of the press. The number of parts made at a time depends upon the size of the part being made. For instance, the binding post dies mold 55 binding posts at one time. Cases for the No. 390 series of audio transformers are made four at a time in the four gang mold illustrated in Fig. 3. Drum dials are also molded four at a time in the mold shown in Fig. 4. Thus the output of each molding cycle is increased without increasing the cost of operation of the molding machines.

METAL INSERTS

One great advantage resulting from the use of molded Bakelite parts is the fact that metal parts may be embedded in the product at the time of molding, thus saving much labor and expense over the method of doing this work by hand after the molding operation has been completed.

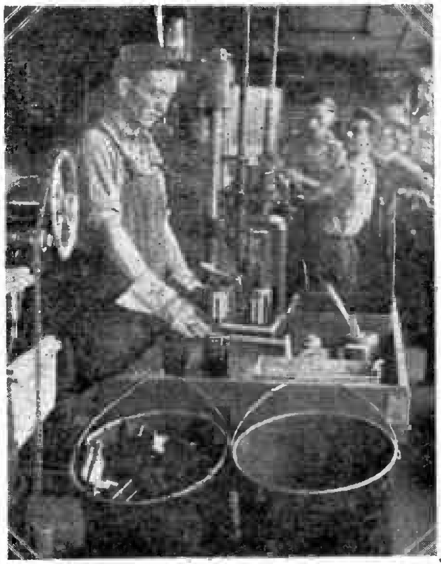


Fig. 3: Removing four Bakelite transformer cases from the die.

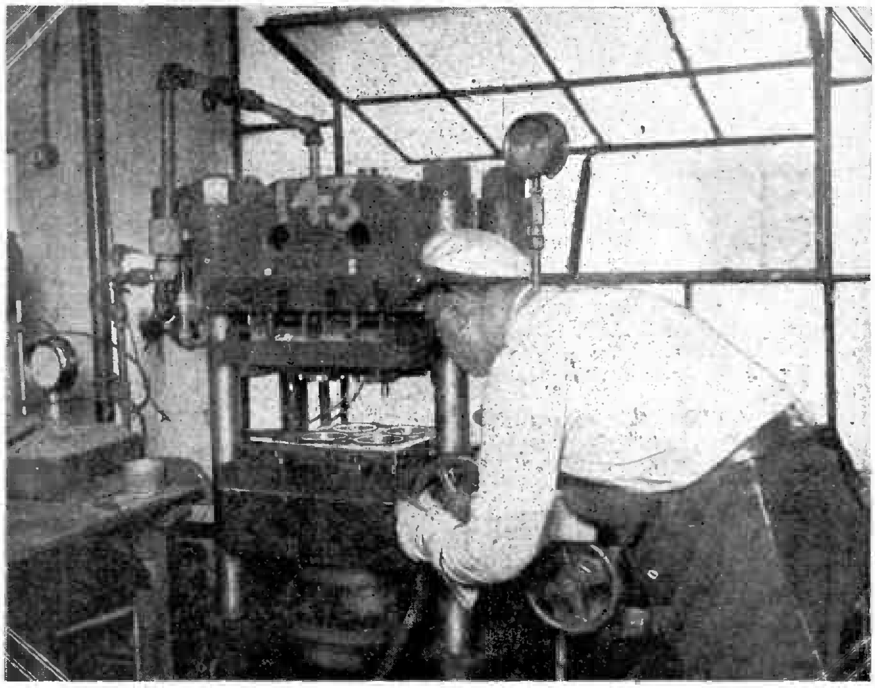


Fig. 4: A hydraulic molding press capable of exerting a pressure of 120 tons.

Look at a Pilot knob or dial. That metal bushing in it was molded into the Bakelite in one operation!

The photograph of Pilot Bakelite parts at the head of this article illustrates the use of metal inserts. The flat piece of Bakelite in the upper center of the picture is a terminal plate for the new K-111 and K-112 power packs. The sixteen drilled and plated brass metal connection tabs are molded into the Bakelite plate at the time it is made. Notice the cross-ribbing scientifically placed for strengthening the plate. You would have to break the plate to get one of those inserts out. Moreover, the heat from the soldering iron used to solder the wires to the connection tabs later will not soften the Bakelite or loosen the tabs.

MOLDING PRESSES

The twenty-two molding presses used in the Pilot plant are of two types, mechanical and hydraulic. The layout employed in the press room is a result of a long study by the Pilot engineers. The relative arrangement of the presses, the mold loading tables, the die strippers, the inspection tables, all have been carefully planned so that there is practically no waste of time or no unnecessary handling operations between the time the pre-molds are made and the finished molded product is loaded on to the belt conveyors for distribution to the various assembly departments.

MECHANICAL PRESSES

Fig. 2 shows a battery of five Terkelson mechanical presses. Continuous or follow-up pressure is obtained in this type of press by the use of four powerful springs enclosed in the cylinders at the top of the machine. By applying the pressure through the springs, the line pressure is maintained during the curing process. To operate the press, the operator loads the mold and places it between the two platens of the press. Then he grasps the curved safety release lever on the right and the straight starting lever on the left. This throws in the electric motor on the base, normally running without load, and the horizontal arm on a toggle moves the upper die block downward, first quickly and then slowly for the last ⅜ inch.

An automatic regulator throws out the clutch when the correct pressure is obtained, allowing the motor to run free again. The operator can read the pressure by a dial mounted in front of the machine. The springs then maintain the correct pressure, which can be set for one to about fifty tons. Heat for the chemical reaction is applied to the mold by steam. To release the press, the safety lever is again thrown out, and the starting lever opened. The mold is then lifted out and the work extracted.

To increase production, two molds are made for each machine. While one mold is in the machine, the operator strips the work from the other and loads it with the raw pre-molds. In this way the presses are kept working practically continuously. The arbor presses shown at the right of Fig. 2 are used for separating the molds and pressing the finished pieces from them.

HYDRAULIC PRESSES

Figs. 3 and 4 show some of the Dunning and Boschert hydraulic presses used. These consist essentially of two pressure surfaces which are brought together and held in that position by means of a ram acting in a steel cylinder. Water forced into the cylinder under the ram by means of a small hydraulic pump builds up the necessary pressure to force these platens together. When this pressure is released, the water flows back to the pump reservoir and is used over and over again. The plates are heated to the required temperature by steam.

The press shown in Fig. 4 is capable of exerting a total pressure of 112 tons. After the pressure has been applied and the Bakelite formed, it may require as much as five tons of pressure to separate the two halves of the mold. The molds can be opened on the smaller press by merely opening a valve to release the pressure acting on the ram. Then the weight of the ram, the table and lower half of the mold are sufficient to cause the mold to open. On the layer presses a special valve is opened to create a hydraulic pressure to move the lower table of the press down and open the mold. In these presses as the entire molds are large and too heavy for convenient handling, the two halves of the mold are made so that the upper part is smaller than the lower and can be slid in and out from the upper platen of the press for removing the Bakelite pieces. The lower half of the mold is loaded with the pre-molds. Fig. 4 shows a hydraulic press with a mold for forming four Pilot drum dial wheels in one operation. Fig. 3 shows a mechanic stripping the Bakelite audio transformer cases from a four gang mold.

In all of the presses used in the Pilot plant, the molds are heated indirectly by steam which is generated in gas fired boilers. After the steam has given up most of its heat to the mold it is returned back to the boiler. Thus the heat which it still contains is made use of and not wasted.

PRODUCTION SCHEDULE

In the Pilot factory the Bakelite molding presses are on a mass production schedule, and are in operation twenty-four hours a day for a large part of the season. As many as 34,000 pieces have been turned out in a single day, every one under the control and rigid inspection of the Pilot engineering staff.

No EXPERIMENTER, SERVICE MAN *or* CUSTOM *Radio Builder Can Do Good Work Without*

METERS

This article describes the most important types and tells you how to use them

A VOLTAGE indicating device is an essential part of every good radio receiver installation and of every service man's tool kit, since it is an aid toward the protection of the radio investment and is a means of attaining best receiver performance and greatest return for the financial expenditure involved. The service man or custom set builder who attempts to work without measuring instruments of some kind is working blindly, in the dark, and is wasting good time.

The performance of any receiver is governed largely by three factors: filament, grid and plate voltage. Insufficient filament voltage, biasing voltage or plate voltage will mar the operation of the receiver and cause serious distortion, which is unforgivable in these days of high-quality reproduction. Excessive voltages, on the other hand, actually endanger the tubes and shorten their lives, and cause distortion and general instability. How is one to know the applied voltages without a voltage indicating instrument? All "A" supply units do not provide indentical voltage; neither do all "B" power packs furnish the same values of plate potential.

LINE VOLTAGES VARY

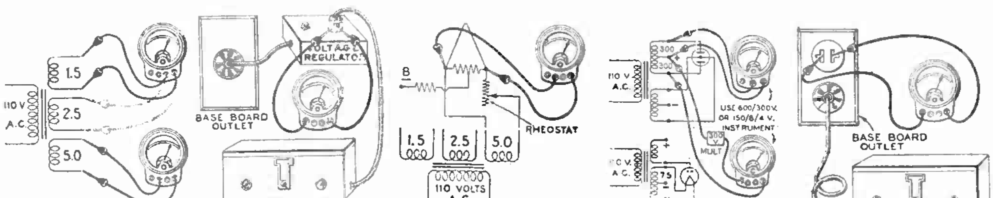
These statements apply particularly to receivers working off house power lines, of either alternating or direct current nature. Even in large cities, where the power house generators are closely watched all the time, changing voltages at the outlets in the home cause trouble. In suburban sections, where the line voltage may be 115 in the afternoon and 98 in the evening, readings with accurate meters must be taken nightly to insure satisfactory results from the loud speaker and decently long life from the tubes.

A HANDY A.C. METER

The filament, grid and plate voltages of an A.C. receiver are usually obtained from the same power source, and therefore all three will vary with the input voltage. The only way to keep check on them is to use multi-range A.C. and D.C. voltmeters of suitable construction. The Weston model 528 A.C. instruments and the model 489 D.C. instruments were designed especially for the purpose, and RADIO DESIGN recommends them because they have been found so extremely valuable both in the laboratory and in the field.

The particular A.C. meter we have found most useful is the one having three scale readings, 0-4, 0-8 and 0-150 volts. Four pin jacks on the molded bakelite case, in conjunction with a pair of flexible cables 30 inches long, allow the use of any scale. The 150-volt scale is used for measuring the house line, which *must* be done when manually operated line-voltage regulators such as series resistances and primary taps are employed. Correct adjustment of the regulating devices is impossible otherwise.

The 0-4 volt scale is used to measure the filament voltages of 224, 226, 227 and 245 tubes, while the 0-8 scale is used for 112A,



Measuring Filament winding output voltage — *Checking line voltage control equipment* — *Adjustment of filament voltage rheostat* — *Measuring Plate Winding output voltage* — *Measuring line voltage*

Some of the uses of a four-range A.C. voltmeter.

171A, 210, 245, 250, 280 and 281 tubes. The importance of maintaining these tubes at their rated voltages cannot be emphasized too strongly. Proper regulation means long life and consistently good results; no regulation means short-lived tubes and much annoyance.

THE D.C. INSTRUMENT

The particular D.C. voltmeter which every radio man should own is the triple scale model 489, which has the high resistance of 1000 ohms per volt and requires only one milliampere of current to produce full-scale deflection. The model having scales reading 0-10, 0-250 and 0-750 volts is the most popular and widely used meter for general radio work. Like the A.C. meter, which has exactly the same appearance and is of the same size, it is equipped with convenient pin jacks and flexible test wires.

Its scope of utility, because of its high "ohms per volt" value, is very wide. As a filament voltmeter for D.C. tubes it affords very accurate readings. As a "B" eliminator meter it indicates the true output, because it does not draw enough current to affect the operation of the power unit. As a grid bias voltmeter it permits accurate adjustment of the grid bias resistance. Its low current consumption, due to its high resistance, does not materially affect the plate current flowing through the biasing resistor.

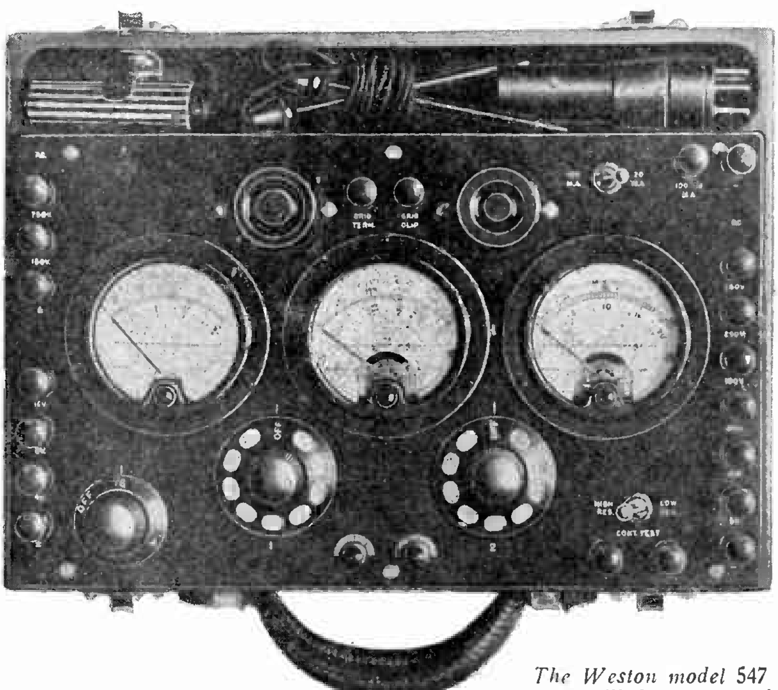
A voltmeter of this type is imperative when adjustment is being made on the plate voltage of A.C. tubes. The "B" potential flexibility of these tubes is rather limited, and if the voltages are not carefully adjusted the voltage ripple or "hum" will be troublesome.

For the man who appreciates the importance and value of measuring instruments, but does not want to spend a lot of money on them, the Weston model 528 and 489 voltmeters are the best investment. The first costs $16.50 and the second $28, and they are extremely desirable to anyone who plays with radio. A few of their applications are pictured diagrammatically on these pages.

A REAL TEST SET

The regular service man or the custom set builder who does service work should equip himself with something more than two separate meters like the ones just described. If he expects to be successful in his business he should invest a little more money in a complete test set like the Weston model 547, which is a real instrument intended for serious usage. The service man who owns such a set will be able to earn far more money than he would without it, as he can find trouble so much more quickly and definitely than with separate meters. Also, the outfit presents a fine appearance that invariably impresses the owner of the ailing radio receiver and gives him confidence in the service man's ability to do the job.

The model 547 is contained in a rugged bakelite case provided with a carrying



The Weston model 547 test set will find any trouble.

The model 533 tube checker. This is a convenient instrument for use on the dealer's counter. It works on the 110 volt A.C. line.

handle and a compartment for housing the set accessories, such as test cords, adapters, test battery, etc., and also a few small tools. It has a snap-on cover which can be removed to leave the meters fully exposed for quick readings. The overall size is 12-3/8 by 9 by 3¾ inches, and the weight is approximately 10 pounds. The panel on which the meters and control switches are mounted is of molded bakelite, as are all the other insulating parts.

THREE METERS USED

The instrument equipment consists of three 3¼ inch meters: an eight range D.C. model for 750/250/100/50/10/5 volts, and 100/5 milliamperes; a double range D.C. model for 100/20 milliamperes; and a five range A.C. model for 750/150/16/8/4 volts. All ranges with the exception of the 750/150 A.C. voltage ranges are made available by means of three rotary switches at the tester plug, which is permanently attached to the set by flexible cable. All voltage and the 100/20 milliampere ranges are also brought out to binding posts for use in making external tests using the flexible leads provided with the set.

Two sockets are provided on the panel, a UX and a UY. The tester plug has four prongs and an adapter is provided to change it to a five-prong plug. All voltage and the 100/20 milliampere ranges are brought out to binding posts. The D.C. voltage and current ranges are brought to binding posts at the right and the A.C. ranges to binding posts at the left. Two binding posts and a 4½ volt "C" battery are provided for use in making continuity tests with either a high or low resistance voltmeter (1,000 or 100 ohms per volt). The resistance is changed by means of a toggle switch.

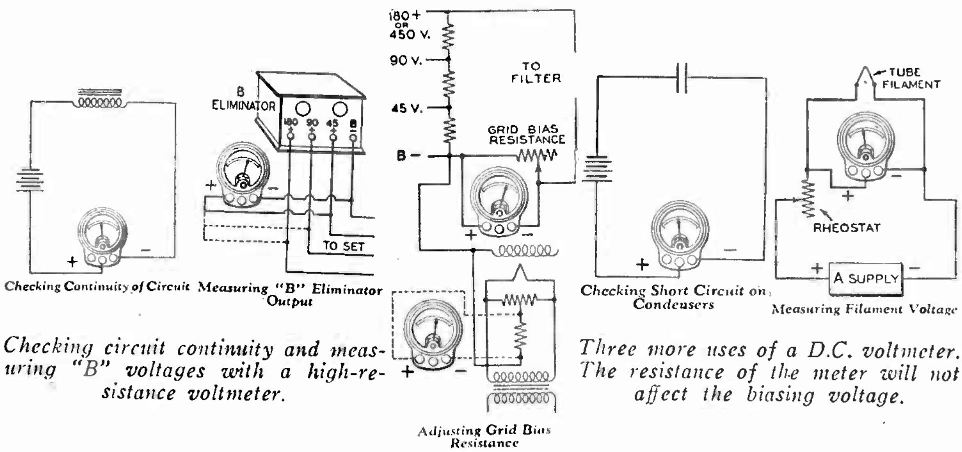
Simultaneous readings can be made of the heater voltages on the A.C. voltmeter and the plate current on the milliammeter, while plate, grid bias, cathode or sc- voltages or the grid screen or rectifier currents are being measured on the D.C. volt-milliammeter.

TESTS WITH TESTER PLUG INSERTED IN THE RADIO SET

1) Filament voltage, + 10 or — 10 volts on the D.C. voltmeter.
2) Heater voltages, 16/8/4 on the A.C. voltmeter.
3) Plate voltages, 750/250 volts on the D.C. voltmeter.
4) Bias voltages, for grid at tube base. ± 100 or ± 50 volts on D.C. voltmeter.
5) "C" bias voltages, D.C. sets with reversed filaments, 50 volts on D.C. meter.
6) Cathode voltages, + 50 or — 50 volts on D.C. voltmeter.
7) Control grid voltages, — 5 or + 100 volts on D.C. voltmeter.
8) Plate current ranges, 100/20 M.A. on the D.C. milliammeter.
9) Screen current range, 5 MA. on the D.C. volt-milliammeter.
10) Grid test on A.C. or D.C. screen grid tubes and '27 used as detector.
11) Simultaneous readings of the currents of both plates of full wave rectifier tubes.

EXTERNAL TESTS USING BINDING POSTS AND FLEXIBLE CABLES

1) Measurement from center tap of power transformer, 750 volts on A.C. meter.
2) Line voltage measurements, 150 volts on A.C. meter.
3) Heater voltages at power pack, 16/8/4 volts on A.C. meter.
4) Plate current at various "B" supply taps 100/20 MA. on milliammeter.
5) "B" supply at power pack, 750/250 volts on D.C. voltmeter.
6) "A" "B" "C" battery voltages, 50/10/5 volts on D.C. voltmeter.
7) Continuity tests, using the self contained 4.5 volt "C" battery and with either 1,000 or 100 ohms per volt resistance in voltmeter circuit.



Checking circuit continuity and measuring "B" voltages with a high-resistance voltmeter.

Three more uses of a D.C. voltmeter. The resistance of the meter will not affect the biasing voltage.

8) Resistance measurement; the voltmeter as used for continuity tests also serves as a direct reading ohmmeter. The instruction card carries a table which converts deflection in volts into ohms for the unknown resistance.
9) Values for condenser measurements (given in instruction book).
10) Measurement or trickle chargers and other devices; the milliammeter 20 range may be shunted for 10 or 2 amperes.

The versatility of this compact test set is what makes it so popular with service men. The instrument costs almost a hundred dollars, but it is the foundation of a real business and is therefore well worth its cost. Once a man has used one, he wonders how he ever got along without it.

A COUNTER TUBE CHECKER

The dealer who sells a lot of tubes (and what dealer doesn't?) will find that a counter tube-checker is quite a necessity. Instead of merely putting a tube in a set and hearing if it produces signals, it is much more effective from the sales standpoint to show its operation by meters, as well. The meters give an idea of the actual quality of the tube.

A convenient tube checker of a simple design is the Weston model 533, which costs considerably less than the 547 test set and can be kept permanently on the counter. This checker operates directly from the regular 60 cycle A.C. lighting line and is so designed that the circuit may have any voltage from 90 to 130 volts. It will check all tubes, A.C. or D.C., having filament voltages of 1.5, 2.5, 3.3, 5, or 7.5 volts, including filament type rectifier tubes, Kellogg tubes, and the A.C. or D.C. screen grid tubes with the aid of an adapter.

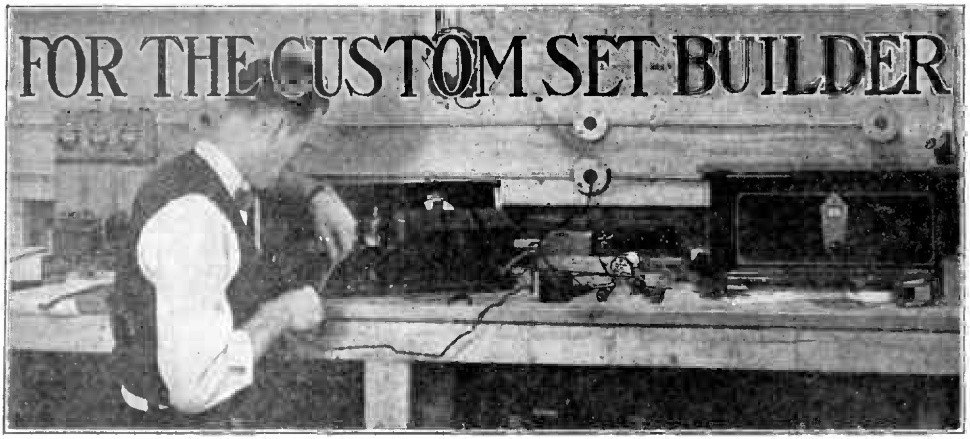
The checker is equipped with sockets for UX and UY tubes, a line voltage adjusting dial, a 5-point filament voltage dial, two push buttons, and two instruments: an A.C. voltage indicator and a double range D.C. plate milliammeter (80/20 M.A.).

OPERATION OF CHECKER

The operation of this checker is very simple, as follows: set the pointer to the arrow on the voltage indicator by turning the voltage adjusting dial; once this has been done it will only be necessary to change the setting when a change of line voltage occurs. Then insert the tube, set the filament voltage dial to the rated filament voltage and read the plate current on the D.C. milliammeter. Then press the button "Press for Grid Test" and obtain a second current reading. The greater the ratio of these two readings, the better the tube. When checking power tubes, the second reading is obtained by pressing the button "Press for 80 M.A. Range."

The condition of the tube will be determined by comparing the two readings with the values given on the instruction card furnished with the checker.

FOR THE CUSTOM SET BUILDER



EVERY custom set builder who has made, installed or serviced short-wave and broadcast receivers has had queer or unusual experiences. I'm going to tell about a few I've encountered, and I would like to have you write in and tell about any other interesting ones. Trouble has a habit of happening in bunches, and if you read about what one man did in a certain case, you may be able to apply the same remedies when you run into a similar trouble yourself.

* * *

A SET builder had assembled a Super-Wasp for installation in the country home of a well-to-do radio enthusiast. The set worked perfectly on his workbench, bringing in a number of European short-wave broadcasting stations with loud speaker strength.

The purchaser decided to have the receiver set up on a bridge table, as there was no other place for it. Accordingly, the custom builder hooked up the "A" and "B" batteries and was immediately rewarded with a series of crashes in the loud speaker. A few weak signals from a 50-kilowatt station about 40 miles away managed to filter through, but the noise made real reception impossible. Puzzled, the builder disconnected the batteries, turned the set on one end, and tested every connection through with a battery and voltmeter. Everything was perfect. Back went the set on the table, and back came the noise. It didn't come from the aerial, because it remained after the aerial was disconnected. A second examination, and a replacement of all fixed condensers, made no difference. Finally the smell of burning fabric gave a clue. Where do you think the trouble was?

The custom builder had fastened clips to the tips of the loud speaker cord, and had connected them to short pieces of wire fastened to the L. S. posts themselves. He did this to allow the quick removal of the speaker and the connection of a pair of earphones instead. The minus end of the "B" batteries was grounded to the frame of the Super-Wasp in the proper manner.

The top of the bridge table was actually conductive, and allowed the "B" battery circuit to complete itself through the phone tips to the frame of the set. The cloth seemed to have a metallic weave, of fairly low resistance. When the ends of the "B" batteries were touched to it directly, it flashed and started to burn. *That* certainly was a queer trouble!

* * *

DID you ever hear or hear of a radio receiver that reproduced voice and music without the aid of a loud speaker or earphones? Well, such a set was actually brought to me for examination by its somewhat frightened owner, who was beginning to suspect his own sanity. It was a five-tube neutrodyne of good design and construction, and about two years old. It had been moved around a bit, but seemed to be in good condition. When connected up and tuned to any local station, the program could be heard coming right out of the wooden cabinet. The signals were not strong, but

they could be heard about three or four feet away when the room was quiet. When the speaker was connected it performed in good style. Where did the sound come from?

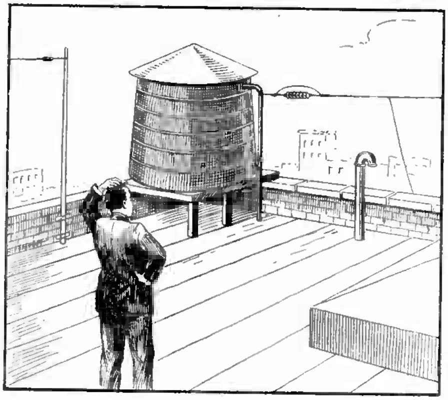
When the receiver was removed from the box the signals became weaker, and their source was quickly found. It was the last audio transformer!

The thin iron laminations had evidently become loose and under the influence of the strong signal currents flowing through the windings, vibrated in sympathy with the signal modulation. The installation of a new pair of transformers silenced the set and relieved the mind of the worried owner. If you heard music that you shouldn't hear you'd feel worried too!

* * *

THERE are always the classical cases of the man who forgot to put the line plug in the base outlet and of the fellow who forgot to put in the tubes. Sound impossible, but they've happened. Then there is the custom builder who blew out fuse after fuse with an absolutely perfect Pilotone Electric Six, to discover, finally, that the house current was D.C.

There is a known instance of two people having their lead-in wires connected to the opposite ends of the same aerial with somewhat peculiar detuning effects resulting. Of similar nature is the case of the lazy set builder who connected his lead-in to an existing aerial on the roof of his apartment house, to discover that said aerial was the business end of a 100-watt short-wave transmitter! The receiver worked fine for about ten days, because the owner of the transmitter happened to be away on a vacation. When he returned, he decided to retune his outfit, and light wisps of smoke soon started drifting out of the other man's outfit. Moral: put up your own aerial.



* * *

THERE is an authenticated case of a man who decided the insulators on his aerial were not strong enough to stand the strain, so he bridged them with heavy bare copper wire. As one of the insulated ends happened to be tied around a pipe leading out of a water tank, the operation of his receiver was not materially improved, as he learned of his sorrow!

* * *

ONE of the commonest troubles in receivers using the old type sockets with the bayonet catch (and there are many thousands of such sets still in active use) is the failure of the springs to touch the contact pins in the bases of the tubes. By reaching in with your little finger you can raise the springs sufficiently to insure good pressure against the pins.

* * *

THE lessons to be learned are few and simple. In cases of trouble attack the simple and obvious things first, because trouble always exists in the places you least expect to find it. To start, make sure you have juice, both at the outlet and at the set. See that the tubes are in their sockets, and that the aerial, the ground and the loud speaker are connected. If the speaker is absolutely silent, disconnect it from the set and tap the tips of the cord across the A.C. line. If it growls, it's O. K. See if the tubes light. One or more of them may be dead, as you can determine with the aid of a tube tester or merely by substituting spares for those in the set. If the tubes test O. K. your real work starts. Servicing ideas differ, and you must apply the methods you have found through experience to be most effective.

* * *

SOMETIMES an instrument will test O. K. in one position, but not in another. For instance, in the resistance-coupled audio amplifier of a broadcast receiver being tested by one of our staff members, the circuit was closed up to the first audio tube, but apparently dead beyond that. The .01-mf. condenser in the Resisto-block was suspected, but it tested all right. Finally, the whole Resisto-block was removed, and it was discovered that while the condenser itself was perfectly good, the constructor had neglected to connect it to the brass straps in the base of the device. When the connecting screws were passed into the condenser from the bottom, the amplifier came to life immediately. The moral in this case is: Don't pass over any suspected instrument until you have examined it on all sides.

It is an old axiom that the most obvious things are the ones overlooked most easily. I was once attempting to demonstrate a receiver, and discovered that it wouldn't work for the simple reason that I had forgotten to put the detector tube in the socket!

John Geloso

Technical Consultant for Radio Design.

A New Book of Interest to Every Radio Fan

Theory of Radio Communication

***Lieut. John T. Filgate's Radio Manual, Used by U. S. Army Signal Corps, Published Exclusively by* Radio Design**

IT is not often that a private firm is allowed the privilege of publishing a technical government book, particularly when that book is used by the United States Army for instruction purposes. Therefore, RADIO DESIGN has been signally honored by the War Department in being permitted to handle the first public printing of Lieutenant John T. Filgate's work, "Theory of Radio Communication", which is the radio manual used by officers attending the Army Signal School at Fort Monmouth, N. J., the training school for the personnel of the Signal Corps.

A DISCOVERY

The only copies formerly available consisted of mimeographed sheets stapled together between paper covers. Last summer a representative of RADIO DESIGN, while visiting a friend at Fort Monmouth, met Lieut. Filgate and discovered his book. He took it home, read it from cover to cover, and decided it was too good to be kept from the radio fans who were hungry for good books. After prolonged negotiations, War Department officials agreed to let RADIO DESIGN print it, and we are glad to announce that copies are now ready. The edition is limited, so if you want to obtain a copy for yourself or as a gift to a friend, it would be a good idea to order now.

"Theory of Radio Communication", as it now stands, is a thoroughly up-to-date and handsomely printed volume, containing 256 pages and more than 200 illustrations. As the author states in his preface, it has been written as a text for students who are already familiar with the elementary principles of electricity and magnetism. It therefore is not a book for the rank beginner, but rather for the radio experimenter or constructor who has built a radio set or two and who has acquired some slight knowledge of radio theory by reading the current radio magazines. As all the readers of RADIO DESIGN are in this class, the book will be very valuable to them. To quote directly from the preface:

MATHEMATICS AVOIDED

"An effort has been made to present the principles of radio which must be known in order to intelligently operate radio sets and equipment, and also to give the student sufficient information relative to the modern trend of radio developments to permit him to keep up with the subsequent improvements in the science of radio communication. The use of mathematics has been avoided wherever possible."

VACUUM TUBE EMPHASIZED

The book is divided into twelve chapters. It begins with a discussion of the general aspects of radio communication, and ends up with a description of the latest advances in line radio and television. Five of the twelve chapters are devoted to the vacuum tube and its uses as detector, amplifier, oscillator and modulator. In his treatment of this most important of all radio devices Lieut. Filgate uses exceptionally clear language and explains in simple words the many complicated actions of different forms of tubes.

He gives the theory and practical application of coils, condensers, loud speakers, phonograph pick-ups and power packs, and analyzes to the last detail some representative broadcast receivers of modern design. By way of acquainting the reader with some of the older means of radio communication, he describes rotary and quenched spark transmitters, the high-frequency alternator, the arc, and the crystal detector. One very illuminating chapter deals with antennas and the radiation, propagation and interception of radio waves, and throws considerable light on a subject of which most radio fans have only a hazy conception.

SELF-EXAMINATION IS FEATURE

One of the features of "Theory of Radio Communication" is the list of questions appearing at the end of each chapter. By attempting to answer these on paper, the reader can tell just how much he has learned and on what points his knowledge is weakest. Each set of questions is preceded by a summary of the facts brought out in the chapter.

"Theory of Radio Communication" sells for $2.00 a copy. This is a low price for the many dollars worth of valuable informations that the book contains. Order your copy now from your local book dealer or direct from RADIO DESIGN. We will pay the postage.

Get a Big Pay Radio Job

LIKE THESE

$400 A Month

"I was making good money before, but I'm making more than ever now—more than $400 a month. The Radio field hasn't been scratched yet and it is getting bigger and better every day."

J. G. Dahlstead,
1484 So. 15th St.,
Salt Lake City.

Seldom under $100 a wk

"My earnings seldom fall under $100 a week. My profits for the past three months were $577, $645, $465. You give a man more for his money than anybody else."

E. E. Winborne,
1414 W. 48th St.,
Norfolk, Va.

$10,000 more in *Radio*

"I work 38 hours a week and make more than three times the weekly salary I did before I enrolled. I can safely say that I have made $10,000 more in Radio than I would have in my old job."

Victor L. Osgood,
7101 Bay Parkway,
Brooklyn, N. Y.

I Have Trained Hundreds of Men to make *much more money* in Radio than they *could make* in other fields

Let me show you, too, how, in a short time, you can be making $5 to $20 a week more. How, in a year or less you can be ready for a big-pay Radio job. Others are winning big success through this training - why not you? Men and young men from practically every trade and profession are getting into Radio. Why?

Because it is today's fastest growing business. Because there are so many opportunities for quick success. Look at the salaries above. What field other than Radio offers the chance to make that kind of money after about one year's training? None that I know of.

Big growth making many big pay jobs

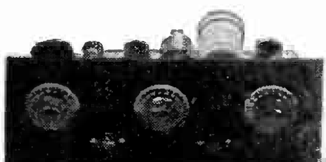
Don't slave your life away for $25, $35 or $40 a week in a no-future job. You can't enjoy yourself—get the good things of life—an automobile, a home, money in the bank, on that salary. Begin now to get ready for Radio where $50 to $75 a week is only the beginning.

Many jobs lead to as high as $200 a week. In the short space of a few years Radio has grown to rank among the world's greatest industries. Every year there are hundreds of new jobs among the 30,000 Radio dealers, 600 broadcasting stations, 900 manufacturers, over 1,000 ships and other branches. My book gives the facts.

Many make $5 to $25 extra a week almost at once

The day you enroll I will show you how to do 10 Radio jobs most common in every neighborhood in connection with installing, repairing and maintaining sets. G. W. Page, 1807 21st Ave., S., Nashville, Tenn., says, "I picked up $935 in my spare time while studying." F. J. Margraf, Lapeer, Mich., writes, "After one month with you I started earning extra money."

I give you the Radio Parts for a home experimental laboratory. Six Big Outfits. With them you can build practically all receiving set circuits. Two you build are shown here.



N.R.I. trained Men are Recognized *Radio Experts*

I will train you at home. Give you practical Radio experience

Hold your job. My 50-50 method of training—one-half from lesson books and one-half from practical experiments using Six Big Outfits of Radio Parts, given without extra charge, makes learning at home easy, fascinating. It is unequaled. You don't have to be a high school or college graduate.

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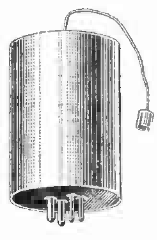

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