RADIO DESIGN

MAGAZINE OF CONSTRUCTION FOR STUDENTS & SET BUILDERS

The Pilot "Super-Wasp"—The K-106 A. C. Screen-Grid Receiver—A Combination Radio-Phonograph Amplifier—Short-Wave Operating Hints—Byrd's Radio Equipment

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

Volume 2 SPRING ISSUE Number 1

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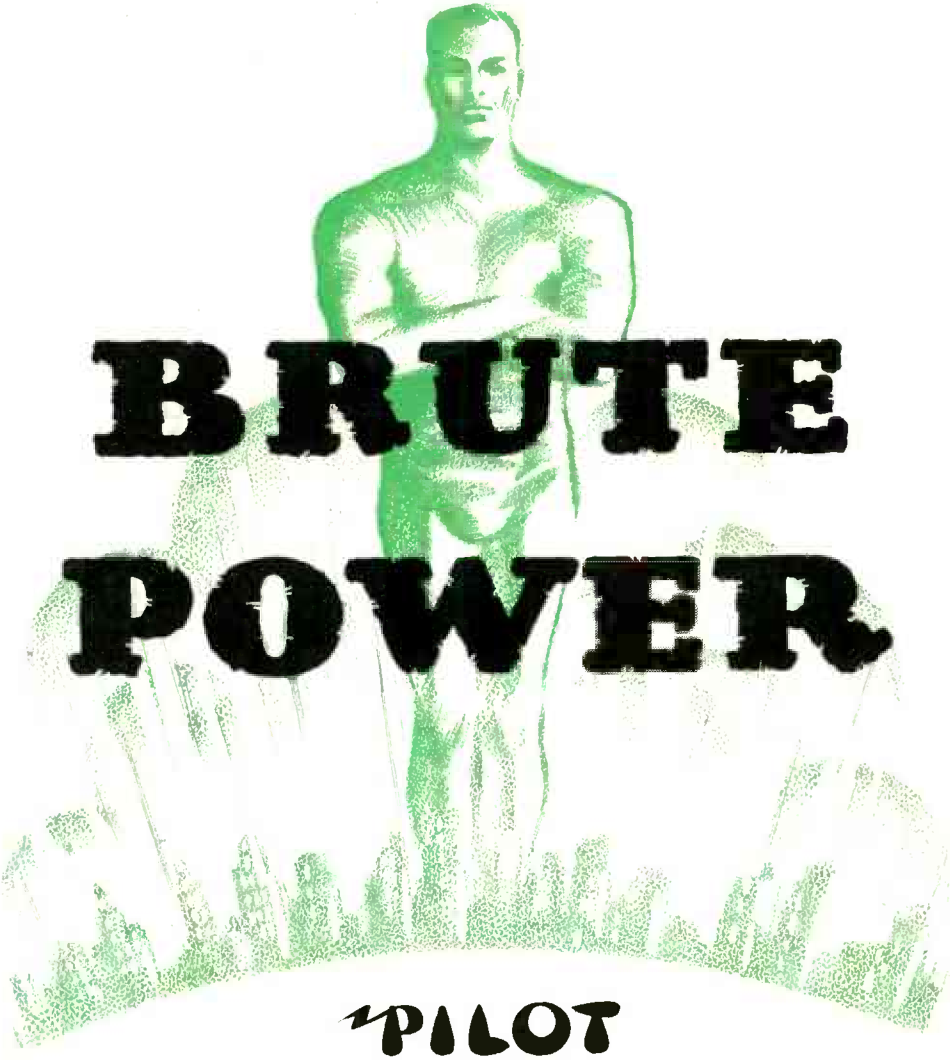

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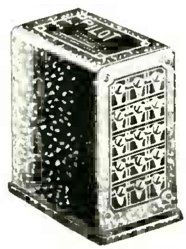

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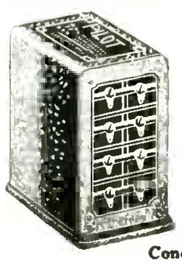

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RADIO DESIGN

MAGAZINE OF CONSTRUCTION FOR STUDENTS & SET BUILDERS

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ROBERT S. KRUSE........*Contributing Editors*........ZEH BOUCK

Vol. 2 No. 1 — Spring 1929

CONTENTS OF THIS ISSUE

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RADIO DESIGN

MAGAZINE OF CONSTRUCTION FOR STUDENTS & SET BUILDERS

EDITORIAL

THE Radio Corporation of America recently announced to the trade two new alternating-current tubes, which will be generally available by the time this number of RADIO DESIGN appears.

One is a screen-grid valve similar in operating characteristics to the direct-current UX-222, but equipped with a heated cathode identical with that used in the well-known UY-227; it will be known as the UY-224. The other is an audio amplifier with a maximum output of 1.6 watts at the conveniently low plate rating of 250 volts, and will be designated the UX-245. Eventually this tube will probably replace the present 250 and 210 tubes for general broadcast reception purposes, as it nicely fills the gap between the unnecessarily large 250 and the not-quite-large enough 210, and at the same time eliminates the troubles incidental to the use of the high plate voltages required by the latter.

The really significant feature of these new and decidedly desirable tubes is their filament ratings. Both of them work on 2½ volts of alternating current, the screen-grid model drawing 1¾ amperes, and the A. F. tube 1½ amperes. This equalization of the filament voltages of two different types of tubes is the first sensible thing that has happened in the tube field since the introduction of the first A. C. models some years ago, and all radio manufacturers, home set constructors and experimenters should feel happy about it.

We do not doubt that within the near future all A. C. tubes will be modified to conform to one standard filament voltage, which obviously will be 2½, so that only one transformer filament winding, one set of connection terminals and one pair of filament wires will be required for any A. C. receiver. What a blessing that will be!

Tricks of Short-Waves

"I MADE a Wasp short-wave receiver according to the description in the Fall issue of RADIO DESIGN," writes a reader in Pennsylvania. "I followed the wiring exactly, and then checked it again against the full-size blueprint. I know everything is perfect, yet all I can hear is about five code stations and some weak broadcasting that I cannot identify. Can you tell me what might be wrong?"

"I assembled a Wasp set from the standard kit as described in RADIO DESIGN," writes another reader, who lives in Boston, "and I want to tell you that it certainly is a knockout. I hear station PCJJ in Holland loud enough to put him on the loud speaker, and I have brought in Chelmsford, England, Bandoeng, in the Dutch East Indies, and many other short-wave broadcasting stations all over the world, to say nothing of hundreds of amateur and commercial code stations. These code stations just fall in one right after the other, but I can't get all their call letters because I don't know the code well enough yet. Believe me, I'm getting a big kick out of the outfit, even if I am losing a little sleep."

Every mail brings letters of this kind, in about equal proportion. The whole answer to the short-wave receiver question is this:

You must have a fair degree of patience, which you can cultivate through practice and application; a thorough knowledge of your set's operating characteristics, which you can acquire through study and experience; and lastly, a good location, which is purely a matter of luck.

Its very uncertainty is what makes short-wave reception so fascinating. If you connected up a set and pulled in Hong Kong or Constantinople the first time you turned the switch on you wouldn't keep the outfit a week, because you would run out of thrills in that time. Everything would be too easy, and you wouldn't enjoy the receiver. Don't deduce from this statement that short-wave sets are deliberately designed to be cranky and irregular; as a matter of fact, short-wave receivers are by far the simplest of all radio receivers. The actual short waves themselves, as radiated from a transmitting station, are the uncertain quantity. They have the peculiar habit of skipping hundreds and even thousands of miles through space before hitting the earth, the "skip distance" depending on the particular wavelength, the hour of the day, and other factors.

If you are not entirely satisfied with the results you are obtaining from your short-wave receiver, read over at least three times the article in this issue entitled "How to Get the Most Out of a Short-Wave Receiver." The tricks of short-wave operation are few and simple, and once you master them you will find your set a constant source of enjoyment.

PROTECTION FOR YOU

BEFORE being written up in RADIO DESIGN, *all sets are tested in our laboratory in Brooklyn, in several homes in different parts of New York City and its suburbs, and in a farm house in upper New York State. If they work satisfactorily in all these places, we know they will work everywhere else. If they fail to pass any one of the tests, they never appear in print. Therefore, when you decide to build a receiver described in* RADIO DESIGN, *you can be very sure that you will not be wasting money on an untried set. This is protection for you.*

About Our Page Size

ALTHOUGH it was announced in our previous number that the page size of RADIO DESIGN would be increased, this small size will be continued, because many readers have written in to express a preference for it. In its present form the magazine can be slipped flat into a coat pocket when it is being carried around, and it will stand upright in all bookcases, making it generally convenient at all times. The latter feature is especially important, as the majority of readers like to save their copies for future reference. Magazines of larger page size cannot easily be filed in this way, as they will not fit upright in most book cases.

We wish to emphasize the fact that the amount of reading matter will not be decreased; on the contrary, it will be increased, to allow us to answer the increasing number of questions being written by our readers.

The Free Question Service

SPEAKING of questions, we might add that thousands of readers have taken advantage of the free technical service started with the Fall number. Their letters swamped the office for a while, but the staff worked overtime a few nights and answered every one of them.

Please help us to help you by writing your questions clearly with ink or on a typewriter. Whenever possible send along a diagram of the set you are inquiring about. If you want a hook-up for certain parts, don't forget to give us a list of them. We have received a surprisingly large number of letters which state merely: "Please send me a diagram of a radio set that I can make out of my parts." The members of the RADIO DESIGN technical staff are good engineers, but they are not mind readers.

This service is absolutely free, and is one of the things you enjoy as a reader of RADIO DESIGN. The only thing we ask you to do is to include a stamped envelope addressed to yourself in your letter to us. *Don't forget to put down your address.* We have dozens of letters that we can't answer because the writers forgot that little detail.

The Enlarged Staff

This number of RADIO DESIGN was prepared by an enlarged staff under the direction of a new editor, who wishes to introduce both himself and the other new members. The new men are Robert S. Kruse, Zeh Bouck, and Alfred A. Ghirardi, all of whom are well known in the radio field in general and to our readers particularly because of their past contributions to this magazine.

Mr. Kruse was technical editor of "QST" Magazine for five years, and is universally regarded as one of the leading experts on short-wave radio. Mr. Bouck has been an outstanding radio writer for more than ten years, being famous for his former weekly column in the New York *Sun* entitled "What Are the Air Waves Saying?" Mr. Ghirardi is an instructor in electricity and radio at a well-known technical school in New York, and has a keen understanding of the needs and problems of the young radio enthusiast. Your new editor was managing editor of "Radio News" for two and a half years before coming to RADIO DESIGN, and has had considerable experience on other radio publications.

Mr. John Geloso, chief engineer of the Pilot Electric Mfg. Co., will continue as technical consultant.

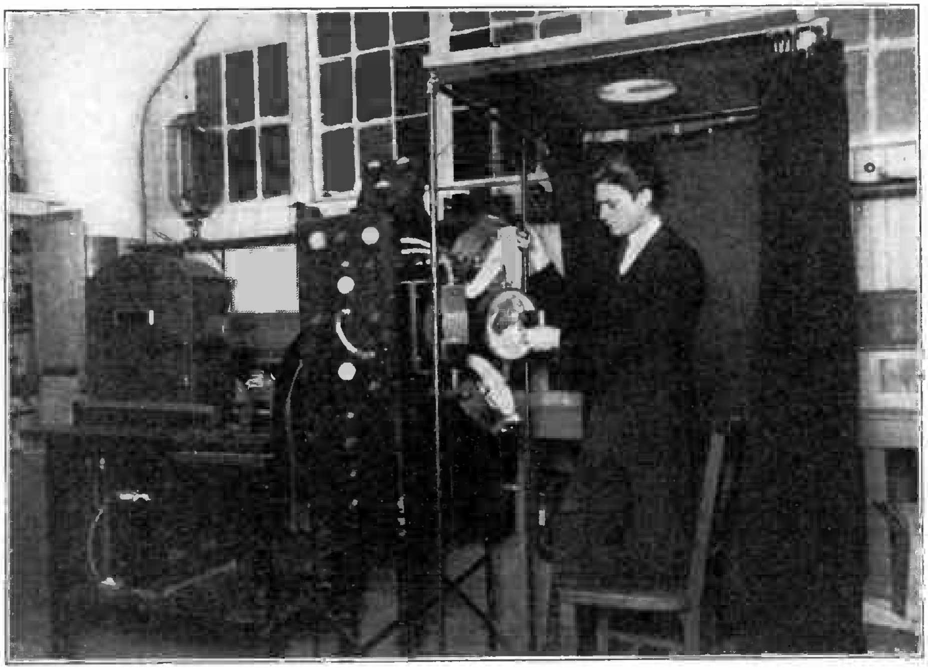
—The Editor.

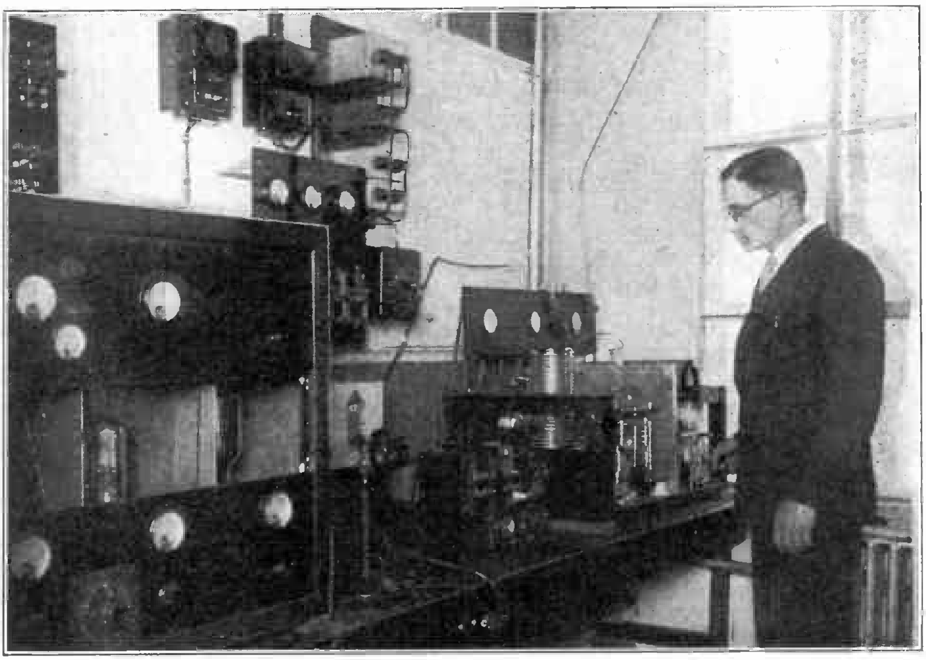
Robert S. Kruse

Alfred A. Ghirardi

Robert Hertzberg

John Geloso





Television broadcasting on a regular schedule will begin soon from station W2XCL, two views of which are shown above. This station is owned and operated by the Pilot Electric Mfg. Co., Inc., of Brooklyn, N. Y., one of the few firms licensed for television work by the Federal Radio Commission. The apparatus, constructed entirely in the Pilot plant, will use 250 watts of power on frequencies of 2,000-2,100 kilocycles (143-150 meters) and 2,750-2,850 kilocycles (105-109 meters). Top picture shows John Geloso, chief engineer of the Pilot company, standing in front of the "televisor"; bottom picture shows radio transmitter proper. The station went on the air for the first time during April, many listeners reporting excellent reception of its signals.

THE PILOT SUPER-WASP

By ROBERT S. KRUSE

VERY seldom is one permitted to hear anything about a receiver except an explanation of the good points of the final set. This story will violate the traditions by telling how the receiver came into existence, and what it will *not* do. This is done with the conviction that the prospective buyer will be better off if he knows these things and that in the end he will find more uses for the Super-Wasp, whose performance need not be apologized for.

Some months ago the Pilot organization became displeased with the short-wave receivers then available. Analysis showed that without exception they suffered from one or more defects, which may be listed as follows:

Flimsy plug-in coils.

Poor contacts between coils and set.

Difficult tuning because of hand capacity or by reason of tuning effect of regeneration control.

Noisy or inadequate regeneration control.

Set of no use in the ordinary broadcasting range of 200-500 meters.

The first two defects were cured at one motion by the adoption of a ribbed bakelite coil form with pins fitting a UY tube socket. This was a construction which the writer had vainly tried to introduce to several makers. It has been rather amusing to watch the haste with which they followed the Pilot lead.

The set was also made useful in the broadcast range by adding a 200-500 meter coil to the usual short-wave coils.

There remained the regeneration problem. Resistance control is smooth but frequently not adequate, beside being subject to a distressing tendency toward noisiness. Condenser control was used.

Thus we had a Pilot UY-base coil connected to a tube which worked as a regenerative detector. With a set of five of these coils a continuous range (with good control) could be obtained over the whole region of 17 to 500 meters, which is to say, the short-wave region plus the important part of the broadcast range.

About the Author—

MR. ROBERT S. KRUSE, the designer of the new Pilot Super-Wasp, is without question one of the world's foremost short-wave experts. For five years he was technical editor of "QST," the official organ of the American Radio Relay League, and in that capacity was probably more intimately concerned with the extraordinary development of the short waves than any other single radio engineer. We are sure our readers will be greatly interested in this fine receiver, his latest development.—EDITOR.

THE WASP TUNER

Having a satisfactory short-wave-and-broadcast detector system, the question now was whether we should merely add an audio amplifier or at once attempt a stage of R.F.—or perhaps two stages. Even a very brief analysis showed that it would be wise to defer the R.F. stage until several questions could be replied to in better form than that represented by the short-wave tuners then on the market. The Wasp therefore appeared with an audio amplifier only. Having but three tubes it made small demand on batteries and was therefore offered as a battery-driven set in preference to encountering the added cost of an A.C. set.

Seemingly the set so devised was satisfactory, for it has been exceedingly well received by short-wave broadcast listeners, by those who wanted a portable set for regular broadcast reception and by radio amateurs who desired to receive amateur radio-telegraph (so-called "code") signals. Since the amateur bands are very narnow a modification of the usual Wasp set is useful in spreading them over the dial and the way of doing this has been described in an article by Harold P. Westman in the September, 1928 issue of QST. It is altogether the nicest "band-covering" tuner I have seen and those interested in this sort of work should obtain a copy of the issue mentioned.

THE NEW SUPER-WASP

Having found the Wasp to be satisfactory in the field as well as in the laboratory, we were encouraged to proceed with the original purpose of using a stage of tuned R.F. This has been done in the Super-Wasp, to the final form of which the entire Pilot staff has contributed in one manner or another. A considerable portion of the work was done simultaneously in New York, by John Geloso and Robert Hertzberg, and at the writer's home in West Hartford, Conn., so that independent information might be used to disclose any of those errors which happen too often when all work together at one place and become victims of an opinion.

Beginning with the matter of shielding, one had at once the question of the material to be used and the thickness required. Aluminum has some evident advantages in that it does not tarnish readily, may be formed easily and is light. It was therefore used and a light gauge made possible by placing the R.F. shield and the detector shield at opposite ends of the set. The baseplate or "subpanel" of the set was made of much heavier sheet aluminum so as to provide a zero-potential plane which would not be upset by currents flowing in it. For the same reason also the panel was made of heavier material.

There is not space here to discuss the reasons which led to the particular location of the wiring, the use of a ground at each socket, the series feed of the 222 plate supply through the tuned detector-feed circuit, or the rather unusual circuit arrangement inside the cans. We can say only that the R.F. amplification obtained has been so adjusted that it produces a very handsome improvement in performance (as compared with the Wasp) while at the same time assuring a gratifying freedom from "crankiness." Since the set is to be used with all sorts of antennas this obviously means that the R.F. gain cannot be pushed to extremes.

For this no apology is offered. On the contrary, I wish to assert that any materially greater gain would be worse than useless since the "useful selectivity" of the set would be ruined thereby, besides creating operating difficulties in the way of uncontrolled oscillation when the set is worked under improper conditions. The practical set for sale in kit form is the one which *works* when correctly assembled—not the one which works *if* everything is exactly and critically adjusted.

Reference to selectivity and sensitivity naturally calls for comparison with normal broadcast receivers, since the set also covers this range. At the time that this is written my measurements are not complete. They do, however, show that the sensitivity is materially better in the short-wave region than that of any other set I have encountered, excepting only double-detection receivers using six or seven tubes and much more equipment.

The Best Short-Wave Set—

THAT is the comment made by everyone to whom the advance models of the Super-Wasp were shown. The points of superiority are as follows:

1) Increased sensitivity and selectivity made possible by the TUNED screen-grid R.F. stage.

2) Universal wavelength range. Tunes from 14 to 500 meters. An excellent broadcast receiver as well as the finest of all short-wave sets.

3) Absolutely no "hand capacity" effects.

4) Completely shielded.

5) Easily assembled and wired from kit of parts.

6) Inexpensive.

And last, but most important,

7) Ability to bring in short-wave broadcasting stations better than all previous short-wave receivers.

Build a Super-Wasp and experience the greatest of all radio thrills—hearing foreign broadcasting stations. The editor of RADIO DESIGN, while testing a Super-Wasp for a few minutes after dinner and then again before going to bed (location: New York), heard stations in Chelmsford, England; Manitoba, Canada; and Costa Rica, Central America! These were broadcasting voice and music, NOT CODE.

AN EXCELLENT BROADCAST SET

In the broadcast region the Super-Wasp can be thought of as comparing very nicely indeed with other four and five-tube sets. Obviously one must not expect the same selectivity from two tuned circuits as from three or four, nor will a single 222 develop the same gain as a number of the same. It is therefore not pretended that seven-tube performance has been obtained. None the less, both the sensitivity and the selectivity are such as to permit good use of the set to be made in the normal broadcast band whenever the short waves are behaving badly. Similarly, when the normal receiver is struck by a "dead evening," the Super-Wasp need but be shifted to the short waves.

Thus far nothing specific has been said as to either sensitivity or selectivity. With regard to the short waves this cannot be helped. We have no really reliable method of making gain-measurements at (for instance) 20 meters. One is referred to listening tests, the results of which are never too good. However, work on signals and on a weak oscillator produced figures which at least justify the statements that have been made.

In the broadcast region the usual rating by input microvolts is less important here than some comparisons with familiar receivers. Here a detour is necessary.

The first model Super-Wasp had been provided with R.F. coils carrying primaries, also providing for condenser feed from the antenna to the top (grid) end of the tuned circuit. This was the same arrangement that had been used in the original Wasp receiver. It was found that the condenser feed was not well suited for use in the broadcast region of 200-500 meters for the reason that satisfactory coupling could not be obtained unless the feed condenser was enlarged materially. When this was done the condenser was of a capacity which tuned the antenna as a series system and produced a condition of two-frequency response—a wholly inoperative condition.

AUTOMATIC AERIAL CHANGEOVER

The user would find this out for himself, just as he had in the simpler Wasp receiver, but the shifting of the antenna is less convenient in the case of a shielded set of larger dimensions. It was therefore decided to use a device suggested by Mr. Geloso. This was a set of coils so connected that the 200-500 meter coil carried an antenna, or primary, coil, while the others had none and were so connected that the feed-condenser was automatically connected in when they were put into the socket. Thus without any need for two antenna posts it was possible to use the primary coil in the 200-500 meter region while retaining the convenient feature of variable coupling through a small condenser at shorter waves.

Having arrived at this point, it was believed that the short-wave performance could be taken for granted, with the possible exception of the regeneration control. The broadcast-range response was again checked and the primary, or antenna, coil adjusted so that the average receiving antenna will have somewhat more coupling than is strictly necessary. The proper value may then be obtained by putting into the antenna lead a "postage stamp" mica condenser whose value is to be found by trial. There is nothing critical about this and the proper value will be found by trying .0005, .00025 and .0001 mf., all of which are usually at hand. With smaller antennas the condenser is not needed.

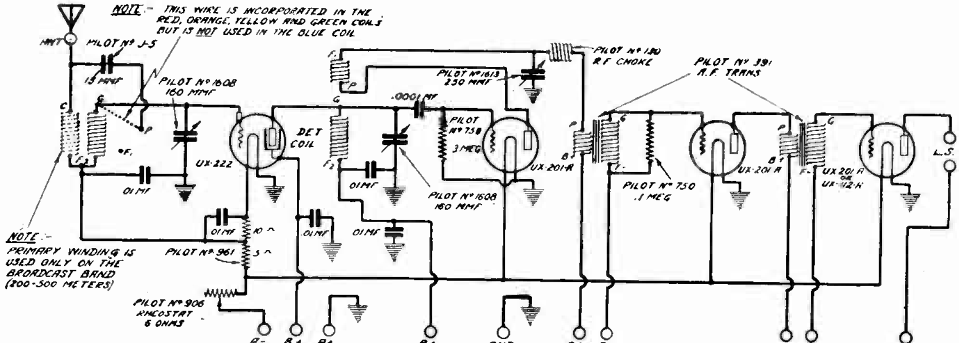
This is the antenna arrangement in the present receiver. Using a moderate but steady broadcast signal from WEEI and one from WCAC, as fairly well representing the ends of the broadcast spectrum, some rough measurements were made of the voltage across a loud speaker, first obtaining the resonance voltage and then detuning until the signal was supposed to be "tuned out." For the latter there was taken the arbitrary value of one per cent as high a voltage. The difference in ear-response is materailly greater than 100 to 1, and the assumption is therefore fair enough.

It was not desired to strike any particular value of sharpness of tuning but rather to make sure that over the 200-500 range the sharpness compared decently with sets that have been found acceptable for regions in which battery-operated sets are used for broadcast reception. It was realized fully that one cannot, with two tuned circuits, obtain extreme selectivity except by the use of a small antenna. This does no harm, since the city-dweller can use such a 10-30 foot antenna with perfect satisfaction. It is effective on short waves and his 200-500 meter signals are strong because of their nearby origin, hence can also be received on such an antenna.

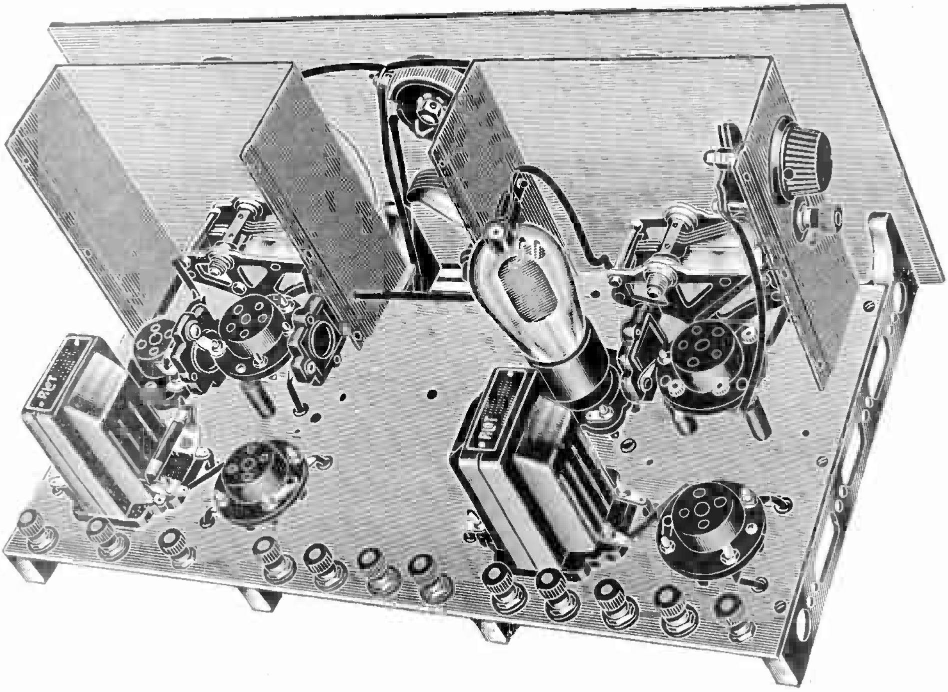
The comparison was therefore made as to both sensitivity and selectivity (by the detuning method mentioned) on the Super-Wasp, on a very popular set with a stage of 199-tube tuned R.F. on a set with an "untuned" 222, and on a set with a tuned 222 having its condenser ganged with that of the detector. All of the sets used a regenerative detector and two audio stages.

Next after the Super-Wasp the set with the 199 stage showed the best gain, likewise the best flatness of response over the 200-500 meter region. The Super-Wasp had a considerable advantage, however. The gang-tuned job was very uneven because the condensers did not run together, especially on the smaller coils. For this exact reason the Super-Wasp was made two-control.

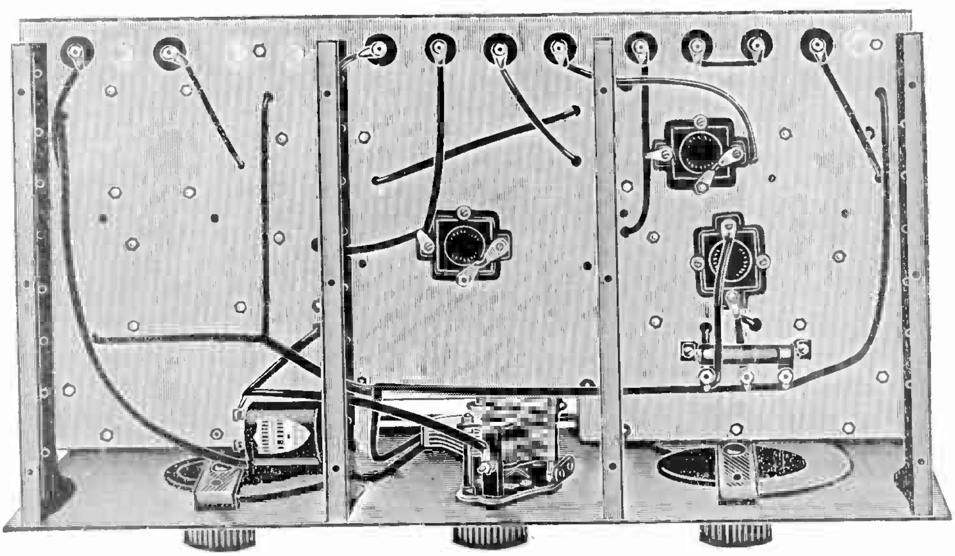
As to sharpness of tuning, the Super-Wasp gave a performance which can be measured by the dial-movement required to produce the 100-to-1 drop, and which was about twenty-



The schematic diagram of the Super-Wasp. The various ground symbols indicate connections to the metal chassis of the receiver.



Above: The assembled and wired Super-Wasp with the backs of the two shield cans removed to show the placement of the parts. Notice how the two five-prong sockets for the plug-in coils are elevated above the sub-panel by insulating bushings. Below: what you see when you turn the set over. The three fixed condensers are spaced away from the sub-panel by ¼-inch hexagonal spacers. The various wires running through the sub-panel pass through eyelets which have smooth sides that will not cut the spaghetti.



five per cent better over the whole region except at the 500-meter end, where the difference was smaller.

REGENERATION-TUNING

One thing that one does not want in a receiver is to have the regeneration control affect the tuning. Since condenser control of regeneration is being used, the suspicion naturally arises that a disagreeable amount of this effect will be found. In the broadcast (200-500 meter or blue coil) region this will be found to be entirely wrong, the tuning effect being exceedingly small. As the smaller coils are used the effect begins to be perceptible, though never very serious. When the smallest, or red, coil is used it will be found that the antenna tuning is somewhat less sharp than before and one may therefore set it at about the right value, after which the regeneration control and the detector-tuning may be handled easily together.

When proceeding in this manner one does not become particularly conscious of the remaining tuning effect, while one does at the same time remain thankful for a control method that works on the smallest coil as well as the largest—which is not the least important manner in which the Super-Wasp differs from current practice.

THE RECEIVER ITSELF

Now that something has been told about the background of the Super-Wasp, we can proceed to a description of the final receiver as it is assembled from a complete kit of standardized parts made up by the Pilot company. The illustrations on these pages show a finished set made exactly in accordance with the following instructions and with the accompanying illustrations. When you buy a kit you will receive with it a set of full-size blueprints which will greatly facilitate your work.

It should not take you more than an hour and a half to assemble a Super-Wasp. Once you have mounted everything, you should be able to wire the whole outfit in another hour, or even less. The arrangement of the parts has been worked out so carefully that most of the connections are only an inch or two long; all the longer leads are part of the filament circuit, which is not critical as to length of wiring.

Before tightening up a single screw, take out all the parts from the box, unwrap them, and place them before you on the table. Study the illustrations and drawings very carefully, and identify each piece of apparatus. Don't rush right into the assembly work the minute you receive your kit; the few minutes you spend in studying the various parts will make up for themselves many times over when you start mounting sockets, condensers and transformers.

THE NECESSARY PARTS

The following Pilot parts are used in the construction of the Super-Wasp:

1—No. 705 metal front panel, 7½ x 18 by 1/16 inches, drilled and engraved.

1—No. 706 metal sub-panel, 8 x 17 by 1/16 inches, drilled with all mounting and wiring holes.

4—No. 37 metal sub-panel brackets.

2—No. 1608 .00016-mf. variable condensers.

1—No. 1613 .00025-mf. variable condensers, with bakelite knob.

2—No. 1282 illuminated vernier dials.

1—No. 906 rheostat, 6 ohms.

1—No. 961 tapped resistor.

2—No. 600 special Super-Wasp shield cans.

1—No. J5 midget condenser, 5 plates.

2—No. 931 audio amplifying transformers.

2—No. 212 five-prong sockets (for plug-in coils).

2—No. 206 four-prong shock-proof socket (for 222 and detector tubes).

2—No. 213 four-prong sockets (for audio tubes).

2—Pairs grid-leak clips.

1—No. 758 3-megohm grid leak.

1—No. 750 100,000-ohm grid leak.

1—No. 50B fixed condenser, .0001-mf.

5—No. 59 fixed condensers, .01-mf.

1—No. 130 R.F. choke coil.

2—Sets of plug-in coils, made especially for the Super-Wasp; Nos. 601A and 601D.

4—Packages of hardware, including thirteen binding posts, ten sets of insulating bushings for them, four lengths of spaghetti tubing, 12 feet of tinned copper wire, all necessary nuts, bolts and washers, Mueller clip for connection to screen-grid tube, and six special double-end lugs for mounting of fixed condensers.

The only tools you need in assembling the Super-Wasp are a screwdriver, a pair of long-nosed pliers, and a Spintite wrench to fit the small 6-32 nuts used throughout in the set.

GETTING STARTED

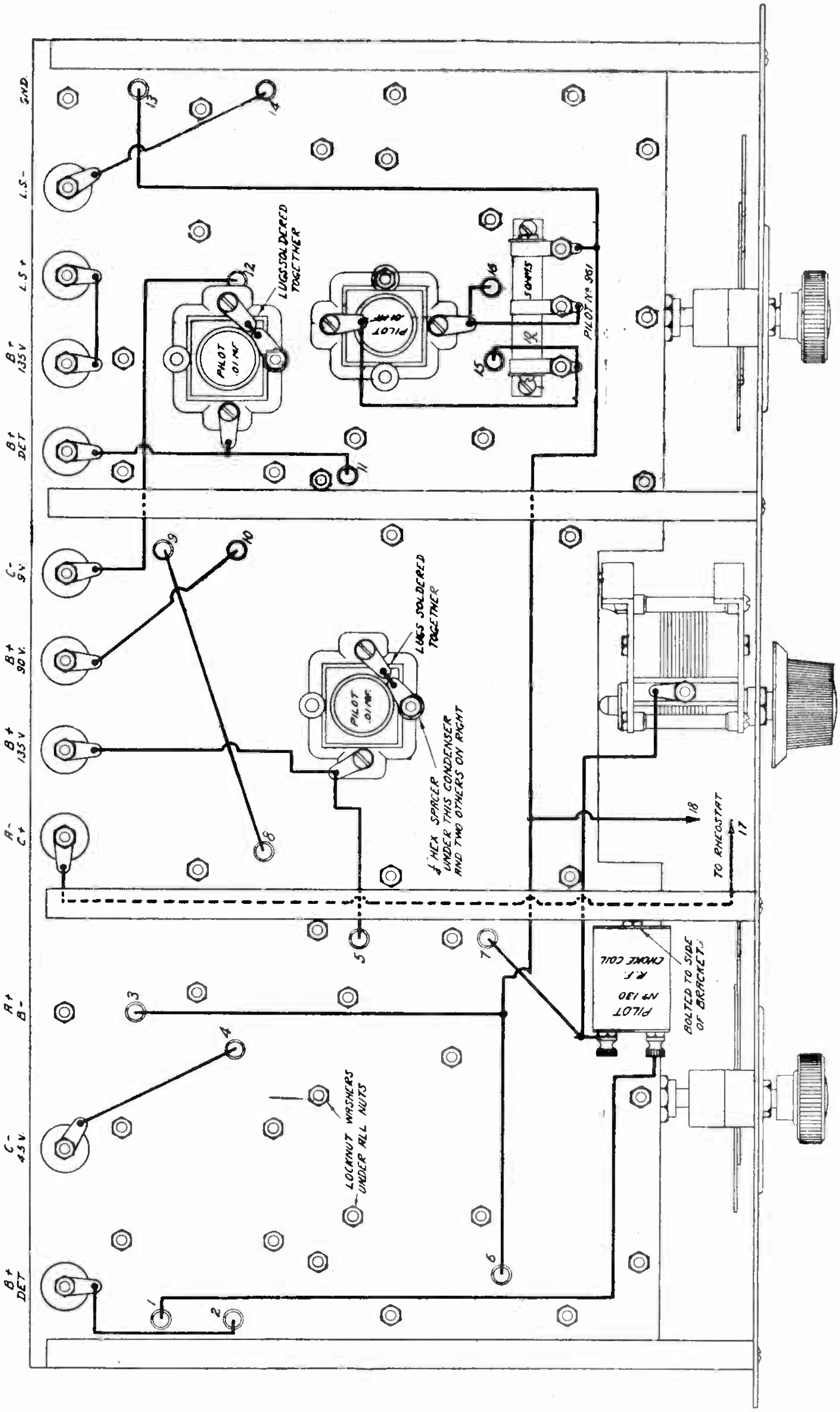
Commence by screwing the sub-panel to the four brackets. Put three ⅜ inch oval head screws through each, using a lock nut washer and a nut on the under side. The brackets are spaced uniformly along the sub-panel, and you cannot mount them incorrectly because of the accurate drilling of the holes.

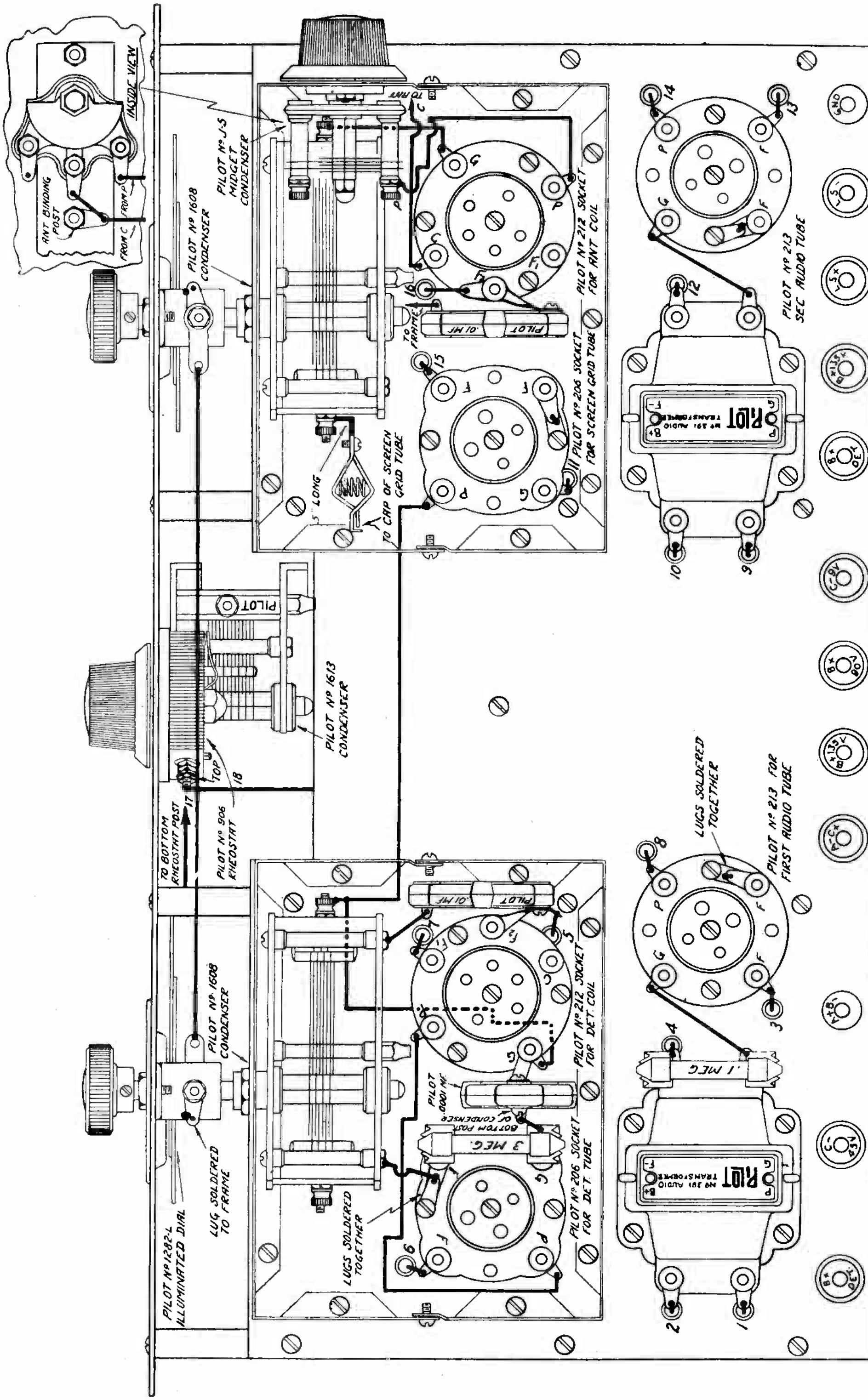
Now place the front panel against the upright feet of the brackets, and screw it in place with two nuts per bracket. Again do not fail to place locknut washers under the nuts. The panel will now be straight and rigid, and you will be able to work on it comfortably.

The first thing to mount on the front panel is the single No. 1613 .00025 mf. variable condenser, which is the regeneration control. This fastens with a single nut. Mount it upright, as shown, so that the rotor plates open out to the left. Put a soldering lug on the bottom stator binding post.

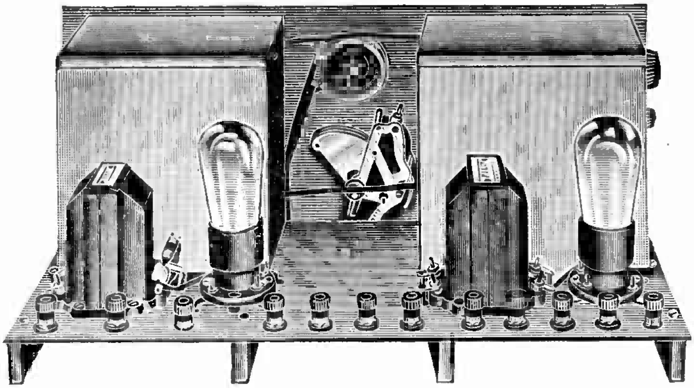
All directions as to right and left will be given with the understanding that the rear edge of the sub-panel is nearest you, as you will do most of the work from the back.

Next comes the rheostat, which fits directly above the regeneration condenser. Break through the two holes in the bakelite base, using a nail or a scriber, so that 6-32 screws ½ inch long can be pushed through. Mount the rheostat with a couple of these screws, keeping it spaced away from the back of the front panel by means of two of the special ¼ inch hex spacers slipped over the mounting screws. The idea of this spacing, and also


GND.
L.S.-
L.S.+
B+ 135 V
B+ DET
C- 9 V
B+ 90 V
B+ 135 V
A- C+
A+ B-
C- 4.5 V
B+ DET
LUGS SOLDERED TOGETHER
PILOT .01 MF.
5 OHMS
PILOT No 961
LUGS SOLDERED TOGETHER
PILOT .01 MF.
1/4 HEX SPACER UNDER THIS CONDENSER AND TWO OTHERS ON RIGHT
TO RHEOSTAT
PILOT No 130 R.F. CHOKE COIL
BOLTED TO SIDE OF BRACKET
LOCKNUT WASHERS UNDER ALL NUTS



Complete picture wiring diagrams of the Super-Wasp. When you wire the set, put a tack through the center of the preceding page and into the wall, so that will be able to view both these drawings at once. Notice particularly how one F post of each four-prong tube socket is grounded to the chassis through the adjacent socket mounting screw. Study the litte notes on the drawings carefully before starting the wiring.



Rear view of a complete Super-Wasp with the shield cans in place and with the two audio tubes in their sockets. The antenna plug-in coil and the screen-grid tube are enclosed in the can at the right, and the detector coil and the detector tube in the one at the left.

of the large hole for the shaft, is to insulate the rheostat completely from the panel. Put one soldering lug on the lower binding post, and two on the upper post, one facing down and the other up.

Take the vernier dials, and mount them in accordance with the directions included in the packing boxes. Remove the slotted back pieces entirely, as they will not be used. Do not turn in the panel screws and nuts tightly until after you have mounted the variable condensers and the back sections of the shield cans. You will notice that the dial mounting holes in the front panel are slightly oval in shape, to allow the screws to be tightened in the best positions.

Put the covers of the shield cans and their back sections out of the way, as you will not need them until you have assembled and wired the whole set; the back sections will then slip nicely in place, and you will fasten them down to the sub-panel with a few screws.

MOUNTING THE SHIELDS

Mount one of the No. 1608 .00016-mf. condensers on the rear side of the shield can that has a small bakelite strip riveted to its right side. Use only the single large mounting nut, and twist the condenser so that the edges of the stator plates lie parallel with the top edge of the can. Mount the J5 midget condenser in the large hole in the bakelite strip, and an "Ant" binding post in the other hole.

Put the shield aside for a moment and mount the No. 961 resistor on the under side of the sub-panel, using two ¼-inch round head screws pushed through from the top side of the sub-panel. It is necessary to do this now because the variable condenser will cover the holes after the shield is mounted in place. These holes for the resistor are near the inside edge of the sub-panel, and you can locate them by studying the picture wiring diagrams closely.

Place the can on the sub-panel so that the shaft of the No. 1608 condenser slides into the mounting stud of the right dial. Screw the can down to the sub-panel using ¼-inch screws through the drilled feet. Turn the dial to 0, pull the condenser plates out until they are entirely unmeshed, and then tighten the set screw in the stud of the dial. Finally, tighten up the screw and the nut that hold the dial on the panel.

Repeat these operations, except for the detail of the midget condenser, with the other No. 1608 condenser and the other shield can. The mounting of the condensers is really half the work of the set, and if you follow the foregoing directions carefully you will have no trouble.

ELEVATING THE COIL SOCKETS

In one of the hardware packages you will find six long 6-32 screws and six hard-rubber bushings one inch long. These are for the mounting of the five-prong sockets, in which the plug-in coils fit. Study the picture wiring diagram closely, and note the way the sockets are placed as regards the binding posts. The actual mounting is easy enough. Simply pass the long screws through the sockets holes, through the hard-rubber bushings, and then through the sub-panel, fastening them on the under side with locknut washers and nuts. Hold the heads of the screws with the screwdriver, and tighten the nuts with the Spintite wrench or the pliers.

The long screw that passes between the two F posts on the five-prong socket for the antenna coils also holds, on the under side of the sub-panel, one of the .01-mf. fixed condensers, which is marked C1 in the blueprint. Slip a ¼-inch hex washer over the end of this screw, place the condenser over it, and then tighten with a nut.

Another of the .01-mf. condensers is fastened and connected directly to the variable condenser and to the F2 post of the five-prong socket in the right-hand can, which houses the components of the antenna or R.F. stage. Put a double-end lug under each terminal screw of the condenser. Bend one lug at right angles and tighten the free end over the short mounting stud on the back of the variable condenser, using a ¼-inch screw. Twist the other lug so that its free end will fit over the F2 socket post, with the condenser standing upright.

Proceed to the left can, and mount another of the .01-mf. condensers in the same manner. One lug goes under the F2 post of the five-prong socket, and the other under the nut that holds the right side of the condenser frame together. The .0001-mf. grid condenser is similarly mounted between the G post on the elevated socket and the G post on the No. 206 socket next to it.

GROUNDING THE FILAMENTS

This method of mounting the blocking and grid condensers practically eliminates wiring in the critical radio-frequency circuits, and is responsible to a great extent for the smooth operation of the Super-Wasp.

Proceed with the assembly work by mounting the three remaining tube sockets. Put a soldering lug under the head of one of the screws going through each socket, as shown in the picture wiring diagram; these lugs are soldered directly to other lugs fastened beneath the F posts, which are thus grounded to the aluminum framework of the set.

Mount the binding posts, using the insulating bushings for all posts except the "A" plus "B" minus, which is third from the left and "Gnd," which is all the way over on the right. Place soldering lugs beneath the mounting nuts on all the posts except these two, which automatically connect with the framework.

Fasten one pair of the grid-leak clips to the G and F posts of the detector-tube socket, which is in the left can, and the other pair to the G and F posts of one of the audio transformers. Do not mount the transformers yet.

Before going any further, do as much wiring inside the shield cans as possible with the audio transformers out of the way. The wire between the P post of the No. 206 socket in the right shield can and the stator post of the variable condenser in the left can passes through holes in the facing sides of the shields. Of course use a piece of spaghetti over the wire to prevent it from short-circuiting against the metal.

The wiring is so exceedingly simple that no detailed explanation of it is necessary. The three variable condensers are automatically grounded to the framework, as is one side of each of the tube sockets. The mount of wiring is thus reduced fully fifty per cent from what it would be with an unshielded set. Wherever a ground symbol is shown in the schematic diagram, it indicates a connection made to any part of the framework.

For the wiring, use the tinned copper wire and the fabric tubing ("spaghetti") furnished with the kit. Solder all connections with a clean, hot iron, and use nothing but rosin-core solder.

After you have wired the sockets and condensers in the shield cans, mount the audio transformers in place, putting the one with the grid leak clips on it in the left position—in back of the detector compartment. Use ½-inch screws through all the transformer holes except the one in the upper right hand corner of the right hand transformer—the one in front of the antenna shield can. Use a 1-inch screw here. Slip a ¼-inch hex washer over its end on the under side of the sub-panel, and then fasten down a .01-mf. condenser (C2 in the blueprint) by means of the same screw. Put a soldering lug under the fastening nut.

The last .01 condenser (C3 in the blueprint) is fastened by means of a separate ½-inch screw in the center of the sub-panel. After doing all this you can complete the wiring in short order.

You will notice that some holes in the sub-panel are fitted with eyelets, and that others are not. The bare holes are for mounting screws, while the eyeletted ones are for connections that pass through the aluminum. The eyelets are not insulated, but provide smooth holes through which the spaghetti can be pushed without being cut.

You will also notice in the picture layouts that the wiring holes are correspondingly numbered in the top and bottom views. This is to help you in locating the holes when you are turning the set upside down during the wiring process.

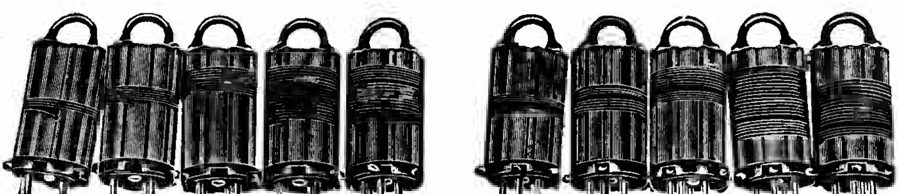
With all the wiring finished, place the backs of the shield cans in place, and screw them down. Use the very short 6-32 screws for fastening the upright edges together. You are now ready to connect the set to the batteries and to start receiving signals.

However, first make certain that none of the binding posts except the "A" plus and the "Gnd" is short-circuited to the sub-panel. Use the old battery-and-phones test.

GETTING INTO OPERATION

Two sets of plug-in coils are furnished for the Super-Wasp, one set acting as antenna coils in the R.F. stage and the other as interstage coils between the plate of the screen-grid tube and the grid of the detector. The red, orange, yellow and green ring coils for the antenna position contain only one winding apiece; the blue ring coil, covering the broadcast range, has two windings, a primary above a secondary.

(Continued on page 51)



The complete set of plug-in coils for the Super-Wasp. Left, antenna stage coils; right, detector stage coils. Their wavelength range is 14-500 meters.

Short Wave Jottings

by Robert S. Kruse

BRINGING LIFE TO THE DEADSPOT

VERY often short wave broadcasting and amateur signals can be received nicely with a horizontal doublet when the ordinary antenna refuses utterly to transact business. The arrangement is shown in Fig. 1. A straight wire is stretched so that its center (not its end) passes near the set. It is important that the wire run nearly horizontal, and nearly in a straight line. Such departures as indicated in Fig. 2A are not important, but a form like Fig. 2B will not be a huge success, since it approaches the ordinary antenna too closely.

The length L should really be one-half a wavelength, but since this is usually not possible, the loading coil LC is provided. It is convenient to make L 30 feet for the 20-40 meter region. In this case LC will have a diameter of 3 inches and a length of 6 inches, the winding having around 80 turns tapped at 5-turn intervals. Ordinary "annunciator" or "bell" wire is handy, since it has insulation which gives the proper spacing and is competent to survive the mauling received when tapping the winding.

Incidentally, tapping does NOT mean that tails are to be soldered or twisted onto the coil. It merely means that a short loop is to be taken out and twisted, after which the winding proceeds. When the job is done, skin all the loops so that the clip may be put on them. It is convenient if the loops are not taken out in a line but spread around, to avoid mechanical interference.

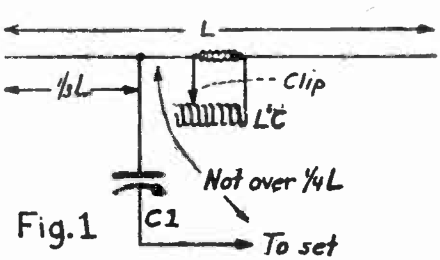


Fig. 1

If one is not fussy about the 20-meter region, better results will be obtained at higher wavelengths by making L equal to 40 feet. If one is interested in a single region the proper length should be chosen at once. This will mean about 30 feet for the 20-meter region, 60 feet for the 40-meter region and 120 feet for the 80-meter region. It does not pay to go above this, for the horizontal reception idea depends on distortions which are absent above this region. Even at 80 meters the gain is not important.

DOING IT BETTER

A more precise job can be done with the arrangement of Fig. 3 The values of L for this depend somewhat on the region one works in, but the figures already given will serve as a good guide. Making L equal 40 feet is perhaps the best compromise. C2 and C3 are NOT an ordinary two-gang condenser, but two independent condensers connected by an *insulating* coupling. LC remains as before.

Having the antenna, we wish to connect to the set. This may be done by tapping off as suggested in either Fig. 1 or Fig. 3. The condenser C1 has a maximum capacity of .000015 mf. In such receivers as the "Wasp" and the "Super-Wasp" this condenser is built in and need not be provided separately. When used with a set having unshielded coils, scheme 3 may be used in another way by omitting the tap and simply putting LC near the input coil of the set.

No promises are made that this method of reception is always best or that it is

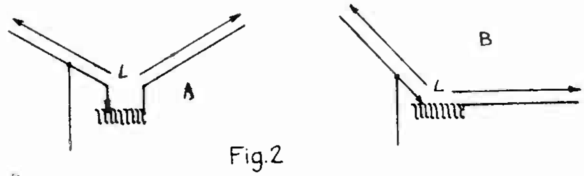


Fig.2

good at all locations and distances. The effects are complex and while they are reasonably well understood, one had best provide both the horizontal antenna and an ordinary antenna. It is always easy to change and see which is best.

One matter more. While the figures show this rather plainly one must take some care with the placing of the downlead. The length "1/3 L" is not absolute; a little changing may help.

THE USELESS WAVELENGTHS

Short waves are older than radio, having been the ones with which Heinrich Hertz made the confirming experiments that have made radio possible. None the less they are, despite all press agenting, not enough appreciated or used. I have not taken leave of my senses, but am perfectly serious and sane. Recall that some few years ago the leading wireless magazine editorially and in articles denied the possibility of radio communications for more than perhaps 75 miles at such unhappy wavelengths as 200 meters. While reading that editorial I was listening to the signals of an Ohio amateur station on 195 meters. The distance was 650 miles and my phones were on the table!

Rather uniformly that has been the attitude; we deny the existence of the things we have not seen or heard.

Not so long after that the entire amateur world was howling for special licenses to go about 200 meters because one "can't work a tube set below 200." Now we know that those despised waves below 200 were excellent for tube work, just as they were for spark.

And yet today the 5-meter region is being denounced as worthless, by folks who know very little indeed about it. Now I do not pose as an authority; on the other hand, I am one of a group which has certainly spent as much time as anyone on the 5-meter business. From that position there is ventured the prophecy that within the lifetime of all of us the worthless 5-meter region will be fought over quite as thoroughly as the worthless 20-200 region has been fought for in this last year at Washington.

CONCERNING SILENCES

As far as I know, the queerest thing in radio is the reaction of a beginner in short wave reception. Almost invariably he solemnly assures the designer or builder of the set that it is not working well and the signals are failing to come in on the shorter wavelengths. Some times he is right and the set has an important disease. Far more often he has simply failed to appreciate the difference in performance between such a set and the usual broadcast receiver.

CRAMPED TUNING

Thus, for instance, the "blue" coil of a "Wasp" or a "Super-Wasp" covers about 900 kilocycles, while the "red" coil covers about 7,650 kilocycles. Obviously the tuning on the red coil (17-30 meters) is about 8½ times as cramped and one must proceed with care to find signals. When such care is used a surprising number of signals are found that previously were overlooked nor are they all feeble signals by any means. I have seen a beginner fail completely to find any signal whever when English 5SW was available at ear splitting intensity, KDKA's short wave almost as loud and half a dozen others with useful intensity. This considers phone signals only. The same "dead" tuner produced over 60 telegraphic stations in 20 minutes of casual wandering about amongst the coils and condenser settings.

CRANKY OPERATION

That is not all of the story, of course. Frequently the set is cranky because of a minor oversight—the builder has failed to try several grid leaks and detector tubes to get smooth action, the antenna is too big, or the set is being blamed for the inherent tendency of short-wave broadcast signals to become "chewed" as to quality on the way in. Of course this last does not produce a silence in the phones or loud speaker. Instead it generates horrible noises that are not recognized as signals. Before being asked what to do about it I will admit that I do not know. From the present position of the art we see no hope in the matter. More power makes it worse, less distance from the station makes it worse (unless the distance is very short) and one has no seeming relief except to move to the opposite side of the world, where the signals are usually both clear and strong.

THE EXTRA COIL

Such consideration as this led to the addition of a 200-500 meter coil in the design of the "Wasp" and the "Super-wasp." When the short waves are misbehaving one has but to change coils!

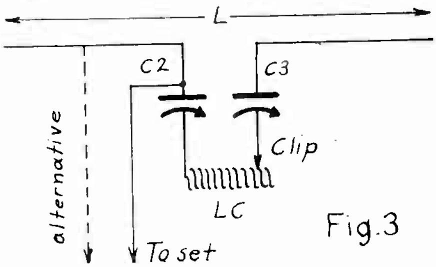


Fig.3

HOW TO GET THE MOST OUT OF A SHORT-WAVE RECEIVER

By ROBERT HERTZBERG

THERE are many owners of short-wave receivers who have picked up broadcasting stations in distant parts of the world with little trouble. There are also many who barely manage to bring in the harmonics of some badly adjusted local stations, and who are beginning to think that this whole short-wave business is a lot of bunk. For people in the latter class this article, telling how they may improve their reception, is intended.

The advice contained herein applies to the Super-Wasp receiver.—EDITOR.

THE following instructions and hints on the tuning of short-wave receivers may be applied to practically all existing types of short-wave instruments. However, because so many readers of RADIO DESIGN have made "Wasp" sets in accordance with the data published in our Fall, 1928 number, this particular outfit will be taken as the model.

Let us assume that you have already assembled the set and have it connected to the necessary batteries and the usual aerial and ground. You have already used it for a while—a few evenings, let us say—and are rather disappointed in not hearing those much-mentioned foreign stations. We will also assume that all the wiring is correct; few people fall down on this point, because the hook-up is such a simple one and the large blueprint furnished with the kit makes every connection plain.

SET MUST OSCILLATE

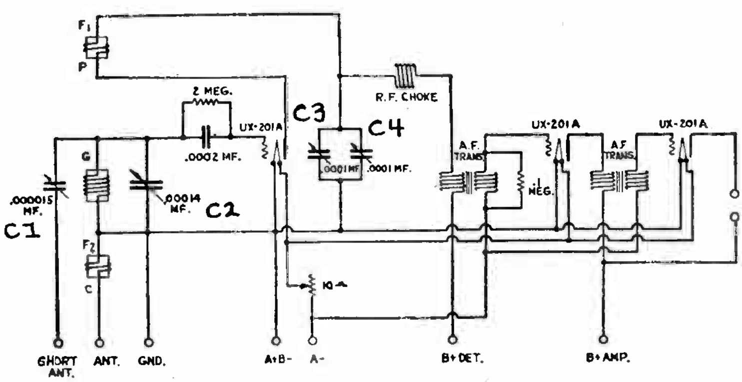
The first thing to learn is that a short-wave receiver is absolutely worthless unless it can be made to oscillate smoothly over the entire range of the tuning condenser, with each coil. Oscillation in a regular broadcast set is usually a nuisance, because it is difficult to control, but in a short-wave outfit it is the whole life of the circuit.

If your tubes and batteries are good the factor that determines whether or not the set will oscillate is the aerial series condenser—the small one on the sub-panel. However, before starting to adjust this, fasten the aerial wire under the post marked "ant." This will connect it to the fixed primary winding on the Pilot plug-in coil.

Put the green-ring coil in the socket and switch on the set by turning the rheostat knob around to the right. Set the tuning condenser C2 (the one controlled by the vernier dial) at O, and set the upper regeneration condenser (which we will call C3 for convenience) about half way up. Now slowly advance the lower regenerations condenser C4. Somewhere along it you should hear a soft, hushing sound which will build up into a sharp plop and then disappear. If you don't hear anything more than the usual slight tube noises, which indicate that the circuit is alive, the set does not oscillate, and you should connect the aerial wire to the other post, marked "Short Ant."

ADJUSTING THE AERIAL CONDENSER

By doing so, you connect the aerial to the grid of the detector tube through the midget condenser C1 on the sub-panel. Set this condenser at about half its capacity, and repeat the foregoing operation. Try turning the tuning condenser to different settings, and listen

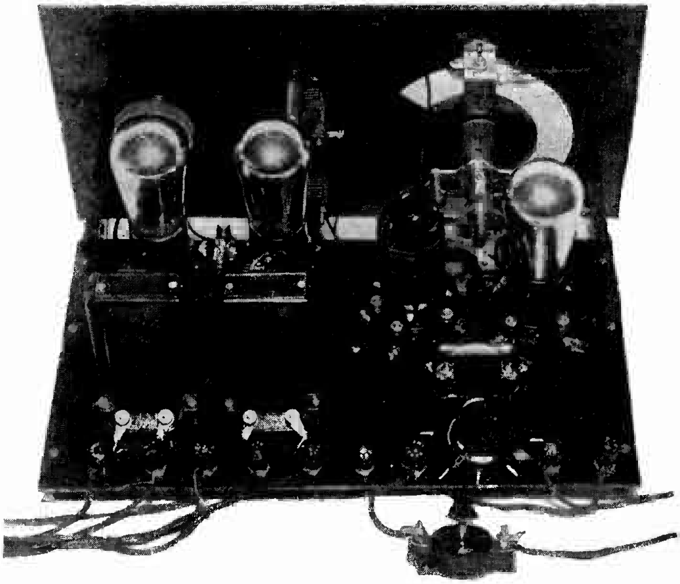


The hook-up of the Pilot "Wasp." C1, antenna condenser; C2, tuning condenser; C3, C4, regeneration condensers.

for the telltale hush and plop. If you still are unsuccessful, or obtain the sounds over a limited portion of the tuning condenser scale, reduce the setting of the aerial condenser C1, and try again. You can determine the correct position for this condenser after ten minutes of trial. Mark a line or scratch on the sub-panel for this position, so that you can go back to it any time you want.

If the hush is followed by a prolonged squeal instead of a plop, don't worry about this yet, as you can clear it later.

Repeat these operations with each of the plug-in coils, in each case noting the setting of the aerial condenser. The primary connection in many instances works very well, but most Wasp owners report better results from the series-condenser arrangement.



Above: A "Wasp" receiver with a VM80 Micrograd in series with the aerial wire.

With the red and orange ring coils you may find that even with the antenna condenser at zero, the set will refuse to oscillate. This means that your aerial is too long. Instead of climbing up on the roof and cutting out a few yards of wire, connect another midget condenser in series with the aerial lead. The Pilot No. VM80 Micrograd, which has a capacity range of .00001 to .00005 mf., is ideal for this purpose. Try different settings of this condenser in conjunction with the sub-panel condenser C1.

The use of an external condenser is almost a sure cure for a non-oscillating set, especially when an aerial intended for long-wave broadcast reception is used.

If you happen to have twenty or thirty feet of insulated wire of any kind on hand, hang it out of the nearest window and use it as an aerial. You will find that even a shorter piece, thrown along the floor, will yield good results. The Wasp without any aerial at all will bring in many stations, as the pick-up effect of the coils themselves is enough to affect the sensitive circuit.

The blue ring coil, which is intended to cover the regular broadcast band, very rarely gives trouble. For loudest signals you probably will have to turn the antenna condenser C1 all the way in; or use the fixed primary. With the latter the tuning will be somewhat broader than with the series condenser arrangement.

KILLING THE SQUEAL

If you now can make all the coils oscillate readily at any setting of the tuning condenser C2, but find that the hushing sound is followed by a terrific squeal, first look at the 100,000-ohm fixed resistor connected across the secondard of the first A. F. transformer, and make sure that it *is* connected. Many severe cases of howling are due to defective or missing resistors.

The grid leak and the value of the "B" voltage applied to the detector tube are also important factors that determine how smoothly the set oscillates. Grid leaks of two, three, four and five megohms should be tried, and the "B" voltage varied by means of a series resistance like the Pilot Resistograd. A voltage of 22½ is usually about right for 201A tubes, although 45 may sometimes work better.

A word about tubes. The 201A's are the most satisfactory tubes for all three sockets in the Wasp. A 200A may be used as the detector and will prove more sensitive than a 201A, but it is somewhat noisy in operation. A 112A or 171A can be used as the second audio amplifier, but this means more "B" batteries. The 201A's in general are more convenient, as they require only 90 volts and will even work very well with only 45 volts. If you do not care to make much of an investment in batteries, and will do all your short-wave listening with earphones, a single 45-volt block will produce just as many signals—if slightly weaker ones—as two or three blocks.

After you have made the foregoing adjustments the receiver should be capable of smooth oscillation, under ready control of the two midget condensers C3 and C4. You will find that with the two smaller coils (those with the red and orange rings) the top condenser can be set at zero and all adjustments made with the bottom one. As you go up the wavelength scale you will need more and more capacity in the regeneration condensers. Use the top condenser as an auxiliary to the bottom one, as the latter is easier to handle, being nearer the bottom of the panel.

You are now ready to try for short-wave broadcasting stations. Make yourself comfortable, with your feet well under the table and with the set pushed back so that your elbows are resting on the table.

TWO METHODS OF TUNING

There are two methods of tuning-in broadcasting stations with a regenerative receiver.

Starting at O, turn up the tuning condenser slowly with the left hand, and keep the set oscillating by manipulating the regeneration condenser C4 with the right hand. When you run into the signals of a broadcasting station you will hear a whistle mixed in with badly distorted music or voice. You hear this mixture because the incoming signals are beating or "heterodyning" with the oscillations produced locally in the receiver. To clarify the signals, turn down the regeneration condenser very, very carefully, at the same time twisting the vernier dial back and forth a fraction of a degree to keep the tuning accurate. The music should clear up just as the whistle disappears. If the music disappears *with* the whistle, or becomes too weak to be understandable, you will have to try the second method, which is known as "zero beating."

With the foregoing method, you hear a whistle because the frequency of the broadcasting station's carrier wave is just a little different from the frequency of the oscillations generated by the receiver circuit. If you leave the set oscillating, but tune it with extreme accuracy to the *same* frequency as the incoming carrier wave, you will not hear a whistle, because the difference between the local and the incoming oscillations is zero, and no beat notes will be produced. However, the voice and music impulses, which cause the carrier to wobble slightly, will come through, and you will be able to distinguish the program. The signals are likely to be somewhat distorted, but you won't mind that.

You can tell when you are zero-beating a station by turning the tuning condenser a hair's breadth above and below the point at which the signals are understandable and clear of whistling. You will hear a whistle each time, as each time you move the condenser you change the frequency of the local receiver circuit and therefore cause a beat note to be set up.

Zero beating is an excellent means of fishing out very weak stations, because the receiver is in a very highly sensitive condition when it is oscillating.

Many weak and distant stations that you cannot hear at all with the set thrown just out of oscillation you at least will be able to identify if you zero-beat them.

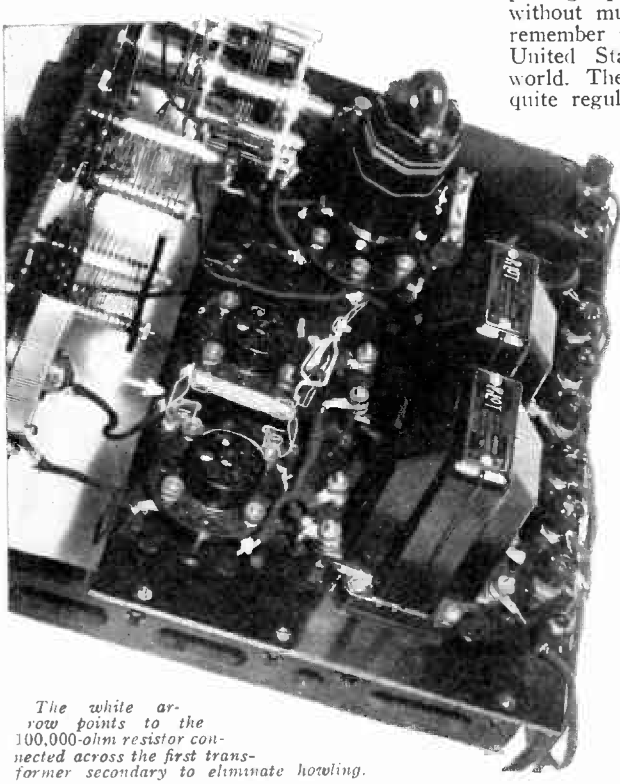
LEARN THE CODE!

In running up and down the scale with each coil you will encounter hundreds of code stations. If you learn the code you can have loads of fun identifying them and listening to their exchange of messages. An easy method of learning the code is described in "The Radio Amateur's Handbook," the official manual of the American Radio Relay League. You can obtain copies through Radio Design at a dollar apiece.

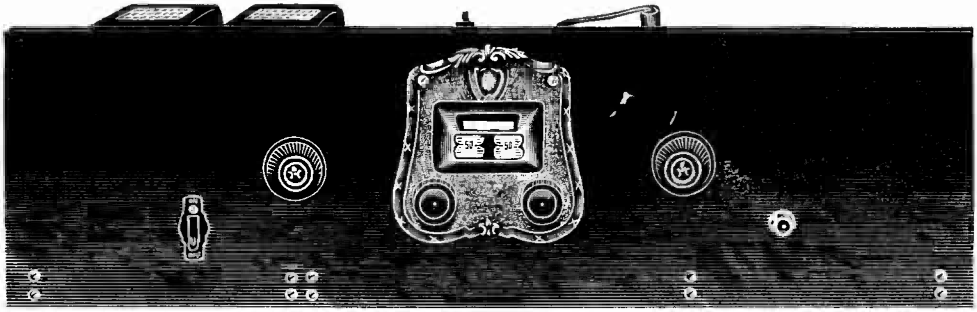
Once you have mastered the two tricks of tuning described in this article you will begin picking up short-wave broadcasting stations without much trouble. One thing you must remember is the time difference between the United States and other countries of the world. The European stations are heard here quite regularly around supper time, 5SW at Chelmsford, England, and PCJJ, at Eindhoven, Holland, being the star performers. PCJJ in particular comes through with terrific volume sometimes, many Wasp owners reporting fine loud-speaker signals. The Australian stations also roll in nicely, and you can hear them if you care to roll out of bed about 5 o'clock in the morning.

The directions given in this article apply to the new Super-Wasp as well as to the regular Wasp. The only difference is that you have to advance two tuning dials. This sounds complicated, but in practice is really easy. The same tricks of regeneration control and zero-beating can be used.

Radio Design will be interested in hearing from short-wave set owners and of their experiences with their receivers. Drop us a line, especially if you are having some little trouble; we will try to help you.



The white arrow points to the 100,000-ohm resistor connected across the first transformer secondary to eliminate howling.



THE K-106 A. C. SCREEN-GRID T. R. F. RECEIVER

By JOHN GELOSO

THE tone quality of most receivers designed for extreme DX (distance) reception is not of a very high order, because the required circuit sensitivity is usually obtained by making the R.F. amplifiers or the detector, or both, highly regenerative. Up to a certain point regeneration does not seriously distort the incoming signals, but the action is invariably pushed to the point where the voice and music begin to sound "mushy."

This state of affairs is not at all satisfactory to the many builders and buyers of custom-constructed radio sets, who nowadays expect receiver performance that was considered well-nigh impossible several years ago. These people are not satisfied with a set that is good on DX alone and poor on tone quality, or one that sounds like the proverbial million dollars and won't bring in two stations outside of the same state; they want outfits that will do both.

The new Pilot K-106 Receiver, which is supplied complete in knock-down form, was brought out to meet this insistent demand. It might truthfully be described as the last word in kit receivers for home construction, as it makes use of the convenient and highly sensitive A.C. screen-grid tubes, shielded R.F. tuning coils, plate detection, both resistance and transformer coupling in the audio amplifier, and a complete built-in power pack.

It has one little feature that DX fans—and their families—will greatly appreciate: a jack that allows the use of earphones. Thus when the rest of the family finishes its enjoyment of a local program and decides to go to bed, you can plug in the phones on the first audio stage and tune in station after station without disturbing anyone's slumbers. Without knowing it, you miss many stations when you "fish" for them with the loud speaker alone. With the aid of the phones you can locate them very easily.

NO HUM—EVEN WITH PHONES

Many readers will undoubtedly ask, "How can you listen with earphones on an A.C. set? Doesn't the noise drive you crazy?"

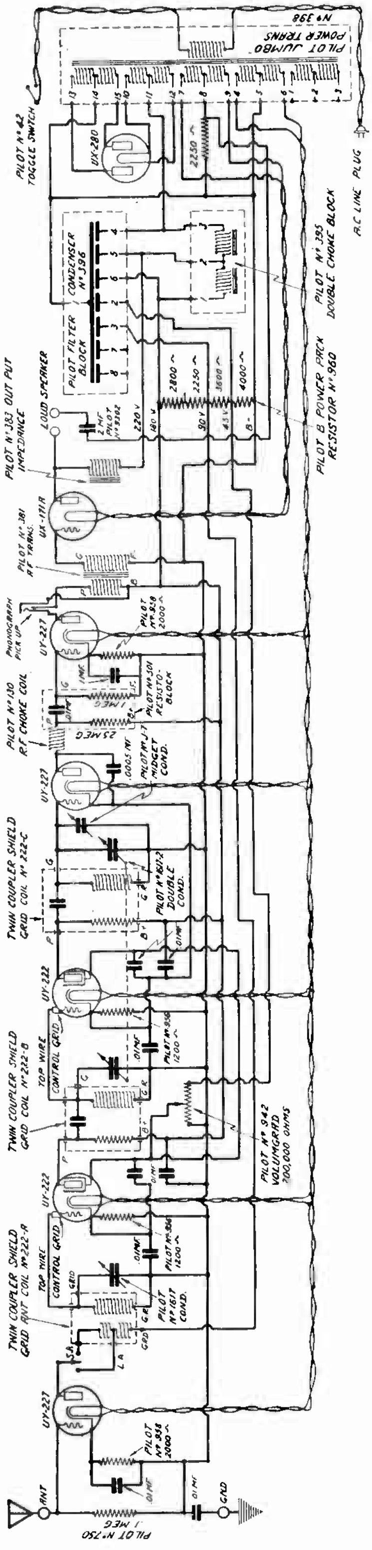
The answer is that the K-106, making use as it does of heater cathode tubes, is beautifully quiet in operation. Of course there is some A.C. hum in the phones, but it is so weak that you forget all about it after ten minutes of listening. During one of the preliminary tests on the receiver, conducted at Yorktown Heights, N. Y., James Brothers of the Pilot engineering staff listened in continuously from ten o'clock in the evening until half-past four the following morning, and when he finally removed the phones from his head to gargle a little coffee he said:

"Hum? didn't even know there was any!"

The list of stations Jim pulled in, first on the phones and then on the loud speaker, reads like a call book, so we won't waste space printing it here. We might say that KNX, in Hollywood, California, was one of the stations that came through loud enough to be heard all over a ten-room house.

THE ELECTRICAL CIRCUIT

Let us examine the schematic circuit diagram of the K-106 and see what the set consists of electrically. From the antenna circuit we run into a 277 tube, which is used merely as a coupling device to eliminate the annoying detuning effects of different lengths of aerials. It furnishes a slight amplification, but not very much since it is untuned. The 100,000-ohm resistor across the grid and ground fits in a pair of fuse-type grid-leak clips on the under side of the sub-panel.



THE HOOK-UP OF THE K-106

This diagram shows, in schematic form, the complete wiring of the K-106 receiver. It corresponds in all details ***with the*** *picture diagrams on pages 26 and 27.*

The next two tubes are of the A.C. screen-grid type, and are responsible for the high sensitivity of the receiver. The 227 is coupled to the first one through a No. 222-A antenna coil, which has a tapped primary. Either all or half of this primary can be used, a small single-pole, double-throw knife switch being provided on the sub-panel between the 227 tube and this 222-A coil. The tuning is sharper with half of the primary than with all of it.

The secondary of the 222-A coil is tuned by a single variable condenser, which is controlled by the left section of the double drum dial.

Coupling between the first and second screen-grid tubes, and between the second and the detector, is furnished by a 222-B and a 222-C coil, respectively. These consist of a plate resistor, a blocking condenser and a grid coil. The two grid coils are tuned by a double variable condenser, which is controlled by the right section of the double drum dial.

The one volume and sensitivity control is a No. 942 Volumgrad connected to act as a potentiometer. It regulates the voltage applied to the screening elements of the screen-grid tubes, and is very smooth in action as well as highly effective. Signals can be throttled down to a mere whisper, or amplified until they make the windows rattle.

The detector section of the double tuning condenser is supplemented by a J7 midget variable condenser, which is mounted on the panel to the right of the drum dial. This does not require much attention, but is useful in tuning in extremely distant or faint stations.

The three tuning units are identical in appearance, being enclosed in neat metal cases equipped with bases which fit in standard tube sockets. The 222-A takes a five-prong socket, and the 222-B and the 222C four prong sockets.

PLATE DETECTION

The detector does not use a grid condenser and leak, but works on the principle of plate rectification. To become technical, we might say that the tube is working on the lower bend of its plate-current, grid-voltage curve. In this condition it is capable of handling without distortion very much stronger signals than the ordinary grid-condenser grid-leak arrangement can handle. Most radio experimenters do not realize that the grid condenser and its leak are the one weak point of many receivers having powerful radio-frequency amplifiers; the latter develop strong signals, and the detector then fails to handle them and causes serious distortion.

The first audio stage of the K-106 is resistance coupled. If you will follow out the circuit, you will note, perhaps with alarm, that the detector is fed 180 volts. However, it goes through a coupling resistor of 250,000 ohms, so the actual voltage that reaches the plate in less than 180.

The first audio tube is a 227. It feeds to the second tube, a 171A, through the big Pilot

No. 381 A.F. transformer. This combination of resistance and transformer coupling is a very fine one, the tone quality of the receiver being all that anyone could desire. The loud speaker is connected to the plate of the 171A through a protective system consisting of a No. 383 output impedance and a 2-mf. blocking condenser.

SIMPLE POWER SYSTEM

The power supply system of the K-106 is of simple and dependable design. It consists of three main units; a power transformer, a choke coil block and a filter condenser block, along with a 280 rectifier tube and a No. 960 output resistor.

The mechanical arrangement of the parts of the K-106 greatly resembles that of the popular K-108, which was described in Volume 1, Number 3 of RADIO DESIGN. The front panel holds the on-off switch, the Volumgrad, the double drum dial, the midget condenser and the telephone jack.

The power supply components occupy a sub-panel by themselves behind the front panel, in the left corner. The R.F. and A.F. parts are strung along a longer panel, immediately adjacent. The exact disposition of the parts is made clear in the accompanying wood cuts and the picture wiring diagrams.

THE PARTS USED

Following is a complete list of the parts used in the K-106. These are made by the Pilot company, and are available in complete kit form, with drilled and engraved panels.

1—Front panel, 24 x 7 x 3/16 inches, bakelite.
1—Sub-panel 16¼ x 7 x ⅛ inches, bakelite (receiver end)
1—Sub-panel 7 x 10 x ⅛ inches, bakelite (power pack)

Power panel components:

1—No. 398 power transformer
1—No. 396 condenser block
1—No. 395 choke coil
1—No. 960 resistor
1—No. 214 socket (for rectifier tube)
1—No. 42 switch
1—No. 9302 condenser, 2 mf.
1—No. 951 resistor, 2250 ohms
1—No. 958 resistor, 2000 ohms
2—No. 59 condensers, .01 mf.

Receiver proper:

5—No. 35 shelf brackets
1—No. 1617-2 double condenser
1—No. 1617 condenser
1—No. 1283 L dial
1—No. 942 Volumgrad, 200,000-ohm potentiometer type
1—No. J7 midget condenser
1—No. 1165 midget jack
3—No. 214 sockets
6—No. 215 sockets
1—Special switch, single-pole, double-throw
1—No. 130 R.F. choke
1—No. 500 Resistoblock
1—No. 750 grid leak, 100,000 ohms
1—No. 751 grid leak, 250,000 ohms
1—No. 754 grid leak, 1 megohm
1—No. 381 A.F. transformer
1—No. 383 output impedance
4—Binding posts; one each No. 20—ANT.
No. 21—GND.
No. 19—L.S.+
No. 32—L.S.—
6—No. 59 condensers, .01 mf.
1—No. 52 condenser, .0005 mf.
1—No. 801 condenser. 1.0 mf,
2—No. 950 resistors, 1200 ohms
1—No. 958 resistor, 2000 ohms
1—Pair fuse-type grid-leak clips
1—Set Twin Coupler screen-grid plug-in coils; one each 222-A, 222-B, 222-C
Package of hardware, including all screws, wire, etc.

The K-106 is not a simple set, something a rank beginner can put together in an evening. It is a more or less advanced outfit, but will present no particular difficulties to the man who has built one or more modern A.C. receivers. It can be assembled very easily, as the three panels supplied with the kit are accurately drilled; the main work is in the wiring. If you proceed along the following lines, you will have no trouble.

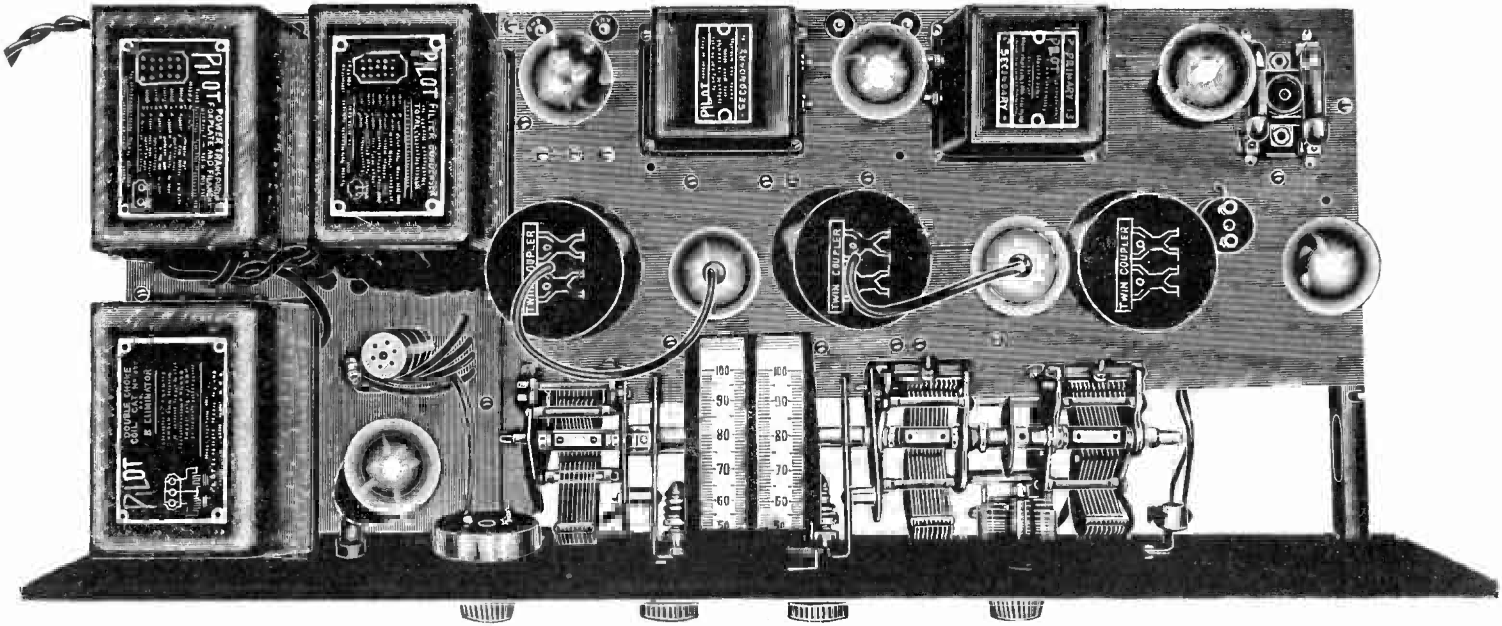
POWER PACK FIRST

First mount the three fixed condensers and the two fixed resistors on the under side of the small sub-panel, which is for the power supply units. Push the screws through the top of the panel, and tighten the nuts over locknut washers on the bottom side. Now mount two of the sub-panel brackets, to give the panel feet to stand on. Then proceed to the three heavy instruments: the transformer, the choke coils, and the filter condenser block. These will cover the heads of most of the mounting screws of the condensers and resistors. The tube socket is next, and the No. 960 resistor after that. Note that the latter stands upright.

Now drill out the 6-32 screw holes in the remaining six .01 mf. fixed condensers, so that they will freely pass the ⅝-inch long round head screws, and fasten them as shown. Mount all the other parts on the under side of the long sub-panel. Put locknut washers under all the nuts, and use a Spintite wrench for tightening the latter. Mount the other three sub-panel brackets and turn the sub-panel over, so that you can work on the top.

The nine sockets for the tubes and the screen-grid coils will mount readily in the holes drilled for them, as will the resisto-block, the audio transformer and the output impedance. Note how the little single-pole, double-throw baby knife switch fits between the sockets for the first 227 tube and the 222-A coil.

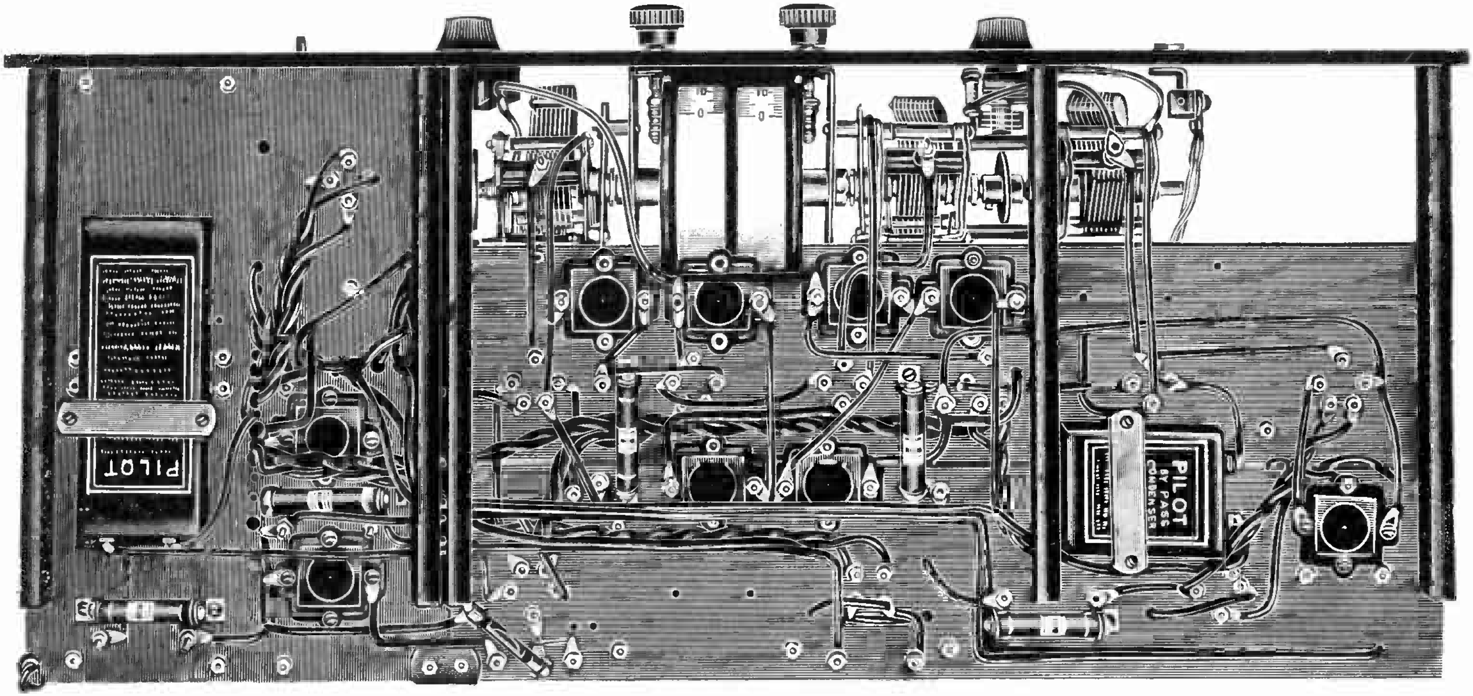
Continue with the front panel, mounting the double drum dial first, then the variable condensers, and then the incidentals like the J7 midget, the telephone jack and the power switch.



TOP VIEW OF A COMPLETELY ASSEMBLED AND WIRED K-106

The three large units on the left are the power transformer, filter condenser block and choke coil block of the power pack. To right of the choke are the 280 rectifier tube and the output resistor, both of which stand upright. The long sub-panel holds the receiver proper.

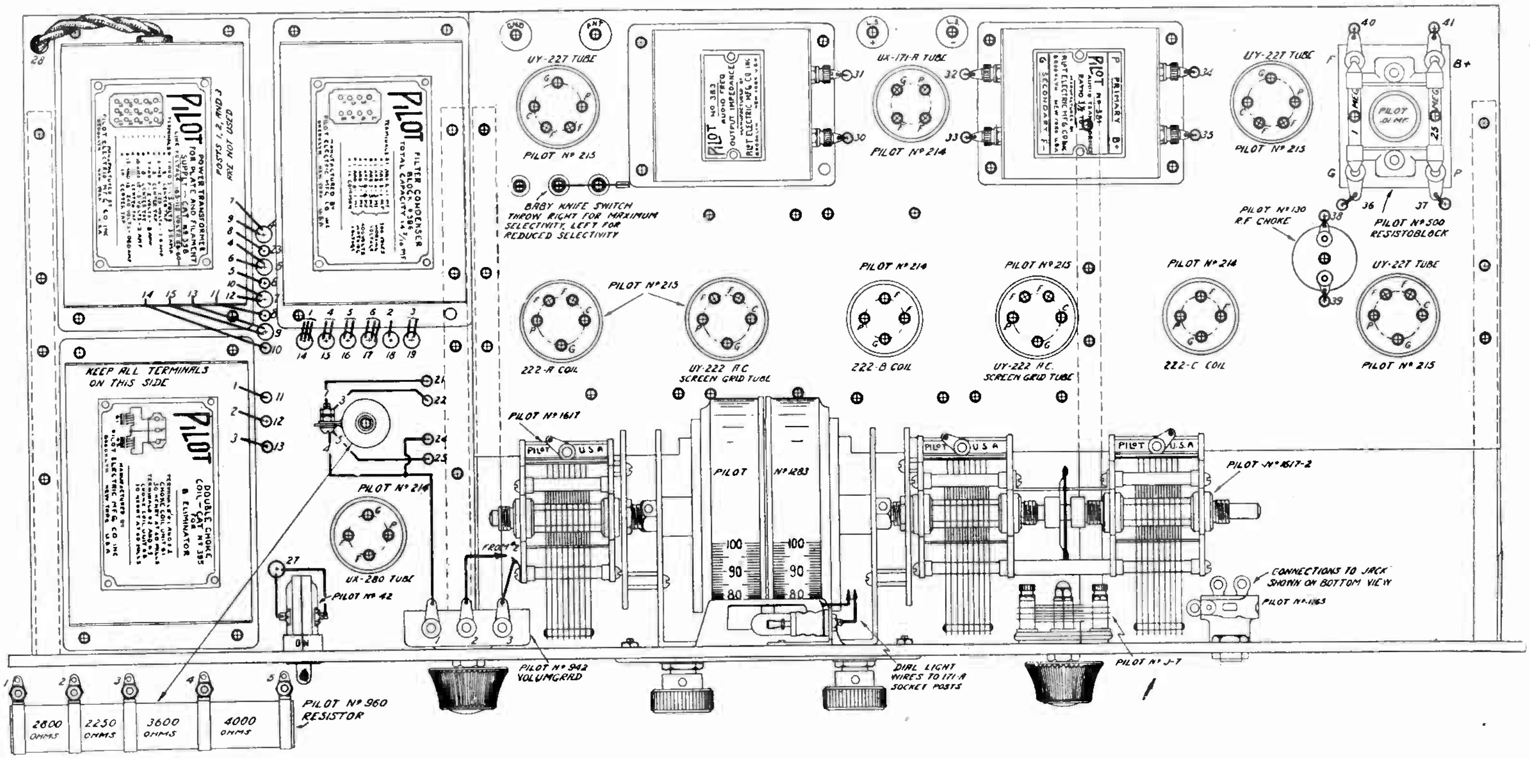
The wires coming out of the tops of the first two shield cans of the plug-in coils are fitted with clips, which in turn snap over the caps on the tops of the two screen-grid tubes. The third can on the right has no such wire. The audio-amplifier parts fit along the back edge of the sub-panel.



UNDER VIEW OF THE K-106

What you see when you turn the set over. Notice that there are five sub-panel brackets. The two on the left support the small sub-panel holding the power-supply units, while the other three are for the long sub-panel of the receiver proper. Also note that the two sub-panels are fastened together by means of a little brass strip, which can be seen just below the second and third brackets from the left.

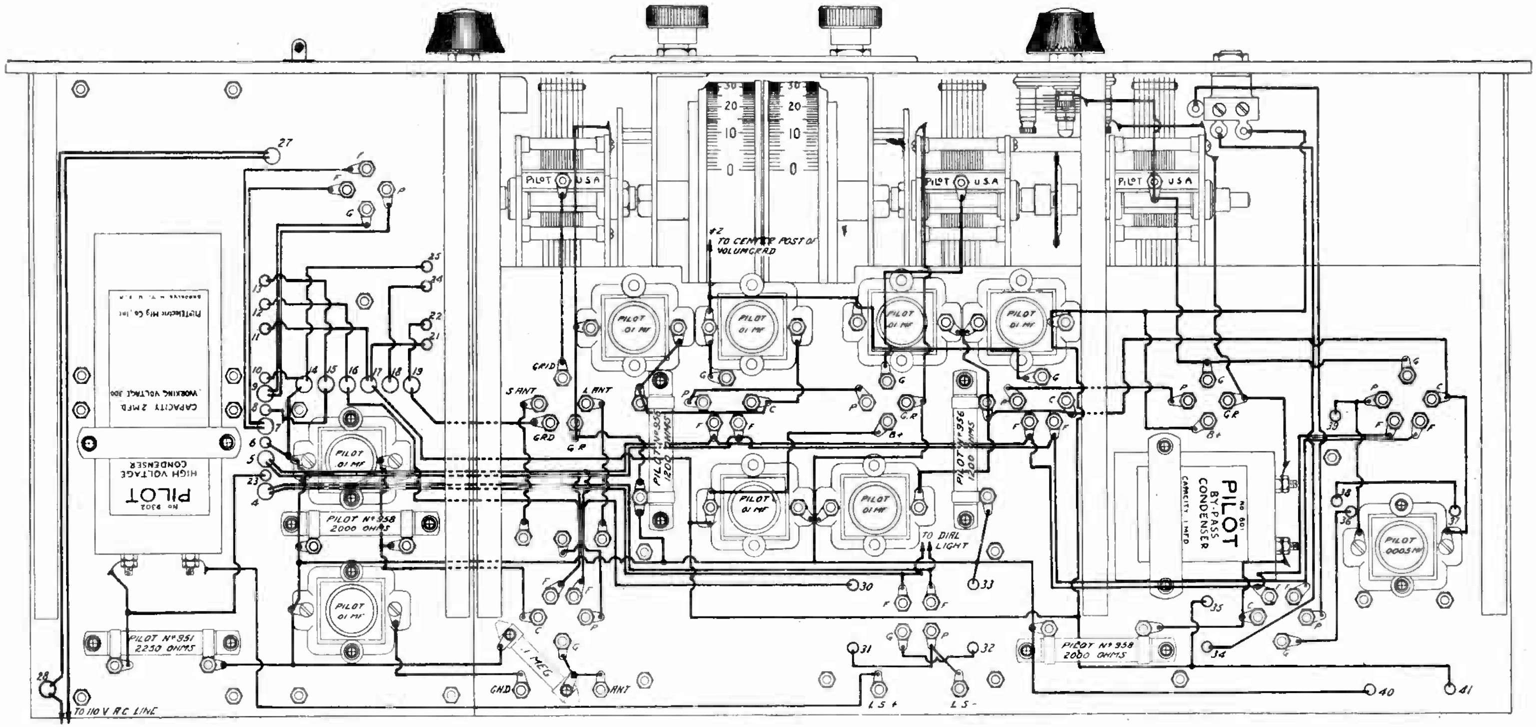
The two big by-pass condensers, on the extreme left and right, are held in place by brass clamps, which themselves are tightened down by screws passing through the sub-panel. The other fixed condensers and the resistors are fastened by means of short screws.



TOP PICTURE WIRING DIAGRAM OF THE K-106

There is comparatively little wiring on the tops of the sub-panels, most of the connections being made on the underside. Holes carrying wires through to the underside are marked with numbers, which reappear in the drawing shown below. The numbers drawn inside of the edges of the power transformer, filter condenser block and choke-coil unit represent the terminals of these instruments, as molded into the connection plates.

The plug-in coils are not shown, as they fit merely in the first, third and fifth sockets; the connections from the coils to the caps of the screen-grid tubes are shown in the top view of the K-106 on page 24.

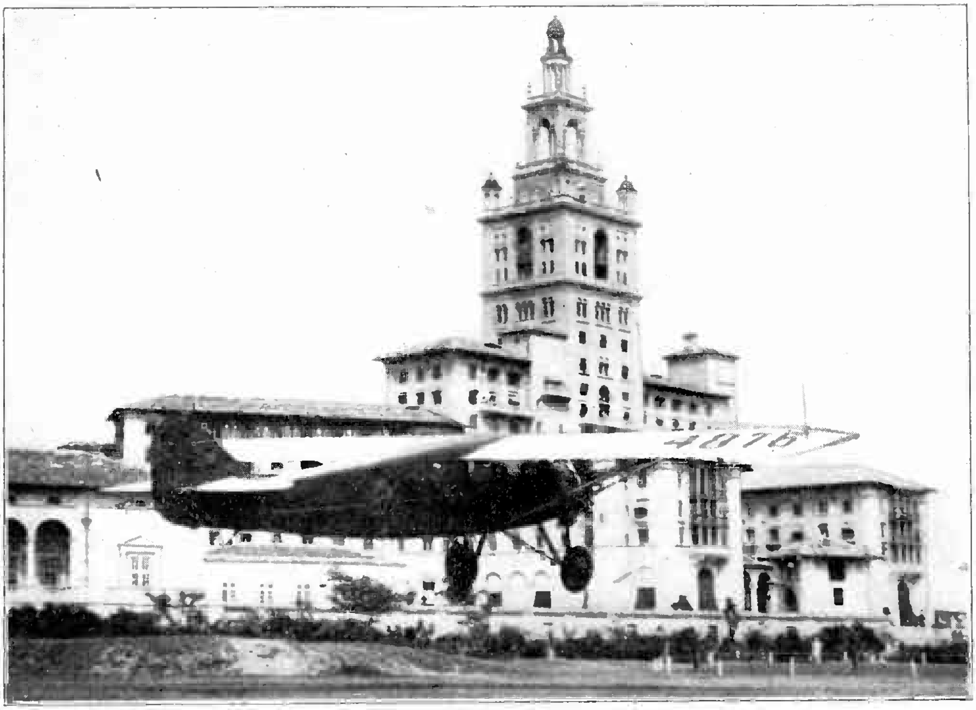


BOTTOM PICTURE WIRING DIAGRAM OF THE K-106

For the sake of clarity, the two pairs of wires coming out of holes 4 and 5 on the left are shown as straight lines, but actually they should be twisted, to represent the twisted wires. These connections are for the filaments of the various tubes in the set. The wiring of the K-106 is a bit complicated, but if you follow the instructions in the text, and do the job carefully, the set will work the first time you turn it on.

The wires in the extreme lower left-hand corner, marked "to 110 v. A.C. line" should consist of a length of flexible lamp cord with a socket plug on the end. As usual, solder all the connections thoroughly with rosin-core solder.

BROADCASTING FROM THE AIR



AN action picture of the Pilot flying laboratory taking off from the golf links in back of the Miami-Biltmore Hotel, at Miami, Fla. The Stinson Detroiter plane flew to Miami during the height of the winter season, and broadcast over radio station WIOD at Miami Beach the last week of February. This was the first time aerial relay broadcasting had been attempted south of the Mason-Dixon Line, and it was highly successful.

Through the cooperation of the southern station, and Jesse Jay, its engineer manager, special amplifying apparatus was used in conjunction with the transmitting apparatus on the plane, resulting in the finest quality it has yet been possible to transmit from a flying broadcasting station.

Two-way communication was maintained with the ground station during the tests, and the signal strength from the plane, W2XBQ, was sufficiently powerful to permit telephonic broadcasting from distances up to ten miles. The daytime telegraphic range of the airplane is considerably in excess of this, communication having been maintained with ground stations several hundred miles away.

THE K-106 A. C. SCREEN-GRID RECEIVER

(*Continued from page 23*)

Before fastening the front panel against the feet of the brackets, do as much wiring as possible on the power transformer, choke coils, condenser block and upright resistor, as you will not be able to reach their connections posts very easily with the panel in place. This is important; make note of it and save yourself the trouble later of removing the panel in order to get at the transformer terminals.

WIRING HINTS

With the kit you will find a quantity of flexible rubber covered wire and some bare tinned copper wire and spaghetti tubing. Use the flexible wire for the filament and other power circuits, and save the stiff wire for the R.F. and incidental connections.

Do the filament circuit first, as the wires must be twisted in pairs. Follow with the "B" circuits, and end up with the short R.F. leads. The wiring as shown on the accompanying diagrams looks horribly messed up, but actually, when you put in one pair of wires at a time, it won't be difficult at all. Merely solder all joints well, do not let bare wires touch each other, and everything will be all right.

The operation of the K-106 is simple. All you do is put the tubes in the proper sockets, connect to the loud speaker to the L.S.+ and L.S.— posts, with the aerial and ground to their posts. There is no troublesome neutralizing or balancing to be done, as the screen-grid tubes require no operations of this kind.

SOME RADIO QUESTIONS AND THEIR ANSWERS

Uses of the UY-227

1.—Is the UY-227 intended for use only as a detector, or can it be used for other purposes in a set?

Answer: The UY-227 is a general purpose tube, and is highly effective as a radio-frequency amplifier, detector, or first stage audio-frequency amplifier. It is merely operated at different values of plate voltage and grid bias for its functions as either amplifier or detector.

The latest tendency in set design is to use 227's throughout, except, of course, in the last A.F. amplifier position. The use of this type of tube reduces the audible hum and simplifies the wiring of the set.

THE questions on this page were selected from the thousands of letters written in by readers as the ones most frequently asked. The answers contain much useful information, so you should read them carefully.—EDITOR.

A.C. Tubes for Short-Waves

2.—Why can't A.C. tubes be used in short-wave receivers like the Wasp?

Answer: Because practically all listening on the short waves is done with a pair of telephone receivers, and the hum caused by the alternating current in the sensitive circuit is usually so annoying that it makes continued reception very uncomfortable. We are not saying that it is impossible to use A.C. tubes in short-wave sets; the technique of the art simply hasn't yet reached that point. Mr. Robert S. Kruse, one of the country's leading short-wave experts, is now experimenting with an all A.C. short-wave receicer for Radio Design, *and we hope to describe his experiments soon.*

"Grounds" Up in the Air

3.—Where is the "ground" connection made on an airplane that carries radio equipment?

Answer: If the framework of the plane is made of metal, as it is on practically all modern planes, the so-called "ground" is made directly to it. The aerial usually consists of a trailing wire hanging beneath the body, or of a pair of wires stretched from the wing tips to the tail, as on the airplanes being used by Commander Byrd in the Antarctic and on the Pilot flying radio laboratory.

Using the Right Meter

4.—The current from both "B" batteries and "B" power units is direct current. Why can't an ordinary battery voltmeter be used to measure the voltage of a "B" unit?

Answer: This is a very common question. The answer is that ordinary battery voltmeters have a comparatively low resistance, and therefore consume an appreciable amount of current for their own operation. The voltage of "B" batteries is not seriously affetced by this drain if the meter is connected only for a second or two, so the instrument gives a true reading. A battery, because of its low internal resistance, will supply considerable current before its terminal voltage drops.

On the other hand, the usual "B" power and has a relatively high internal resistance, and the load imposed on it by the current requirements of the voltmeter will cause the voltage to change very decidedly. The meter will then read the output voltage which is produced by the unit under the normal current load of the set plus the current load of the meter (which is often as great as that of half the set) and the reading will be a false and useless one.

For "B" unit measurements, a special voltmeter must be used. Instruments of this type have such a high resistance that they draw only a milliampere or two, as compared to 15 or 20 milliamperes drawn by battery meters. This very light current drain has no appreciable effect on the power unit, and the meter gives a true indication of the output of the latter.

The Best Aerial Length

5.—How long should an aerial be for best results? What is the best ground connection?

Answer: For general broadcast reception an aerial should be between 85 and 150 feet in overall length. This figure includes both the elevated wire itself and the "lead-in", which is attached to it, as the lead-in is just as much part of the signal pick-up system as the so-called "aerial" itself. A little longer or a little shorter aerial will work perfectly well. The longer the wire, the more energy will it pick up out of the air, so the more stations will you hear. Also, the longer the wire, the greater the possibility of interference between stations.

The most effective ground is one which makes the best contact with the earth. For all ordinary purposes, the water pipe system is usually best, as the metal pipes in the house connect with other metal pipes which are buried for miles just under the surface of the street. Radiator pipes are also good, as they connect with the water system. Never use gas piping, under any conditions.

There is no limit to the number of ground connections you can use; the more the merrier. Some people who can boast of verified

(Continued on page 31)

SHORT-WAVE BROADCASTING STATIONS

THE number of short-wave broadcasting stations throughout the world is increasing rapidly, and owners of short-wave receivers are finding more and more sport "fishing" for them. RADIO DESIGN is glad to be able to present to its readers the very latest list of these stations, all of which use wavelengths that come within the tuning range of the Wasp and the Super-Wasp receivers. The following chart will help you to select the proper coil for the station you want to try for:

Coil	*Wasp*	*Super-Wasp*
Red Ring........	17 to 30m.	14 to 27m.
Orange Ring.....	30 to 52	26 to 50
Yellow Ring.....	48 to 105	50 to 100
Green Ring......	93 to 203	100 to 200
Blue Ring........	200 to 500	200 to 500

We regret that we do not know the exact hours of operation of the short-wave stations listed below. It is impossible to obtain reliable information of this kind even from many American stations, as they transmit usually at irregular intervals. However, you can try your luck; thousands of short-wave fans are finding that they run into foreign stations at all odd hours of the day and night, and they are getting a big "kick" out of them. If you hear any of these stations, drop us a line and let us know.

Please understand that the following stations broadcast regular musical programs, and announce in voice, *not code*. The list is by no means complete, but it is very useful. Cut it out and save it. The letters on the left are the call letters, and the numbers on the right the wavelength in meters.

	AFRICA	
AIN	Casablanca, Morocco.........	51.00
8KR	Constantine, Tunis...........	42.80
JB	Johannesburg, South Africa.	32.00
7LO	Nairobi, Kenya..............	35.00
	AUSTRALIA	
2BL	Sydney	32.50
2FC	Sydney	28.50
2ME	Sydney	28.50
3AR	Melbourne	55.00
3LO	Melbourne	32.00
6AG	Perth, West Australia......	32.90
6WF	Perth	104.50
	AUSTRIA	
OHK2	Vienna	70.00
EATH	Vienna	37.00
	Vienna	22.20
	BELGIUM	
EB4A2	Brussels	42.00
	BRAZIL	
SQBE	Bahia	24.00
	Para	34.00
	CANADA	
CF	Drummondville, Quebec.....	32.00
CJRX	Winnipeg, Man.............	25.60
VAS	Louisburg, N. S............	28.00
	COSTA RICA	
NRH	Heredia	30.30
	DANTZIG	
EK4ZZZ	Dantzig	40.00
	DENMARK	
D7MK	Copenhagen	32.05
D7RL	Copenhagen ....42.12 and	84.24
	ENGLAND	
5SW	Chelmsford	24.30
2NM	Caterham	32.50
GBS	Rugby	24.40
	FINLAND	
	Helsingfors (Helsinki).......	31.50
	FRANCE	
F8GC	Paris ("Radio LL")........	61.00
F8AV	Nogent	80.00
Radio Vitus	Paris	37.00
Eiffel Tower	Paris (time signals)........	32.50
YR	Lyons ("Radio Lyon")......	40.20
	Agen	30.75
YN	Lyons	58.00
	Nancy	15.50
FW4	Ste. Assise..................	24.50
	GERMANY	
AFI	Konigswusterhausen	14.00
AFL	Hamburg ....70.00 and	52.00
AFT	Konigswusterhausen	14.00
AFU	Konigswusterhausen	14.00
AFK	Berlin (Doberitz).......37.65	67.65
HEA	Nauen	11.00
AGC	Berlin	17.20
AGJ	Nauen	56.70
AGK	Nauen	11.00
LA	Langenberg	43.90
POF	Nauen	11.00
POZ	Nauen	18.10
	Stuttgart	41.00
	HOLLAND	
PCJJ	Eindhoven	31.4
PCKK	Kootwijk	16.00
PCLL	Kootwijk	18.00
PCMM	Ymuiden	46.50
PCPP	Kootwijk	16.50
PCRR	Kootwijk	37.00
PCTT	Kootwijk	21.00
PCUU	The Hague	37.00
	ITALY	
I1AX	Rome 20.00,	40.00
IAY	Placenza 20.00,	45.00
	JAPAN	
JFAB	Taipeh, Formosa...........	39.50
JHBB	Ibarakiken (Hirasio)........	37.50
JIPP	Tokio	20.00
JKZB	Tokio	20.00
JOAK	Tokio 30.00, 60.00 35.00 70.00	
IAA	Iwatsuki	40.00
	JAVA	
ANE	Bandoeng 15.93,	31.26
	Surabaya	140
	MEXICO	
XC51	Mexico City................	44.00
	MOROCCO	
AIN	Casablanca	51.00
	NORWAY	
LCHO	Oslo	33.00
LGN	Bergen 31.25,	30.00
	U. S. S. R. (RUSSIA)	
RDRL	Leningrad	28.50
RDW	Moscow	83.00
RFM	Khabarovsk (Siberia).......	70.20
RFN	Moscow	50.00
RA19	Tomsk (Siberia)	37.00
	SPAIN	
EAM	Madrid	30.70
EAR55	Barcelona	
	SWEDEN	
SAS	Karlsborg	52.50

SAA	Karlskrona	44.40
	Motala	41.45
SAJ	Karlsborg	47.00
SMHA	Stockholm	41.00
	SWITZERLAND	
H9OC	Berne	32.00
H9XD	Zurich ....85.00 and	32.00
	UNITED STATES	
KDKA (W8XK)	East Pittsburgh, Pa.	62.50
	W8XS, W8XP-portable	42.75
KEJK(W6XAN)	Los Angeles, Calif.	105.90
KEWE	Bolinas, Calif.	14.10
KFPY (W7XAB)	Spokane, Washington	105.90
KFQU (W6XBH)	Holy City, Calif.	31.00
KFQZ (W6XAL)	Hollywood, Calif.	108.20
KFVD (W6XBX)	Culver City, Calif.	105.00
KFWB (W6XBR)	Los Angeles, Calif.	105.00
		40.00
KFWO (W6XAD)	Avalon, Calif.	53.07
KGER (W6XBV)	Long Beach, Calif.	48.86
KGB	San Diego, Calif.	65.18
KGDE	Barrett, Minn.	40.00
KGO (W6XAX, W6XN)	San Francisco, Calif.	10 to 40
KHJ (W6XAU)	Los Angeles, Calif.	104.10
KJBS (W6XAR)	San Francisco, Calif.	61.00
KJR (W7XC, W7XO)	Seattle, Washington	105.20
KMOX	St. Louis, Mo.	49.00
KMTR	Los Angeles, Calif.	108.20
KNRC (W6XAF)	Santa Monica, Calif.	108.20
KNX (W6XA)	Los Angeles, Calif.	107.10
KOIL (W9XU)	Council Bluffs, Iowa	61.06
KWE-KEWE	Bolinas, Calif.	14.10
KWJJ (W7XAO)	Portland, Oregon	53.54
WAAM (W2XBA)	Newark, N. J.	65.18
WABC (W2XE)	Richmond Hill, N. Y.	58.50
WAJ	Rocky Point, N. Y.	22.48
WBRL (W1XY)	Tilton, N. H.	109.00
WBZ	Springfield, aMss.	70.00
WCEL	Chicago, Ill.	37.24
WCGU (W2XBH)	Brooklyn, N. Y.	54.00
WCSH (W1XAB)	Portland, Maine	63.79
WCX	Pontiac, Mich.	32.00
WEAJ	Rocky Point, N. Y.	22.48
WEAO (W8XJ)	Columbus, Ohio	54.02
WGY (W2XAF)	Schenectady, N. Y.	31.40
(W2XAD)	Schenectady, N. Y.	21.96
		5.00
WHK (W8XF)	Cleveland, Ohio	66.04
WJR-WCX (W8XAO)	Pontiac, Michigan	32.00
WIZ	New Brunswick, N. J.	43.45
WJZ (W3XL)	New York, N. Y.	59.96
WLW W8XAL)	Cincinnati, Ohio	52.02
WNAL (W9XAB)	Omaha, Neb.	105.00
WNBT	Elgin, Ill. (Time Signals)	35.50
WND	Ocean Township, N. J.	46.48
WOR (W2XAQ)	Kearny, N. J.	65.40
WOWO	Fort Wayne, Ind.	22.80
WRNY (W2XAL)	New York, N. Y.	30.91
WSM (4XD)	Nashville, Tenn.	31.43
WTFF	Mt. Vernon, Va.	56.00

You can obtain from the Government complete printed call books listing all American broadcasting, commercial and amateur stations and giving their call letters, names of owners, and addresses. The title of the book containing the broadcasting stations is "Government and Commercial Radio Stations of the United States," and costs only fifteen cents. The amateur call book is entitled "Amateur Radio Stations of the United States," and costs twenty-five cents.

If you want to be kept informed of all the last-minute changes in call letters, wavelengths, etc., of all classes of radio stations, you should subscribe to the "Radio Service Bulletin," prepared by the Department of Commerce. This is a small pamphlet, and is issued monthly. Address your orders for any of these publications to the Superintendent of Documents, Government Printing Office, Washington, D. C. Send cash or post office money orders; do not send stamps, as they will not be accepted.

Some Radio Questions and Their Answers

(*Continued from page 29*)

reception from stations thousands of miles away use all the available piping in the house, and also old wash boilers, automobile radiators, bath-tubs and other odd metal bodies buried in the back yard.

Tube Differences

6.—What is the difference between the 112 and 112A tubes, and between the 171 and the 171A?

Answer: The difference is only in the relative filament consumptions. Both the 112 and the 171 draw half an ampere of current at five volts, while the 112A and the 171A, which have replaced them entirely, each draw only one-quarter of an ampere. Otherwise the operating characteristics of the respective types are exactly the same.

The 200A Is More Sensitive

7.—Is there any advantage in using a 200A in place of a 201A as the detector?

Answer: Yes. The 200A is noticeably more sensitive, although it is also a trifle noisier in operation.

Using A By-Pass Condenser

8.—Is it necessary to connect a by-pass condenser across the primary of the first audio transformer in a set?

Answer: Yes and no. In many sets a .001-mf. condenser connected in this position is noticeably helpful; in other sets it makes no difference. The self-capacity of the primaries of most transformers is sufficient to by-pass the radio-frequency component of the plate current around the windings.

Moving The Loud Speaker

9.—How far from the receiver can a loud speaker be placed?

Answer: The speaker can be removed as much as fifty feet, although if possible it should be kept within twenty feet or so. The longer the connecting cord, the more it acts as a condenser in shunt with the speaker, and the more serious will be the by-passing of the higher musical notes.

Dry Cell Tubes

10.—Is there any tube that will work with a single dry cell as the A supply?

Answer: Yes, the W-11 and the UX-12, which are exactly the same electrically and differ only in their bases. Their filaments work on 1.1 volts and draw ¼ ampere. They take the usual B voltages from 22½ to 135. These tubes are not very widely used any more, although they are still obtainable.

Screen-Grid Connections

11.—To what is the metal cap on the UX-222 tube connected?

Answer: To the control grid, which corresponds to the normal grid of an ordinary three-element tube. The G post on the socket connects with the "screen" grid.

A 250 Combination Radio and Phonograph Amplifier

By ALFRED A. GHIRARDI

EVER since combination power amplifier and "B" power units were introduced several years ago, we have had a bone to pick with the designers of most of these outfits. Invariably the unit was built as a "B" pack combined with one stage of audio amplification, using a power tube. Lately the 250 power tube has become popular in units of this type, because of its ability to handle large amounts of power without distortion.

USED FOR TESTING NEW HOOKUPS

The trouble with a unit of this kind is that its usefulness is limited greatly by that one stage of audio amplification. If the experimenter or custom set builder wants to use it as a "B" supply and amplifier for testing out new hookups, he is obliged to include a first audio stage in the new hookup. This means a lot of unnecessary work, because any new features in the various new hookups are up ahead of the detector, the audio system usually being standard. If the power amplifier contains a standard two-stage audio amplifier it can be connected directly to the output of the detector tube in any new circuit that is being tried. This makes it unnecessary to repeat the construction of the first audio stage for every new circuit.

AS A PHONOGRAPH AMPLIFIER

The next weak spot in the ordinary form of power amplifier makes itself evident when it is desired to use it alone as a phonograph amplifier, for playing phonograph records with an electrical pick-up, or as a speech amplifier. At least two stages of audio amplification must be used for good volume with this method. This makes it necessary to add a stage of amplification ahead of the usual power amplifier. This is rather a messy job when the amplifier has already been built and wired.

Another field in which power amplifiers are being used more and more is for bringing old sets up to date by adding a power stage of audio amplification and a "B" power pack. The trouble is that when the one-stage power amplifier is connected to the set in the usual way, (that is after the first audio stage) the first-stage audio transformer in the set is still part of the audio system. In most cases this transformer is one of the type of years ago, with small, insufficient core and windings, and is utterly unable to pass the low notes. This, of course, handicaps the operation of the modern finely designed power stage which comes after it. This condition may be likened to a fine new Rolls Royce car just rarin' to go, but equipped with four flat tires.

The remedy lies, of course, in a complete, new, up-to-date audio system designed to pass all the notes through to the power tube and loud speaker. The wonderful improvement in volume and tone quality which can be effected by the addition of such a unit to an old set is truly astonishing. In most cases it is hard to realize it is the same set.

COMPLETE AUDIO UNIT

The reader has no doubt guessed by this

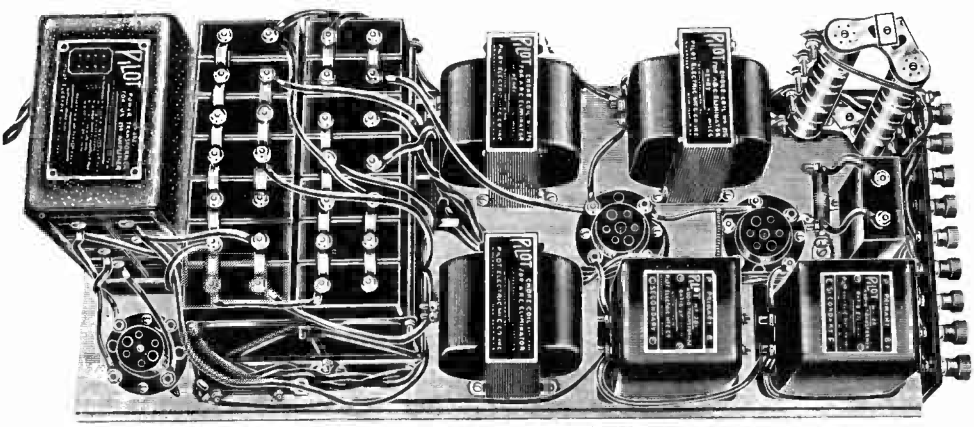


Figure 1: General view of the combination radio and phonograph amplifier, showing the disposition of the parts. The 281 rectifier tube fits in the socket in the lower left-hand corner.

time that the only way to build a really useful and versatile power amplifier unit is to build it complete with two stages of audio amplification, so it can be used directly as a speech or phonograph amplifier, or for connecting directly to the detector output of the tuning unit of new hook-ups or old sets. That is exactly what we have done in the amplifier shown in the accompanying diagrams and illustrations. It makes one of the handiest units a set builder or experimenter can have.

CHOICE OF 250 TUBE

The 250 power amplifier unit described in the Fall (Vol. 1, No. 3) issue of RADIO DESIGN left little to be desired in the way of tone quality at either high or low volume. Hence, we decided to adapt this unit by adding a stage of audio amplification to it and making whatever changes were necessary in the original circuit and parts layout.

It was decided to use a 227 tube for the first audio stage on account of its hum-free characteristics. The problem was to obtain the 2.5-volt filament supply for this tube from the eliminator itself without adding another filament heating transformer. At first we tried operating it from the same 7.5-volt filament winding that supplies the filament current for the 250 power tube, putting a 5-ohm fixed resistance in series to reduce the 7.5 volts to the required 2.25 volts. This method worked satisfactorily but it introduced the difficulty of obtaining a standard 5-ohm rheostat capable of dissipating the 9 watts of energy without damage.

At the suggestion of Mr. John Geloso, we tried connecting the 227 filament across half of the 7.5 volt winding (between one end and the center tap) with a fixed resistance of about 0.9-ohm in series to reduce the 3.75 volts across half the filament winding to the 2.25 volts for the 227 tube. This resistance only needs to dissipate about 2.7 watts.

We found we could make this resistance easily from 20 inches of resistance wire taken from a Pilot No. 904 4-ohm rheostat. This wire was coiled into form around a No. 18 drill, then pulled out slightly to space the turns so they would not short circuit, and bent around into semicircular shape. This was attached directly to one filament terminal on the 277 tube socket.

We know this arrangement is going to raise the question of unbalancing the electrical center of the 7.5-volt filament winding, because the current for the 227 flows only through half of this winding. To be sure, some unbalancing will result, but this is not serious because any slight 60-cycle hum voltage introduced in the 250 power tube circuit as a result of this is hardly heard in the speaker because the 250 is the last audio tube and hence this 60-cycle hum frequency is amplified very little. The proof of this is the fact that the slight hum from the complete power unit when used with a high grade dynamic speaker and large baffleboard can hardly be heard one foot from the speaker!

THE CIRCUIT

You will notice from the circuit diagram that the amplifier uses two of the giant No. 381 audio transformers. These have a ratio of 3½ to 1. They are mounted side by side in the unit. The 227 tube socket is mounted nearest the binding post strip. The 9-volt "C" bias for the 227 tube is obtained by a No. 958 2,000-ohm fixed resistance in the cathode circuit, shunted by a No. 801 1-mf. by-pass condenser. The 84-volt "C" bias for the 250 power tube is obtained by a No. 956 1200-ohm fixed resistance connected in the filament winding center tap lead. In some cases by-passing this resistance with a No. 801 1-mf. by-pass condenser will improve the volume and quality. This is shown in the circuit diagram, and is worth trying.

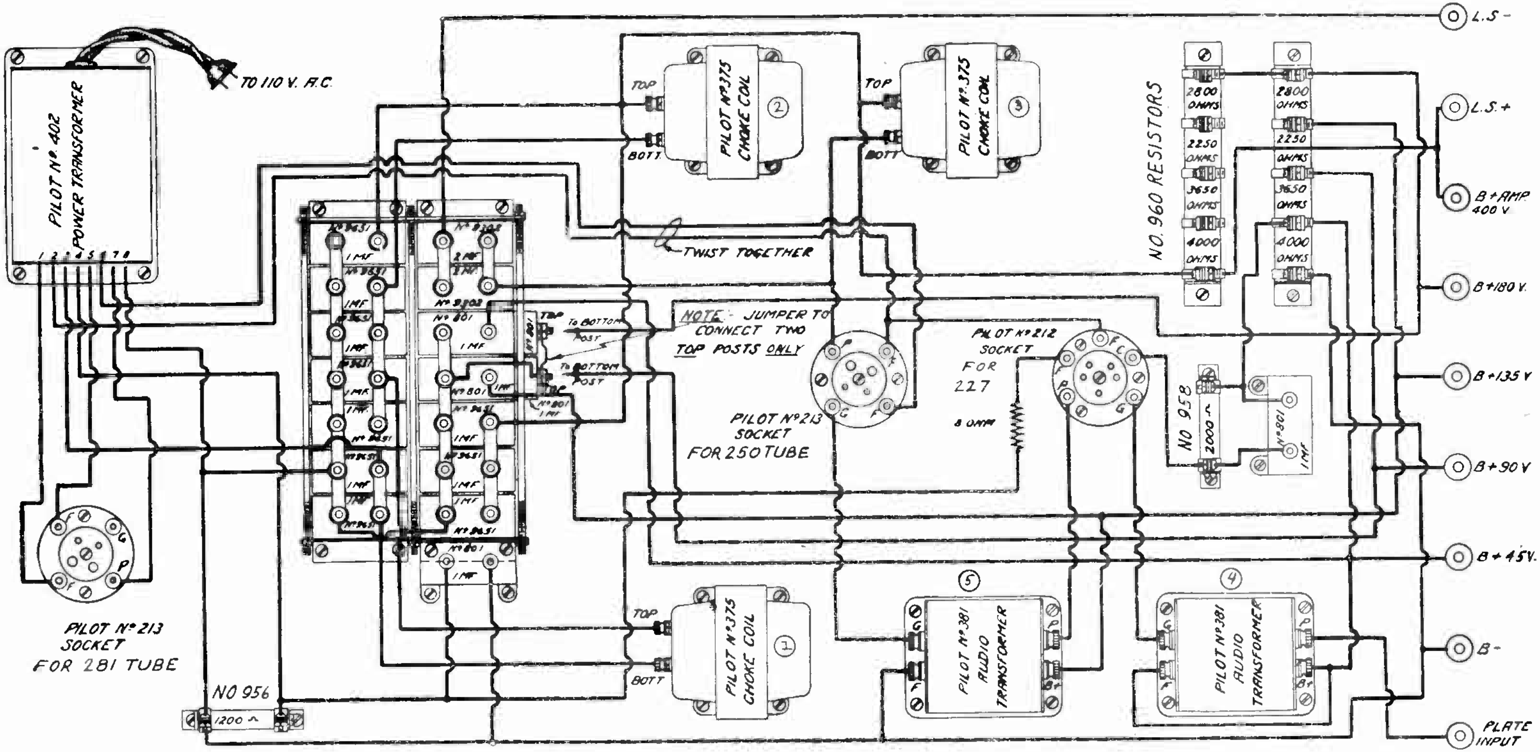
The grid circuit return for the 227 tube was brought to the "B+" 45-volt tap for a special reason. Due to the 84-volt drop in the 1200-ohm resistor, the center tap terminal No. 4 an hence the filament of the 277 tube is at a potential 84 volts positive with respect to the "B—" terminal. There is a 9-volt drop in the 2000-ohm "C" bias resistor. If the grid return for the 227 tube were brought to the "B—" lead (as is usually done) this would make the filament 84 minus 9 or 75 volts positive with respect to the cathode and 84 volts positive with respect to the grid. This high relative positive filament potential would interfere with the electron flow inside of the tube. To avoid this, the grid circuit return is brought to the "B+" 45 tap instead of the "B—." This makes the filament only 30 volts positive with respect to the cathode, and is not objectionable. This rather technical explanation will clear up any misunderstandings as to why the connections were made this way. The rest of the "B" supply circuit remains the same as in the previous model of this amplifier.

No. 801 1-mf., 180-volt by-pass condensers are used across the taps of the output resistor, as the voltages here are low. Special 650-volt condensers were developed for use in the filter circuit. Two No. 9302 2-mf., 300-volt condensers are used in the output filter.

NEW POWER TRANSFORMER AND LAYOUT

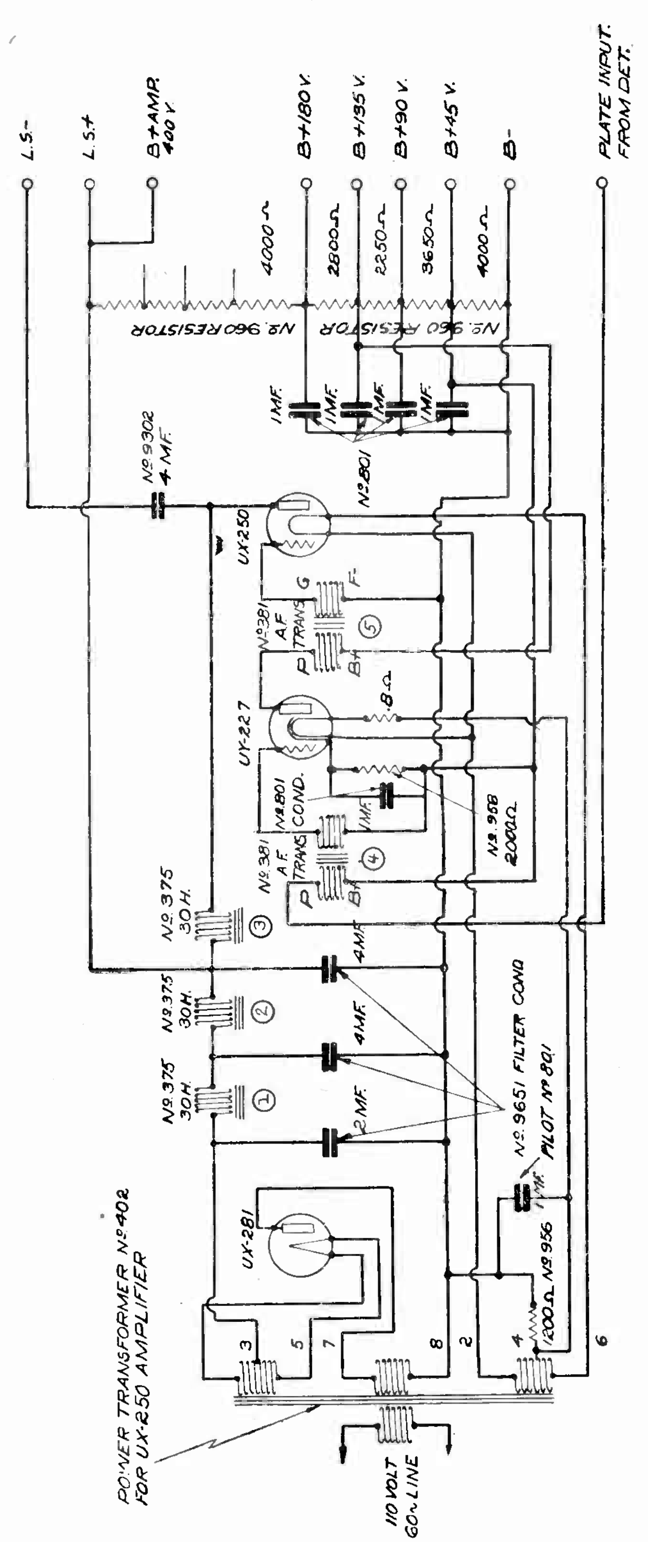
You will notice by comparing the illustrations of this amplifier with those of the original unit described in the Vol. 1, No. 3 issue of this magazine, that a new type No. 402 power transformer is used. This is larger than the former one and is able to carry a heavier load without heating. The terminal number arrangement on this transformer is different than that on the old type, and we caution you to follow the markings given on the nameplate of the particular transformer you use.

The general layout of the amplifier was changed somewhat, as can be noted from the picture wiring diagram and the accompanying woodcut. The condenser bank is located between the power transformer and the filter



ABOVE: PICTURE WIRING DIAGRAM OF 250 AMPLIFIER; BELOW, SCHEMATIC DIAGRAM

The picture wiring diagram, above, clearly shows the wiring between the various parts of the amplifier. It corresponds exactly with the schematic diagram, below. Notice that the G post of the socket for the 281 rectifier tube is left idle, and also that the three No. 375 choke coils and the two No. 381 transformers are marked with the same respective numbers in both diagrams, to distinguish them from each other. Solder all connections with a hot iron and rosin-core solder.



chokes. This separates the transformer and chokes by about five inches, eliminating any stray field pickup from the transformer. If the chokes are mounted close to the power transformer a hum will result, due to the pickup.

The two sections of the voltage-dividing resistor are fastened together with a ½" R.H. 6-32 machine screws in the upright position shown.

The output filter condensers are placed at the right rear corner of the condenser bank. Next to these (with the two lower ones lying horizontal and the two upper ones standing vertical) are the four 1-mf. by-pass condensers. All the rest of the condensers in the bank are 1-mf. 650-volt filter condensers.

The 1200-ohm resistor is mounted on the baseboard near the 281 rectifier tube socket. The 2000-ohm resistor with its 1-mf. by-pass condenser is mounted near the first audio socket.

The binding posts for input, speaker, and "B" power supply voltage connections are conveniently arranged on a bakelite strip at one end.

Because of the high potentials employed in a unit of this kind it is important to put the amplifier in a well protected place where no one will get his hands on it by accident. Also provide plenty of ventilation, for the tubes give off quite a bit of heat.

Do not touch the filter condensers without first discharging them by placing a screwdriver across their terminals.

ASSEMBLING SUGGESTIONS

The baseboard must be of well seasoned wood 18½ by 7½ and ¾ in. thick. Fig. 1 shows the general plan of the layout, with further details in the picture wiring layout. Start the assembly at the power transformer end and work across. Space each part carefully and make sure that each device is fastened down securely with wood screws. The complete list of parts is as follows:

1—No. 402 Pilot power amplifier transformer.

3—No. 375 Pilot choke coils.

2—No. 381 Pilot A.F. transformers.

10—No. 9651 Pilot 1 mf. 650-volt filter condensers.

2—No. 9302 Pilot 2-mf. 300-volt filter condensers.

6—No. 801 Pilot 1-mf. 180-volt by-pass condensers.

1—No. 956 Pilot 1200-ohm resistor.

1—No. 958 Pilot 2000-ohm resistor.

1—No. 904 Pilot 4-ohm rheostat (to be opened.)

2—No. 960 Pilot "B" pack resistors.

2—No. 213 Pilot bakelite UX sockets.

1—No. 212 Pilot Bakelite UY socket.

2—No. 9000 Pilot Condenser Clamps.

1—Binding post strip with nine binding posts.

1—Baseboard 18½x7½x¾ in.

50—½ in. No. 6 R.H. wood screws.

8—1 in. No. 6 R.H. wood screws.

75—6-32 hex nuts.

1 set of flexible connecting leads.

The illustrations show how the brackets are arranged to hold the large bank of condensers. Do not squeeze them too tightly, but see that they are firmly clamped. Connecting links are supplied with the condensers to slip over the condenser terminal screws.

Check each filter condenser carefully to make sure it is a No. 9651 and not one of the two No. 9302 condensers used for the output filter only.

When you mount the two No. 960 resistors, compare the terminal markings with those shown in Fig. 9. If you make a mistake and reverse the position of one of these resistors you will not get the right voltages at the binding posts.

CONNECTIONS TO YOUR SET

No changes in the receiver are necessary when you use this amplifier with your receiving set except that you will have to switch the leads from your present "B" pack to the corresponding posts on the amplifier.

On the amplifier is a post marked Plate Input, in the diagrams. If you are going to connect the amplifier directly to the output of the detector tube, connect this Plate Input post to the wire which now goes to the P terminal on your present first audio transformer. Connect the B— terminal of the eliminator to the B— terminal on your set. Connecting it this way feeds the plate of the detector tube directly through the primary winding of the first audio transformer of the power amplifier.

We wish to caution prospective builders of this amplifier against using the unit as a power amplifier and also as a "B" power supply device for receivers drawing more than about 10 milliamperes of plate current. In other words, do not try to supply the "B" current for an 8-tube super-heterodyne with it. The heavy current drain for such a set will cause overloading. It will supply "B" current for a set using up to three stages of R.F. amplification and detector satisfactorily.

AS A PHONOGRAPH AMPLIFIER

This unit makes a very fine self-contained phonograph amplifier when used with a high-grade phonograph pickup. The new type electrically cut records should be used for best results. The reproduction with this amplifier and a good dynamic speaker is truly wonderful. The deep, well-rounded tone is a source of satisfaction to even the most critical music lover.

The unit, being entirely self contained, is admirably adapted for portable phonograph reproduction work in connection with dances, meetings, etc. The phonograph pickup should be connected directly to the Plate Input and B+45 volt binding posts. This connects it to the primary of the first audio transformer. A microphone can be connected to the same posts for speech amplification and public address work.

Resurrect the old discarded phonograph. Buy a good electric phonograph pickup attachment. Connect it to this power amplifier, with a good speaker, and you will have music comparable if not superior to that produced by the most expensive phonographs. It will astonish you.

FOR RADIO STORES

Radio stores and custom set builders can use a unit of this kind for operating a good dynamic speaker outside of the store as a crowd-getter. It will make a valuable unit for announcing baseball and football scores. It can be used as a test unit for the R.F. and detector end of receivers.

Put a real good dynamic speaker on this power amplifier, connect it up to your old set, and you will think you have a whole new receiver. The power amplifier is an excellent addition to a battery-operated set, since it furnishes all the "B" voltages and plugs directly into the 110-volt A.C. lamp socket. Then you will need only the storage battery to light the filaments in the set itself. No current is drawn from the storage battery to light the tubes in the power amplifier.

Tubes Get Hot? Don't Worry About Them

When they use audio power tubes of the 210 and 250 type for the first time, many radio constructors become unduly worried about the amount of heat these tubes generate. Sometimes they will shut off their amplifiers after fifteen or twenty minutes of service, for fear the glass will crack.

Don't let this cause you any concern. The 210 and 250 tubes, and even the comparatively small 171A, become hot as a natural result of their operation, and as long as the plate and grid voltages are kept at their proper values, nothing will happen. We do not know of a single instance of a tube ever cracking, even when it was heavily overloaded.

Merely see that there is air on all sides of the tube, and do not jam it plumb up against a transformer or condenser. The heat may cause the wax to run out of the condenser.

REVAMPING THE SG-105 RECEIVER

Addition of Resistograd Makes Control of Regeneration Easier

By JOHN GELOSO

Chief Engineer, Pilot Electric Mfg. Co., Inc.

THE Pilot SG-105 screen-grid regenerative receiver, which was described in the last number of RADIO DESIGN, has proved to be a highly popular set, and the many people who have built it are enthusiastic about the results it is yielding.

However, there have been a number of complaints that the regeneration control in the detector circuit is a bit critical. We did not experience this trouble with any of the several experimental receivers we built, but after trying a number of sets brought in to us for examination, we decided to change the control to make it work a little more easily for all kinds of tubes under all kinds of operating conditions. If you have an SG-105 and find that the setting of the tickler coil of the No. 174 three-circuit tuner is somewhat cranky, you can make the change at very little trouble and expense.

The only additional material you need is a Pilot Resistograd and a small piece of brass. The idea is to take the three-circuit tuner off the front panel altogether, to mount it instead on the sub-panel, and to control the regenerative action with the Resistograd, which is a smooth-action variable resistor.

The Resistograd fits in the hole formerly occupied by the mounting stud of the three-circuit tuner, so the front panel need not be drilled. You will have to drill only two extra holes in the sub-panel, near the socket for the A. C. screen-grid tube. The changes in the wiring are likewise slight, and should not take you more than ten minutes. The whole revamping job can be done in half an hour. The illustration on this page shows how the tuner sits between the detector-stage tuning condenser and the 200,000-ohm potentiometer (Fig. 1).

In starting to revamp the SG-105, first remove the three-circuit tuner from the panel, carefully unsoldering the leads running to it. Mount the Resistograd in its place. This device is fitted with a threaded stud and is held in place with a single nut.

Now obtain a piece of brass 2-15/16 or three inches long, and drill it in accordance with the drawing shown on the next page (Fig. 2). Bend it to form an L-shaped bracket. Fasten the three-circuit tuner in the 5/16-inch hole in the short arm of the bracket and place the latter on the sub-panel so that the coil just overhangs the inside edge of the latter and occupies the space between the detector stage tuning condenser and the potentiometer.

Spot the points on the sub-panel where the holes for the mounting screws for the bracket belong, and drill through with a hand drill. Fasten the bracket down securely with 6-32 round head brass machine screws one-half inch long.

The rewiring is very simple, and is clearly shown in the schematic diagram Fig. 3 and the picture diagrams Figs. 4 and 5. These are enlarged sections of the SG-105 blueprints.

The operation of this arrangement can be mastered in a short time. Turn the Resistograd all the way out (twist knob to left), so that the maximum resistance is in the circuit. Turn on the receiver and adjust the tickler coil with your fingers so that the set just starts to oscillate at a wavelength setting

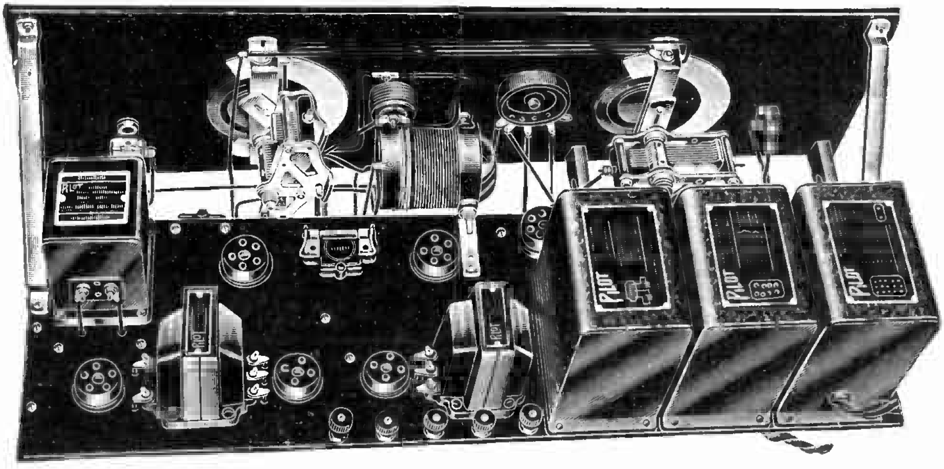


Fig. 1: The "revamped" SG-105 receiver. Note that the three-circuit tuner lies parallel with the sub-panel, being mounted on it by means of an L-shaped bracket.

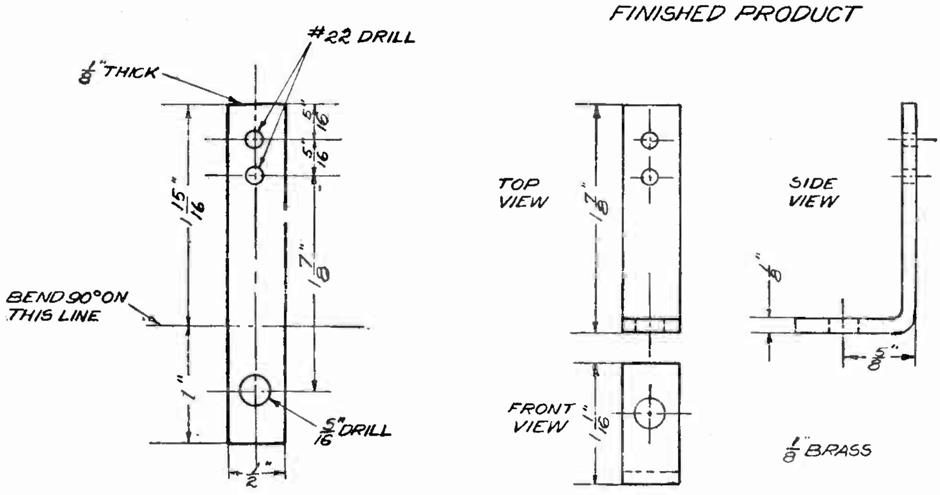


Fig. 2: Details of the brass bracket that supports the three-circuit tuner on the sub-panel.

of about 400 meters (750 kilocycles). You will now be able to control regeneration nicely by turning in the Resistograd.

The theory of this system of control is not complicated. The Resistograd, being connected directly across the tickler coil, acts as a variable short-circuit on it. With its resistance high, most of the plate current of the detector tube flows through the tickler coil, which then reacts on the secondary to produce the regenerative action. With the resistance comparatively low the current divides, part going through the Resistograd and part through the tickler. The exact proportions depend, naturally, on the setting of the Resistograd. This method of control is a very good one.

In resoldering the connections, use rosin-core solder and a clean, hot iron. Hold the latter against each joint for a few seconds, so that the rosin melts thoroughly and allows the solder to really adhere to the wire. The iron should be hot enough to melt the solder the instant the latter is touched to it.

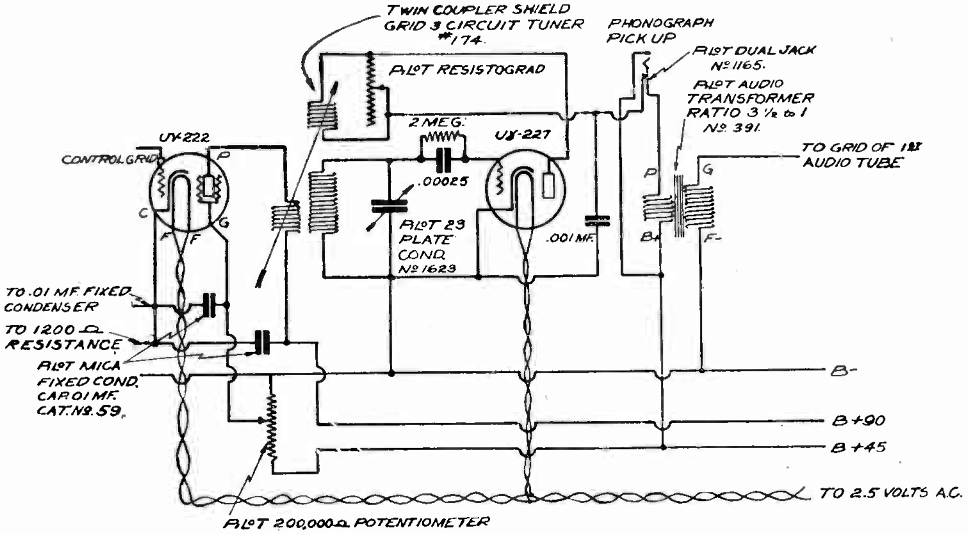


Fig. 3: How the Resistograd is connected across the tickler coil of the three-circuit tuner to act as the regeneration control. This is an enlarged section of the diagram on page 76 of Volume 1, Number 4 of Radio Design, *the rest of which remains unchanged.*

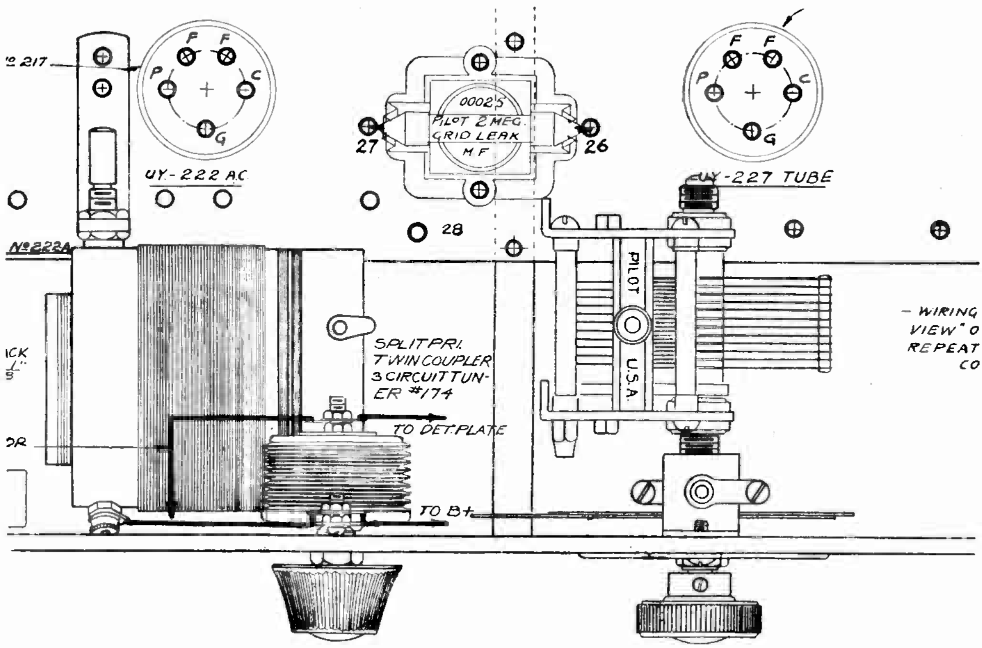
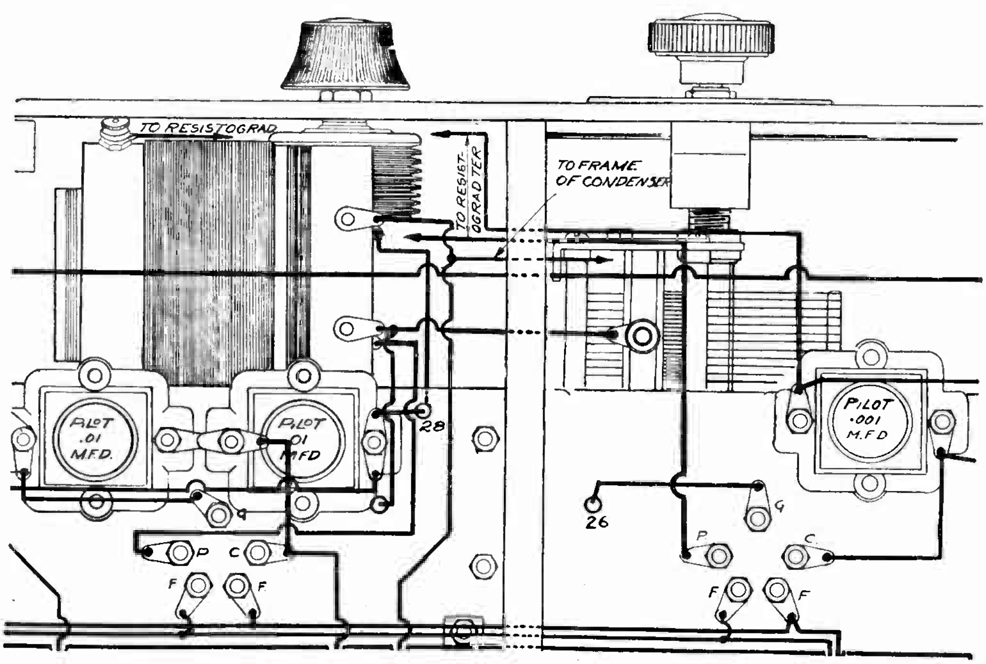
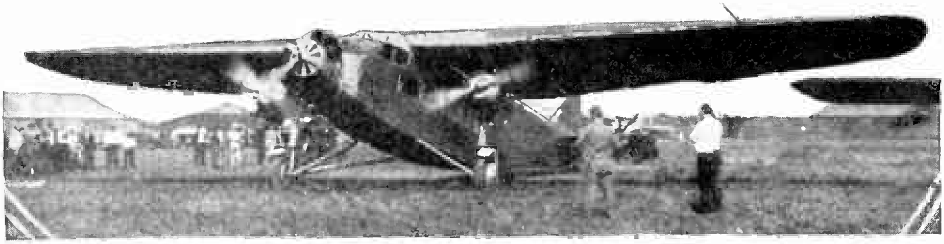


Fig. 4, above: Top view of the "revamped" SG-105, showing how the three-circuit tuner mounts on the sub-panel just under the newly installed Resistograd. The knob has been removed from the tickler shaft, as the tickler can be set once with the fingers and then left alone. Fig. 5, below: Under view of the sub-panel, showing the detailed connections between the three-circuit coil and the Resistograd. These are enlarged sections of the complete picture diagrams on pages 78 and 80 of Volume 1, Number 4 of Radio Design, *which contains the full description of the popular SG-105. Copies of this issue can be had for ten cents each; stamps are acceptable. Send your orders to 103 Broadway, Brooklyn, N. Y.*





The "Floyd Bennett," the giant tri-motored Ford plane taken by Commander Byrd on his South Pole expedition. This picture was taken at Mitchel Field, L. I., last fall.

HOW WE TESTED BYRD'S AIRPLANE RADIO EQUIPMENT

By R. J. GRIFFITH

TO MOST people radio is merely a source of amusement, furnishing music and other entertainment or providing a very interesting subject for experimentation. There are others, however, to whom radio is a very serious business and to whom it may even be a matter of life and death. The equipment described in this story is for use by the latter class. Commander Richard E. Byrd, realizing the part which his radio equipment would play in his Antarctic expedition, has given it the importance it deserves, and has taken more than $75,000 worth of radio apparatus with him to the South Pole.

Since it would be too long a story for the space at hand to describe all the radio apparatus of the expedition, we shall confine our attention to the equipment used on the four airplanes.

The "Floyd Bennett," named for the man who piloted Commander Byrd over the North Pole, and who gave his life in an attempt to rescue the German transatlantic flyers, is the largest of the four planes. It is a Ford all-metal ship constructed entirely of duralumin, a metal that possesses the strength of steel and the lightness of aluminum. It is equipped with three Wright motors, the centre one being a "Cyclone," with a 500-horsepower rating, and the two wing motors being "Whirlwinds," rated at 250-horsepower each. The three remaining ships are the "Stars and Stripes," a Fairchild plane, the "Virginia," a Fokker Super-Universal, both equipped with "Wasp" engines, and the "Commander," a small plane made by the General Aircraft Corporation.

Each of the three larger planes carries a 50-watt transmitter, which has two wavelength ranges; one between 30 and 45 meters, and the other between 400 and 600 meters. The smallest plane carries a battery-operated transmitter of the 210 type, which is entirely adequate because this plane never flies a great distance from the base. The 600-meter wave is being used for direction finding and the other for general communication.

The power for the larger transmitters is furnished by generators of a novel type. The Ford has two of these, one geared to each of its wing motors, and either being available for use by means of a plug and socket system. The Fokker and the Fairchild each have a generator of the same type geared to the single engine. In all cases the gear ratio is 5 to 1, and the generator speed from 7000 to 8000 revolutions per minute. The novel feature of the generators lies in the fact that they are self-regulating, regardless of speed, within reasonable limits. Their design is such that the hysteresis losses rise with an increase in speed, so the voltage does not rise when the engine is speeded up, as would be the case were these precautions not taken.

These generators have two twelve-volt windings, one of which feeds the filament of the 50-watt tube, while the other furnishes the plate current through a transformer which steps the voltage up to 1500. The raw alternating current applied to the plate has a fre-

Commander Richard E. Byrd, wearing a heavy fur garment intended for use in cold climates.

Photo by World Wide Photos, Inc.

quency of about 300 cycles.

In addition to these engine-driven generators, each plane carries a wind-driven generator, for use in case of failure of the engine units. Each also carries an emergency power-supply source for use in case of a forced landing. This consists of a two-cycle, one-cylinder gasoline engine, coupled through a clutch to a generator of the type described above; when used it is only necessary to plug in its output in place of that of the engine-driven generator. The unit is equipped with legs so that a small stove may be placed under it to heat it, and so facilitate starting in polar temperatures. The entire plant measures about twelve by twelve by twenty inches and weighs only about 45 pounds, including gasoline.

In addition to the regular telegraph key in the rear compartment, the Ford has another key and a switching system near the pilot's seat, so that if he desires to, the pilot can operate the radio apparatus, while in flight.

The receivers of the three larger planes are of the super-regenerative type, being very efficient for receiving the modulated telegraph signals of the planes' transmitters. Since most communication is with the base and ship stations of the expedition it was deemed desirable to have receivers which would receive such stations efficiently. It was with this end in view that they were developed by Lieut. Malcolm P. Hanson, of the Naval Radio Laboratory at Bellevue (near Washington, D. C.), who has been assigned to the expedition as chief radio engineer, and whom it was the writer's privilege to assist in the design, installation and testing of the equipment. While designed for modulated code reception, the receivers are also efficient for telephony and straight C. W. reception.

MR. GRIFFITH is well qualified to tell you how Commander Byrd's Antarctic radio equipment was designed, installed, and tested in the planes that are now being used on the expedition. Before the war, Mr. Griffith, using call 8 AKA, was a familiar Pittsburgh amateur, and later he was associated with 8BK at Cleveland.

Lieut. Malcolm B. Hanson, radio engineer of the Byrd Antarctic Expedition, wrote Mr. Griffith while the S. S. Eleanor Bolling was at Balboa in the Canal Zone saying, "Thank you for all the splendid help you gave us in radio and without which we could not have adequately completed our preparation. Working incessantly with us practically day and night, you have obtained an idea of the extent of our radio preparation, and we owe a large debt of gratitude for your services and capable help in obtaining much needed supplies for the construction of special ship radio sets, air craft equipment, air craft radio installations and in aiding in our flight tests, as well as your great help in the final design of our special air craft radio receivers."—EDITOR.

Each receiver employs four Western Electric "peanut" tubes of the "N" type, comprising a regenerative detector, oscillator, and two audio stages. The filaments are lit by four dry-cells in parallel, while the plate voltage is supplied by two 22½ volt B batteries. The latter are contained in the receiver itself.

Pilot plug-in coils are used as the tuning inductances, assuring a wide wavelength range. Coupling to the antenna system is secured by means of a special coupling coil consisting of ten turns of wire wound on a three-inch bakelite tube, the centre of the winding being grounded to the metal frame of the plane. Three taps are brought from each half of the winding to binding posts on the panel, allowing various connections to the "doublet" aerial. This coupling coil is so placed that when a plug-in coil is plugged into its socket, it is surrounded by the former. Between the two, however, is a "static shield," consisting of a 2¾ inch bakelite tube wound with copper magnet wire, the winding having all its turns cut (after being secured to the tube with varnish) to avoid eddy current losses and dead-end effects. This shield allows inductive coupling to the antenna, but

"The Stars and Stripes," which is now using its radio equipment to great advantage near the South Pole. The signals from its short-wave transmitter were picked up in New York during a recent flight; the total distance was about 10,000 miles.

Lieut. Malcolm P. Hanson, chief radio engineer of the Byrd Antarctic expedition, in the cabin of the "Stars and Stripes." Notice the two aerial wire reels at the right and left.

being grounded, prevents capacitive coupling

In addition to this, the outer bakelite tube carries an "inductive shield" at each end, this being a copper ring of ⅜ by 1-32 inch copper. These shields prevent stray magnetic fields and are so effective that the hand may be placed inside the receiver case without detuning the set.

In addition to using a trailing wire aerial and the metal of the plane as ground, each of the three large places has a wire running from each wing tip to the tail, and thence through two Pyrex insulators into the tail and forward to the radio instruments. Each of these two wires is connected to opposite ends of the coupling coil of the receiver. Since the engine is grounded to the frame and the coupling coil is also connected to the frame, we now have a system that will balance out ignition noises but will have no such effect upon the incoming signals. Since the two doublet wires will be affected equally by the radio waves from the spark plugs of the engine, and since they will set up equal currents in the coupling coil, which is so wound that the currents due to the ignition system will oppose and cancel each other, no current will be induced into the secondary coil, and so the ignition will not be heard. Radio signal waves, however, affect each of the doublet wires differently, their extreme ends being caused to assume opposite potentials at any instant. This causes a radio-frequency current to flow through the coupling coil and to induce a current into the secondary coil, causing a response in the phones worn by the radio operator.

A trailing wire is used as the transmitting aerial. This allows a two-way communication without a switching arrangement, since the receiver is connected to the doublet and the transmitter is connected to the trailing wire.

The planes carry kites for use in forced landings. There are two types, one for light breezes and one for heavy winds. These will be for use on the 600-meter band.

The "Stars and Stripes" carries a new and special type of doublet for experimental use. On each side of the cabin is a reel, from which a wire runs through the side of the wing, which carries a bakelite pulley. The wire passes through this pulley and terminates in a wind-cone.

This cone is made of dural metal and is four inches in diameter at the base. The apex of the cone is cut off, leaving an opening one inch in diameter. The wire is attached to the base of the cone, and when the plane is in flight these cones exert a strong pull on the wires. By means of the two reels in the cabin, the length of the trailing doublet may be adjusted to any length up to about 250 feet.

The smallest plane carries only two antennas, the trailing wire and the kites.

Most of the preliminary testing of the apparatus in the United States was done in the "Floyd Bennett," as the equipment is practically identical on the three larger planes, and the "Bennett" was considered likely to do most of the long-distance flying. When the planes flew from Mitchel Field to Hampton Roads last fall, previous to the departure of the expedition, the largest ship was the only one whose radio gear was in operation, as

The pilots and radio engineers associated with the Byrd expedition, photographed at Norfolk, Va. Mr. Griffith is the second from the left.

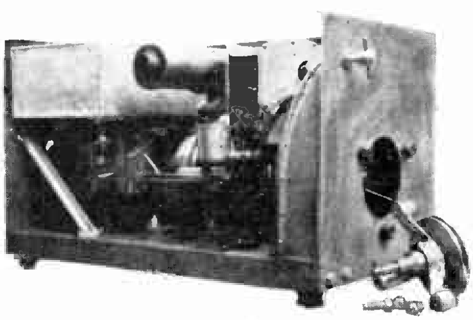
all the testing was done on her.

At 11:00 a. m., September 7th, 1928, the three large planes hopped off for Washington, the small plane having gone to Teterboro, N. J., for minor repairs. As soon as the Ford got into the air, an attempt was made to raise 2UO, (now WHD), the station of the "New York Times," on wavelengths of 34 and 45 meters. A Brooklyn amateur was "worked", and he offered to call the Times by telephone and let them know we were calling. After this, a number of amateurs in New Jersey, Delaware and North Carolina were worked. When about half way across New Jersey, communication was established with 2UO, after which the Times and the "Floyd Bennett" were in constant touch with each other for the rest of the trip. Transmitting was done on a wavelength of 34 meters, the transmitter output being about 30 watts in the antenna.

During the tests, comparison was made between reception on the doublet and on the trailing wire. The doublet was very much superior, no ignition noise being heard except when the receiver was tuned to the fundamental wavelength of the doublet.

Transmission was also tested on the doublet, both as an antenna-counterpoise system and with the two wires connected together, using the plane as ground. While both gave fairly good results, the normal system was superior, especially in convenience.

In the vicinity of Baltimore the fog became so heavy that Brent Balchen, the pilot, deemed it wise to land and wait for the fog to lift, especially since the fog flying instruments had not been adjusted. Station 2UO was thus advised and we came down at Logan Field. This landing gave us a chance to test our emergency unit, and it was accordingly placed on the ground, and after oil and gasoline was procured, it was started up. Within ten minutes after landing, 2UO was raised and communication established, using the two doublet wires as aerial and the plane as ground. Station 2UO reported our signals as very strong, proving the emergency unit could be depended upon to furnish power when necessary.



Above: Small gas engine to drive emergency power generator. Right: Portable radio transmitter used on expedition.

An attempt was made to fly one of the kites, but lack of sufficient wind prevented the kite from rising, so this test had to be abandoned. Such a condition as this will hardly be met in the Antarctic, as plenty of wind will be encountered there.

After the fog cleared away, and the plane rose into the air, the trailing aerial was reeled out, and immediate communication was established with 2UO. This was continued until we reached Washington.

Immediately upon landing at Bolling Field, the emergency unit was put into operation, and the Times was raised within five minutes after landing. This certainly left little to be desired in the way of speed, and again demonstrated the reliability of the emergency outfit.

After advising 2UO of our landing and arranging a schedule for the next day, operations were suspended until the following morning, when the planes were to leave for Hampton Roads. After all our experiences of the day with radio, we were amused when a friend of Lieut. Hanson, seriously and with the best of intentions, asked us to come over and "listen to his radio". This invitation, needless to say, was declined with thanks.

Next morning, as per schedule, 2UO was worked, the operator reporting that he was able to hear our signals fifty feet from the phones. This work was done before hopping off.

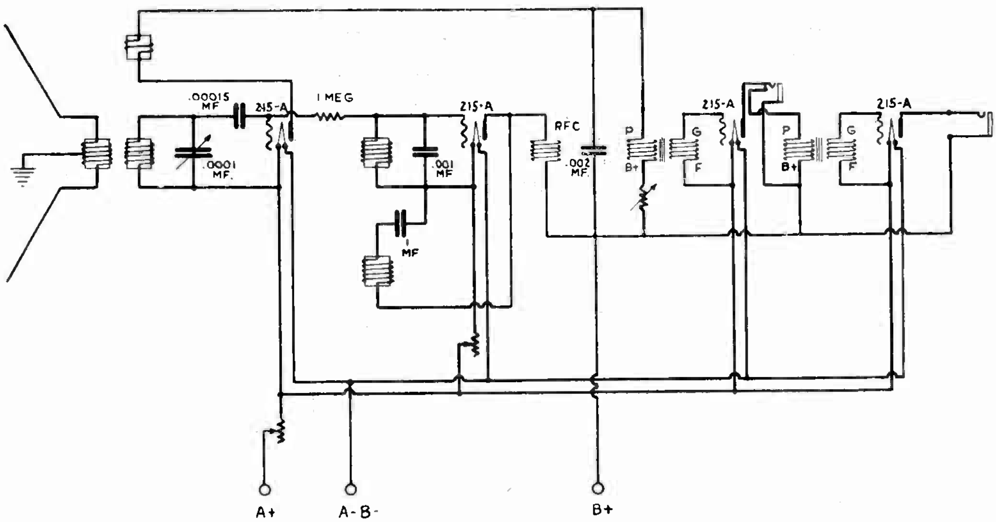
At 10:00 a. m. the ships hopped off for Hampton Roads, and during this flight quite a few amateurs were worked in Boston, Georgia and neighboring states. When we were close to our destination, 2UO was worked, and after landing, communication was continued, as in Washington and Baltimore, the emergency unit again performing well. After scheduling 2UO for next day, the apparatus was removed from the Ford, in preparation for the plane's crating, and our attention was devoted to the Fokker.

The constant communication with 2UO had a greater significance than might at first be obvious, for this station has a 500-watt transmitter almost identical with those now used at the base stations in the Antarctic.

At about 3:00 p. m. of the day following our arrivel at Hampton Roads, the Fokker was completely radio equipped and made ready to take the air on a flight which had a dual purpose. It was necessary for Lieut. Hanson and the writer to return to Washington to have the final receivers built, so this trip was used as a test flight for the Fokker. While 2UO was not worked, it was due to the fact that the installation on the ship was not completed until after the hour set for 2UO to listen for us. A number of amateurs, one being in Chicago, were worked, and many from the first, second, third, fourth, fifth, eighth, and ninth districts were heard, using the fixed doublet aerial.

From Washington the plane returned to Hampton Roads to await shipment, while the receiver was taken to Lieut. Hanson's home for further tests. With the Pilot plug-in coil with the orange ring, amateurs were heard in all districts except the seventh, and using the red-ringed coil, PCTT, Holland, SUZ, Egypt, ANF, Java and XDA, Mexico City were heard. The last named was audible several hundred feet from the phones, even though a very poor antenna was used.

The outstanding features of the tests might be considered the performance of the receiver and the success of the doublet antenna in removing ignition noises. All the apparatus did just about what was expected of it, and it is now proving its tremendous value under the difficult field conditions in the frozen antarctic



Schematic diagram of the short-wave receivers used on the Byrd expedition.

HOW TO BALANCE THE PILOTONE ELECTRIC SIX

Some "Dope" That Will Be Useful to the Many People Who Built This Receiver According to the Description in Our Winter Issue, Volume 1, Number 4

By FRANK T. SULLIVAN

IN order to obtain the best results from the Pilotone Electric Six, it is necessary that the set be carefully and thoroughly balanced; otherwise it will tune rather broadly and you will miss the many distant stations a properly adjusted receiver is capable of bringing in. The balancing operation requires a little patience on your part, but you will not find it very difficult if you proceed as follows:

After finishing the wiring, insert the tubes in their sockets, connect the aerial and the ground and the loud speaker and turn on the switch. Wait about thirty seconds before doing anything, to give the tubes a chance to heat up properly. Set the dial to 100 and turn the small compensating condensers on the side of the large triple-gang condenser to about the center position. Also adjust the micrograd and the Adjustograd to about their middle settings. Then turn the dial down slowly and stop when you pick up the first high wave station, which will probably be on about 525 meters. Tune it in to maximum volume, using the Resistograd and without touching anything inside the set.

ADJUSTING THE COMPENSATING CONDENSERS

Now try varying each of the small compensating condensers on the triple condenser, a little at a time, meanwhile twisting the dial back and forth a trifle to keep the entire receiver circuits in resonance. By this means you probably will be able to bring the station in louder than before; continue experimenting until you obtain the loudest signals. Now turn the dial down to 50 on the scale, and locate a station on or near this setting. Repeat the operation of varying the small compensating condensers. Note for future use how much of a change you have to make on these condensers for maximum volume at a dial setting in the neighborhood of 50.

As the third part of the test, turn the dial to 10 or 15, and tune in some weak station on a low wavelength. Repeat the balancing operation previously described.

SETTING THE MICROGRAD PROPERLY

If you do not find it necessary to change the compensating condensers for maximum volume on any of the three points on the tuning scale, your receiver is properly balanced over its entire wavelength range. However, if you do find some considerable changes necessary, turn in the Micrograd ***one turn*** and repeat the whole three-part balancing operation. If the compensating condensers require less adjustment than before, turn the Micrograd in another turn, and again test the circuits for balance. This sounds like a lot of work, but actually you can make a complete and accurate test in a few minutes.

Possibly you may have to decrease the capacity of the Micrograd, by turning its knob to the left, one turn at a time. A little trial with both increased and decreased capacities of the Micrograd will quickly tell you which adjustment will bring your receiver to perfect balance.

The above mentioned method is most generally effective, and should be followed closely. Please bear in mind the fact that local conditions have a great deal to do with the balancing of radio sets, and the best treatment for a receiver in one location may not be the best treatment for a similar set in another location.

If your aerial is too long, you many find it difficult to obtain a setting of the Micrograd that will allow you to balance the set properly. To overcome this unusual condition, connect a fixed condenser of .0001 or .00025 mf. capacity directly in series with the aerial wire.

KILLING THE UNDESIRED SQUEAL

With the set perfectly balanced over the whole wavelength range, you will find that it oscillates freely; that is, it squeals when you tune in a station to maximum volume. To minimize this oscillatory action, simply put more resistance into the grid circuit of the second R. F. tube by turning the Adjustograd to the left. A slight oscillatory action is desirable, as it increases the sensitivity of the receiver and makes the reception of distant stations easy.

REASON FOR THE COMPENSATING CONDENSERS

Perhaps you are wondering why it is necessary at all to use compensating condensers on the triple-gang condenser. The answer is that while the sections of the condenser itself are well matched as to capacity, it is impossible to take into consideration the different lengths of the wires in different receivers, and also the widely varying characteristics of different aerials. The tubes also seriously affect the circuit. The compensating condensers make up for these discrepancies, and allow you to obtain the maximum results from your own particular receiver under your own particular conditions of reception.

A Multiple Tuned New Year's Eve

WITH this issue RADIO DESIGN starts its second year. All of which reminds us of New Year's Eve and the possibilities that radio has brought to this hilarious occasion.

It was our pleasure a few weeks ago to ride uptown from a meeting of the Institute of Radio Engineers with radio engineering's most versatile technician and philosopher. With New Year's Eve only a few days in the background, it came up naturally enough in a conversation considering the non-technical aspects of radio.

"Radio," I averred, "tends to emasculate perhaps the only festive event on our calendar justified by anything like logical considerations. After all, the arrival of a new year —the turning over of a cosmic new leaf— is certainly more deserving of jubilation from a purely utilitarian standpoint than any other holiday. Before radio came along, think of the hundreds of thousands that journeyed forth the last night of the year to make merry with champagne and to stuff twenty-dollar bills down the stockings of pretty waitresses. Today we merely stay at home, in the economical comfort of our living room, turn on the radio and listen to the chimes ring out the old and ring in the new. If we crave a little verisimilitude of night club life we can siphon up a few fingers of electrolyte from the 'A' battery. Really, doctor," I concluded, "radio has made New Year's Eve as safe and sane as the Fourth of July!"

"That all depends," said our companion (nameless; it is always understood between myself and present company that anything said before me is not for publication). "That all depends—I once tried a multiple tuned New Year's Eve which worked out very successfully."

Multiple tuned? We had heard of multiple-tuned antennas and such like, but this was a new one on yours truly, so we encouraged the doctor with an inquiring brow.

He continued:

"I had a super-heterodyne at that time—a particularly good one—and a jolly party had gathered around my hearth and cellar to celebrate the coming of the New Year without a cover charge. We started making preparations fairly early in the evening and by the time midnight rolled around we had cheered the departing old fellow with the pleasant music of popping corks and clinking glasses. At 12 o'clock we tuned in on a local New York station and as the chimes rolled in we lifted our glasses and toasted the New Year with gusto.

"As the last mellow note of the chimes floated into the infinitely higher frequencies of memory, I tuned the set to Chicago and caught up with the old year. It was a good old year, after all, and we hated to see him go—pass into the oblivion of the cold, dark night, without a bit more consoling music to his frost-bitten ears. So we popped and clinked for another hour.

"At 12 o'clock, central standard time, the Chicago station bid us a Happy New Year and as the chimes rolled in we lifted our glasses and toasted the New Year with gusto.

"As the last mellow notes of the chimes floated into the infinitely higher frequencies of memory, we tuned the both receivers to a Denver station, and caught up with the old year. That dear, dear old year. How we loved him.

"At 12 o'clock mountain time, the Denver station bid us a Happy New Year and as the chimes rolled in, we lifted our glasses and toasted the New Year with gusto.

"We intended to tune in on a west coast station and get the chimes there too, an hour later. But somehow we didn't," concluded the doctor, rather sorrowfully, "and I still don't think it was the fault of the set."

How Much Power?

How much power is really required in the output of a radio receiver or phonograph amplifier, for home entertainment? R. P. Clarkson recently observed 100% truthfully that the average fan needs a 250 tube power amplifier in his parlor about as much as he needs a carillon.

With the expense and danger involved in powerful amplifying apparatus, this matter is worthy of consideration. And our original question is easily answered by simple reasoning involving the physics of radio sound reproduction, in reference to the amounts of power existing in different sounds at different intensities and the efficiencies of speakers.

The amounts of power represented by various well known sounds are amazingly small —that is, to the ear and mind of the layman whose correlation of power and sound intensity is anything but academic. The power in a symphony orchestra, during fortissimo, rarely exceeds one watt of sound energy! If the power consumed in the average electric light bulb existed as sound it would make as much noise as seventy-five philharmonic orchestras all going at once!

The maximum power output of a good singer like Caruso is probably in the neighborhood of one one-hundredth of a watt! A violin solo, at fortissimo, represents an acoustic power of about .001 watt.

The electro-acoustic efficiency of speakers refers to the efficiency with which electrical energy is transferred to audio or sound energy. If ten watts of electrical energy going into a speaker produces one watt of sound power, the efficiency of the speaker is 10%. Considering averages, the cone has an efficiency of 2%, the horn of 1% and the dynamic of 10%.

In other words, for an equal volume the cone speaker will require five times as much power from the amplifier as the dynamic, and a horn speaker ten times as much. Distortionless reproduction of ample volume can be obtained from a dynamic speaker in cases where the amplifier would be overloaded (thereby introducing distortion) to produce the same value with less efficient speakers.

Using the dynamic speaker as the basis for our calculation, and assuming that we shall be satisfied with a volume in our parlors equal to the maximum output of a good singer, the following calculation is simple:

Sound energy required........	.01 watt
Efficiency of speaker..........	10%
Power required from amplifier	.1 watt

A cone speaker will require an undistorted power output from the last audio tube of at least .5 watt and a horn speaker of at least 1.0 watt.

The undistorted output of a 171A tube is approximately .7 watts, of a 210, 1.7 watts and of the type 250, 4.5 watts.

In recapitulation, using a high grade dynamic speaker, a 171A tube will furnish all the power one can desire in one's home for the purpose of entertainment. If malice aforethought, in reference to one's neighbors, is to be taken into consideration, a larger tube can be used—or simply overload the 171A. It is all the more annoying.

How to Tune Your Receiver

The majority of folks make a practice of tuning their sets to music, probably because music forms the greater part of a broadcast program and perhaps because it is easier to make music sound better than voice. It is this latter consideration that shows it to be the wrong process of tuning.

The pitch or general tone quality of radio reception is affected by tuning. A variation in pitch from muffled low to accentuated high notes can be effected by a variation of the tuning dials. Only to the experienced ear of the musician can a receiver be correctly tuned on a musical program.

However, we are all experts as far as naturalness of the human voice is concerned. The radio receiver should be tuned, during an announcement, until the voice is natural —until it is neither squealy nor drummy. When this adjustment is secured the reproduction of music will be as near perfect (in terms of naturalness) as the receiver-amplifier-speaker combination is capable of outputting—an adjustment that could be sesecured only by chance with a musical program, and a lack of which would be evident as a subtle dissatisfaction with reception for the evening.

Apropos of all this, we recall a recent conversation with Dr. Alfred N. Goldsmith in which he declared that he would take an engineer's opinion on reception before that of a musician.

Peculiarly, many musicians are poor judges of radio reproduction—if one may judge from the various receivers (all incapable of faithful reproduction) which prominent musical virtuosi have endorsed during the past five years. Of course, considerations other than aural contributed to the sponsorship. The crackling of a fat check is music to any ears.

But the fact remains that musicians are notoriously poor judges of musical reproductions —"notorious" because one expects so much from them.

Musicians were satisfied with the old phonographs (they performed for them when they would not appear before the microphone for any price) which engineers knew were utterly lacking in low-frequency response.

The musician's dimension seems to be that of esthetics, and the engineer's, technical perfection. Jazz or classical music is one to the engineer if the bass notes are there, and 8,000 cycles is not more than 2 TU up or down. To the musician jazz is rotten and classical music good almost regardless of missing or spurious harmonics.

How to Make a Lead-in Without a Hole

A clever idea came to us through Radio Broadcast, with whose permission we pass it on to you. The technically simple matter of a lead-in has always presented mechanical complications all out of proportion with its electrical significance. The heretofore only really satisfactory sort of a lead-in contrivance has been an insulated hole drilled either through the window glass or casement, or through the wall, all of which have often stumped the amateur mechanic. Lead-in strips are never altogether satisfactory, and are shivvery draft producers in the winter.

A Canadian fan, located up north where the slightest crack lets in snow drifts and flu, devised an ingenious and effective stunt whereby nothing more material than electrons can get in via his lead-in, and they, by the way, go right out again. He merely pastes a ten inch by ten inch square of tin foil on the outside of the window, and the same on the inside, so that the two squares of foil are separated only by the glass. This makes an effective condenser, and he connects the lead-in from the aerial to the outside square and the lead to the aerial post on his set to the inside square. Simple—and most effective!

What Is the "TU"?

The layman, familiar with the conventional nomenclature of amplification, is more and more often running across the term TU, or transmission unit, in the more technical papers on radio amplification and attenuations. He has logically assumed that this new expression is a criterion of amplification, but its exact significance is somewhat of a mystery to him.

The TU has been used in telephone engineering for several years, and was invented to meet the need of an appropriate measure of relative intensities.

There are several types of "functions" encountered in the physical and mathematical world—which worlds are one and the same. A function means the dependence of one quantity upon another. For instance, the amount of money that one has in an interest account at the bank is a function of time; it depends on how long the money has been there.

Some functions are arithmetic, such as problems in simple interest, in which the principal grows bigger by the same amount year after year. If A is the amount of money in the bank, P the principal, r the rate of yearly interest and t the number of years the money has been in the bank, the amount is expressed in the equation, $A=P+Prt$ or $A=P\ (1+rt)$.

Some functions repeat themselves periodically, arriving at the same numerical place or values after equal times, as a wheel duplicates its position every revolution. Functions of this type are most easily considered by the help of trigonometry, and we run into such expressions as "sin pt", and so on.

There are also power functions, in which a quantity varies in accordance with the power of one of the elements in the equation. For instance, the distance traversed by a falling body is expressed by the equation, distance equals one half the acceleration of gravity multiplied by the time in seconds squared—distance being proportional to the second power of time.

Still another function varies with the logarithm of the elements involved, and this is known as a logarithmic function. Such functions are, logically, most easily understood and considered by an application of logarithms.

For instance, our reaction to sound is logarithmic. The sensitivity of the ear to noise varies according to the law of logarithms. Hence it would be logical to consider sound problems, such as amplification, on a logarithmic basis.

The TU or transmission unit is 20 times the common logarithm of the voltage amplification of an amplifying system under certain specified conditions of impedance. The fol-

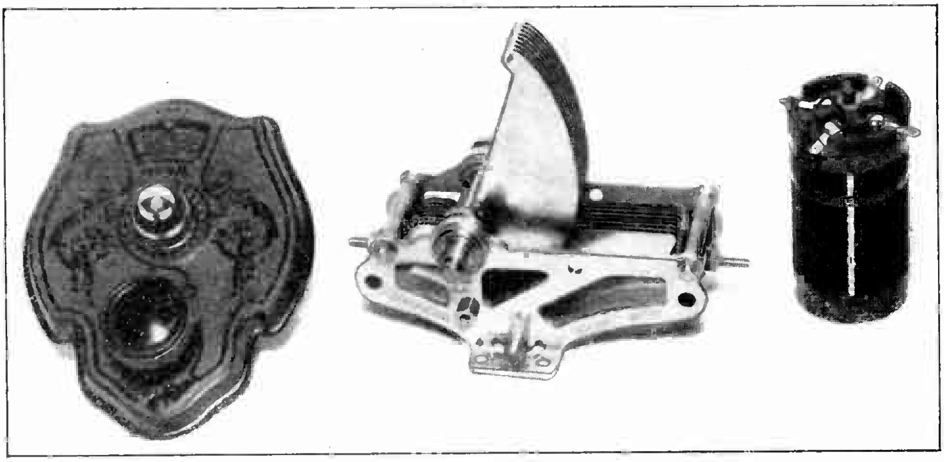


Fig. 2. The parts you need to make a simple but effective wave trap: a dial, a .00035-mf. variable condenser, and a standard R.F. transformer. These may be mounted on a panel about six inches square. The hook-up is shown on the following page.

lowing table, Figure 1, gives a good idea of how the usual considerations of amplification compare with the TU system.

VOLTAGE AMPLIFICATION	TU
2	6
3	8.5
4	12.
5	14.
10	20.
25	28.
50	34.
75	36.4
100	40.
1000	60.

Figure 1

If the first stage of a two-step amplifier has a gain of ten and the second step a gain of 5, the total gain is an addition of the TU's—20 TU plus 14 TU or 34 TU. Which, incidentally, is the number of TU corresponding to an amplification of 10 times the amplification of 5. The amplifier is said to be "up" 34 TU.

Reverse calculations are also simplified by the TU system. A loss of signal strength to one tenth the original value is said to be "down" 20 TU.

The Wave Trap Again

One of the bits of radio history that most persistently repeats itself is the wave trap. The wave trap is almost as old as radio itself, but in these days of superabundant broadcasting stations and the new allocations (O.K. in general but often inimical to good reception in particular instances), the wave trap more than survives as a useful instrument.

Its commercial form has gone the way of the crystal detector, but it is a simple matter to build up a satisfactory trap. A standard tuned coil (r.f.) and a variable condenser, of the proper value, represent the outlay. The writer recommends a Pilot type 175 coil and a type 1517 variable condenser.

The condenser is connected across the secondary of the coil and the primary of the coil is connected in series with the aerial lead-in to the set. The primary coil can be readily identified by the initialing "B+" and "P." The remaining two connections are the secondary. The essential parts are shown in the photograph Figure 2, while the connections are sketched in Figure 3.

The operation of the instrument is simple. The wave trap is used to eliminate interference from nearby and powerful stations. Often it is the only possible way of eliminating one station in order to receive another. Tune the receiver to the station that you wish to eliminate. Next tune the wave trap until this station is weakest. You may now return to any station you wish to tune in, and will probably experience no interference from the first station.

If the trapping action of the instrument described is insufficient, it may be increased by adding a few more turns of wire to the primary coil—winding in the same direction as the primary. These extra turns can be wound directly over the secondary—more turns being added until trapping action on the undesired station is sufficient.

Tracing Radio Noises to the "Ground"

The writer has come across several instances of baffling radio noises that were finally traced to a variety of microphonic effects existing in the ground connections. These were due to subtle defects in plumbing. In one case it was found that two pipes crossing each other resulted in a microphonic contact that caused trouble by varying the resistance of the ground circuit every time any one walked across the floor above.

It is a very difficult and tedious job to locate and eliminate troubles of this kind. The simplest solution is a counterpoise.

Merely string up a second aerial and connect this to the ground post on your receiver. Reception will generally be as good as when employing the usual ground, and will often be improved. At any rate, you can be sure that whatever noise you are experiencing is not coming from your ground circuit.

Voltmeter Hints

An 0 to 1 milliampere meter can be used as a high-resistance voltmeter by connecting a Pilot 500,000-ohm resistor in series with the meter. Full scale deflection, or 1 milliampere, indicates a voltage of 500, and fractions in proportion. The resistance of this combination is so high that it will not draw enough current to affect the accuracy of the reading.

Watch Out!

The filter condensers of "B" power packs usually retain healthy charges of electricity after the primary circuits of the step-up transformers have been opened, and many experimenters are badly stung when they stick their fingers into the wiring. To avoid temporary paralysis of your hand, simply brush a screw driver lightly across the condenser terminals until the sparking ceases. The size and and brilliance of the discharge will surprise you.

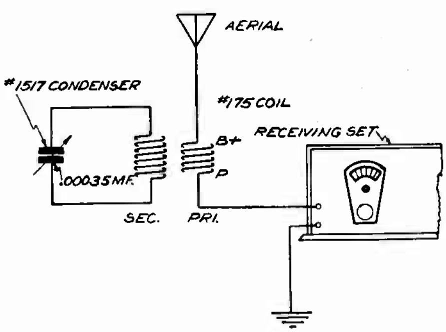


Figure 3: How a wave trap is connected to a receiving set.

Educational Department

Conducted by Alfred A. Ghirardi

Along with the rapid growth and expansion of the radio industry during the past few years, and its settling down to an engineering basis, has come an ever-increasing demand for young, technically-trained men with a knowledge of the principles of electricity as applied to radio and the ability to do testing, service or design work. That the leading educational institutions all over the country are recognizing this demand is evident by the increasing number of radio courses being offered as part of high school and college curriculums.

Many of these institutions of learning are approaching the problem cautiously, having no precedents to guide them. Radio instruction is being introduced as part of the regular electrical laboratory work, in many cases under the supervision of older teachers who have not been able to devote the large amount of time necessary to keep up with the many advances in the radio art. These men are at a great disadvantage, as there is no really worthwhile, up-to-date radio text book on the market suitable for use in high school and elementary college radio courses.

Most of the theoretical and practical radio work has been described in the leading radio magazines in the country and at meetings of the Institute of Radio Engineers and the Radio Club of America. It is almost impossible for a man to attempt to master the entire subject as it stands today, from the back numbers of these magazines.

The publishers of Radio Design realize this situation and will endeavor in future issues to include a certain amount of theoretical and practical construction information for use by readers interested in educational radio work. The Educational Section starting in this issue represents the first step taken toward this end.

The Radio Physics Course, which appears in installments in Radio Design, has been written and used successfully in a technical high-school radio course for several years by the author. No pains have been spared to make it the most complete, practical and up-to-date course possible. The hundreds of questions in every phase of radio work which rise in the minds of the bright and eager school boy have been answered carefully and completely. It will be available in book form shortly, for use as a text book in radio courses. It will contain over 200 illustrations and diagrams, and has been written by a teacher, for teachers.

The construction articles on the Grid-Dip Oscillator and the Little Pal Receiver, in this issue, form the first of a series on school projects. Handy instruments and sets which we have found useful in school work and in the Pilot laboratory will be described from time to time. We will pass on any new kinks or tricks which we believe will be helpful to you.

HELP FOR THE ASKING

We are anxious to become acquainted and shake hands with our readers via the "mail

A scene in a rather well-equipped school radio laboratory, showing a group of boys at work.

box route." We want to discuss your problems with you and help you whenever we can. We welcome suggestions from both teachers and students alike, concerning the theoretical and construction articles they would like to see in the Educational Section of RADIO DESIGN. We want to present material which will prove of greatest benefit to the largest number of readers. Address your letters to the Educational Editor.

The use of Pilot precision parts for radio laboratory equipment and school set building projects enables the students and instructors to secure more good parts per dollar than they could obtain in any other way. Quantity production, direct control of all production under one roof, plus a careful design of all parts by a corps of competent engineers, results in low production costs, elimination of waste and better products selling at lower prices. The economies are passed on directly to the set builders.

Many radio instructors are taking advantage of this fact by making their radio apparatus appropriations do double duty by the purchase of Pilot parts for laboratory equipment. They are using the official set kits with the full-size working blue prints and printed instructions, in their classes for set building projects.

One instructor in a leading Chicago technical high school writes us:

"Your engineered kits and full-size blueprint set layouts enable our boys to produce sets they are really proud of. They result in a great saving of time and money, and are helping us prove that young boys with a limited technical knowledge and radio construction experience can build real radio sets. Some of our boys are paying their way through high school on the money earned by set building and servicing."

THE SCHOOL RADIO CLUB

Many high schools are sponsoring radio clubs so that groups of boys interested in radio can get together during their spare time and discuss radio or build sets. In a number of these clubs the members have built short-wave transmitters with which they carry on regular communication with boys of other schools. Many "Wasp" receivers are being used in this work. RADIO DESIGN is being used as the official club radio magazine in a number of schools.

Invariably the formation of a radio club or the inauguration of a radio course in a school awakens in the boys a great deal of interest in scientific things. They take greater interest in their electrical studies and become good mechanics by virtue of the training they get in the handling of tools and delicate scientific apparatus in the construction of radio sets. They begin to appreciate the wonders of science and the real beauty of a fine piece of radio apparatus.

To the average boy who has never been on speaking terms with radio, a vacuum tube is merely a glass bulb with a black base, and something or other inside. Oh yes, the radio set at home has several of them! To the young radio bug who is building his first set at school, a vacuum tube is a marvelous thing. The mystery of the many unseen actions going on inside of it appeals to his imagination, and there is nothing more inspiring to some of us elders than the keen imagination of a bright, wide-awake American boy.

THE PILOT "SUPER-WASP"

(*Continued from page* 15)

These coils are thus easily distinguished from the detector stage coils, all of which have two windings apiece, a grid winding above a tickler, and four connections pins in the base. The coils are always used in pairs; that is, if an orange ring coil is in the first can (the R.F. stage), the other orange-ring coil must be used in the detector can.

The tuning ranges of the coils are as follows:

Red: 14 to 27 meters, 21,420 to 11,110 kilocycles.

Orange: 26 to 50 meters, 11,540 to 6,000 kilocycles.

Yellow: 50 to 100 meters, 6,000 to 3,000 kilocycles.

Green: 100 to 200 meters, 3,000 to 1,500 kilocycles.

Blue: 200 to 500 meters, 1,500 to 600 kilocycles.

TUBES AND VOLTAGES

A 222 screen-grid tube is used in the R.F. stage—in the left can. (You are now regarding the set from the front). Tubes of the 201A type are specified for the other positions, but you may also use a 200A as detector, with increased sensitivity but also increased noise level, and either a 112A or a 171A in the second audio stage. You will notice that separate "B" and "C" leads for the plate and grid return leads of both audio stages have been provided, so that you may use any of the three combinations with the correct plate and biasing voltages as specified by the tube manufacturers.

If you use 201A's, run one wire from the 90 volt tap of the "B" batteries to both the first "B" + 135 post (next to the L.S. post) and the "B" + 90 post; similarly bridge the "C" — 4½ and "C" — 9 posts, and use 4½ volts on both. The "B" + Det post next to the "C" — 9 post takes 45 volts for the screen-grid of the 222 tube, while the other "B" + 135 post takes this much voltage for the plate of the 222 tube.

TUNING THE SUPER-WASP

For detailed instructions on tuning the Super-Wasp, see the article entitled "How to Get the Most Out of Your Short-Wave Receiver," elsewhere in this issue. You simply keep the left dial more or less in step with the right dial, and manipulate the regeneration condenser in the manner described. The setting of the small aerial condenser, on the left side of the left shield can, is not critical, and you can mark the best positions with pencil lines right on the aluminum.

RADIO PHYSICS COURSE

FOR HIGH SCHOOL STUDENTS

By ALFRED A. GHIRARDI

CHAPTER 4

The Receiving Station, Detection, Crystal Detectors and Circuits

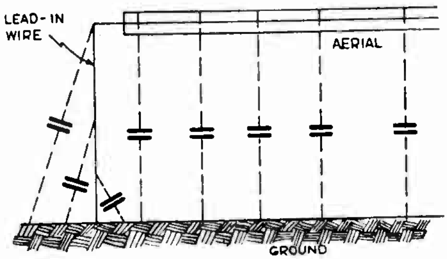
43. **RECEIVING:** At the receiving station the radio waves in the air are separated, amplified, and made to reproduce the original program from the radio station it is desired to receive. It will be remembered from the previous chapter that the modulated high-frequency current flowing in the antenna circuit of the broadcasting station sets up an electrostatic and an associated electromagnetic field, which travel outward in space in all directions at the rate of 186,000 miles or 300,000,000 meters per second. As the fields spread out continuously over a larger and larger area, their intensity decreases as the distance from the station increases.

When they reach a receiving antenna or aerial of the common type, consisting of one or more elevated wires, the electrostatic field sets up an alternating voltage between the wires and the ground. If the circuit between the antenna and ground is complete, this emf. causes a current of the same frequency as that of the broadcasting station to flow, the strength of the current being determined by the impedance of the circuit.

Of course, as the radio waves spread out in all directions from the transmitting station their strength naturally decreases. At twice the distance their amplitude is halved, at four times the distance it is only one-quarter. The strength is inversely proportional to the distance. There is also a decrease in strength due to the fact that whenever the waves strike any object in which they can produce electric currents (such as the steel framework of a building), the currents are produced at the expense of the energy of the waves and heat up, to minute degree, the material in which they flow. This dissipation of energy acts simultaneously with the inverse distance effect to reduce the strength of the waves and the signals received, as the distance from the transmitter increases. The latter effect is specially great around large cities like New York, Chicago, etc.

The current, however, is practically an exact duplicate, as regards wave form, of that sent out from the broadcasting station. It is possible by means of certain apparatus to convert this current back into sound waves similar to those put into the microphone at the studio.

It may be said that with the ordinary antenna system at the receiving station, the potential is produced by the sweeping action of the moving electrostatic field on the exposed aerial and ground, as the intensity of the impinging lines of force varies and changes in direction, at the same frequency as the waves. The aerial and ground really form a condenser, having the aerial wire as one plate, the ground as the other plate and the air between them as a dielectric. This is a complete circuit and an alternating current will flow in it when an alternating voltage is introduced. Fig. 25.



FORMATION OF CONDENSER BETWEEN AERIAL AND GROUND

Fig. 25

If a loop antenna is used at the receiving station, the current set up is due practically entirely to the action of the electromagnetic field. This will be discussed in greater detail when explaining loop antennas.

The object of the receiving apparatus is to amplify and convert the antenna current into corresponding sound waves. Some idea of the complexity of the current impulses transmitted when speech and music are broadcast can be gained from the photograph shown as Fig. 26, which shows the modulated carrier currents for the words New Hampshire, Concord, and Manchester. These are reproduced here by courtesy of the American Telephone and Telegraph Comanpy.

44. **EARPHONES.** In the ordinary telephone, the current is changed into sound by means of the telephone receiver. The same type of instrument, modified slightly, can be used for radio reception. It is commonly known as the headset or earphones. Earphones, like the ordinary telephone receiver,

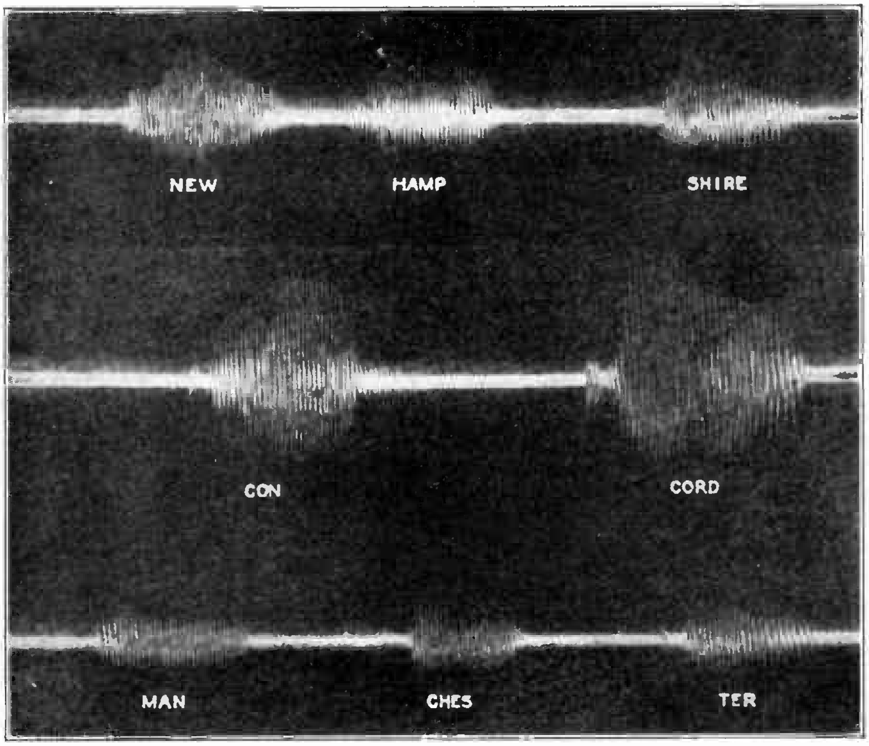


Fig. 26. Oscillograph photograph of a carrier wave modulated by the words "New Hampshire," "Concord," and "Manchester."

operate on the electromagnetic principle. However, they are made much more sensitive than those used in telephone work as the radio currents are usually much weaker than those used in telephone work.

They usually consist of two separate earpieces connected in series and held to the ears by a metal headband. Each earpiece has a metal or hard rubber cup, D, Fig. 27, with a hard rubber cap G. In the bottom of the cup is a strong permanent horseshoe magnet E, with pole pieces F. Around each pole piece a coil H, of many thousands of turns of fine insulated wire (No. 40 to 50), is wound. The two coils are connected in series so the current passes through both windings. Sensitive headsets have 10,000 or more turns of wire on the coils, so that even very feeble currents flowing through them produce an appreciable magnetic field. Suspended above the pole pieces, and very close to them, is a thin, flexible, soft iron diaphragm about .004 inch thick.

45. **EARPHONE OPERATION:** When no current flows through the coil, the magnetism of the permanent magnet attracts the iron diaphragm and bends it slightly, as shown by position A in Fig. 27, producing an initial deflection. Assume the left-hand pole piece to be a North pole and the right hand one a South pole. If one complete wave of an alternating current is flowing through the receiver, so that the current during the first half of the wave flows through the coils in such a direction as to produce magnetic poles similar to those of the magnets, then this magnetism adds to that of the magnets and the field is strengthened. This increases the attraction on the diaphragm and pulls it down further, to point B. On the next half wave, the direction of the current reverses, and so the magnetic field produced by its flow through the coils also reverses, and opposes that of the permanent magnet. The resultant field is now weaker than that of the magnet alone, so the diaphragm springs back to position C. At the end of the cycle it goes back to A. Therefore, during one cycle it makes a complete vibration from A to B to C, depending on the amount of variation of current flowing through the coils. This back-and-forth movement of the diaphragm sets the air in motion and creates sound waves that travel out through the opening in the cap. If the frequency of these waves lies within the audible range—about 16 to 20,000 cycles—they can be

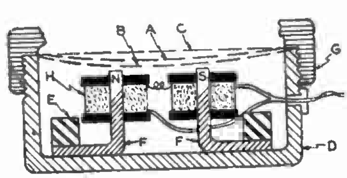


Fig. 27. Cross-section view of a typical telephone receiver.

heard by the human ear.

At first thought it might seem that the currents set up in the antenna circuit could be changed into sound waves directly by connecting a pair of earphones in it, as shown in Fig. 28. This would not work, as is evident from the following considerations:

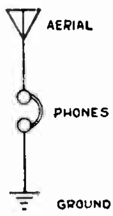


Fig. 28

46. **NEED FOR DETECTION:** In order to transmit the broadcast programs over a considerable distance, it has been found necessary to use carrier currents of high frequencies, because they are capable of being radiated into space. They are modulated by the currents of voice frequency. The carrier-current frequencies used in most broadcasting at the present time range from 1,500,000 to 500,000 cycles, corresponding to 200 to 600 meters, respectively. The range of frequencies to which the ordinary human ear will respond is from 16 to 20,000 cycles. Therefore, even if the high-frequency current received by the antenna could be made to flow through the earphones, and the diaphragm made a complete vibration for each cycle, it would be vibrating so rapidly that the ear would not respond to it. Actually, it is impossible for the diaphargm, which is not perfectly flexible and has some inertia, to vibrate this fast. And lastly, the magnet coils of the earphones, having a necessarily large inductance due to the great number of turns of wire wound on an iron core, offer a very high impedance-(opposition to the current flow) to currents of such high frequency; so that practically no current at such high frequencies is able to flow through them anyway. A set of earphones having a direct-current resistance of 2,000 ohms may have an impedance as great as four or five thousand ohms at a frequency of only 1,000 cycles. It is evident from these considerations that the circuit shown in Fig. 28 is impractical.

To make the signal audible, and the voice currents heard, the circuit must be arranged so the diaphragm does not follow the current variations in each individual cycle of the carrier wave, since this is a high frequency and we are not interested in hearing it. The diaphragm must be made to follow the variations in the maximum strength of the current in one direction: i.e., follow the wave form or envelope of the high-frequency current. Fig. 29 A. This, it will be remembered, is the true wave form of the voice waves.

To do this, it is necessary to make only one or the other half of the alternations effective, so the current flows through the earphone coils in one direction only. This is accomplished by the detector, and the process of cutting off or eliminating half of the received wave is called rectification or detection.

47. **CRYSTAL DETECTION:** The simplest rectifier is the common crystal detector, Fig. 30. This usually consists of a very fine wire called a catwhisker, making light contact with a crystal of a particular mineral, such as galena.

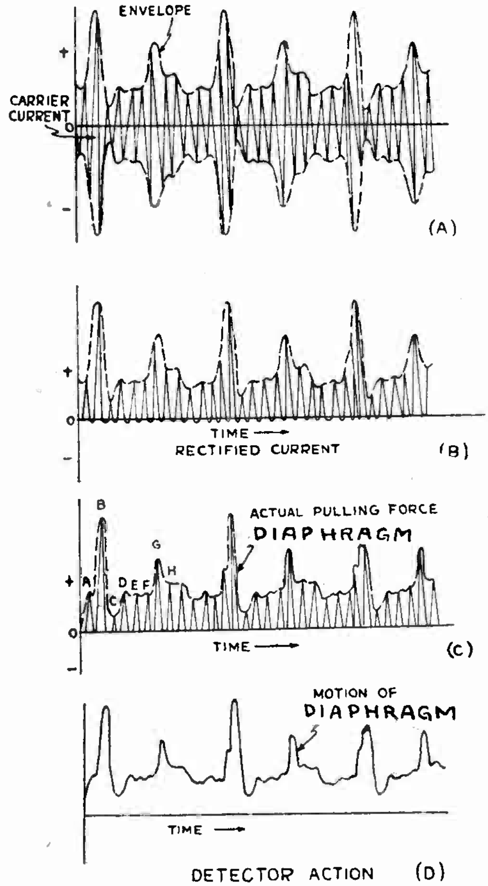


Fig. 29

Other mineral combinations can be used, but for our purpose of explanation the galena detector will suffice.

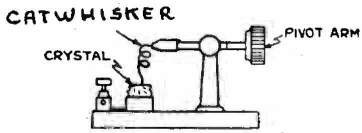
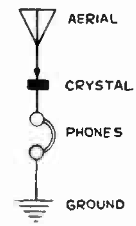


Fig. 30

When an alternating voltage is applied to the combination, it tends to make current flow from the catwhisker to the crystal (Fig. 30), during the first half cycle. The resistance which the crystal and contact offer to current flow in this direction is low so the current is able to flow through easily. On the next half cycle the voltage is reversed and tends to send current in the opposite direction. The detector contact offers a very high resistance to current flow in that direction, so very little current is allowed through. The action is repeated for each cycle. This is shown graphicaly in Fig. 29 A and B, where A is impressed alternating current and B is the rectified pulsating current.

Notice that practically all of the current in the direction represented below the axis line has been eliminated and that which does get through, flowing from catwhisker to crystal, consists of a series of pulses of current of varying amplitude. It is the difference in strength of these two currents which determines how well or how poorly the crystal operates as a detector. A good crystal will eliminate the current in one direction practically entirely.

48. **DETECTION**: The pulses or fluctuations of current would still seem to be too rapid to actuate the diaphragm, since their frequency is that of the carrier current. Their effect on the receiver diaphragm, however, is for each wave train to give force by successive addition, as can be seen from the following. The first impulse A, Fig. 29 C, passes through the earphone coils and produces a movement of the diaphragm. If the station is transmitting at say 200 meters, corresponding to a frequency of 1,500,000 cycles per second, then the time interval between two successive maximum values of currents, as A and B, is one-one million five hundred thousandth of a second. Obviously, since the diaphragm has inertia and stiffness, it is somewhat sluggish in action and cannot possibly make a complete vibration in this time, so the second impulse B will occur before the diaphragm has had time to spring back in place, and will therefore deflect it further. So will the following impulses C, D, E, etc., the result being that the diaphragm is deflected once for every wave train and its motion follows more or less faithfully the shape of the envelope of the carrier current, as shown in Fig. 29 C. Since this is the same shape as the wave form of the sound impressed at the broadcasting station, the movement of the diaphragm sets up similar sound waves which can be heard by the listener at the receiving station. The changing of the electric currents induced in the aerial into corresponding sound waves is accomplished in this way, and the circuit is shown in Fig. 31.



SIMPLE RECEIVING SYSTEM

Fig. 31

Crystal detectors are not used much at present, having been supplanted almost entirely by the vacuum-tube detector.

48. **IMPROVED DETECTION**: Fig. 31 represents the simplest basic receiving circuit. The volume, and frequently the quality, of the sound in the receivers is improved by connecting a small fixed condenser C of about .0005 mfd. capacity across them, as shown in Fig. 32 A.

The operation is then as follows: During the period of duration of one impulse A of the rectified current of Figs. 29 C and Fig. 32 B, the current flows through the earphone coils and also charges the condenser C. During the next half cycle no current flows through the detector D. At this instant the condenser C, however, being connected across the phone coils and having an electric charge on it, partially discharges through them. The discharge current of the condenser is in the same direction as that of the impulse A. This acts to keep the diaphragm in position until the next impulse B comes along. The current flowing in the telephone receiver is then like that shown in the somewhat enlarged and exaggerated drawing in Fig. 32 B. There is then, during each wave train, a more continuous attraction on the earphone diaphragm, with resulting improved reproduction, since the diaphragm folows more nearly the outside curve or envelope of the current.

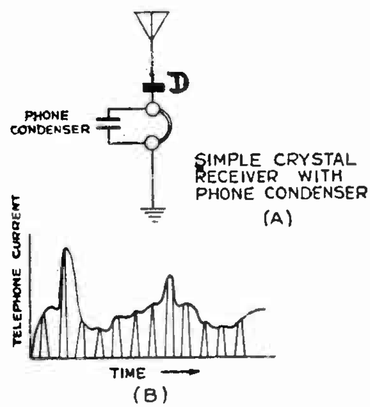
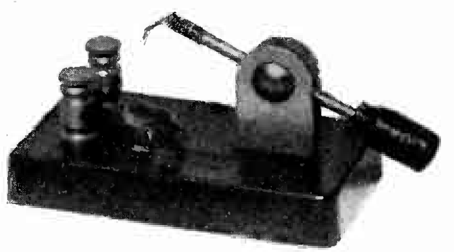


Fig. 32

In most modern earphones there is some capacity existing between the windings on the



A typical old-fashioned crystal detector. The crystal fits in the clip next to the binding posts coils, and the usual five-foot external connection leads being close together also form a condenser. This combined capacity is usually enough to give the above action, so that no additional condenser C is necessary. In diagrams in future chapters the condensers will be omitted, although the reader should remember that capacity really does exist there.

50. **AMPLIFICATION AND SELECTIVITY:** It is evident that the circuit of Fig. 32 A will respond to waves from any station, provided enough current is induced in the antenna circuit by these waves to operate the phones. This suggests at once the two important drawbacks of this arrangement. Since it will respond only to waves of comparatively great strength, its receiving range is limited to 5 to 25 miles, depending on local conditions. As there are hundreds of broadcasting stations, many of them in the same city, if several of them transmit at the same time with enough power to permit of reception by the crystal set, they will all be received together, creating interference, and reception will be anything but pleasant.

These facts make it evident that if programs from distant stations are to be heard, some form of amplifying device must be employed to strengthen the currents induced in the antenna circuit. This will be considered later. Since it is desired to hear only one station at a time, some provison must also be made for selecting the program of any one station to the exclusion of all others. This is accomplished by having all the stations in the same locality operate with carrier currents of different frequencies or wavelengths. Thus in New York City, station WEAF transmits with a carrier wave frequency of 660 kilocycles (454 meters); WJZ with 760 kilocycles (395 meters), WOR with 710 kilocycles, (422 meters), etc. These frequencies are assigned to stations by the Federal Radio Commission. Some stations located in the same city, as WHN and WPAP, are assigned the same frequency, but they do not broadcast simultaneously.

51. **TUNING:** In order to select the station desired and exclude all others which may be transmiting at the time, some means must be provided for excluding the induced currents of the frequencies of the stations not wanted, and at the same time allow the currents of the frequency of the desired station to flow through the receieving apparatus. The ability of a receiving set to do this satisfactorily is a measure of its selectivity. This is called tuning and the process is commonly spoken of as tuning in a station. All tuning in radio sets at the present time is accomplished by making use of the resonance effect of alternating currents explained in Chapter 1, to reduce the impedance of the circuit to a minimum for the particular frequency which is to be received.

The circuit of Fig. 32 A can be roughly tuned to any frequency by the introduction of an inductance coil C, Fig. 33, consisting of a number of turns of insulated wire wound on a cylindrical form. A sliding contact is arranged to make connection with any number of turns of the coil. The inductance is increased or decreased by increasing or decreasing the number of turns respectively. By moving the slider, more or less inductance can be inserted in series with the antenna, thereby changing the frequency to which the circuit will respond most strongly, and the station it will receive.

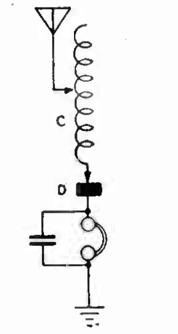


Fig. 33

This receiver is not selective enough for present-day use. Since the crystal detector and phones have a high resistance and they are in the path of the antenna circuit, the tuning is very broad and the volume is poor.

52. **SINGLE-CIRCUIT RECEIVER:** The tuning can be sharpened considerably by removing the detector and phone resistance from the antenna circuit and putting them in a circuit by themselves, as in Fig. 34. Coil C has two sliding contacts. The antenna circuit includes all the turns of wire between 1 and 2, while the secondary circuit, containing the crystal detector and receivers, includes the turns between 2 and 3. It is thus possible to tune both the antenna and secondary circuit to the proper frequency. This is known as the single-circuit receiver.

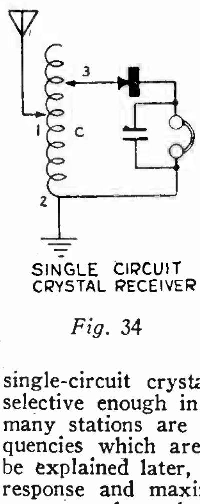


Fig. 34

53. **TWO-CIRCUIT RECEIVER:** The single-circuit crystal receiver is not usually selective enough in congested districts where many stations are operating at once on frequencies which are close together. As will be explained later, in order to get maximum response and maximum selectivity it is important to keep the resistance of the antenna and tuned circuits to a minimum, provided this does not have an unsatisfactory effect on the receiver as a whole in some other way. To do this with a crystal receiver, the crystal and phones are placed in a secondary tuned circuit, coupled in some way to the aerial circuit, the responding to the maximum degree to the incoming signals. Such a circuit is shown in Fig. 35, and is known as a two-circuit receiver. The primary and secondary coils of the inductance L are wound near each other (usually on the same form), so that the magnetic field produced by the antenna current flowing through the primary coil links and unlinks with the turns of wire of the secondary and induces a similar current in it.

The variable condenser C, connected across the secondary coil, tunes the coil and produces resonance in the circuit. This makes the passage for these infinitesimally small currents as easy as possible and so the current in the tuned circuit L C is increased greatly. This causes the largest possible potential differences across the coil and condenser and since these

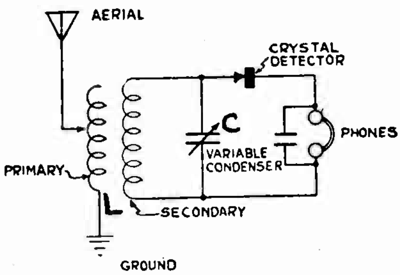


Fig. 35

are applied to the detector and earphones, cause an increase in volume over that produced if the circuit were not tuned. The primary circuit can be tuned independently by the taps which vary the number of turns included in the aerial-ground circuit. By varying the taps and the settings of the variable condenser, the circuit will respond to any desired frequency within the range for which the coil and condenser have been designed.

54. **LIMITATIONS OF CRYSTAL TUNING:** This gives us a system of radio reception in which the volume of sound produced depends entirely on the strength of the received waves. Since the amount of energy decreases very rapidly as the distance from the transmitting station is increased, it is evident that simple crystal sets cannot be used for long-distance reception, because the received currents are not strong enough to operate the earphones.

The use of earphones is becoming unpopular, as people desire to hear their programs in comfort with loud speakers which produce enough volume to fill good-sized rooms. Loud speakers require a stronger operating current than do ordinary earphones, so amplifiers have been developed for amplifying the received radio currents to make loud-speaker operation possible. These employ vacuum tubes in their operation. The crystal detector, while producing remarkable clarity of reception, is unable to handle either very weak or very strong impulses of current satisfactorily.

Crystal detectors have been superseded almost entirely by vacuum tube detectors, due to their greater sensitivity, ease of adjustment, and property of not only rectifying but amplifying at the same time. The rectifying ability of a crystal is an inherent property of the crystal and cannot be altered or improved. The point of best sensitivity must be determined by trial by moving the catwhisker over the surface of the crystal. In most cases, this point is never located. The adjustment is not permanent, and heavy currents such as those received from powerful nearby broadcasting stations may make the detector inoperative by setting up a comparatively great amount of heat at the contact point, thus oxidizing the cat whisker and destroying the conducting properties.

Radio Physics Course Correction

The editors regret that several errors were made at the end of Chapter 2 of the Radio Physics Course, as printed in the Winter, 1928 Issue, Vol. 1, No. 4. For the benefit of those readers who are keeping a file of the Radio Physics Course, articles 27 to 30 are reprinted below in corrected form. Readers are requested to destroy the incorrect part of Chapter 2 as printed previously.

2. **INDUCTIVE REACTANCE:** From the previous explanation, it is evident that inductance tends to oppose the flow of the current in an alternating current. This opposition effect may be considered as an apparent resistance additional to the natural or direct-current (zero frequency) resistance of the circuit. The total effect is called "inductive reactance," and is expressed by the symbol X_L to distinguish it from the direct current resistance R.

Since inductive reactance causes an opposition to the flow of the current, it is expressed in ohms, like resistance. In a circuit containing inductance only, the current lags 90 degrees behind the applied voltage. The value of the inductive reactance X_L in ohms depends upon both the frequency of the voltage and the inductance of the circuit. It may be expressed by the formula:

A pair of standard earphones. The phone on the right has been opened to show the screw cap (center) and the diaphragm (right).

$$X_L = 2 \times 3.1416 \times f \times L \quad (7)$$

where f = the frequency in cycles per second
L = the inductance in henrys
X_L = inductive reactance in ohms.

28. **CAPACITIVE REACTANCE:** The strength of the charge and discharge currents in a condenser depends on the capacitance C of the condenser, the applied voltage E, and the frequency f. Thus the condenser may be considered as a part of the circuit, having an apparent resistance in ohms, called its "capacitive reactance" and represented by the symbol X_C.

In a circuit containing only capacitance (commonly called "capacity") the current leads the applied voltage by 90 degrees. The capacitive reactance is equal to:

$$X_C = \frac{1}{2 \times 3.1416 \times f \times C} \quad (8)$$

where f = the frequency in cycles per second
C = the capacitance in farads
X_C = the capacitive reactance in ohms.

From this formula it can be seen that as either the frequency or the capacitance, or both, is increased, the resistance or reactance which a condenser offers to the flow of alternating current decreases. This is exactly opposite to the effect of inductance in a circuit.

29. **IMPEDANCE:** Thus far we have considered alternating current circuits which contain only inductance or capacitance. The circuits met with in practice always have resistance as well as inductance or reactance, and in some cases circuits contain resistance, inductance and capacitance. When a circuit contains both inductance and capacitance, the net reactance X is equal to the arithmetical difference between the inductive reactance X_L and the capacitive reactance X_C, or $X = X_L - X_C$. This is because the effects of the inductance are exactly opposite to those of the capacity.

The combined opposition to current flow offered by the resistance, inductance and capacitance of a circuit is called the "impedance." It is represented by the symbol Z and is expressed in ohms.

The impedance of a circuit containing resistance R, inductance L and capacitance C is

$$Z = \sqrt{R^2 + (X_L - X_C)^2} \quad (9)$$

or substituting in equation (9) the values of X_L and X_C from equations 7 and 8 we get

$$Z = \sqrt{R^2 + \left(2 \times 3.1416 \times f \times L - \frac{1}{2 \times 3.1416 \times f \times C}\right)^2} \quad (10)$$

In dealing with alternating currents, Ohm's law must be modified slightly. The current I in any circuit is equal to the voltage E applied to the circuit divided by the impedance (or total opposition to current flow) Z, of the circuit.

$$\text{or } I = \frac{E}{Z} = \frac{E}{\sqrt{R^2 + \left(2 \times 3.1416 \times f \times L - \frac{1}{2 \times 3.1416 \times f \times C}\right)^2}} \quad (11)$$

30. **RESONANCE:** From formula 11, it can be seen that if we have an alternating current circuit to which a definite voltage E is applied, a maximum current I will flow when the impedance Z is made as small as possible. Now let us examine formula 11. In order to make Z as small as possible, we must reduce the resistance R to zero and make the inductive reactance X_L equal to the capacitive reactance X_C so that

$$X_L - X_C = 0 \quad (12)$$

It is quite impossible to make R equal to zero, since all conductors have some resistance; but for any given frequency f, we can choose the inductance and capacity so that the inductive reactance X_L is equal to the capacitive reactance X_C, so that

$$2 \times 3.1416 \times f \times L = \frac{1}{2 \times 3.1416 \times f \times C}$$

then in such a circuit

$$Z = \sqrt{(R)^2 + (0)^2} = \sqrt{R^2}$$

therefore $Z = R$

The circuit then operates as though there were neither inductance nor capacity present, and it is said to be in "resonance" with the impressed alternating frequency.

This resonance effect is applied in practically all of our present radio receiving circuits today where the minute voltages set up in the aerial circuit are made to produce the largest currents possible in the tuned circuits. The usual circuit to obtain resonance is one having a variable condenser connected in series with a fixed inductance. By varying the capacity of the variable condenser the circuit can be brought to resonance for currents of any frequency within the range of the particular coil-condenser combination used. This will be studied in more detail in connection with the design of tuning coils.

THE "LITTLE PAL" RECEIVER

A Simple, Inexpensive Broadcast Set That Any Boy Can Build at Home or at School; Works on Two Tubes with Earphones, or on Four Tubes with Loud Speaker

By Alfred A. Ghirardi

ANYONE who comes in contact with young American boys, either in daily work as a teacher, or at home with members of his immediate family, cannot help but notice the live interest they are taking in scientific subjects nowadays. The flights of Lindbergh and the general advances in aviation, the modern design tendencies in automobiles, the marvels of electricity and the ever-increasing discoveries and inventions in the field of radio are never-ending sources of interest and discussion to modern wide-awake American boys. Their own mas and dads would be surprised at the first-hand knowledge they possess of subjects pertaining to these great branches of science. They are keeping in touch with the progress of the world.

Boys—

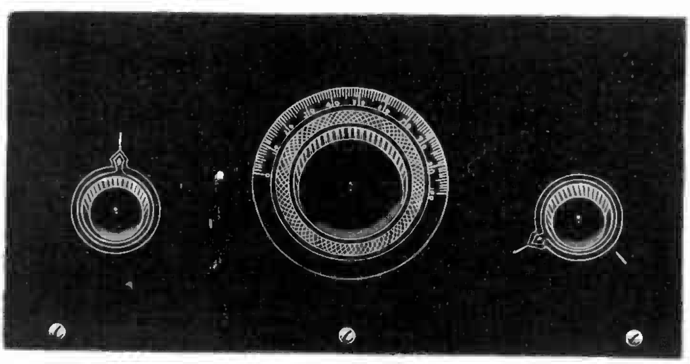
HAVE you been wanting to make a little radio set for yourself? The Little Pal is just the outfit for you, because it is very cheap and easy to put together. As your dad to buy the parts for you; they cost less than fifteen dollars, and you can have no end of fun wiring them up.

The hours of spare after-school time they spend in the attic, cellar or kitchen workshop, instead of on the old-time street-corner hangouts, is preparing them for a finer and better citizenship. Parents and teachers should do everything they can to foster and encourage these new, wholesome interests of their boys.

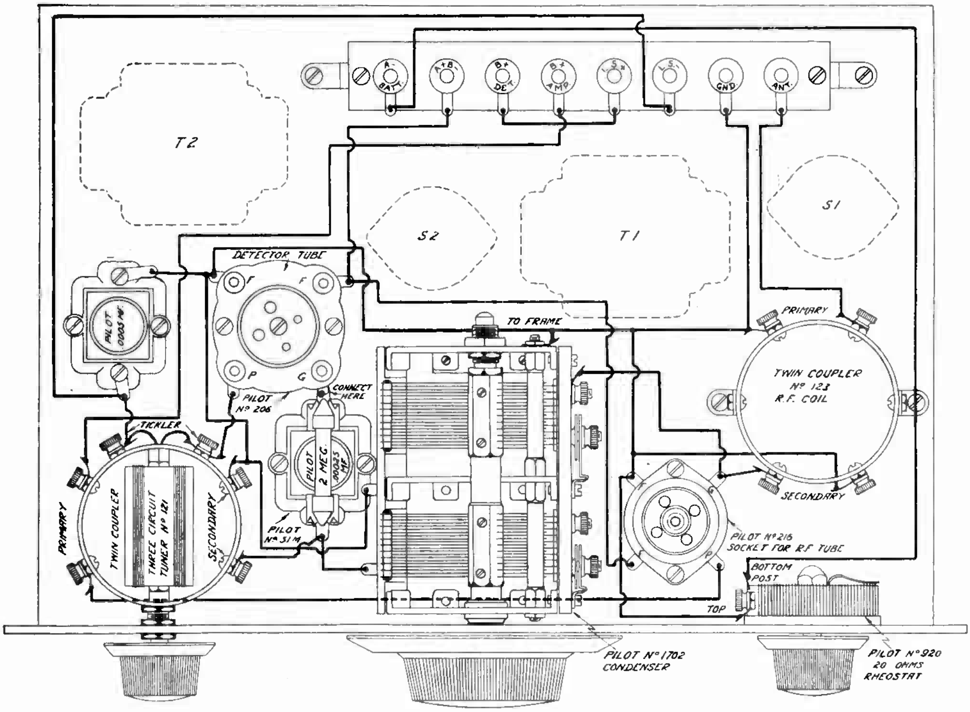
So many of our broadcasting stations are sending out interesting and instructive programs that many boys, who in the past might have been satisfied with less desirable forms of entertainment in their spare time, are now turning to radio as a means of entertainment and education. Every boy is thrilled with the idea of having a small set, A Little Pal, located in his hoom where he can listen in alone or with his chums. He wants to listen in with earphones for distant stations, without interference from other members of his family. He wants to be boss and sole owner and operator with full authority to do as he pleases with it. Later he will begin experimenting, perhaps learning to build more elaborate receivers and thus gaining valuable experience in set construction.

A SIMPLE SET

The writer has received so many requests for a simple, cheap set from the many boys of his acquaintance that work was started on The Little Pal. The intention was to build a simple two-tube set consisting of one stage of tuned-radio-frequency amplification and regenerative detector, as a start for earphone reception. The layout is such that two stages of transformer-coupled audio amplification can be added at any time for loud-speaker reception without changing the size of the panels or binding post strip. Only one of the original wires will have to be disturbed, and the two additional tube sockets and audio transformers will be mounted in the positions marked on the baseboard in the accompanying illustrations.



The front panel of the Little Pal. Condenser dial in center, tickler knob on left, rheostat knob on right.



Picture wiring layout of the Little Pal. The connections are simple, and if you follow them exactly as shown, the set will work the first time you hook it up. The outlines marked S1, S2, T1 and T2 show where the sockets and transformers for a two-stage amplifier are placed.

The set employs single-dial control, and can be used either with UX-199 dry-cell tubes with dry batteries, or with UX-201A tubes with a six-volt storage battery for filament supply. All parts are standard, easily obtainable Pilot products. The total cost of the parts for the two-tube set, complete with dry-cell tubes, batteries, and earphones, is less than fifteen dollars. Surely any father can donate this small sum for the entertainment and education of his boy. The wonderful smile of triumph and happiness that will light up his face when the first station is tuned in will more than repay any father or mother for the small sum advanced. Earphones can be bought cheaply now, as the demand for them is small. Many radio dealers are glad to dispose of any earphones they may have in stock, at bargain prices. This set makes a splendid project for the radio clubs or classes in high schools.

THE PARTS USED

The complete list of Pilot parts for the two-tube set shown is as follows:

1 No. 1702 .00035-mf. 2-gang Compact condenser.
1 No. 121 3-Circuit Tuner.
1 No. 123 R.F. coil to match No. 121 coil.
1 No. 920 20-ohm rheostat.
1 No. 51M .00025-mf. fixed condenser with grid leak clips.
1 No. 756 2-megohm grid leak.
1 No. 52 .0005-mf. fixed condenser.
1 No. 206 Shock-proof 4-prong socket.
1 No. 216 4-prong S.C. type socket.
1 No. 1274 4-inch round dial.
8 engraved bakelite binding posts.
1 14x7x⅛-inch formica front panel.
1 7x1x⅛-inch formica binding post strip.
1 13x9x½-inch wood baseboard.
Hookup wire, wood screws, soldering lugs,
Two small metal brackets.

ACCESSORIES

2 Tubes, either UX-199 or U%-201A.
1 Six-volt storage battery if 201A tubes are used.
3 No. 6 dry cells if UX-199 tubes are used.
1 45-volt "B" battery.
1 Pair of earphones.
Aerial and ground wire and insulators.

There are no wiring tricks in this receiver. The parts layout was worked out so as to make every binding post easily available for connection, and wiring simple enough for even the most inexperienced person to do correctly.

CONSTRUCTING THE SET

First cut the baseboard to the size given above and sandpaper it smooth. It should be of well seasoned whitewood, oak or mahogany and should not be warped. A coat of white shellac will keep it from absorbing moisture and causing electrical leakage, as well as from warping.

Now examine each part you are going to use in the set. See that it is in perfect condition, so far as the eye can detect.

Fathers—

HAS that youngster of yours been showing an interest in radio; If he has, you can make him the happiest kid in the world by spending a few dollars for the parts for The Little Pal, which is a fine two-tube receiver that really gives good results. The set will keep him off the streets evenings and will decidedly increase his confidence in his own abilities.

Make sure that none of the rotating (rotor) plates of the tuning condenser touch the stationary (stator) plates, for this will cause a short circuit. Tighten up all terminal nuts on the parts. Place each part on the baseboard temporarily in the position shown, and put soldering lugs on the terminals. Point them in the direction shown in Figure 9. Where the wires are to be soldered directly to the terminals of the instruments, as in the case of the grid condenser and shock-proof socket, scrape the nickel plating on the terminals with a small file or a penknife, until the bare copper is exposed.

Now mount the antenna coil, two sockets, and fixed condensers with wood screws exactly in the positions shown. Keep the terminals of the sockets in the order shown. Put a couple of washers underneath the fixed condensers to keep them at least one-sixteenth of an inch above the wooden baseboard. This reduces electrical leakage between the terminals.

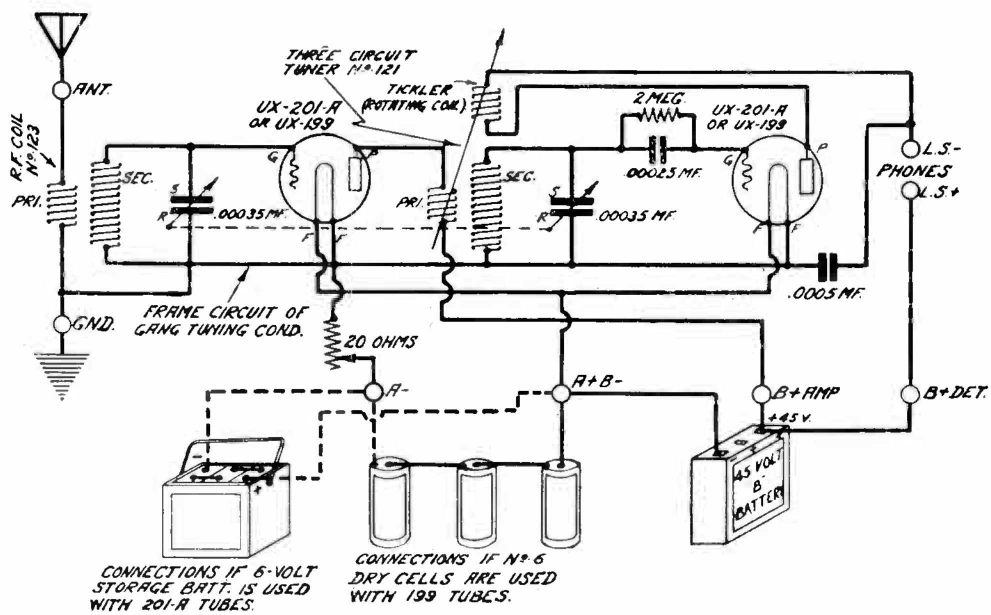
Mount all of the binding posts on the strip in the order shown. Put a lug under each one, and keep the wire holes in all the binding posts pointing straight to the back. This will make it easy to insert the battery wires later. You can stick a small nail through this hole and hold it in position while fastening the binding post. Mount the strip on the baseboard with two metal brackets.

Now for the front panel. Drill the three holes along the bottom for the wood screws which fasten the front panel to the baseboard, with a No. 27 drill. Measure three inches up from the bottom and 2¼ inches from both the right and left-hand edges to locate the holes for the rheostat and the three-circuit tuner. Drill a ⅜-inch diameter hole on the right for the rheostat, and a 5/16 diameter hole on the left, for the three-circuit tuner.

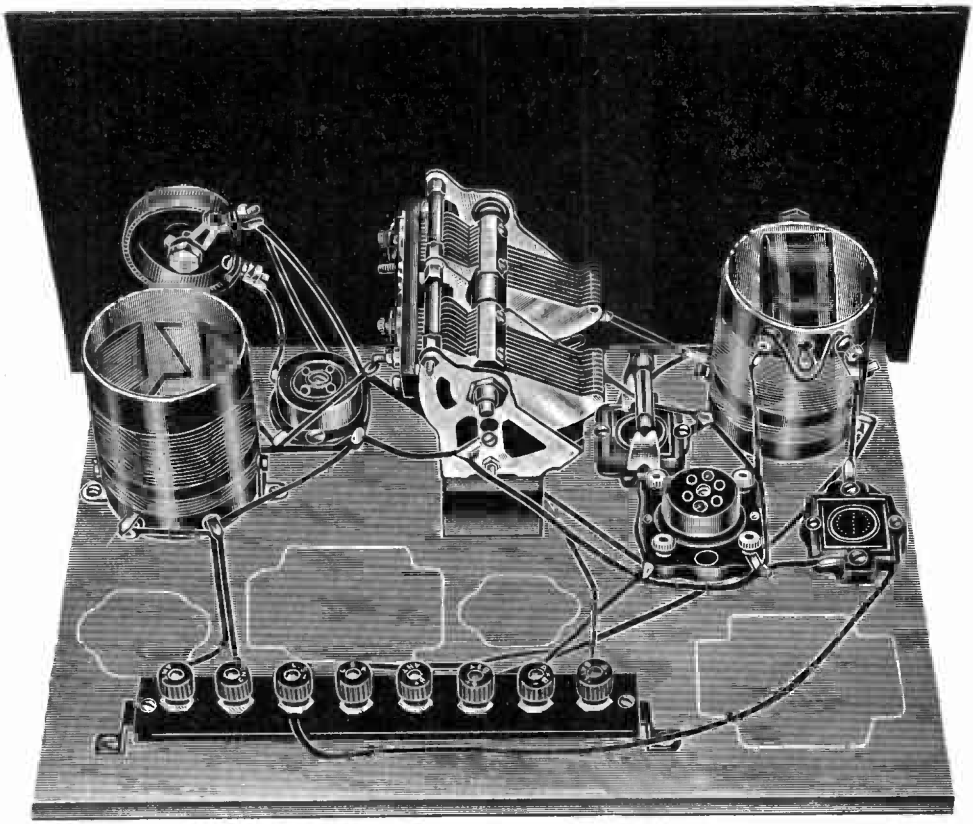
On the center line of the panel (7 inches from the left edge) measure up 3½ inches from the bottom edge. This locates the center for the ½-inch diameter mounting hole for the tuning condenser. Directly below and ⅞ inch from this, drill a No. 27 drill hole for the mounting screw. This completes the drilling for the front panel.

If you prefer the glossy finish on the panel you can now mount the three-circuit tuner, the rheostat, and the tuning condenser on the front panel. Then fasten the panel to the baseboard with wood screws, leaving ½ inch between the edge of the baseboard and the edge of the panel at each end.

If you prefer the rich, dull mat finish, lay



The schematic diagram of the Little Pal. If you don't want to buy a storage battery you can use three ordinary dry cells as the "A." They will last about a month. The "B" battery will last a year or more.



How the Little Pal looks all assembled and wired. The white outlines on the baseboard show where the sockets and transformers of the amplifier are placed. These parts can be put in later if you want to work a loud speaker.

your panel down flat on the table with a piece of newspaper underneath. Now, with a piece of No. 00 sandpaper or with steel wool, rub the panel with a straight forward and backward motion until all the shiny surface has been dulled. Be careful not to get any crosswise scratches on it. Now turn it over and repeat this operation on the other side. Pour a little machine oil on a small cloth and apply this to both sides of the panel, rubbing it in well. Now wipe off all the excess oil with another cloth, and you will have a dull satin finish which lends charm and dignity to the receiver. Now mount the parts and panel.

A small block of wood 1½ inches long by 1/16 inch high by ½ inch thick is fastened both to the baseboard and to the rear mounting foot of the tuning condenser. This supports the weight of the condenser at the rear.

DOING THE WIRING

You are now ready to wire up the receiver. Use regular hook-up wire, which can be bought in small 25-foot rolls. Place each wire exactly as shown in the diagrams. Notice that one soldering lug is fastened to the center of the rear end plate of the condenser frame for a connection here. Also one lug is fastened to the screw which fastens the left-hand (looking from the front) bakelite strip to the middle aluminum condenser frame plate (a wire goes from this lug to a terminal on the three-circuit tuner).

Solder every connection with rosin core solder; do not use pastes for flux. Make sure your soldering iron is clean, hot and well tinned, and leave it on the joint until the solder melts and flows in around the wire and lug, making good electrical connection.

Several years of experience with beginners in soldering has shown the author that most of the troubles encountered with rosin core solder are due to not holding the soldering iron on the joint long enough to thoroughly heat all the metal parts and to melt the solder and rosin so that the solder flows in and fills up the spaces. In most cases the iron is held on only long enough to melt the rosin flux. This runs in the joint and when it solidifies it forms a perfect insulated "rosin joint." This is the cause of imperfect operation of many receivers.

Take your time when wiring. Do not try to rush the job, as this will only result in mistakes, with resulting loss of time. When you have completed the wiring check it all over against the circuit diagram. Have some one check over with you, as it often happens that one will pass over the same mistake several times without noticing it.

> ### *Shop Teachers—*
>
> *YOUR pupils are probably more interested in radio than in any other subject. Start them off with this inexpensive receiver, which was designed for boys by a man who has been teaching them electricity and radio for several years. It is an ideal constructional exercise that every boy in your classes will tackle with enthusiasm.*

Snap the grid leak in place in the grid-leak clips. Fasten the three knobs on the shafts on the front panel.

TUBES AND BATTERIES

You can use either two 199 dry-cell tubes, operated from three No. 6 dry cells and a 45-volt "B" battery, or two 201A tubes operated from a six-volt storage battery and 45-volt "B" battery.

In the former case, connect the three dry cells in series, as shown in the circuit diagram.

When using 201A tubes connect the batteries as shown in the diagram for this. The use of 201A tubes will result in a little more volume than when dry cell tubes are used.

OPERATION OF THE SET

Connect the earphones to the LS+ and LS— binding posts at the rear of the set. An aerial about 75 feet long (including lead-in, and ground wires) will operate this set satisfactorily. Get the aerial up as high as you can and free from all obstructions. Make sure that all joints in the aerial and ground system are well made and soldered. Use a ground clamp on a water pipe for your ground. If the water pipe is painted, scrape the paint off before putting the ground clamp on. This should make good firm contact with the metal of the pipe.

Connect the aerial and ground to the set and insert the tubes. Turn up the rheostat about three-quarters of the way and turn the tuning condenser knob slowly until you hear a station. Get it in as loud as you can. Now rotate the tickler coil knob slowly until the detector goes into oscillation. This will be evidenced by a squeal. Back down the tickler to a point just below this. This is the most sensitive operating point—just below oscillation. Now carefully adjust the small compensating condensers on the side of the main tuning condenser, until the station comes in with maximum volume. This balances up the tuning of the two stages. A little practice will enable you to tune stations in and out very readily. Sometimes an exact adjustment of filament current will enable you to improve reception, especially on distant stations.

This receiver can be housed in a standard 7x14-inch cabinet 9 inches deep. The construction of this cabinet makes a good wood working exercise for the manual training shop of any high school. The cabinet can also be made large enough to house the dry cell batteries.

After you have mastered the operation of the two-tube Little Pal Receiver, you will want to add two stages of audio amplification so that you can operate a loud speaker. Then you can invite your friends to listen in. Detailed instructions for adding the audio amplifier will appear in the next issue of RADIO DESIGN, but if you want the "dope" in advance write in to us and we'll send it along.

Importance of Meters in Power-Pack Work

IN working with A.C. power equipment, you simply must have meters to measure the voltages developed across the various parts of the circuits. Without measuring instruments you are practically "blind," and you will never be able to find trouble when and if it develops.

The two most important meters to have are a high-resistance D.C. voltmeter, reading up to 250 volts and having a resistance between 750 and 1,000 ohms per volt, and a three-range A.C. voltmeter going up to 150 volts.

THE RIGHT METERS

We recommend particularly the Weston Model 489 and the Jewell pattern No. 116 direct-current voltmeters, both of which have scales reading from 0 to 50 and from 0 to 250 volts. As for A.C. voltmeters, both the Weston and Jewell companies make triple-range meters which are ideal for the work of testing filament and line voltages. One scale reads from 0 to 4 volts, which takes the filaments of tubes of the 224, 226, 227 and 245 types; the second from 0 to 8 volts, which takes in the 171A, 210, 250, 280 and 281 tubes; and the third reading from 0 to 150 volts, for measurement of line voltages.

If you are a custom set builder, or have any occasion to do serious "trouble shooting," by all means equip yourself with at least one D.C. and one A.C. meter of the types described. They are a good investment, and will pay for themselves many times over when you are called in to find out what has gone wrong with sets you have sold or installed.

SAFETY FIRST!

A word of caution about using meters:

Never try to test a circuit by holding the connection wires from the meter in your two hands, particularly if you are working on the "B" circuit. Even the smallest of "B" power units develop voltages as high as 300 and 400, on open circuit, and you are likely to be severely jolted by them.

A MODULATED R. F. GRID DIP OSCILLATOR AND WAVE METER

A Simple and Extremely Useful Unit That Should Be in Every School Laboratory, Set Builder's Shop and Service Man's Test Kit; Covers 23-575 Meters

By ALFRED A. GHIRARDI

ANYONE seriously interested in radio work, whether he is a custom set builder, service man, experimenter, or radio laboratory instructor, cannot help but find the modulated R. F. oscillator and wavemeter described here one of the handiest little instruments in his place.

As a grid-dip radio-frequency oscillator it can be used as a generator of radio-frequency waves (of any wave length between 23 and 575 meters when Pilot Wasp plug-in coils are used); to measure the frequency range of R. F. amplifiers; to determine the tuning range of experimental coils and coil and condenser combinations; to measure the gain per stage of R. F. amplifiers; to calibrate the tuning dials of radio receivers; to furnish R. F. current for all R. F. experiments in the school laboratory; and to balance up the various tuned stages in single control receiving sets.

A VERSATILE INSTRUMENT

It is an invaluable aid in short-wave work for measuring the tuning range of receivers, for setting the receiver to a known frequency or wavelength, or for measuring the frequency of amateur short-wave stations.

As a wavemeter it can be used in a great number of experiments in the school laboratory, and in practical receiver testing by the radio experimenter and service man.

It produces a very sharp resonance curve, making measurement work easy and accurate, and it maintains its calibration indefinitely if handled with a reasonable amount of care.

The unit is constructed from standard Pilot parts that are easily obtainable. The Western 0 to 1½ grid milliammeter may be omitted if desired in order to reduce the cost, as will be explained later. This is not recommended, however, as it will seriously limit the usefulness of the unit.

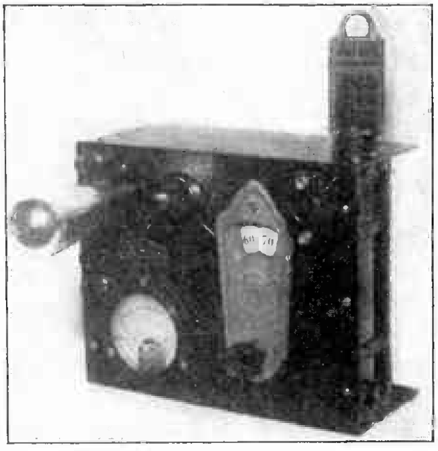
HOW THE OSCILLATOR WORKS

The oscillator is of the Hartley type. For the benefit of those readers who may not be acquainted with the theory of operation of the vacuum-tube oscillator, a short description will be given here.

A vacuum tube can be made to generate radio frequency oscillations and thus act as a source of radio-frequency current for the transmission of radio signals, (See Chapter 3, Radio Physics Course) by feeding a portion of the output current (plate circuit) back into the input circuit (grid circuit). In the vacuum tube oscillator this can be accomplished by employing either electrostatic or electromagnetic coupling between the grid and plate circuits. This divides oscillator circuits into two groups: capacitatively coupled circuits and inductively coupled circuits. The oscillator described here is of the latter type and employs the Hartley circuit.

The circuit is arranged so that any change in grid voltage produces a change in plate current of such magnitude that there is induced back into the grid circuit (by the feedback coil P F1) a larger voltage than that originally acting. This is made possible by the amplifying properties of the vacuum tube, whereby voltage changes in the grid circuit produce amplified current changes in the plate circuit.

Much more power is produced by the variation in the plate current than must be expended in changing the grid voltage to produce these plate current variations. Thus by coupling the plate circuit back to the grid circuit, in such a manner as to supply this small power in proper phase relation to the grid voltage changes, the surplus power is available for use in an external circuit in the form of oscillations of any desired frequency. The common regenerative receiver may be converted into a onscillator by rotating the tickler coil so a large percentage of the plate circuit energy is fed back to the grid circuit.



The completed oscillator, with tube and coil in place. Notice the "loading" condenser next to the upper right corner of the vernier dial

PRECAUTIONS TO OBSERVE

In the oscillator described here the plate current flowing from plate to filament must go through the feedback coil F P (See Fig. 1), on its way to the "B"-terminal through the

B battery to "B+", and back to the plate to complete the circuit. The feedback coil P F_1 and grid coil G F_2 are wound close together so that the varying magnetic field produced by the current in the former coil links with the grid coil and induces voltages in it. These act on the grid and are amplified by the tube. The grid coil G F_2, tuned by the No. 1508 S. L. F. tuning condenser, determines the frequency of the oscillations.

The proper relative polarity between the grid and feedback coils must be observed if the feedback currents are to strengthen the grid voltages and build up oscillation. If these coils are not connected properly the plate currents will tend to weaken the grid impulses and the tube will not oscillate. The proper terminal connections for the Pilot Wasp coils are shown in the circuit diagram. Coil C F_3 is not used. This coil should not be removed from the coil form, as it is needed when the coils are used in the Wasp receiver. The "A"+ or "A"— and "B"— terminals must not be connected together on the oscillator, as this would short circuit the feedback coil PF_1 and make the oscillator inoperative.

CIRCUIT LAYOUT

Any of the various types of tubes except the 210 and 250 can be used. If a 112A tube is used, the grid milliammeter will have to have a range of 0 to 5 milliamperes, as this tube draws a larger grid current than the 199 or 201A types.

The filament current is controlled by a 20-ohm rheostat. A filament switch is incorporated to turn the oscillator on or off without changing the adjustment of the filament rheostat. This feature is especially valuable when it is desired to stop work temporarily while making a series of tests or measurements, as the rheostat setting need not be disturbed.

If it is desired to reduce the cost of the instrument by omitting the 0 to 1.5 milliampere grid milliammeter, the grid circuit should be closed by the connection shown as a dotted line in the circuit diagram (Figure 1).

MODULATED OSCILLATOR

The grid leak and condenser are used to modulate the radio-frequency currents when modulated R. F. is needed for certain experiments (as for bridge measurements). The frequency of modulation (tone of note) can be varied by varying the size of the grid leak. Values from 1 to 10 megohms will give a considerable audio range. When the unit is used as a modulated oscillator the grid meter will not indicate, as the grid condenser blocks the grid circuit.

If the unit is to be used without modulation, as a straight R. F. oscillator, the grid leak and condenser must be short circuited. This can be done by connecting the two grid condenser clips together with a wire.

WASP PLUG-IN COILS

The unit was constructed for use with standard Pilot Wasp plug-in coils, as it was felt that this would increase its usefulness to the thousands of owners of Wasp receivers, since they can use their present Wasp coils in the oscillator if they are able to borrow an additional set of coils for calibrating their own.

The use of these coils also makes it practical to cover a tuning range from 23 to about 575 meters, by simply plugging in the proper coil for the wave length range required. The green ring coil does not quite tune up to 261 meters with the regular No. 1508 S. L. F. tuning condenser. By connecting a No. 50-B .0001-mf. Isograd fixed condenser across it, as shown in the circuit diagram, the tuning range can be extended from 205 meters to about 275 meters (see calibration curves). This condenser is merely slipped on the two No. 6 machine screws which project up from the top panel at the right of the tuning dial. The 6-32 threaded holes in the fixed condenser are drilled out with a No. 8 drill, so the condenser will slip over the screws. Two nuts hold it in place. For tuning ranges below about 210 meters this condenser is removed.

Likewise, the blue ring coil does not quite tune up to 575 meters when used with the No. 1508 S. L. F. tuning condenser. To extend the range of this coil from 503 meters to 575 meters, a No. 50A .00004-mf. Isograd fixed condenser is connected across it as shown in the circuit diagram. This condenser is slipped on the two No. 6 machine screws which project up from the top panel at the right of the tuning dial. A separate tuning curve is plotted for the blue ring coil with this condenser. For wavelength below 503 meters this fixed condenser is removed.

The .00025 mf. R. F. by-pass condensers across the grid milliammeter and "B" battery are necessary, as these two parts of the circuit may have a high enough resistance to materially reduce or even stop oscillation on the low waves. At the 35-meter setting on the dial, for instance, without these by-pass condensers the grid current was 0.7 milliamperes; with the by-pass condensers the grid current increased to 2.5 milliamperes. This large increase in power was due to the reduction in impedance of the radio frequency current paths through the meter and the "B" battery.

PARTS LAYOUT

The use of the horizontal panel makes reading and operating the tuning dial and grid meter more convenient than if a vertical panel were used. However, if desired, the unit can be stood up on any one of its sides for convenience in some tests.

The use of the No. 34 2-inch bakelite brackets for fastening the front and back formica strips to the main panel results in a box-like construction which is very rigid and able to stand the great amount of handling an instrument of this kind always receives, especially in a school laboratory. By mounting all the parts under the main panel, dust collection on condenser plates, etc., with consequent leakage, is avoided.

The five-prong plug-in coil socket is mounted back of the right rear corner, on the rear formica panel. The coil projects out from the rear of the oscillator when mounted so it can be put into any desired coupling relation with coils under test.

PARTS LIST

Following is a complete list of parts used in the construction of the unit:

1—7 by 18 inch formica panel, either 1/8 or 3/16 inch thick, cut into one 7 by 9 inch panel and two 9 by 3½ inch panels.
1—Set No. 180-4-Pilot Wasp plug-in coils.
1—No. 1508 straight line frequency condenser.
1—No. 217 five-prong socket.
1—No. 216 four-prong socket.
1—No. 50A mica condenser (.00004 mf.)
2—No. 51 Mica condensers (.00025 mf.)
1—No. 51 M Type M mica condenser with special grid leak clips (.00025 mf).
1—No. 920 20-ohm rheostat.
1—No. 760 5-megohm grid leak.
2—No. 34 2-inch bakelite sub-panel brackets.
1—No. 1282L illuminated dial with 5-volt bulb.
1—No. 42 filament switch.
1—No. 50-B mica condenser (.0001 mf.).
1—No. 21 "Grid" binding post.
1—No. 23 "A+ Batt." binding post.
1—No. 22 "A— Batt." binding post.
1—No. 24 "A— Batt." binding post.
1—No. 31 "B+90 V." binding post.
1—Model 301 Weston 0 to 1.5 or 0 to 2 milliammeter.
1—Short-Circuited Grid Leak.
Miscellaneous screws, nuts, wire.

CONSTRUCTION WORK

The formica base panel is 9 inches long by 7 inches wide. The two vertical sides are each 9 inches long by 3½ inches wide. All three pieces can be made of either 1/8 inch or 3/16 inch thick formica and cut from a standard 7 x 18 inch panel. This can be rubbed down with No. 00 sandpaper and oil to remove the shiny surface and produce a smooth, satin finish for improved appearance.

Holes 1¼ inches in diameter must be cut out for mounting the tube socket and coil socket. The hole for the Weston Model 301 milliammeter should be 2⅝ inches in diameter.

After the panels have been cut to size and drilled, mount all of the parts on the horizontal panel in the positions shown. You can now complete practically all of the wiring of these parts.

If the wiring checks O. K. mount the brackets under the panel securely with machine screws and nuts. Now mount the front vertical side panel to the ends of these brackets.

Mount the five-prong coil socket to the rear vertical side panel. Mount this panel to the rear ends of the two brackets. A small metal angle bracket can be used to fasten this panel to the horizontal panel for support at the center.

Complete the wiring to the coil socket, making certain that you conect to the proper terminals. The G terminal shown in the circuit diagram goes to the socket G prong. F2 goes to the socket F terminal nearest to the socket C terminal. F2 goes to the socket F terminal nearest to the socket P terminal. This should be connected to the F2 terminal. P goes to the socket P terminal. The socket C terminal is left open.

CONNECTING THE BATTERIES

A 45-volt "B" battery will furnish sufficient plate power for all ordinary work. If a 199 tube is used, the filament power can be supplied by three dry cells connected in series. If a 201A or 112A tube is employed a six-volt storage battery should be used. The battery operation feature is not objectionable, as practically all laboratories and experimenters' shops contain a storage battery and at least one "B" battery used for test work. Batteries furnish the smooth, constant voltages necessary for accurate measurements.

The A+ and B— or A— and B— terminals of the batteries should not be connected together, for the reasons stated previously.

CALIBRATING THE INSTRUMENT

Now you are ready to calibrate the instrument; that is, determine the wave length it is tuned to for each setting of the dial when the various coils are used. The proceedure will be outlined for the broadcast band of frequencies; the same directions will serve

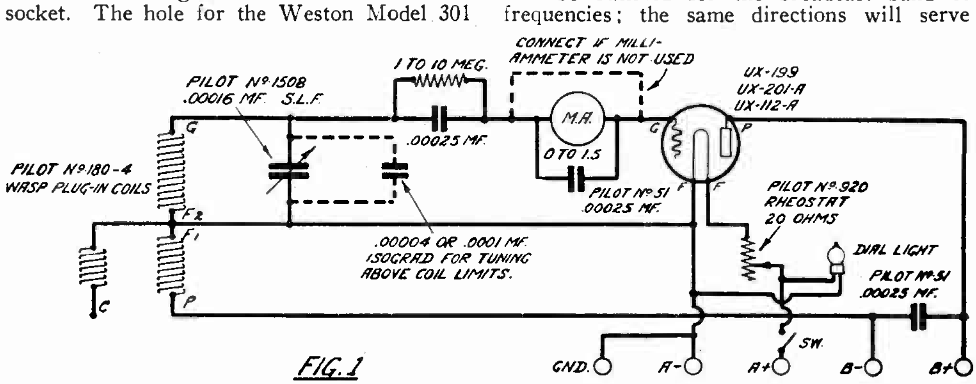
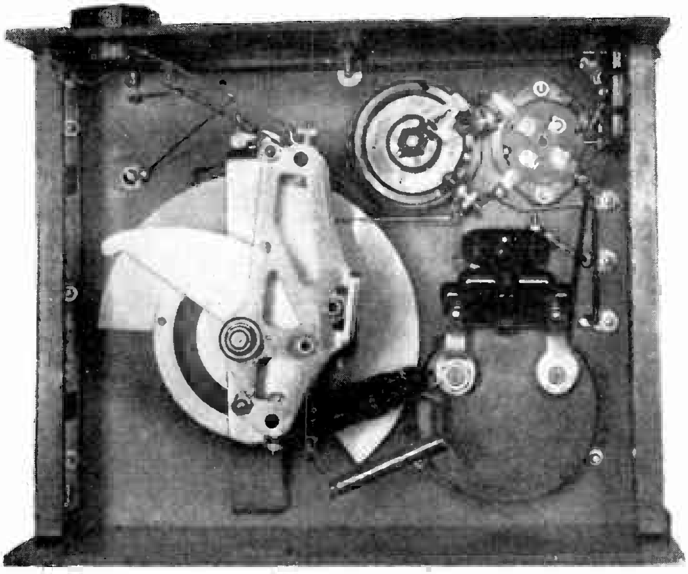


Fig. 1: The wiring diagram of the oscillator-wavemeter. The connections of the "loading" condenser are shown in dotted lines.



A close-up of the insides of the oscillator. The socket on the shelf, in the upper left corner, is for the plug-in coils. Notice how the grid condenser (with short-circuiting plug in the clips) fits neatly between the stator post of the condenser and the left post of the meter.

for the short-wave bands. A simple one-tube or three-tube receiver regenerative is needed. A Pilot Wasp receiver will do very well if an extra set of coils can be obtained for the Wasp for use during the calibrating process. One set will be needed for use with the oscillator and one set will be required for operation in the Wasp.

Both the oscillator and the receiver can be operated from the same "A" battery, but it is essential that a separate 45-volt "B" battery be used for the oscillator. This does not necessarily mean the purchase of an additional "B" battery, as the Wasp receiver can be operated during the calibration on one 45-volt "B" block for both detector and amplifying tubes. The other "B" battery can be used for the oscillator.

Insert the broadcast range coils (blue rings) in both the oscillator and the Wasp receiver. In most cases sufficient coupling between the coils can be secured by setting the two units side by side on a table. If more coupling is needed you can wind a turn of wire around each of the tuning coils and connect the ends together. Connect the receiving set to aerial and ground, insert tubes in both oscillator and set and turn both units on. Short circuit the grid condenser in the oscillator as indicated by the dotted lines in the circuit diagram. This makes it operate as a straight R. F. oscillator.

Beginning at the high end of the tuning dial of the receiver, carefully tune in the highest wavelength broadcasting station you are able to receive. Now without moving the dial of the receiver, rotate the dial of the oscillator slowly.

WATCH THE METER

As the wavelength or frequency to which the oscillator is tuned approaches the wavelength or frequency to which the receiver is tuned, you will notice that the needle of the grid milliammeter begins to fall back and then after resonance is passed it snaps back to its former steady position. The oscillator must be adjusted carefully to the position where the meter is at its minimum reading, that is, when the dip is greatest.

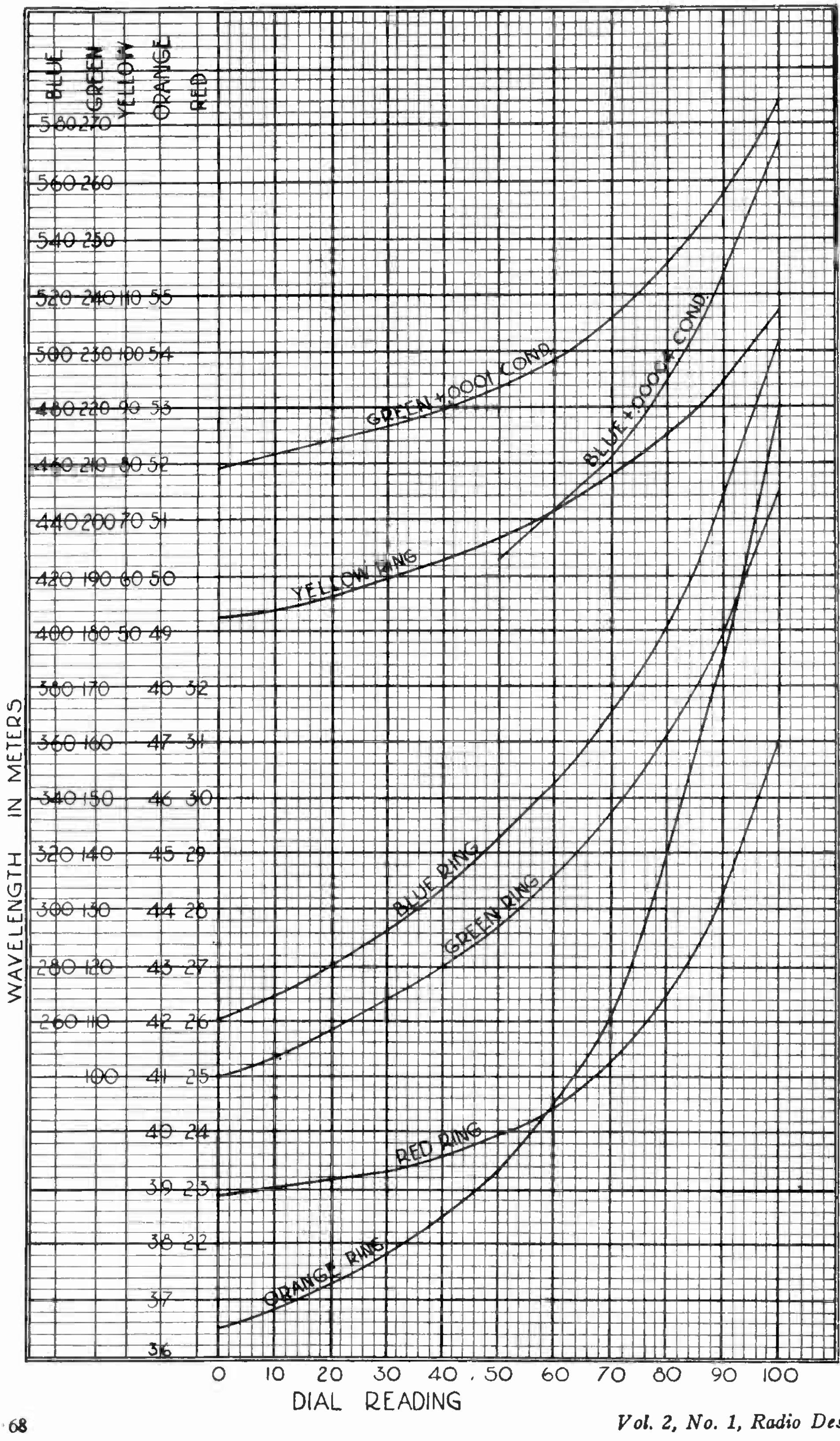
Under these conditions the receiver and oscillator are both tuned to exactly the same wavelength and the tuned circuit of the receiver is absorbing most of the energy of the oscillator, thus weakening the oscillations and causing a reduction in the grid current, as indicated by the grid milliammeter. This wavelength is the same as that of the station being received. Make a note of the reading of the oscillator tuning dial. Now listen for the station announcement and learn the identity and wavelength. Usually this is possible by listening for the station's call and referring to a newspaper or radio magazine program list for the wavelength or frequency. Make a note of this next to the oscillator dial reading.

Be careful not to get too close coupling between the oscillator and receiver coils, as two resonance points will be produced, as shown by two dips of the grid meter. Coupling can be loosened by separating the two units by a greater distance. Loose coupling will result in a more sharply defined but lessened dip in the grid meter needle.

Now progress down the receiver dial and pick up other stations and bring the oscillator into resonance with the detector circuit for each position, noting both the reading of the oscillator dial and wavelength of the station for each position. In this way a number of points may be obtained which, when plotted on cross section paper, as shown on the next page, will result in a tuning curve.

THE CALIBRATION CURVE

The curves shown were made with a set of Wasp coils taken from stock and give a good idea of what the calibration curves should


BLUE
GREEN
YELLOW
ORANGE
RED
WAVELENGTH IN METERS
DIAL READING
GREEN + .0001 COND.
BLUE + .0004 COND.
YELLOW RING
BLUE RING
GREEN RING
RED RING
ORANGE RING
0 10 20 30 40 50 60 70 80 90 100

look like. A variation of as much as 10 per cent may be expected from these values, especially on the short wave coils, due to slight differences in stray inductance and capacities in the wiring, capacities between tube elements, etc.; but for rough measurements these curves may be used with any oscillator built as shown from standard Pilot parts.

It must be understood that for accurate work the same tube and "A" and "B" battery voltages must always be used with the oscillator once the calibration curves are made. If a tube burns out and a new one is substituted the calibration should be checked over again. Where an individual oscillator has been carefuly calibrated and these precautions have been observed, a sustained accuracy of better than 1 per cent can be expected.

When calibrating the short-wave coils, those who know how to do so can pick out the harmonics of stations operating in the broadcast range and so obtain a number of calibration points. A description of this is too lengthy to be included here. Otherwise it is necessary to receive and identify a number of short-wave stations on the receiver and follow the same proceedure as above. This work should be done slowly and carefully, as the usefulness of the oscillator will depend on the accuracy with which it has been calibrated. As many stations as posible should be received so as to get a great many points on the calibration curves.

USING THE OSCILLATOR

To determine the range of a tuning coil condenser combination, either in a receiver or separately, merely couple the coil loosely to each other so the magnetic field of the oscillator coil links with the test coil, or by coupling with one or two turns of wire. Never use more than two or three coupling turns around the oscillator coil, as this wire will change the calibration of the oscillator, especially on short waves.

Set the condenser of the test circuit at the setting at which the tuning wavelength is to be measured. Then slowly rotate the oscillator dial until the maximum dip in the grid meter is observed. This is the point just before the needle "snaps" back. At this setting the test circuit and oscillator circuit are both tuned to the same wavelength or frequency and the test circuit is absorbing a maximum amount of power from the oscillator, causing a reduction in the grid current. By referring to the calibration curves, the exact wavelength of the oscillator at this setting can be determined. The wavelength can be checked for various settings of the test circuit tuning condenser. If two dips are produced near each other, the coupling between the coils is too close. To remedy this, loosen the coupling until only one dip is noticeable.

The grid-dip oscillator and wavemeter can be used for a great many other tests and purposes in the experimenter's shop and in the school laboratory. Space does not permit of a complete description of all of these tests now, but many of them will be described from time to time. The reader will find descriptions of many tests in any good standard radio text book.

London to Wilmington via the Short Waves

ENTHUSIASTIC and sometimes extraordinary reports of reception accomplished on the short waves continue to arrive. As an example, we are publishing here a copy of a letter recently sent to the British Broadcasting Corporation.

401 W. 21st Street,
Wilmington, Del., U. S. A.
March 19th, 1929.

British Broadcasting Corporation,
Chelmsford, England.
Gentlemen:

During Christmas week I built what is known in this country as a "Pilot Wasp Short-Wave Set."

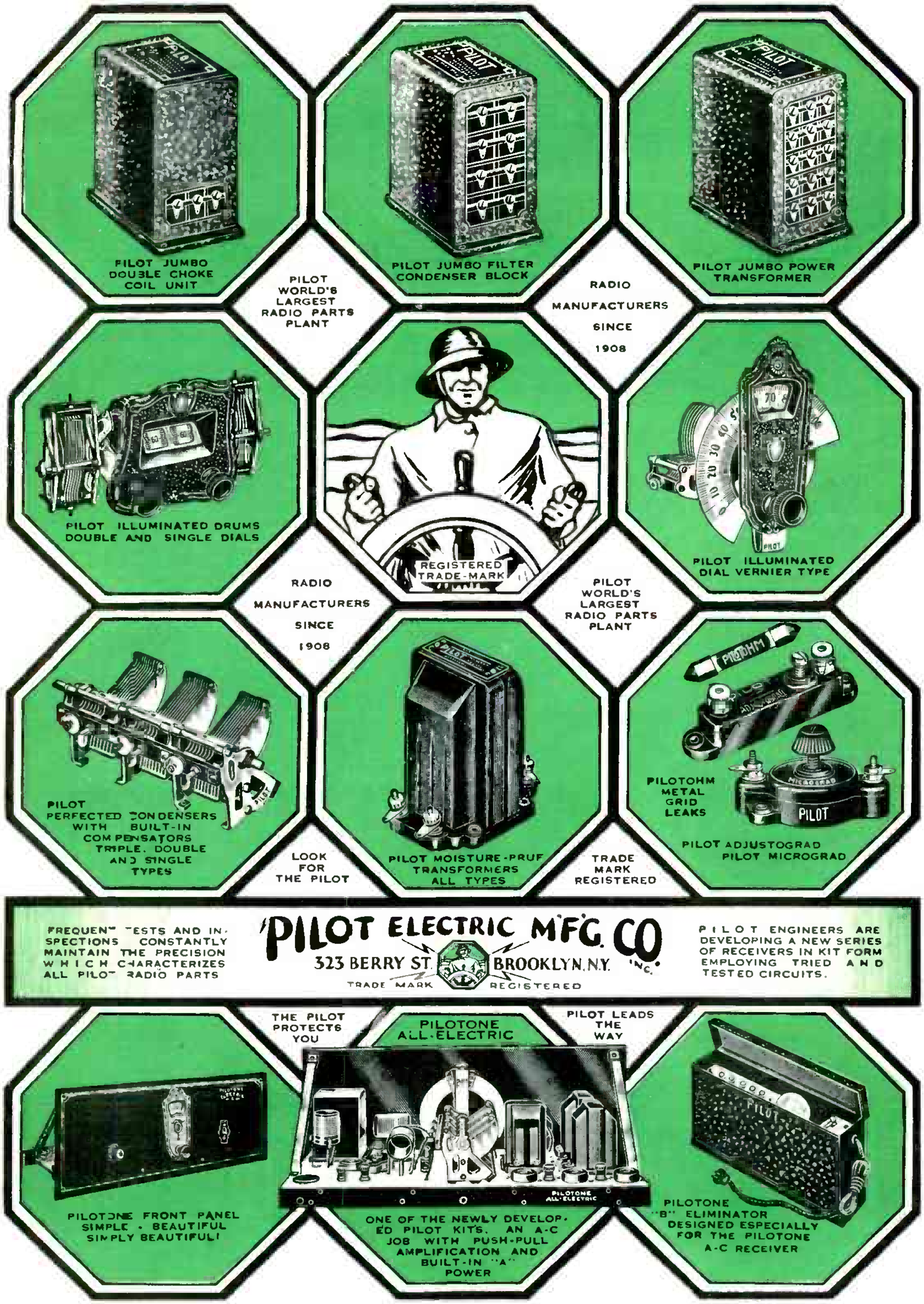
It might be of interest to you to know that I consistently receive your Station 5SW at Chelmsford. Your reception last night, the 18th, was exceptionally clear and while I do not get home early enough to get much of your regular broadcast, originating from 2LO, in London, I usually hear about ten minutes of your program. On Monday nights and Wednesday nights we usually listen-in on your record broadcast.

To verify my statement as to the reception, your first record was "His Master's Voice," B. 5093-Walse by the Troubadours "Marie." The other side was a fox-trot, "All of the Time." This was followed by Columbia Record 5269. The next record was George Olsen No. B5592, etc. Yet signed off at two minutes past nine, our time, but announced two minutes past two, London time, Tuesday morning, with your usual good morning to your friends in the East, and good night to your friends in the West.

This reception was too loud for ear 'phones and had to be toned down, as the ear 'phones were used in the place of the speaker, due to illness in the home.

We have one suggestion to make in connection with short-wave reception, we would like to hear you Saturdays and Sundays.

Yours very truly,
H. A. SENTMAN.


PILOT
PILOT JUMBO DOUBLE CHOKE COIL UNIT
PILOT
PILOT JUMBO FILTER CONDENSER BLOCK
PILOT
PILOT JUMBO POWER TRANSFORMER
PILOT WORLD'S LARGEST RADIO PARTS PLANT
RADIO MANUFACTURERS SINCE 1908
PILOT ILLUMINATED DRUMS DOUBLE AND SINGLE DIALS
REGISTERED TRADE-MARK
PILOT ILLUMINATED DIAL VERNIER TYPE
RADIO MANUFACTURERS SINCE 1908
PILOT WORLD'S LARGEST RADIO PARTS PLANT
PILOT
PILOT PERFECTED CONDENSERS WITH BUILT-IN COMPENSATORS TRIPLE, DOUBLE AND SINGLE TYPES
PILOT
PILOT MOISTURE-PRUF TRANSFORMERS ALL TYPES
PILOTOHM
PILOTOHM METAL GRID LEAKS
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PILOT ENGINEERS ARE DEVELOPING A NEW SERIES OF RECEIVERS IN KIT FORM EMPLOYING TRIED AND TESTED CIRCUITS.
THE PILOT PROTECTS YOU
PILOTONE ALL-ELECTRIC
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PILOTONE FRONT PANEL SIMPLE - BEAUTIFUL SIMPLY BEAUTIFUL!
PILOTONE ALL-ELECTRIC
ONE OF THE NEWLY DEVELOPED PILOT KITS, AN A-C JOB WITH PUSH-PULL AMPLIFICATION AND BUILT-IN "A" POWER
PILOT
PILOTONE "B" ELIMINATOR DESIGNED ESPECIALLY FOR THE PILOTONE A-C RECEIVER

Announcing—a NEW Radio Thrill!

PILOT DOUBLE-DUTY SUPER-WASP

SHORT-WAVE BAND — BROADCAST BAND

TUNED SCREEN GRID — 14 TO 500 METERS

Designed and Developed by Robert S. Kruse

Note These FEATURES:

Covers 14 to 500 meters, making it a splendid broadcast receiver as well as the most efficient short-wave set.

The only Short-Wave receiver having a stage of Tuned R.F. with Screen-Grid Tube.

Condenser Controlled Regenerative Detector.

Four Tubes including Super-Sensitive Screen Grid.

Also works efficiently on dry-cell tubes.

Two sets of plug-in coils furnished.

All-metal chassis.

No A.C. Hum pick up. Completely shielded R.F. and Detector Stages.

Low losses—ingenious design reduces all R.F. connections to 1½" or less!

Splendid loud-speaker results.

Vernier dials for both tuning condensers.

Absolutely eliminates hand de-tuning effect.

Greatest Sensitivity and Selectivity.

Simplicity of assembly due to "sectional cans" and minimum wiring. Assemble and operate it same evening!

On very first test received loud and clear broadcast programs from Chelmsford, England; Costa Rica, Central America; PCJ Eindhoven, Holland; Manitoba, Canada, etc.

Smooth operation, consistent results, easy to tune!

Priced low because produced complete in World's Largest Radio Parts Plant. Complete Kit, including 2 sets of 5 coils each and full-sized blueprint. **$29.50**

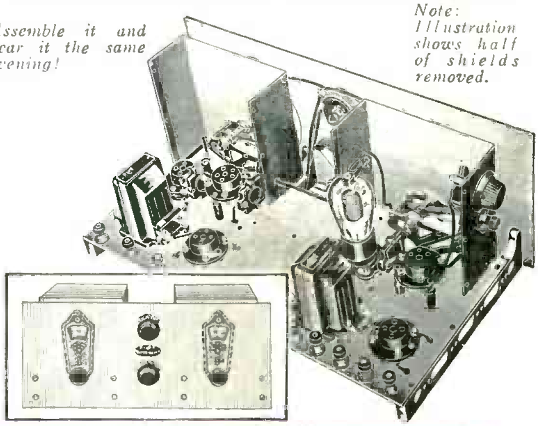
If there is no Pilot dealer in your neighborhood, write us direct.

South African Fan Hears U. S. A. with "Purity and Volume"

"I have just constructed a new all-wave receiver using only Pilot parts and am more than pleased with the result. The set gives remarkable purity and volume, which proves out the transformers. Any wave length from 15 metres to 525 can be had, the Pilot coils being easily interchangeable. I tried it out on Sunday evening for the first time and heard Cape Town, JB, 7LO, Nairobi, 3LO, Melbourne, 2XO, New York; and KDKA, Pittsburgh!"

The above item appeared January 19, 1929, in C. R. Slingsby's radio column in the "Cape Argus," a newspaper published at Claremont, South Africa. This achievement was made with the Pilot Wasp. We await with interest Mr. Slingsby's results with the Super-Wasp, which is even more efficient than its "little brother!"

Assemble it and hear it the same evening!



Note: Illustration shows half of shields removed.

PILOT ELECTRIC M'F'G. CO. INC.

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