RADIO DESIGN

OFFICIAL ORGAN OF THE RADIO INTERNATIONAL GUILD

In this issue

The Pilot "P.E.6", a New Screen Grid Broadcast Receiver—The Short-Wave Broadcasting Stations of the World—The Radio Altimeter—How Tubes Are Made

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

Volume 2 WINTER ISSUE — 1929 Number 4

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The P.E.6 as it appears in the fine cabinet furnished with the K-123 and K-124 kits.

The Pilot "P. E. 6"--A New Screen-Grid Receiver

An Inexpensive, Easily Assembled Broadcast Set, So Sensitive That It Works Perfectly on a Ten-Foot Indoor Aerial

by JOHN GELOSO

MANY readers will recall the Pilotone Electric Six, which was described in RADIO DESIGN a year ago. This was a very fine little six-tube, single control T.R.F. receiver using A.C. tubes of the 226 and 227 type, and was very popular with set builders because it cost very little and was exceedingly easy to put together and wire. With the advent of the A.C. screen-grid tube in the Spring of 1929, it died a more or less natural death, as radio constructors immediately started playing with this new and interesting four-electrode bulb.

The trouble with most of the screen-grid broadcast sets that have been offered the "ian" is that they are large, complicated, costly and difficult to assemble and wire. The screen-grid tube, with its high amplification and stability, was supposed to eliminate a lot of the troubles we used to experience with oscillating R.F. circuits and poor amplification, and although it has done so quite effectively, it has created other troubles of its own, particularly in its requirement of extensive shielding, by-passing, etc. Many of our friends have remarked about this and have inquired why we couldn't put out a simple, sure-fire outfit like the old P.E.6, which any boy, owning a screwdriver and a soldering iron, could put together and make work.

EXPERIMENTAL WORK STARTS

This suggestion started us thinking, so we dusted off a few of the old sets and examined them with the idea of revamping them for screen-grid operation. Frankly, we weren't very optimistic about the undertaking at first, but after a little study, we decided the chassis was really ideally suited for a screen-grid job. We made up completely new sub-panels, wound scores of experimental coils, and tried almost a dozen different circuit combinations. With each attempt we simplified the hook-up and the mechanical arrangement a few degrees, and we finally came out with a receiver that we are proud to offer to the readers of RADIO DESIGN.

SET THOROUGHLY TESTED

In accordance with our custom, a number of identical sample sets were made up after the final form had been agreed on, and were sent to different places for test under actual working conditions. One set stayed in our laboratory in Brooklyn. One went to Staten Island, where Mr. Ghirardi put it through its paces. A third stayed in my own home in Queens for a while. Another went up to the Bronx, to the apartment of Mr. Hertzberg, the editor. Still another was sent to Yorktown Heights, N. Y., the country place of Mr. Goldberg, president of the Pilot Radio & Tube Corporation. A few minor troubles arose, but were quickly ironed out; the sets worked beautifully, meeting all our established requirements for selectivity and ease of control and far surpassing our expectations in the matter of sensitivity.

THREE KITS AVAILABLE

We are now happy to present the new screen-grid P.E.6 to our readers and to recommend it as a fine little broadcast receiver that is extremely easy to assemble and wire and that costs only a fraction of what most other screen-grid sets sell for. It is supplied by the Pilot company in kit form in three different models. The kit number K-122 includes all the necessary parts, a formed and drilled metal sub-panel, and a plain upright front panel, neatly finished to resemble walnut graining; no power pack is supplied with this kit, but the K-111 is recommended. The second kit, K-123, has the same sub-panel and all the parts as before, but includes a handsome metal cabinet, the front of which is drilled to take the tuning dial, the on-off switch and the volume control; no power pack is supplied, as the K-111 or any standard 171A pack may be used. The third kit, K-124, is really complete, and includes both the cabinet and the K-111 power pack. The screen-grid P.E.6 is the first set we have ever presented with a cabinet, and we are sure you will all like it very much, because it adds such a professional air to the outfit. The assembled set looks exactly like a factory-built outfit—and a whole lot better than some commercial sets now on the market.

AN IDEAL CHRISTMAS GIFT

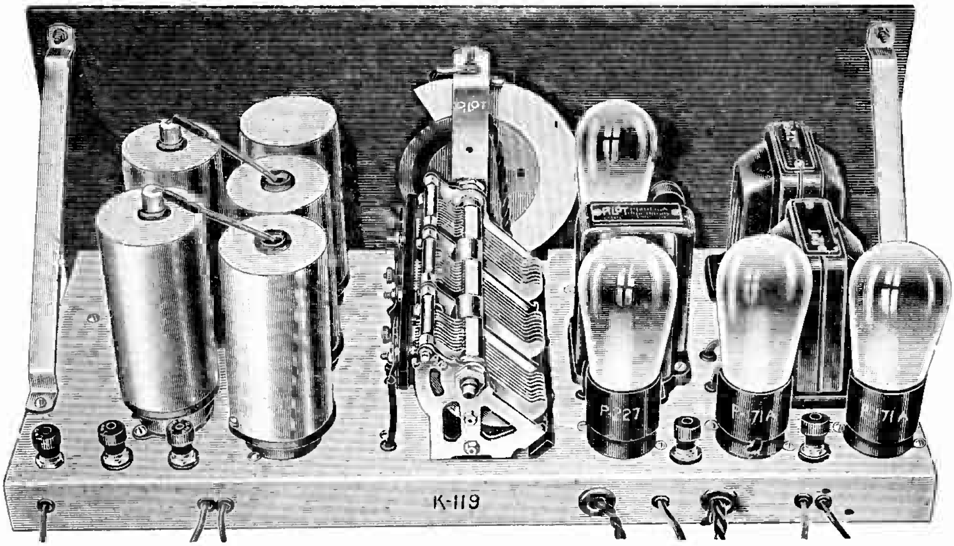
If you have been waiting for an efficient, simple, and low priced screen-grid broadcast receiver, build the new P.E.6. If you have a young son or nephew to whom you want to give a Christmas present that will furnish him real pleasure and enjoyment, buy him a P.E.6 kit and he will be eternally grateful. If you are a custom set builder, or a professional service man, you can build up a nice business on the side by assembling and selling P.E.6's.

One of the big features of this new set is that it works perfectly on a small indoor aerial—a piece of thin wire, fifteen or twenty feet long, hidden beneath a carpet or tacked along the edge of the floor. An outside aerial is neither necessary nor desirable, as the amplification afforded by the screen-grid stages is so great. An outside aerial of any size will cause the second R.F. tube to overload and will cause an apparent broadness of tuning.

LOOSE ANTENNA COUPLING

The P.E.6 is made selective enough for present-day reception conditions by the use of very loose coupling between the antenna and the first screen-grid tube. This loose coupling has an incidental value in that it obviates the annoying detuning effects of the aerial, common to single-control receivers using ordinary degrees of coupling, and permits sharp matching of the three tuned circuits, with increased selectivity. In ordinary circuits the antenna throws out the tuning, usually at the lower and upper ends of the scale, and the individual tuning circuits have to be damped considerably so that even if their resonance peaks do not exactly coincide, at least they overlap enough to let a signal through.

The primary of the antenna coupler con-



Back view of a completed P.E.6, showing the neat and simple arrangement of the parts and the absence of wiring on the top of the sub-panel. This is the plain "chassis" model, K-122, which is supplied with a separate front panel.

sists of ten turns, tapped at the seventh. Two aerial binding posts are provided, so that the individual user can adjust the coupling to suit his own conditions.

If you will examine the circuit diagram of the P.E.6 on page 7, you will see that two stages of screen-grid amplification are used, with a non-regenerative detector and a push-pull audio amplifier with P-171A tubes. Power tubes of this size are used instead of 245's because they are more than adequate for all home purposes, and make the power pack considerably cheaper. However, the set is so arranged that 245's can be substituted by the mere replacement of the biasing resistor, and, of course, the use of a K-112 power pack instead of the K-111.

SMOOTH VOLUME CONTROL

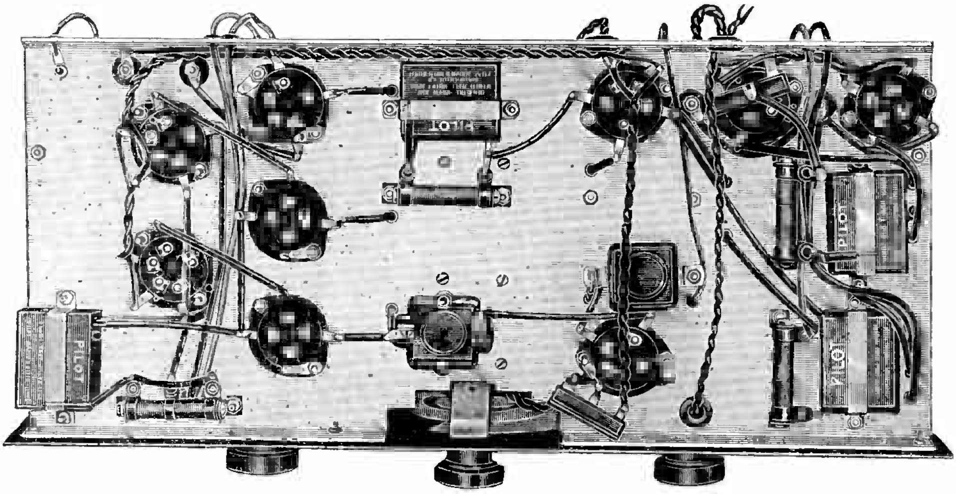
The volume control is a 50,000 ohm Volumgrad, which regulates the voltage to the screens of the P-224's. This is a very smooth and effective control. The cathode, screen and plate elements are by-passed by a No. 806 three section condenser.

Connected across the primary of the push-pull input transformer is a "tone equalizer", which consists merely of a 6000-ohm resistance in series with a .1 mf. condenser. This gives the effect of accentuating the low notes, and makes the tone quality of the receiver very high.

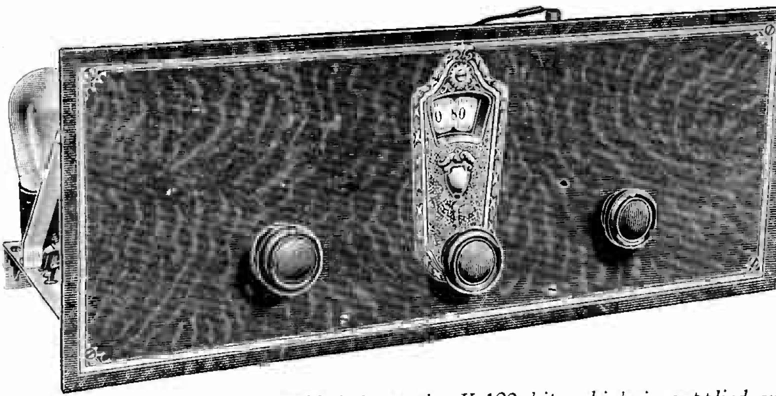
The following parts are used in the P.E.6 receiver, and are supplied in kit form. The front and sub-panels are already drilled with all the necessary holes, so you are saved considerable work.

LIST OF PARTS

No.	Description
1—787	Metal Front Panel, 7x18 inches (supplied with K-122)
1—1521	Metal Cabinet (supplied with K-123 and K-124)
1—K-111	Power Pack (supplied only with K-124)
1—788	Metal Sub-Panel, 7½x17¼ inches
1—1703	Triple Gang Condenser
1—1282L	Illuminated Vernier Dial
1—940	Volumgrad, 50,000 ohms
1—235	Set of plug-in coils consisting of: 1—235A Antenna Coil; 1—235B R.F. Coil; 1—235C Detector Coil
2—222S	Screen-Grid Tube Shields
1—391	Audio Transformer, 3½ to 1 ratio
1—399	Push-Pull Input Transformer
1—401	Push-Pull Output Impedance
1—51	Fixed Condenser, .00025 mf.
1—64	Fixed Condenser, .002 mf.
3—806	By-Pass Condensers, 3 sections, .2 mf. each
1—808	By-Pass Condenser, .1 mf.
1—956	Fixed Resistor, 1200 ohms.
1—958	Fixed Resistor, 2000 ohms.
1—959	Fixed Resistor, 900 ohms. Tapped at 450 ohms.
1—968	Fixed Resistor, 6000 ohms.
1—354	Center-Tapped Resistance, 20 ohms
1—356	Center-Tapped Resistance, 50 ohms
1—756	Grid Leak, 2 megohms
4—216	4-Prong Sockets
5—217	5-Prong Sockets
5	Binding Posts; Ant.; Short Ant.; Gnd.; L. S. + and L. S. — .
1—789	Hardware package: (9 Binding Post Insulators; Condenser Mounting Brackets; Wire; Spaghetti;



Under view of the sub-panel, showing the placement of the various resistors and condensers. Note how little wiring there is.



Front view of a P.E.6 assembled from the K-122 kit, which is supplied with a separate front panel. This model may be mounted in any standard 7 by 18 cabinet or console.

Screws; Nuts; Washers; Lugs; etc.)

Because of the symmetrical arrangement of the parts, the assembly and wiring of the P.E.6 is very easy. The positions of the various components are clearly shown in the accompanying picture diagrams on pages 8 and 9, and are further clarified by the full-size blueprints furnished with the kits. If the following directions are observed carefully, the set will go together very smoothly and will work the first time the switch is snapped on.

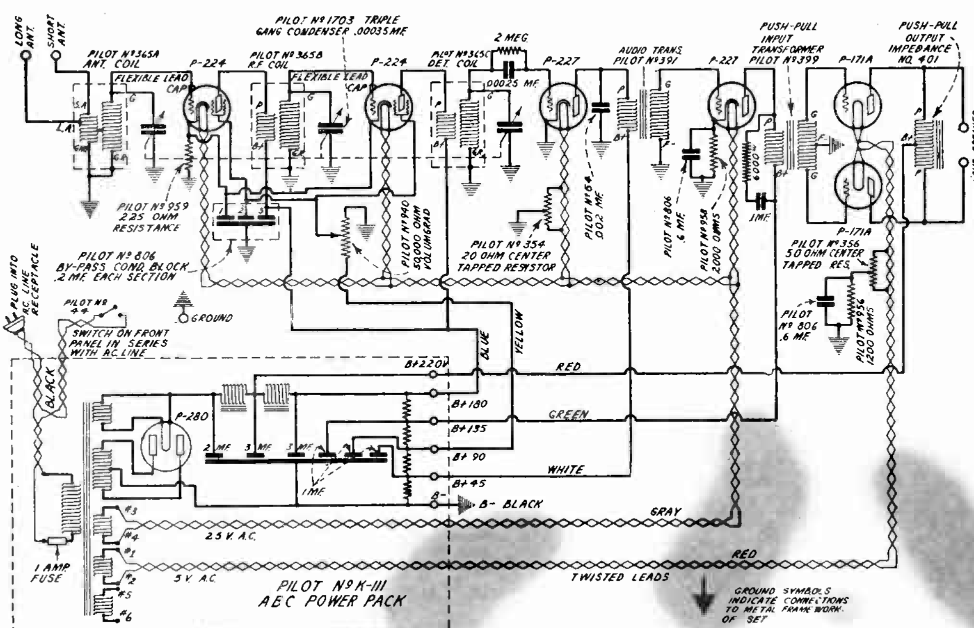
As with any kit, the first thing to do is to unpack all the parts and to identify them. Check each part against the blue-pront, to make sure that you know where it belongs. In the way of tools you need only a medium size screwdriver, a Spintite wrench to fit the small nuts, a pair of cutting pliers, and a soldering iron.

ASSEMBLING THE PARTS

Start by mounting the vernier dial, the snap switch and the Volumgrad on the

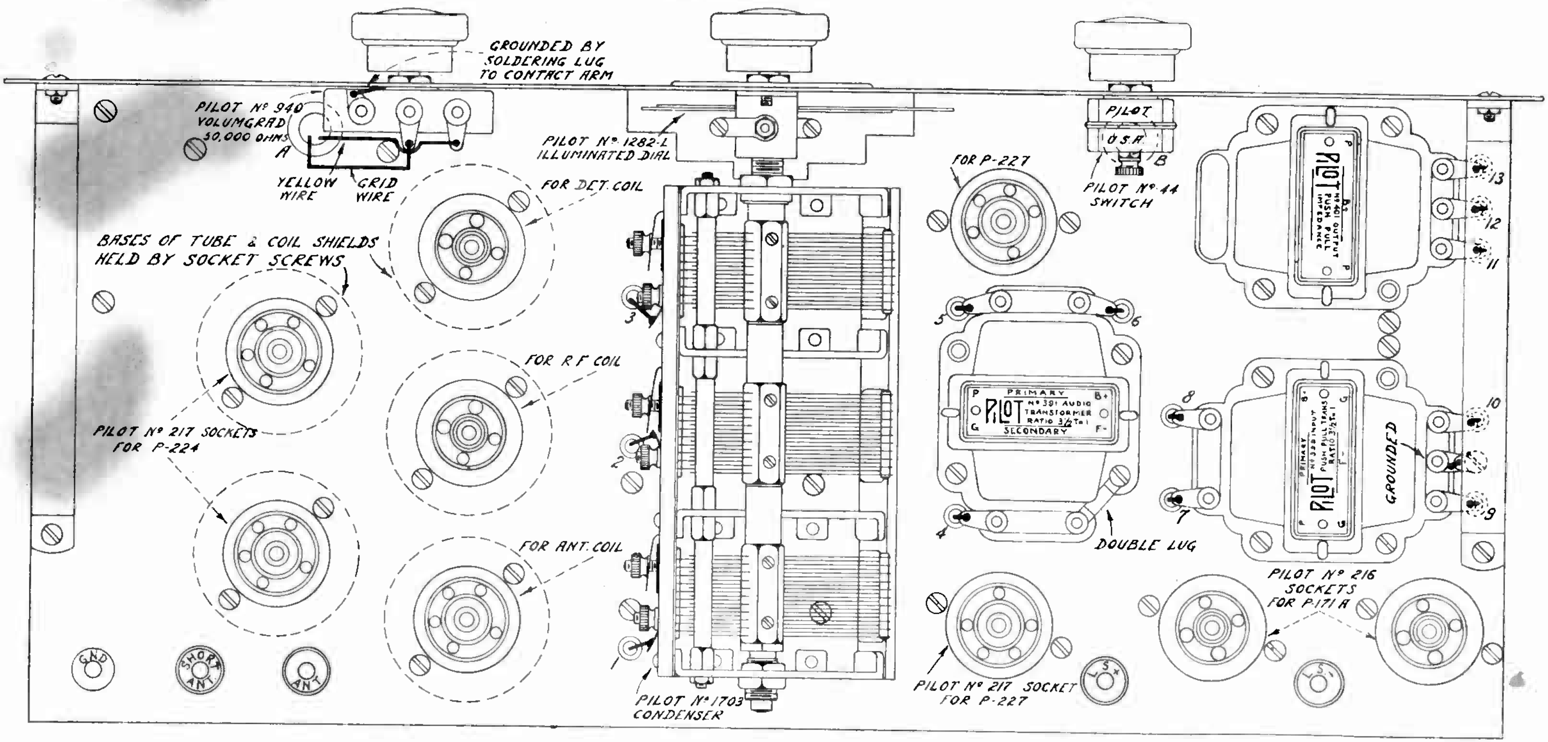
(*Continued on page* 10)

SCHEMATIC DIAGRAM

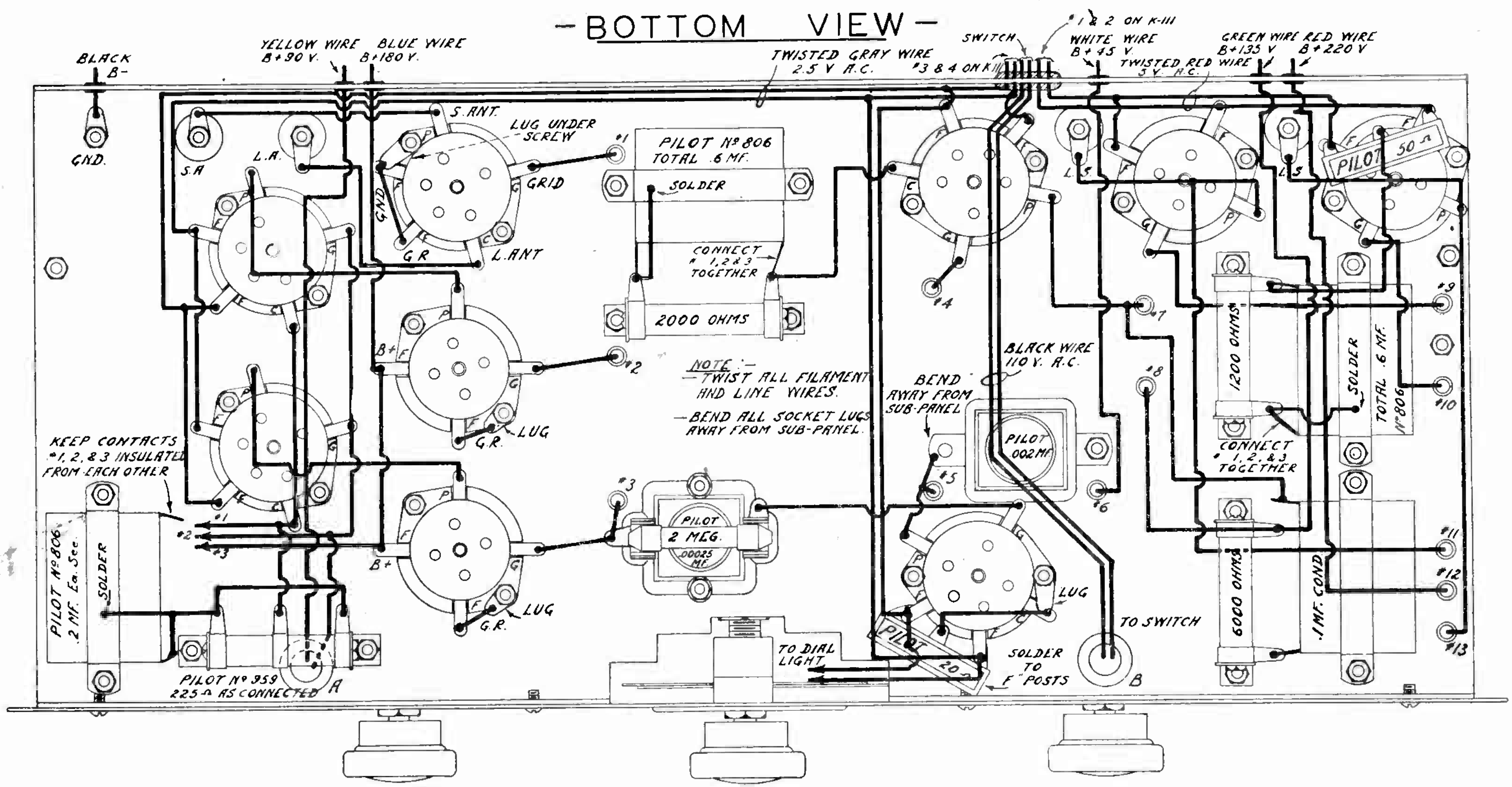


Complete schematic diagram of the P.E.6. Study this carefully.

TOP VIEW



The arrangement of the parts on the top of the sub-panel of the P.E.6 is very simple, as this drawing shows. The only wiring to be done here is to the stator posts of the No. 1703 condenser, the transformer posts, and the Volumgrad and the switch. The dotted circles around the tube sockets on the left indicate the shields of the tubes and the plug-in coils.



Before doing any work on the set, study this drawing carefully, so that you are sure of the placement of all the parts. Follow the procedure given in the article as to assembly and wiring, and you will find the whole job a very easy one. Solder all connections well with a clean, hot iron.

front panel, or on the front of the cabinet, as the case may be. If you have a cabinet remove the top and unscrew the bottom. Put all this away now, and start on the sub-panel by screwing down all the tube sockets and the binding posts. Note carefully from the drawings how the sockets face, and that all the binding posts except the "GND" are insulated from the sub-panel by means of the double washers supplied in the hardware package. Before tightening the screws holding the two sockets for the P-224's (on the extreme left in the top view drawing), slip the bottoms of the 222S tube shields under their heads, and then tighten.

Now mount one No. 806 condenser and the No. 959 resistance by four separate screws in the lower left corner of the sub-panel (see bottom view drawing); and similarly mount another No. 806 and the 2000-ohm resistance in the upper center with four more screws. All these screws are pushed through the top of the sub-panel and secured on the underside by lock washers and nuts. The condensers are held by special little straps.

The No. 959 has a total resistance of 900 ohms, but it is made to act as a 225-ohm resistance by connecting the outer ends together as one terminal, and using the center tap as the other terminal. This puts the two 450-ohm halves in parallel, giving 225 ohms.

MOUNTING THE EQUALIZER

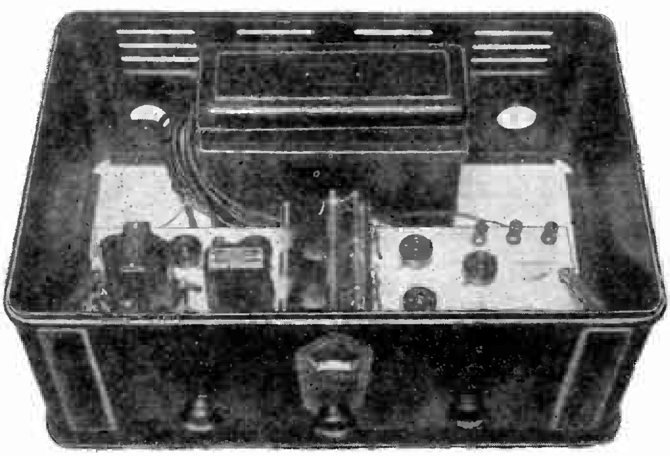
In the lower right hand corner, mount the 6000-ohm resistor and another of the No. 806 condensers with the same three screws that pass through the No. 401 impedance on the top side of the sub-panel. A fourth and separate screw to hold the upper end of the condenser strap is passed through the sub-panel right at the edge of the impedance case. Similarly, mount the 1200-ohm resistance and the fourth No. 806, using three of the screws that hold the No. 399 transformer and a fourth and separate screw directly next to the edge of the latter. In mounting the No. 391 transformer, fasten the .002 mf. fixed condenser on the underside of the sub-panel by the screw near the B+ post. Bend up the other lug so that it does not touch the sub-panel.

The last things to mount are the .00025 mf. grid condenser and the big triple condenser. Pass a screw up through the upper hole of the grid condenser (upper as seen in the bottom view drawing) and fasten with a nut on the top side of the sub-panel. Now place the 1703 condenser along the center of the sub-panel, and you will readily see how the threaded mounting feet slip over the screw holes. Pass screws up from the underside of the sub-panel, putting one through the bottom hole of the grid condenser.

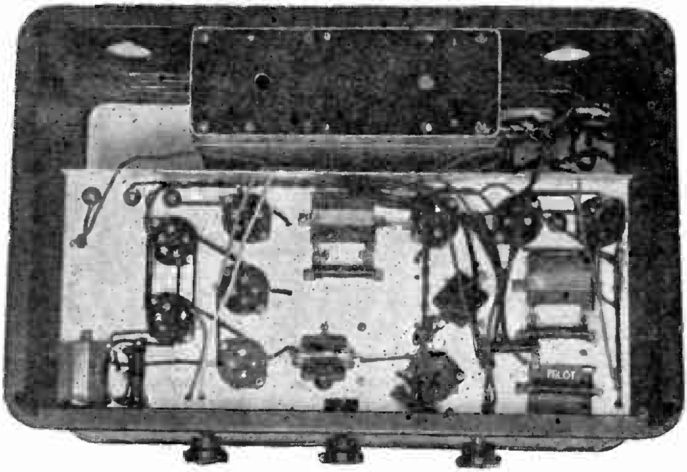
All this sounds complicated, but when you have the instruments actually in hand you will find it quite simple. The holes are all accurately drilled, so you can't go wrong if you try.

DOING THE WIRING

The wiring is likewise easy. Start with the filaments of the four five-prong sockets, which must be connected in parallel. Using the gray wire, start at the lower left socket (as seen in the bottom view), run to the socket above, and then along the back of the sub-panel to the right until you meet the third five-prong socket. Drop the wire to the bottom socket (for the detector tube) and from there leave a length of ten inches or so free for connection later to the dial light. Solder the outer lugs of the 20-ohm center-tapped resistance across the F posts of the detector socket, and solder a two-foot length of gray wire to the upper socket, the one for the first P-227 audio tube, bringing this wire out through the large hole, which is fitted with a soft rubber bushing. This wire connects to posts 3 and 4 on the K-111 power pack.



This picture shows a complete P.E.6, model K-124, with the top of the cabinet removed to show how the K-111 power pack is mounted against the back.



By unscrewing the bottom of the cabinet, you can get at all the wiring of the set and can work on it comfortably with ordinary tools. Very few sets are as accessible as this.

Run a pair of red wires to the F posts of the two four-prong sockets and bring them out through the same hole in the edge of the sub-panel. Also solder the 50-ohm center-tapped resistance to either of these sockets, and, as with the 20-ohm resistance, ground the center tap to the framework.

STUDY THE DIAGRAMS

The rest of the connections are made clear in the drawings, and need no explanation. Study all the little notes on the diagrams before soldering the wires, and you will experience no trouble.

Leave the various wires for connection to the power pack at least 2 feet long. You can always cut them down later.

To complete the whole wiring job, slide the sub-panel against the front panel, or the inside back of the cabinet, and screw it in place by putting four screws through the front edge, and bracing it with the two side arms Run the wires to the dial light, the switch and the Volumgrad. The wires are connected to the K-111 binding posts in accordance with the markings. If you have the cabinet model of the P.E.6, you can improve the appearance of the connection wires by cabling them together, and bringing them in a bunch through the K-111 can. You can identify them by their colors.

To get the P.E.6 into actual operation, insert the tubes and connect the aerial and ground. Also insert the three plug-in coils. The antenna coupler, No. 235A, has five prongs, and fits in the rearmost socket. The interstage transformer, No. 235B, has four prongs, and like the 235A, has a flexible wire with a cap soldered to it coming out of its top. The detector coil, No. 235C, has four prongs and a solid top. Put the two P-224's in their sockets, slip the upper sections of the tube shields over them, and snap the caps from the coils over the protruding electrodes.

The "GND" post is also the B—, you will notice. Connect the loudspeaker simply to the two LS posts. Either a magnetic or a dynamic speaker may be used.

USE A SMALL AERIAL

The inside aerial can be of almost any size from ten feet up. You may use an outside aerial if you want, but it must be short; not more than fifty or sixty feet overall. Try both aerial posts, and see which gives the better selectivity.

When the set is an actual operation, try varying the little compensating condensers on the right side of the triple tuning condenser. Once you find the best adjustments, there is nothing else to touch; merely turn the tuning dial and control the volume with the Volumgrad.

In buying tubes for the P.E.6, get two Pilotron P-224's, two P-227's, two P-171's, and a P-280 for the K-111 power pack. These tubes will give lasting satisfaction.

Let the P.E.6 solve your problem of what to get for that young son or nephew of yours—that boy who is bored by ordinary gifts. Give him a complete K-124 kit, and he will have something that will give him pleasure long after all the other gifts have been forgotten. This receiver is no toy, but a real radio set that both you and he will be proud of. Its price is low and its value is high.

This Article Deals With

"Radio Understanding"

And Recounts Some Interesting Technical History from Which You Can Learn a Great Deal

WHAT particular training or qualifications must one have to enable him to devise new circuits and to analyze old ones? This question has been asked of me so often that I have tried to concoct a general answer which will really mean something.

There certainly is something intriguing about circuit development work. It has captivated the attention of thousands of radio fans throughout the world and has continued to maintain almost a throttle hold on the pocket books of most of them. There is something of the "game" in it—the desire to pit one's wits against certain given conditions, with the hope of arriving at a solution. From this angle, it is very similar to solving any form of puzzle.

Hence, we arrive at our first conclusion: to be moderately successful with radio circuit experimentations, one must approach the work much in the same spirit as a game. And how do we do this? First we acquaint ourselves with the rules. If it is a game of bridge, we must learn the value of the cards—we must learn to judge what cards the others hold by watching their plays. If the game be chess, we must familiarize ourselves with the move of each individual piece and then learn to anticipate the moves of our opponent by studying out his possible combinations. But the all important thing at the start is to so thoroughly understand the rules that these become part of our second nature and we accept them without thought. This leaves our mind free to concentrate on combinations, rather than on minute details.

THE RULES OF THE GAME

I am anxious to make this point perfectly clear, so please bear with me. When we first learn to read, we must first learn the letters, then words. When these can be read without thinking, then you are ready for complete sentences where thoughts alone impress themselves on your mind without confusion from the technical details of spelling, sentence construction and what not. You, yourself, have no doubt met experimenters who are losing most of the enjoyment of the work by not being familiar with the rules of the game. And these rules in radio are not so complicated, not half as complicated as the rules of chess. In chess, there is the King, Queen, Bishop, Knight, Rook, and Pawn, all of which follow different rules and move differently. When these pieces are thrown into a combination, the number of possible combinations resulting from the number of possible moves is rather staggering. In radio, how simple! We have really only three pieces. These three pieces are Resistance, Inductance, and Capacity.

BIBLICAL ADMONITION

After we have thoroughly mastered the performance of these three factors and know just how they behave under different conditions, and can recognize them by their voices, even though their faces may be masked, we are ready to consider complex combinations of them. This is most interesting and is not so very hard because we have already completely mastered their individual actions. So far, this consists of what we are pleased to call the knowledge of the game. But knowledge and understanding are two quite distinct things, and you haven't yet an understanding—you merely have the knowledge. Understanding comes from a little experience; it is a sense of perspective; it is that thing which permits you to see the woods without being lost in the trees. Someone has said that a little knowledge is a dangerous thing. Quite true, it must always be tempered with understanding. Even the Bible admonishes us: "With all your knowledge, gain understanding".

Radio, like most of the fundamental sciences, has developed surely but slowly. It did not dawn upon us suddenly or by accident. It did not start in 1922 with the broadcasting era. It didn't even commence with Armstrong in 1912. Dr. DeForest, in spite of his important contributions, was a rather late arrival on the scene. And Marconi! Why the basic conceptions were fairly clear cut when he understood his labors. Now think that over for a minute, for it will put you in the proper mood for the next step.

You have all heard of Alexander Graham Bell. Of course, he is famous as the in-

by

DAVID GRIMES

David Grimes

ventor of the telephone. But Bell was primarily an expert on acoustics; he knew little or nothing about electricity in those days. He and his progenitors before him were instructors of the deaf. Bell knew about all there was to be known about sound, for he thoroughly understood the construction of the vocal organs and the mechanism of the human ear. It was this understanding that was responsible for his success in developing the electrical telephone when others, better versed in the electrical art, had failed. The real principle he applied in the solution of his problem was obtained directly from his other knowledge.

Professor Bell argued if the thin skin diaphragm in the ear responded to all the complex vibrations of the voice and thus impressed them on the brain, that a mechanical diaphragm could be made to respond and duplicate all the intricate motions caused by speech or music. He built such diaphragms and, by constructing them partially out of iron, was able to generate electrical impulses similar to the motions of the disc when a magnet was brought near the vibrating iron. So much for that, as that phase of his work is too well known to bear repetition. The telephone grew and prospered until to-day it is about our biggest industry.

A GREAT DISCOVERY

Professor Bell had discovered something infinitely bigger than the telephone. He had proved that the vibrations of music and speech could be imparted to mechanical ears, or discs, and from there used to generate similar vibrations in other mediums than air, such as an electrical circuit. This first telephone of his he demonstrated at the Philadelphia World's Fair in 1876. It is significant to note, in view of the above analysis and exhibition, that Edison took such a diaphragm and proceeded to impart its vibrations to a wax record in 1878, two years later. Edison invented the phonograph, but wasn't it fortunate that Professor Bell had a keen understanding of fundamentals?

However, the telephone was not the culmination of his efforts to adapt his vibrating diaphragm to practical ends. The big drawback to his electrical communication infant was that it required a lot of wires for interconnections and these were costly over any great distance. In many cases, it would not be possible to install them; such as between a lighthouse and the shore. Bell set about to devise a system of wireless telephony. He reasoned from the known to the unknown. Beams of light had been used for signalling purposes as far back in the ages as the history of man is written. The ancients used fires on the hill tops. Certainly, a light ray requires no intervening metallic medium on which to travel from the sending to the receiving end. Why not employ a beam of light and impart to it the vibrations of the voice?

The first experiments were eminently successful. The sun was made to shine on a thin, metallic mirror, whose surface was highly polished. From this surface, a reflected light ray was sent out in the desired direction. In front of the mirror a mouthpiece was mounted, so that the sound vibrations were collected and impressed on the mirror, which, in turn, vibrated to and fro, giving the reflected beam a flickering characteristic. Naturally, the flickerings, being caused by the mirror vibrations, would represent quite faithfully the original voice sound wave. Professor Bell had thus imparted his voice onto the beam of light for transmission as far as the beam would go! It is of no particular interest to us here how he got his voice vibration off the beam at the receiving end and back into sound vibrations to be understood by the ear. He used a substance called selenium, whose electrical resistance changed as the light which fell on it flickered. The important thing to remember is that here was the first wireless telephone and Alexander Graham Bell was the father of it.

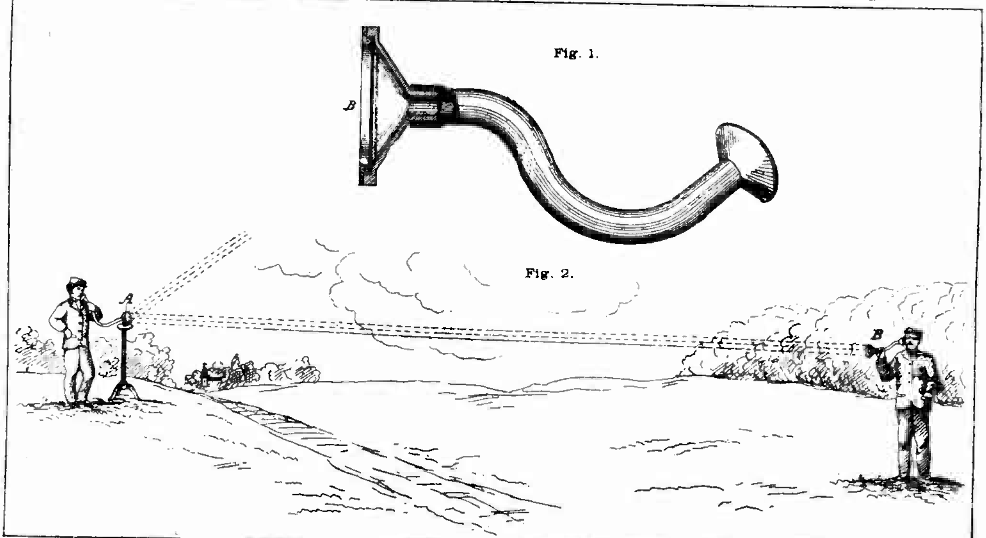
Many of you are wondering what all this has to do with radio broadcasting. Let us go on. Subsequent development work carried on by Bell and his associates resulted in substituting an arc light for the sun. Transmissions could thus be carried on at night and on cloudy days. But even the arc light had its drawbacks. Foggy weather or smoke which lowered the visibility absorbed the beam and the service faded out. By way of information, these tests were carried on in Washington, D. C. about the year 1878.

COLORED SPEECH

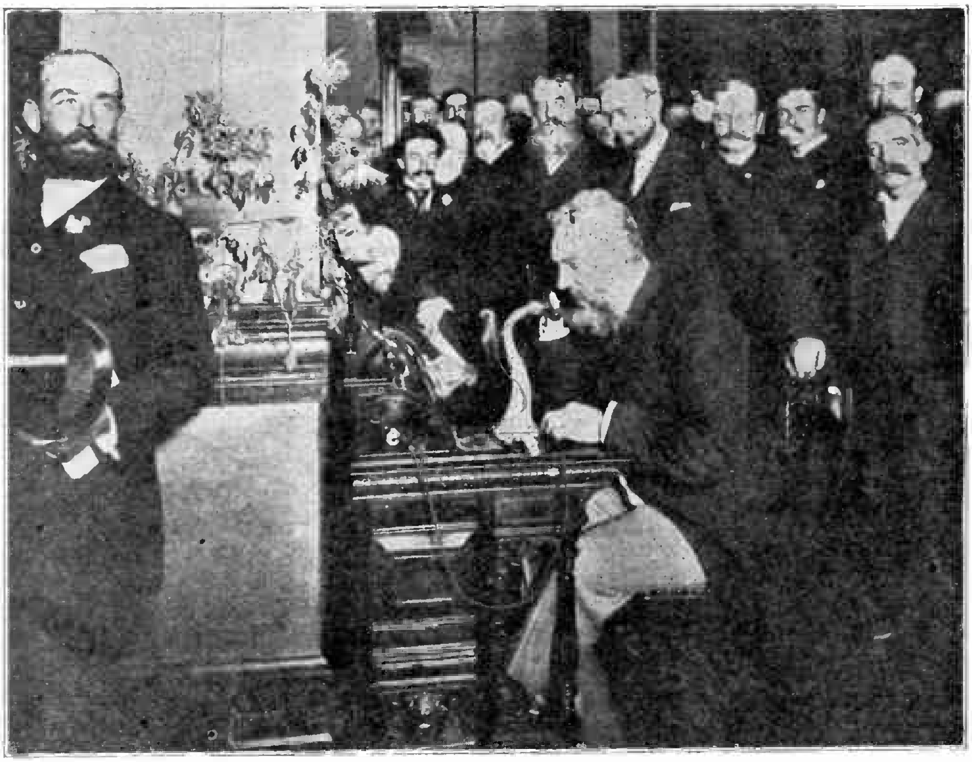
A systematic study was then started on the effect of employing light beams of different colors. Red was found to have more penetrating power than the other end of the visible spectrum in the violet region—or shall we say that the fog had less absorbing effect on the red. Either way it is the same in result. You may check this for yourself any night at sunset. When the sun is low in the sky, the beams have to travel through considerably more air to reach us than when the sun is overhead. This air, particularly if it contains moisture and dirt, absorbs nearly all of the colors in the sunbeam but the red. That is the reason the sunset is nearly always red. This same phenomenon, undoubtedly, led to the use of red light as a danger signal; it travels far under rather adverse weather conditions.

Now, red light is identically the same as violet except that it is a vibration of a little lower frequency. Red light has about twice the wavelength of violet or ½ the frequency. Professor Bell reasoned that if red light passed through moist air better than violet, that still lower frequencies would be still more useful in this respect. It was generally appreciated at the time that there were many other colors the human eye could not see. The eye is rather a limited camera, although much more efficient than the mechanical camera, which only records the difference between light and dark. You see, the eye will not function on colors of higher frequency than violet, nor lower than red. Yet above the violet are literally octaves of ultra-violet rays and still higher are more octaves of "X" rays, etc. The visible range covers one paltry octave. Below this are octaves of invisible infra-red beams, then octaves of heat beams, etc. Maxwell proved mathematically that all light, visible or invisible, was an electromagnetic vibration and such vibrations could be found at almost any wavelength.

The next natural step was to employ heat beams, as these could be easily generated and if they passed more readily through fog and smoke, then the theory was basic. Professor Bell built such a wireless telephone and placed it on exhibition at the Chicago World's Fair in 1892. Because it used a beam of invisible light in the range which manifests itself as heat, he called it a thermo-phone; but it was often referred to during the exhibition as a "radiophone" because it used heat and everyone was familiar with the fact that heat radiated! This was the start of the name "radio" as far as wireless telephony was involved. The theory was proved, as the new colored beams of invisible light did pass much more readily through smoke



Speech without wires 51 years ago. Reproduction of an old drawing showing how the reflected rays of the sun were modulated by voice waves and transmitted successfully a limited distance. The idea is Bell's.



A momentous occasion in 1893: Alexander Graham Bell (seated at the desk) opening the New York-Chicago long distance telephone circuit. Late in November of this year, 1929, there was opened a wire-radio circuit that enabled a business man in New York to converse quite casually with another business man in Sydney, Australia!

and fog than the red rays.

But still there were drawbacks. This new wavelength was obstructed by solid objects. This infant "radio-phone" demanded an unobstructed line of passage between the transmitter and the receiver. It still was far from practical for any great distance. But there was no stopping the inevitable line of reasoning that had been started. Lower and still lower wavelengths were the cries. It was now generally believed that this would offer the solution to the passage of the wave even through wood and stone—who knew? Maxwell had said the waves were there. Nobody knew how to generate them.

RADIO WAVES DISCOVERED

About this time Professor Hertz accidently discovered a method of creating waves of what was then thought to be a tremendously long wavelength — actually inches in length instead of millionths of an inch. True to prediction, these new invisible colors passed easily through walls and other ordinarily opaque objects. Hertz proved them to be none other than light waves by focusing, reflecting, refracting them and performing other tricks which can be done with the waves in the visible octave. Here, indeed, seemed to be the answer to a practical system of real wireless broadcasting. The enthusiasm of the time is well reflected in an article by Sir William Crookes in the Fortnightly Review in England. The article states that the age of wireless transmission is at hand, an actuality. That now all that is necessary is a more powerful transmitter, a more sensitive receiver, and some system of obtaining tuning or selectivity. The author then presents in the publication a method of tuning that is practically the same as is in use to-day! This was in 1892 and Marconi started his work about 1896.

But still there were drawbacks! It developed that the system evolved by Hertz for the generation of the new wavelengths was far from a steady source. The origin of the new invisible beam itself was capable of delivering nothing but flickerings of such magnitude that the feeble flickerings caused by the voice were insignificant in comparison. The system did lend itself admirably to code transmission, as a prearranged sequence of noises is all that is needed.

At this point a division took place. The wireless telegraphic art proceeded with the new wavelengths because of their ability to pass through almost anything. The wireless telephonic art continued to stick to the visible light because of its steadiness on which could be easily impressed the controlled flickering representing the voice. We find Marconi actually transmitting code messages across the Atlantic at the beginning of the twentieth century and at the same time, we find the Germans transmitting wireless telephone conversation between ships and shore over the visible light beams of their searchlights.

THE MISSING LINK FOUND !

This breach continued to widen until Dr. DeForest invented the three element tube about 1906. This was truly the missing link. It proved to be the long sought for source of steady invisible light, ideally suited for the transmission of voice and music. Modern radio started from that day. The experiments on visible beams were immediately abandoned in favor of the colors that passed everywhere and through most anything.

A little reflection will round out the picture. A vibrating electron always sets up a wave disturbance in the ether. The wavelength of this disturbance depends entirely on how long it takes the electron to travel back and forth over its path. The shorter the path of the electron, the sooner it completes a round trip ready to start over and the more closely the outgoing waves in the ether follow the proceding ones; i.e. the shorter wavelength. When these electron paths are within the atom and the electron is set into rapid vibration with heat, the wavelengths are extremely short, in fact, within the visible band, and we say that the substance gives out light. As electrons are placed into vibrating streams, such as we find in an alternately charged antenna system of a radio transmitter, the length of the total path is great and it requires an appreciable time for the electrons to make the complete swing back and forth. The wave disturbance set up is consequently long.

WHY YOU CAN SEE

The proper receiving antenna for such waves needs to be built somewhat in proportion to the size of the transmitting system if any benefit from tuning sensitivity is to be obtained. Thus we find the optic nerves in the rear of the eye of such physical dimensions as to be quite susceptible to the wavelengths in the visible octave. That is the reason those colors are visible. Due to the fact that the visible octave covers a 100% change in wavelength, it is hard to conceive of any tuned receiving system capable of such wide coverage, and there isn't. Nature has provided several sets of optic nerves, each tuned to receive a rather narrow band very efficiently. That is why we can pick out the separate colors and why we can see more than one color. A person who is color blind merely has one or more of these sets out of order.

Imagine for a moment, what a change would be wrought if we could increase the size of those optic tuning circuits of ours. We would immediately see new and different colors and things would take on quite different appearances. As we continued to further increase the dimensions of those seeing antennas of ours, many of the opaque objects would become gradually transparent until, at the present broadcast octave, we would see nothing but the steel ribs in the buildings. Automobiles would pass along about four inches in the air over a rather translucent pavement—the tires would be invisible. Friends we would see not; merely watches and metal pencils and possibly a few coins pass down the street, because people would be invisible.

FANTASTIC BUT TRUE

The various broadcasting stations would appear as huge light houses, sending forth their peculiar and respective colored beams of light in all directions. The antenna would appear as one end of the tremendous arc taking place between it and the ground. No heat would be present in that arc, though as that particular wave band would be lacking! WJZ would be one color, WEAF another, and so forth, all down the line. What colors? No one knows, as no one has even seen them, but colors they would be, none the less.

Another characteristic of these radio lighthouses would be at once apparent. The beam would not be steady; it would be continually flickering. The flickering would represent the vibrations of the program from the studio within. A faint, flickering pastel shade would appear on the horizon—a dimly reflected lumination, having no definite source, but merely a general direction. A distant station we would muse, realizing that such light could only reach us around the curvature of the earth by a reflection process similar to the sunset effect. The flickering reflection on the sky grows strong and then gradually fades away, only to reappear even stronger a moment later. Something has occurred in the atmosphere that changes the efficiency of reflection, even as the sunset never appears twice alike throughout the year, even though it is watched at the same hour. Fading, we conclude, and then the marvel dawns upon us.

How fantastic and impossible it is; a tale worthy of Aladdin's lamp! But it is even more wonderful because it is true. And when one begins to appreciate the frailness of that etherial connection between him and that distant broadcasting station, and the constantly changing sky, he wonders, not that his program is not always perfect, but that he receives anything at all! Perhaps a seed of "radio understanding" is starting to germinate within you.

RADIO PHYSICS COURSE

FOR HIGH SCHOOL STUDENTS

by ALFRED A. GHIRARDI

CHAPTER 7

VACUUM TUBES IN PRACTICE

Types of Tubes — Construction — Filaments — Electron Emission — Thoriated Tungsten — Destruction of Thorium Layer — Oxide Coated Filaments — Oxide vs. Thoriated Filaments — Grid and Plate — Filament Control — Rheostats — Ballast Resistors.

74. TYPES OF TUBES: Vacuum tubes are made in many forms with electrodes of various sizes, shapes and arrangement. The filaments may be designed to be operated from dry cells, storage batteries or even raw alternating current. The tubes can be constructed to handle from one to two milliwatts to several thousand milliwatts of power. The filaments may be either of the thoriated tungsten type or coated with the oxides of barium or calcium to increase the electron emission for a given temperature. They may be made in the form of round wires, or flat ribbons; or arranged in the form of a straight wire, an inverted V, a double V, etc.

The plates are usually plain, box shaped, or nearly cylindrical, with the grids corresponding. The relative spacing of grid, filament, and plate, as well as the fineness of the mesh in the grid, also varies in the different tubes. Some have been designed with a multiplicity of filaments, grid and plates. In Europe, some tubes have been designed with multiple elements so as to contain within the glass bulb all the necessary parts for one or two amplifier stages. These have not attained great popularity in the United States.

75. CONSTRUCTION: Fig. 45 shows the relation of the parts and the construction of the Pilotron 227 vacuum tube. Notice that we have first of all the filament, then the cathode or electron-emitter, surrounded by the spiral wire grid or controller, and this in turn surrounded by the plate. The entire assembly is mounted on a glass flare through which the connecting wires are sealed, and from which a hollow tube extends at the bottom. The flare is then joined to the outside glass bulb, making an upright assembly. The long tube is attached to a vacuum pump and the air is drawn out. To insure a perfect vacuum the tube elements are heated by an induction furnace to release

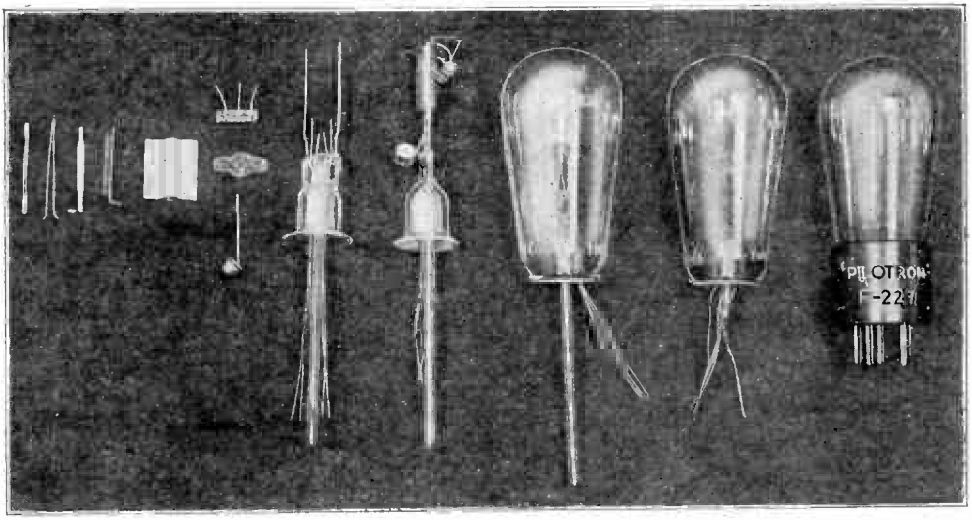


Fig. 45: The various stages of assembly of a Pilotron P-227 radio tube. From left to right we have the filament, cathode, grid, plate, supports, stem, elements on stem, tube ready for evacuation, evacuated tube, and completed Pilotron.

Editor's Note: The reader should read the article "How Pilotron Tubes Are Made", by Mr. Ghirardi, in this issue. This contains a great deal of information on tube manufacture, which ties up well with the material contained in this chapter of the Radio Physics Course.

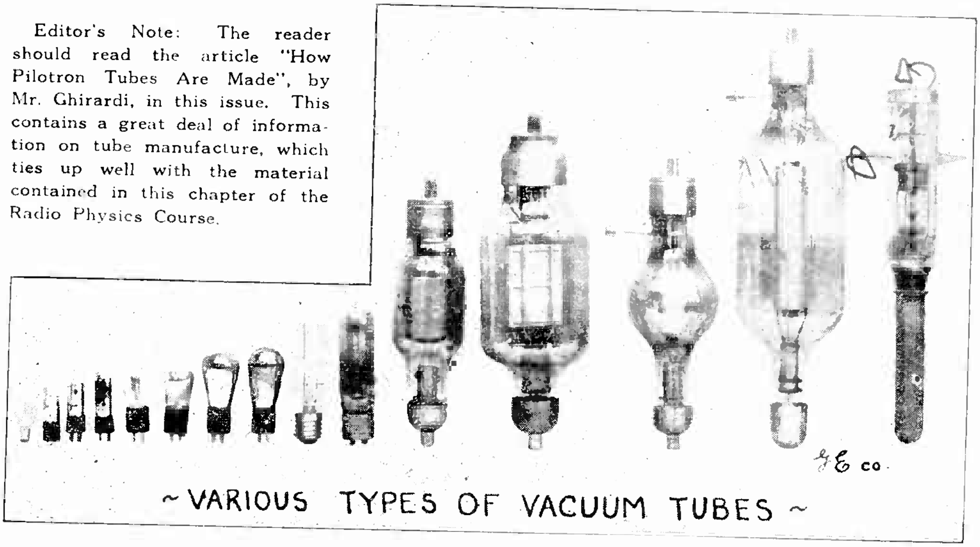


Fig. 46: The first eight tubes on the left are receiving types. The ninth is a ballast tube, and all the others heavy-duty transmitting tubes. The one on the extreme right is rated at 20 kilowatts, and is water cooled.

any entrapped bubbles of air from the pores of the metal and glass surfaces. At this point, a small strip of magnesium (same as ordinary flashlight powder) which has previously been welded on to the plate of the tube (or to a separate little cup), is flashed by raising the temperature, and the vapor or gas produced enters a vigorous chemical combination with any remaining oxygen in the tube. The vapor instantly condenses or deposits itself on the inside of the glass bulb and imparts to it the familiar silver-like look or mirror appearance.

The reddish and oil-film effects on some tubes is the result of some similar process in which phosphorus as well as magnesium is used.

The presence of the silver coating is thus seen to be merely incidental to the course of manufacture of the tube. The glass stem is then sealed off near the base of the flare. The bulb is mounted in a Bakelite insulating base with prongs for external connection. The prongs are made of hollow brass tubing, and copper lead-in wires from the tube elements are run thru them and are soldered at the tips. There are two prongs for the filament connections, one for the grid and one for the plate. The latter two are smaller in diameter than those of the filament, so that the tube can be inserted only one way in the standard UX type socket. This eliminates the possibility of inserting a tube in a socket in the wrong way.

76. FILAMENTS: There are at present three popular classes of vacuum tubes, namely the dry cell type, the storage battery type and the A.C. type, all deriving their name from the current supply used to heat the filament. A number of commercial forms of tubes are shown in Fig. 46. Those at the left are used in receiving sets, while the large tubes at the right are the powerful tubes used for various purposes in transmitting stations.

Since the function of the filament is to give off electrons, it is evident that it is desirable, in battery operated tubes at least, to coax out a maximum number of electrons with the minimum filament temperature. By decreasing the necessary temperature of the filament, the amount of electrical power used to heat it is reduced, thus resulting in longer life of batteries, lower operating cost, etc.

77. ELECTRON EMISSION: As explained at the beginning of Chapter 5, some substances give off electrons readily at low temperatures while most give off very few even though heated to extremely high temperatures. Among the former are the oxides of the rare metals thorium, barium and calcium.

The electron emission from a large number of materials has been studied and it has been found that a tungsten filament with a layer of thorium on its surface gives about 130,000 times more electrons at a temperature of 1,500 degrees Centigrade absolute than a plain tungsten filament of the same dimensions. Other materials, such as calcium oxide, barium oxide and strontium, also produce increased emission. Lately the thoriated and oxide coated filaments have been developed, and they are now used almost entirely.

78. THORIATED TUNGSTEN: At the present time practically all of the commercial D.C. type tubes use a thoriated tungsten filament. This is really a tungsten filament having thorium distributed throughout its mass, and a very thin layer of the metal thorium on its surface. The tungsten serves merely to heat the thorium and to renew the thorium layer as it is used up, the electron emission coming wholly from the thorium layer.

The raw filament wire is made of tungsten impregnated with from one half to one per cent of thorium oxide and some carbon. (Tungsten is the metal used for the filaments of incandescent lamp bulbs because of its ability to withstand high temperatures without melting).

When such a filament is heated, two important actions take place. As the temperature is increased to about 2,500 degrees Centigrade, some of the thorium oxide is reduced to metallic thorium, and then this gradually works its way to the surface of the filament. At this temperature, the thorium which diffuses to the surface of the filament vaporizes immediately, leaving only pure tungsten at the surface. If the temperature is then lowered to about 1,800 degrees Centigrade for a few minutes, the thorium wanders or diffuses through the filament and when it reaches the surface (provided the vacuum is nearly perfect) remains there and gradually forms a layer of metallic thorium atoms which never exceeds a single atom in depth. It is this almost inconceivably thin layer which increases the emission over a hundred thousand fold. When more thorium atoms work their way to the surface and come up under other thorium atoms already there, the latter at once evaporate, thus maintaining the layer only one atom thick. If the temperature is raised a few hundred degrees the metallic thorium is formed from the oxide more rapidly and comes to the surface more abundantly, but it does not stay on the surface. It evaporates at once, leaving a tungsten surface.

This film is very sensitive and must not be heated to too high a temperature, or it will evaporate. It is necessary to operate such a filament within a narrow range of temperature close to 1,500 degrees Centigrade, where the ratio of evaporation is small and the temperature is high enough for the thorium gradually to diffuse to the surface and continually replenish the layer as it is used up by the normal operation of the tube. In the UX-201A tube this condition obtains approximately when five volts is applied to the filament, sending a current of 0.25 amperes through it.

79. OXIDE COATED FILAMENTS: Very early work on vacuum tube filaments showed the value of coating the filament with certain oxides to increase the electron emission. Many of the latest tubes, such as the 112A, 171A, 245, 224, etc., employ oxide coated filaments which operate at a dull red heat.

The so called "oxide coated" filament is usually made with a very thin ribbon of platinum-nickel alloy which serves to conduct the current and heat the electron emitting oxide. Often the ribbon is twisted on itself in such a way as to expose everywhere a sharply curved surface to make the oxide coating stick better. The reader should examine the filaments in some of the larger tubes which use the oxide coating.

A mixture of strontium, barium or calcium carbonate in paraffin is applied to the filament and baked on by heating it to a high temperature for a few seconds. This is repeated several times to build up the coating to the desired thickness.

When the filament is mounted in the glass bulb, and the bulb is being exhausted, the filament is lit by a source of current. This high temperature breaks down the carbonate coating and the reaction with the air in the tube forms an oxide and carbon dioxide, the latter being drawn off by the vacuum pump. This oxide coating emits the electrons.

Oxide coated filaments cannot be reactivated, for all of the active material is on the surface of the filament wire and when this is once used up it cannot be replaced.

Heater type A.C. tubes such as the 227 and 224 types, contain a metallic thimble which is coated with an oxide coating. It is this thimble or "cathode" which gives off the electrons when heated indirectly by the filament.

80. THORIATED FILAMENTS VS. OXIDE COATED: Comparison of the two types of filaments indicates that each has certain advantages. The advantage of the thoriated filament is that if the surface layer of thorium is destroyed it can be renewed by reactivation, as long as there is any more thorium oxide left in the filament wire.

The oxide coated filament has the advantage of being considerably more efficient than the former. The oxide coated platinum-nickel alloy filament uses only about half as much power for the same emission. Also, the oxide coated filament will give the same emission as a thoriated filament when the operating temperature is about 400 degrees lower. If given proper use and care the oxide coated filament has a very long life.

81. GRID AND PLATE: The grid of a vacuum tube is usually made of a fine molybdenum ("Moly") wire wound in the form of a spiral around two nickel wire supports, and welded to them at each turn (see Fig. 45). The plate usually consists of two thin nickel alloy sheets bent and welded together, and supported on nickel wire uprights. The plates of power tubes, rectifier tubes, and other large tubes are covered with a carbonized surface layer. This makes them black and aids in increasing the heat dissipation.

The filament is supported at the bottom and top. In some tubes additional bracing to prevent mechanical vibration of the elements is secured by a triangular shaped piece of mica holding the grid, filament and plate supports rigidly at the top. This reduces microphonic noises caused by variation of distance between the elements with consequent variation in plate current. Nickel is used extensively in radio tubes because it has a high melting point and is readily freed from the "occluded" gases which are present in the pores of all metals and which cause erratic performance of tubes. Molybdenium is also used extensively by some manufacturers for grids and plates.

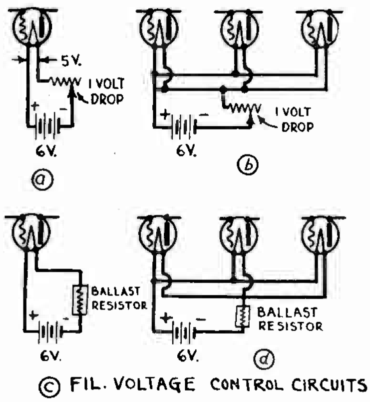


Fig. 48: Four methods of controlling filament current by means of series resistances.

82. FILAMENT CONTROL:

Manufacturers of early tubes found it necessary to employ a current control in the filament circuit of the tube, so that the tube could be adjusted to its most efficient point of operation. It was not practical to use a six-volt filament energized by a six-volt storage battery because the terminal voltage of the battery decreases as it discharges (Fig. 47), consequently the filament would be burning at its proper temperature only during the short time the battery was fully charged. By designing the filaments for operation on five volts the necessary leeway of one volt was provided. The same applies when using dry batteries for filament supply. The surplus voltage between that required by the filament and that supplied by the battery is most conveniently absorbed by a resistance introduced in the filament circuit (Fig. 48A). If this filament rheostat is made variable it can be adjusted at will for best operation.

83. RHEOSTATS:

A filament control rheostat usually consists of a small coil of special resistance wire (nichrome) arranged in a circular shape so that when a sliding contact passes over it more turns of wire are cut in or out of the circuit, thus changing the resistance offered to the flow of current. Another type of rheostat employs a number of small graphite discs which, when compressed by an adustable rod, make good contact and offer a low resistance. When the pressure on them is released, the resistance increases.

Sometimes two or more tubes in a radio set are controlled from the same rheostat, as in Fig. 48B. Since the total current is now the sum of the current for each of the tubes, in order to produce the same voltage drop the rheostat resistance must be decreased. The table of Fig. 49 gives the rheostat size recommended where one or more tubes are to be controlled from a single rheostat. Resistances of these values give a smooth and wide variation of filament current and make it possible

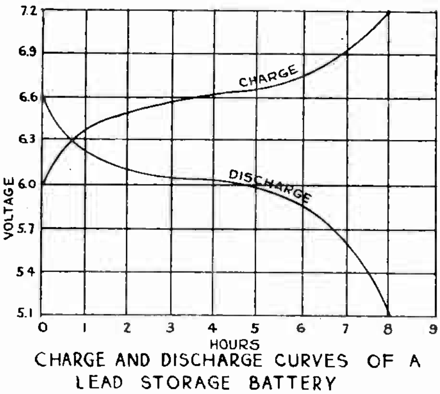


Fig. 47: How the voltage of a storage battery varies during charge and discharge periods.

RHEOSTAT SIZES RECOMMENDED								
Nº OF TUBES IN PARALLEL →	1	2	3	4	5	6	7	8
TYPE OF TUBES	RHEOSTAT RESISTANCE IN OHMS							
112-A, 171-A, 201-A WITH 6V. SUPPLY	20	10	6	6	3	3	2	2
171, 172 WITH 6V. SUPPLY	10	6	3	2				
199 WITH 4.5 V. SUPPLY	30	20	10	10	6	6	3	3
199 WITH 6 V. SUPPLY	100	60	40	30	25	20	15	10
120, 222 WITH 4.5 V. SUPPLY	20	10	6	6				
120, 222 WITH 6V. SUPPLY	50	30	20	15				
11, 12 WITH 1.5 V. SUPPLY	10	6	6	6	3	2	2	2
11, 12 WITH 2V. SUPPLY	10	10	6	6	6	3	3	3
VT-2, 216-A WITH 6V. SUPPLY	3	2						

Fig. 49: With the aid of this chart you can quickly choose the right rheostat size for any battery set.

to operate the tubes below rated voltage, either for volume control or some other reason.

Rheostats are made with various maximum resistances, usually 2, 4, 6, 10, 20, 30, 60 and 100 ohms. The rheostats having low resistances are wound with heavier wire and are able to carry more current without excessive heating.

84. **BALLAST RESISTORS:** The elimination of a multiplicity of controls on receivers has become popular. It has been found that, in battery operated receivers, most of the rheostats can be supplanted by automatic voltage regulating devices called *filament ballast resistors* (Fig. 50). Their purpose is to regulate automatically the flow of current in a tube circuit and maintain the current value approximately constant over the entire voltage range of the "A" battery between its fully charged and discharged periods. They simplify set wiring and as there are no moving parts, rheostat wires are not noticeable. As the filament is kept at a more constant temperature, the tube life is lengthened.

Ballast resistors usually take the form of a piece of iron resistance wire hermetically sealed in a glass tube filled with an inert gas such as hydrogen. The iron resistance wire increases rapidly in resistance with an increase in temperature. Since the amount of current flowing through the wire determines the amount of heat generated, the resistance is self-regulating. If for any reason more current attempts to pass, the wire becomes hotter and its resistance increases, tending to reduce the current to its correct value. The effect of the gas in the tube is as follows. As the wire tends

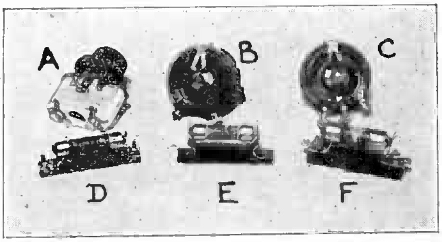


Fig. 50: A, B and C, filament rheostats. D, E and F, ballast resistors.

to get hotter with an increase of current, the gas temperature increases and it becomes a poorer conductor of heat and less heat is conducted from the wire. It therefore tends to make the temperature and resistance of the wire increase more, and so assists the regulating action.

Ballast resistors are made in various sizes, for controlling single tubes of the various types (Fig. 48C) or for controlling a number of tubes (48D). They are made with metal end caps and mount in clips (see Fig. 50).

Radio Fans Hail A.C. Super-Wasp As Best Short-Wave Set

Smoothness of Operation and Absence of Hum Elicit Enthusiastic Comment From Builders

by ROBERT HERTZBERG

THE popularity achieved by the A.C. Super-Wasp immediately after the appearance of the Fall number of RADIO DESIGN is a flattering tribute to the skill of the engineers who designed this all-electric short-wave receiver, and a comforting indication of the faith which the readers have in this little magazine. In his article describing the set, David Grimes fully answered every question radio fans had to ask about the circuit and its operation, and convinced everyone pretty thoroughly that he knew what he was writing about.

Thousands of Super-Wasp kits have already been sold, and those purchasers who followed instructions about using the K-111 power pack and Pilotron tubes, obtained good results from the first time they turned their switches on. As we expected, there were complaints about hum on the point of regeneration, but in every case of this kind it was found that an ordinary 227 was being used in the detector socket. The substitution of a Pilotron P-227, which was developed especially for the Super-Wasp, made such a startling difference in results that the former complainers are now the set's biggest boosters.

A FEW TESTIMONIALS

If there are left among our readers any people who still refuse to believe that a tuned screen-grid short-wave receiver can be made to work on alternating current, let them read the following letters, which were selected at random from the ever-growing testimonial file in our office:

FROM CHICAGO

"Having bought and built one of your A.C. Super-Wasps, I feel I must tell you that it is by far the best short-wave receiver I have ever had or listened to, which means many in the past ten years. I think it is as good as anyone could want on all the waves. Very smooth, no hum, and easy to operate.

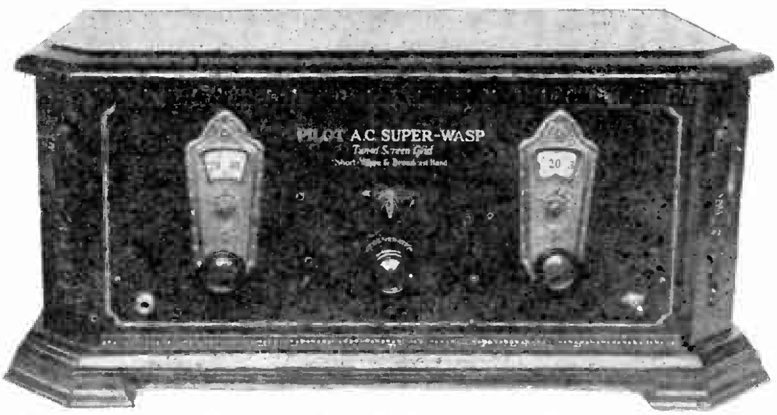
"Until now I didn't believe it was possible. As a ham (W9OJ) and a builder since 1918, I want to compliment the Pilot Radio & Tube Corporation on really having done something. Just 'wonderful' expresses it in a single word."

G. Edwin Farley, D.D.S.,
1539 Marshall Field Annex Building,
Chicago, Ill.

FROM WATERTOWN, N. Y.

"With regard to the Pilot A.C. Super-Wasp, I can say that it is the best of four short-wave sets I have. In my opinion it is quieter than the battery-operated short-wave sets which I own."

Cecil B. Aiken,
International Burr Corporation,
Watertown, N. Y.



The advent of the Pilot "Super-Wasp" has dispelled the old idea that short-wave receivers are necessarily ugly. Here is a K-115 installed in a standard Corbett cabinet to show what a handsome outfit a short-wave set can be.

To skip around the world a bit, read the following letters about the Super-Wasp, and you will understand why it has earned such a wonderful reputation.

FROM ECUADOR

First, from Mr. A. Francis Ewell, an American engineer, at Quito, Ecuador, who writes:

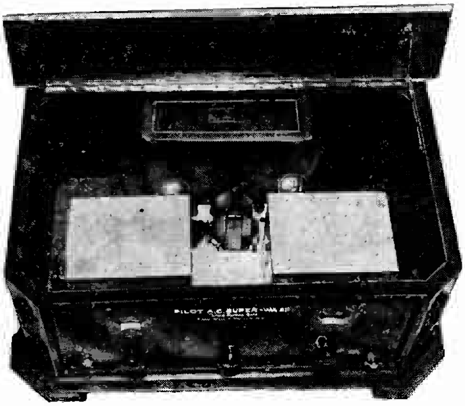
"Believing you might have some interest in the behaviour of the Super-Wasp short-wave receiver, I am writing you about the results as received here in Quito, Ecuador.

"Beginning in the days of 1925, radio has always been a hobby. However, my efforts have always been confined to the broadcast band, the short waves being a mystery.

"While residing here in the highest capital in the world which also straddles the Equator, I sent to New York for one of your sets, for the broadcast band is not received here.

"The Super-Wasp arrived and after a short time was assembled. Like any innovation the set was, according to various predictions, doomed to silence in these altitudes. Several short-wave sets have been tried up here but outside of squeals and a faint whisper they are now gathering dust. Well, the first night, after a little experimenting, the following were received on a loud speaker and were too loud, and had to be toned down: Holland, Pittsburgh, Schenectady, New York (WABC), and Sydney, Australia.

"As I am leaving shortly for New York, I sold the set and could have disposed of a dozen. As it is, I know that two of these sets have been ordered for the President of the Republic. I can certainly unqualifiedly recommend the Super-Wasp as the perfect short-wave receiver. This letter is sent to you voluntarily."



With the K-111 power pack installed in the back of the cabinet, you have the A.C. Super-Wasp as a self-contained short-wave receiver, requiring only aerial and ground and a connection to the nearest lamp socket. Contrast the appearance of this splendid set with that of other short-wave outfits, which sprawl all over the table!

FROM HULA-HULA LAND

Now we'll skip across the Pacific and see what Mr. Paul Kaelemakule, Jr., of Kohala, Hawaii, has to say:

"You will recall that I wrote to you about getting the Pilot Super-Wasp short-wave receiver. I bought a kit from the Mutual Telephone Company of Honolulu and five days later was listening to stations 10,000 miles away. The list of stations I now have on my log is as follows: WGY, New York; KDKA, Pennsylvania; 5SW, England; JOAK, Tokio, Japan; JOHK, Sadai, Japan; RA77, Saline, Russia; KNX, KPO, KFI, KGO, KOA, KSL and many others."

From Central America, comes a letter in picturesque English written by Amando Cespedes Marin, owner of station NRH:

"At last I got the parcel post, and the Super-Wasp within. As I told you, same was put up and wired the next day, and in a few minutes I was catching code like stars and KDKA and WGY clear as a bell. Tried long wave and got WLW and WJZ loud enough to dance by. But gee, a fan station from San Jose come in so loud that words cannot clear me to make you understand."

PREVENTING OSCILLATION

As the tuning of the A.C. Super-Wasp is exactly like that of the battery model, which has been the subject of several articles in Radio Design, very few purchasers of the K-115 had any real difficulty with the dials. However, a minor and unexpected trouble did arise with the broadcast coils which can be cured very easily. This was the tendency of the circuit to break into oscillation, even with the regeneration condenser turned down to zero.

As this effect took place even with the tickler winding of the detector plug-in coil altogether disconnected, the trouble obviously was in the screen-grid stage. It was discovered to be due to too high a voltage on the screen of the P-224. In some locations the K-111 power pack delivers more "B" voltage than usual, which is not at all harmful. The simplest cure is to connect a No. 941 (100,000 ohm) Volumgrad, as shown at the bottom of page 24. In this connection it acts as a potentiometer, and the voltage to the screen can be reduced. The Volumgrad can be mounted anywhere in back of the set, as once adjusted, it need not be disturbed. The right adjustment is quickly found by experiment. The idea is to plug in the blue ring coils, turn the regeneration condenser to zero, and to try to make the set oscillate with the Volumgrad turned all the way to the left. Due to power line variations it may not oscillate at some times but will at others. Once you get it into this condition, merely turn down the Volumgrad until the signals clear up. Trouble of this kind has happened only in a few cases, but it is a good thing to know what to do about it.

"DOLLING UP"

As many owners of the A.C. Super-Wasp use the sets are regular broadcast receivers, we are showing how the set can be "dolled up" in a cabinet, with all the wires out of sight. The cabinet pictured on pages 22 and 23 is a standard 7 by 18 Corbett product, with the removable top bar trimmed down to accomodate the 7½ inch panel of the Super-Wasp. The back is cut out to expose the back of the K-111 power pack, which is mounted in back of the chassis. Exposing the back of the K-111 in this way is a decided advantage, as otherwise the heat of the rectifier tube makes things pretty uncomfortable inside the wooden cabinet.

A good way to dispose of the plug-in coils is to screw five ordinary brass hooks to the left and right insides of the cabinet, and to hang the coils on them. Put the antenna coils on the left and the detector coils on the right, and you will always have them nearby when shifting from one wavelength range to another.

We would like to hear from owners of Super-Wasps. Tell us what results you are obtaining, and what little tricks you have applied, if any. Radio fans always have ideas of their own, and it is good sportsmanship to let the other fellow know about them.

K-110 STILL POPULAR

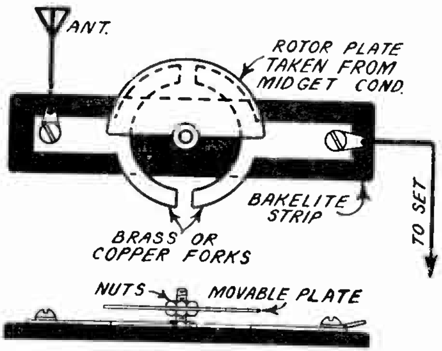
As many people still have perfectly good batteries on hand, the battery model of the Super-Wasp continues to be sold in large quantities and is giving excellent service wherever it is being used. If you have a six-volt storage "A" battery and three 45-volt "B" blocks, this model, K-110, will fill your need for a short-wave receiver.

By the way, the Spring, 1929 issue of Radio Design, which contained the original description of the K-110, has been completely sold out. However, we have a 12-page folder on the set which we will send you free for the asking. Just say you want No. 7 data sheet.

WORKSHOP SPECIAL HINTS

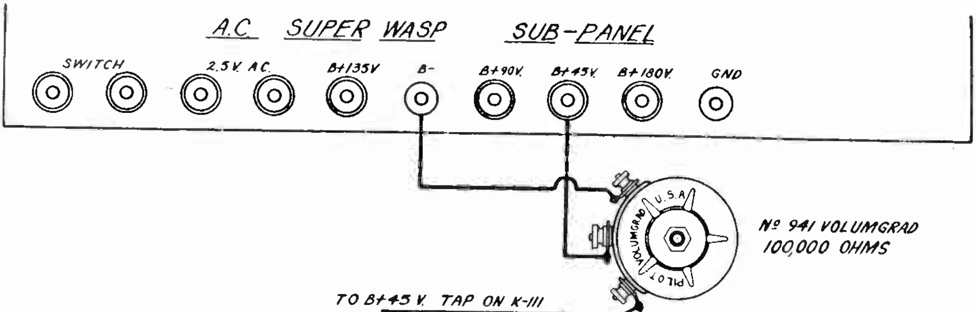
The "Workshop Special" short-wave receiver described in the Fall, 1929 issue of Radio Design made quite a hit. Many readers made this little "breadboard" set as their first short-wave outfit, and although it has bad hand capacity effects, as the article stated, it is producing good signals on the foreign short-wave broadcasting stations.

Some builders of the "Workshop Special" had trouble in making it oscillate. This is invariably due to an improper antenna series condenser. We are indebted to Mr. James L. Williams, 2700 Olive Street, Kansas City, Mo., for the excellent little condenser shown in the sketch below. We recommend this gadget as a good wrinkle.

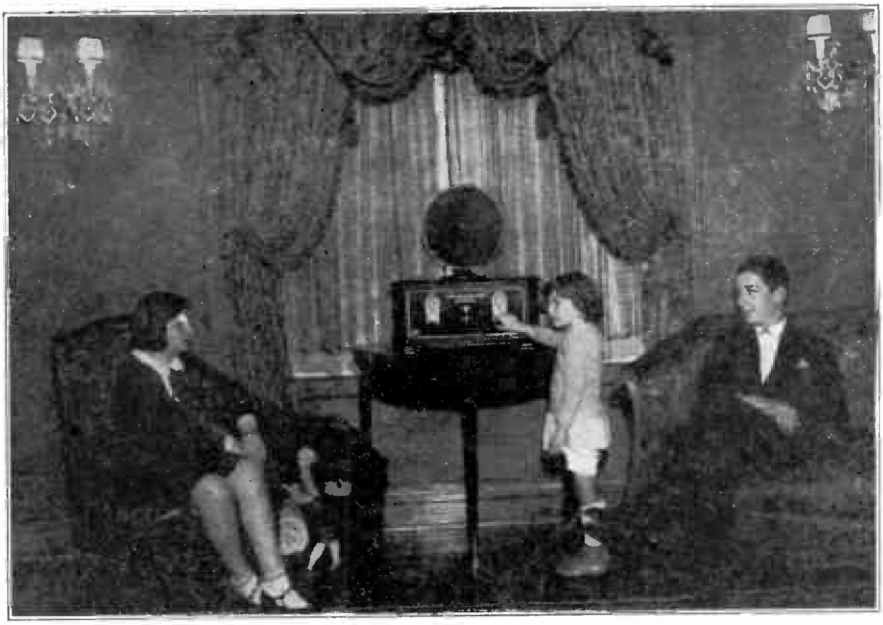


The rotor plate may be taken from a Pilot midget condenser. It should be raised about a half inch above the two fixed plates, and arranged so that it can be turned with the fingers. The capacity of this condenser is highest when the rotor plate is in the position shown, and lowest when turned all the way, either to the right or left.

Another thing: the 199 dry cell tube is rather irregular. If you have two, try switching them around. One may be a much better oscillator than the other.



A No. 941 Volumgrad, connected to the A.C. Super-Wasp as shown, will provide accurate adjustment of the screen voltage to compensate for different power conditions.



A Study in Contrast

These unusual pictures are silent tribute to the widespread popularity of the Super-Wasp, which, in the short time of less than a year, has firmly established itself as the world's leading short-wave receiver. The top picture shows an A.C. model installed in the luxurious living room of a New York millionaire's apartment, with the children of the family listening to a program from G5SW, Chelmsford, England. The bottom picture shows a group of savages listening to G5SW, on the Super-Wasp carried by the Dickey Orinoco Expedition into the unexplored wilds of Venezuela.

Some

Radio Questions and their Answers

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

VOLUME CONTROL IN A.C. RECEIVER

1. Will you kindly publish a circuit showing how to properly connect a volume control in the audio circuit of an A.C. electric receiver using 227 tubes?

Answer: Connect the two outside terminals of a 500,000 ohm potentiometer (Pilot No. 945 Volumgrad) across the secondary (G and F— terminals) of the first audio transformer in the set. Connect the grid of the first audio tube to the sliding contact arm of the potentiometer, as shown in Fig. 1. This method of volume control can also be used successfully in battery operated receivers.

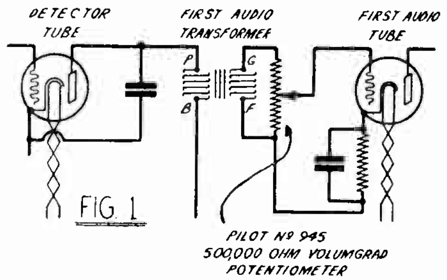


Fig. 1: How a 500,000 ohm potentiometer is connected as a volume control in audio amplifier.

FUSE FOR "B" POWER PACKS

2. What is the principle of operation of a flashlight bulb fuse in a "B" power pack? Kindly publish a diagram of a Pilot "B" pack with a flashlight fuse connected properly.

Answer: The ordinary flashlight bulb lights up on a very small current, about 0.30 ampere (300 milliamperes). Therefore, if it is connected in the B— lead of a "B" power pack which is furnishing less than about 250 milliamperes, the "B" current will flow through the bulb, as indicated by the arrows in Fig. 2, and light it up. If a short circuit should occur anywhere in the power pack itself, in the rectifier tube, or in the "B" circuit of the set to which the "B" unit is connected, the heavy current drain will burn out the filament of the flashlight bulb instantaneously, thus opening the circuit and protecting the parts of the pack from serious damage. All the parts and the wiring of the unit and set should then be carefully tested and the defect repaired before a new flashlight bulb is put in. As the bulb lights up under normal operation of the "B" unit, it also serves the purpose of indicating that current is flowing in the circuit.

The several types of common flashlight bulbs are rated at 2.2 volts, 2.5 volts, 3.8 volts and 6 volts. The current carrying capacity of these various bulbs under normal load is nearly the same. The 2.2 bulb carries about 0.25 amperes and the others vary between this and about 0.30 ampere in normal operation. All of these bulbs burn out at currents ranging between 0.35 and .50 ampere. There-

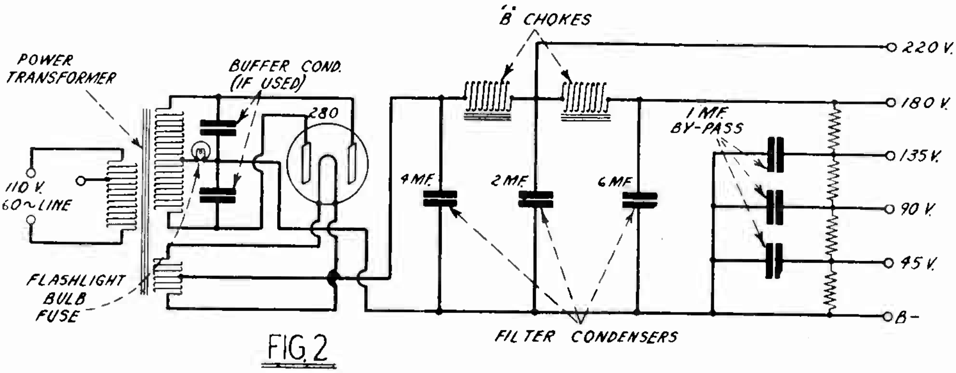


Fig. 2: A flashlight bulb connected as shown, acts as a protective fuse in a "B" power pack.

fore they are all satisfactory for use as "B" fuses. Regular miniature sockets for these lamps can be purchased in any electric supply store.

The diagram for the connection is shown in Fig. 2. The lamp must be connected just after the power transformer as shown in order to blow on short circuits which may occur within the circuit itself.

A flashlight bulb connected in the circuit between the B— terminal of a block of "B" batteries used in a battery operated receiver

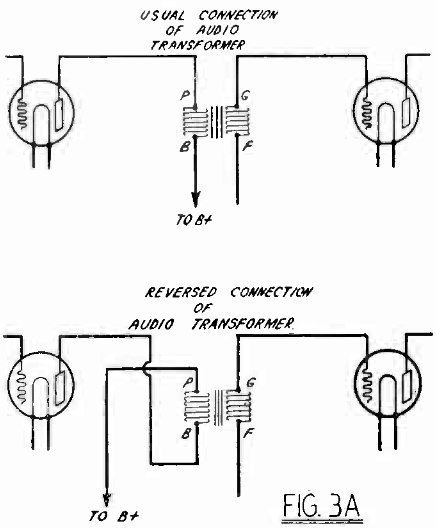


FIG. 3A

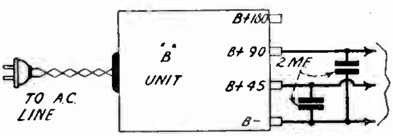


FIG 3B

Above: Two cures for motorboating. 3A, reversing the primary connections; 3B, using by-pass condensers across the "B" leads.

and the + or A— terminal of the "A" battery (depending upon whether the B— goes to A+ or A— in the particular set) will prevent running down of the "B" batteries in case a short circuit develops in the "B" circuit, and will also prevent burning out the filaments of the tubes in case the "B" batteries are accidently connected incorrectly to the filament circuit.

SPEAKERS FOR SUPER-WASP RECEIVERS

3. Must special loud speakers be used on short-wave sets? What type of speaker do you recommend for use with the Wasp, battery operated Super-Wasp and A.C. Super-Wasp receivers?

Answer: No special type of speaker is required for use with short-wave receivers. Use any good magnetic or dynamic speaker with these sets. Any speaker which works well on a regular broadcast range receiver will work well on a short-wave set.

CURE FOR MOTORBOATING

4. My receiver constantly makes a sound which sounds like the putt-putt-putt of a motorboat engine. Is this what is commonly known as motorboating? How can I stop this?

Answer: The objectionable noise you describe is undoubtedly due to "motorboating". This is a form of low-frequency oscillation set up in the audio system of receivers usually by common coupling in the plate supply unit.

We do not know of any one practical remedy which will apply to all cases of motorboating. Some remedies work best on certain types of receivers and we advise you to try the following suggestions out on your set in the order given.

One remedy which is usually effective in sets using two stages of transformer coupled audio amplification is to reverse the connections to the primary terminals of either the first or second audio transformers. This is shown in Fig 3A.

Another common remedy is to connect a condenser having a capacity of 2 mf. or more between the B— and B+ 45 or between the B— and B+ 90 volt terminals of the "B" power pack. This is shown in Fig. 3B. The larger the capacity used the less the tendency to motorboat will be.

Another effective remedy is to connect a Pilot Resistograd variable resistor in the lead between the B+ detector terminal on the set and the B+ 45 terminal on the "B" unit, and connect two 2 mf. condensers across the B— and B+ DET circuits, as shown in Fig. 3C. Vary the setting of the Resistograd resistor

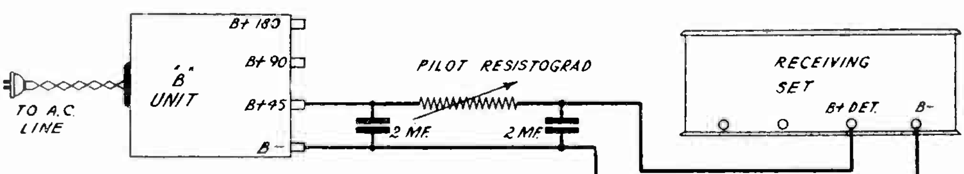


FIG 3C

A third method of eliminating motorboating: connecting a Resistograd in the "B"+ detector lead.

Free Question Service

One of the most valuable services "Radio Design" gives its readers is answering their questions free of charge by mail. As the number of letters daily runs up to as many as 300, please be patient with us, and remember that it takes time to study your diagrams and to gather the information you want.

Please observe these rules: Write plainly, and include as much data as possible relative to the question. Keep technical questions separate from orders for books, parts, etc. Include with your letter a stamped envelope addressed to yourself.

by turning the knob and turn it down as far as you can consistent with non-motorboating operation.. On some sets when this method is used the voltage drop in the resistor makes it necessary to operate the detector from the B+ 90 volt tap on the "B" pack in order to have 45 volts effective at the plate of the detector tube.

TUNER FOR K-113 AMPLIFIER

5. I built the K-113 push-pull amplifier described in the Fall issue of RADIO DESIGN and it works perfectly. Now I would like to build a good tuner unit, using screen-grid tubes if possible, to work with this amplifier. The power pack on the K-113 amplifier is to furnish all voltages for the tuner unit also. Will you kindly publish a circuit for this combination?

Answer: The R.F. and detector portions of any good set can be used with the K-113 amplifier. The set can employ P-227 tubes or P-224 screen-grid tubes.

A circuit diagram for an excellent tuner using P-224 A.C. screen-grid tubes is shown in Fig. 4. This is similar to the R.F. and detector portion of the Pilot Twin Screen-Grid 8 receiver described in the Fall issue of RADIO DESIGN, *and the parts layout for this set can be followed when constructing the tuner. One connection is made from the .01 mf. blocking condenser of the tuner unit to the input G terminal of the K-113 amplifier. The F— input terminal on the amplifier is left open. The B—, and B+ 45 volt, B+ 180 volt, and 2½ volt filament supply lines are run from the tuner unit directly to the K-112 power pack and connected as shown. Try a 2 megohm grid resistor in the grid circuit of the first audio tube in the K-113 amplifier in place of the 0.1 megohm resistor which is supplied with the K-113 kit. This combination will produce enormous volume and only a good dynamic speaker capable of handling this should be used with it.*

DEFINITIONS OF COMMON RADIO TERMS

6. What is meant by the terms "fixed condenser", "filter condenser", "buffer condenser", "by-pass condenser", "variable condenser", and "tuning condenser"? I am a beginner in radio and would like to know just what each term means, as I see them used in all radio magazines.

Answer: The terms you refer to are used to indicate the various types of condensers used in radio work.

A "fixed condenser" is a condenser whose capacity value is fixed, and cannot be varied. A "filter condenser" is a fixed condenser used in the filter circuit of a "B" power pack; a "buffer condenser" is a two section 0.1 mf.

SCREEN GRID TUNER UNIT

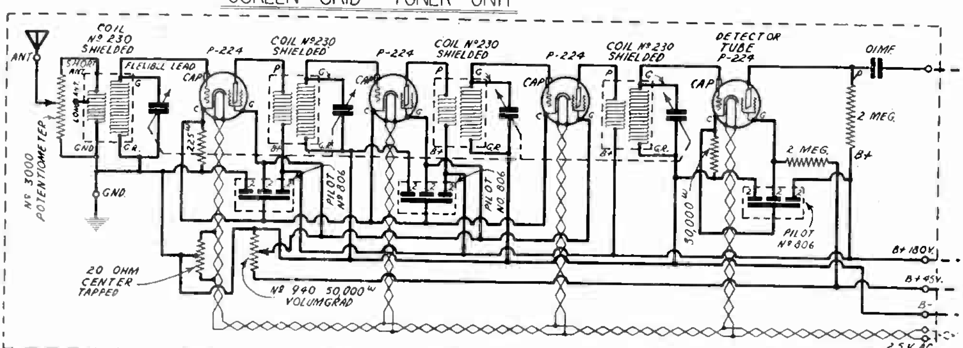


Fig. 4: Complete circuit of the screen-grid tuner section of the "Pilot Twin Screen-Grid 8". This makes a fine tuner to go with the K-113 amplifier, the diagram of which appears on the facing page.

fixed condenser connected across the output terminals of a power transformer used with a Raytheon rectifier tube in a "B" unit; a "by-pass condenser" is a fixed condenser connected across some high impedance device in order to present a low impedance path around it for the radio or audio frequency current to flow. All of these types of condensers are usually made of long strips of metal foil rolled up in compact form with sheets of waxed paper insulation between.

A "variable condenser" is a condenser constructed so that its capacity can be varied. A "tuning condenser" is a variable condenser used to tune a coil to a given resonant frequency in the R.F. stage of a receiver. Variable condensers usually consist of two sets of metal plates insulated from each other and arranged so they may be meshed together by various amounts so as to change the effective plate area exposed between them and thus change the capacity. By referring to some of the set photographs in this magazine you can see how condensers are constructed.

"C" BIAS RESISTORS

7. How are "C" bias resistor values calculated?

Answer: Tubes are designed to operate with certain values of "C" bias voltage for various plate voltages applied. You will need a tube characteristic table for finding the various factors needed to figure the "C" bias. The "C" bias resistor is figured by dividing the required "C" bias voltage by the plate current in amperes. Thus for a 245 tube operating with 250 volts on the plate, the required "C" bias voltage is about 50 volts. The plate current with this plate voltage applied is 32 milliamperes, or .032 ampere. Therefore the "C" bias resistor is

$$\frac{50}{.032} = \text{about } 1500 \text{ ohms.}$$

If two or more similar tubes are to obtain their "C" bias from a single resistor, the value of this resistor is calculated by dividing the resistance of the resistor required for one tube by the number of tubes to be operated with it. This is due to the fact that under this condition the total plate current of all the tubes flows through the "C" bias resistor causing the voltage drop used for "C" bias. Thus, since the voltage drop equals the current multiplied by the resistance, it requires less resistance to produce the given voltage drop. Thus if one 227 tube requires a 2000 ohm "C" bias resistor, four tubes operated with one resistor will require one of

$$\frac{2000}{4} \text{ or } 500 \text{ ohms.}$$

INCREASING WAVELENGTH RANGE OF SUPER-WASP RECEIVERS

8. How can I increase the tuning range of the Super-Wasp receiver to about 550 meters?

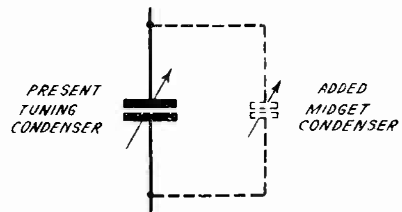


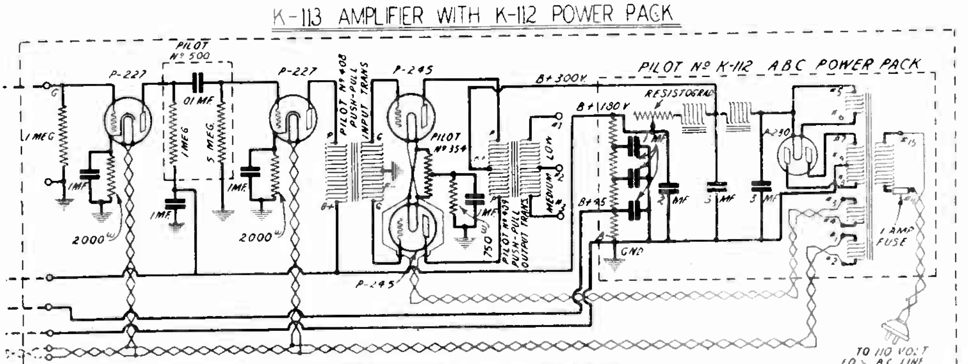
FIG. 5

Increasing the wavelength range of the Super-Wasp by adding midget condensers.

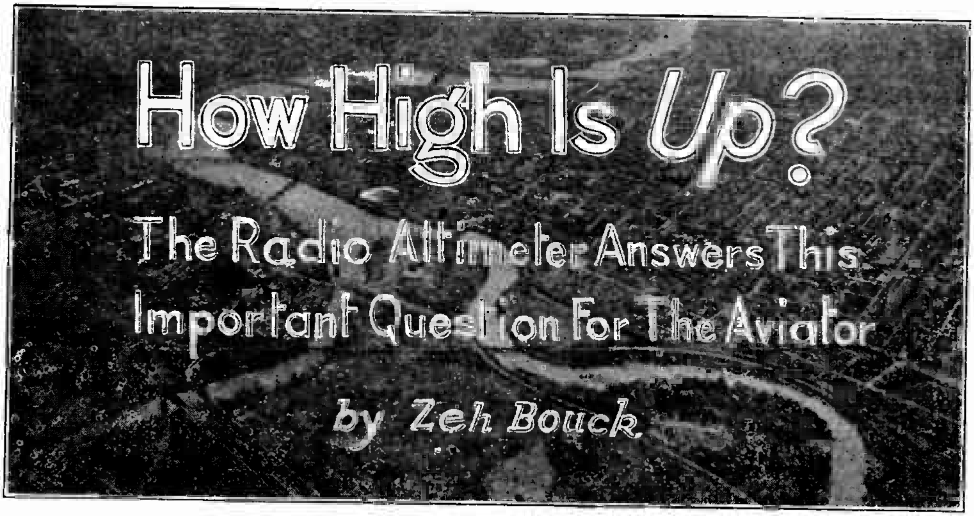
Answer: You can increase the wavelength range of your set by connecting a Pilot No. J-23 midget condenser across each of the tuning condensers in the set. They should be set at a fixed maximum capacity when receiving stations above 500 meters and should be set at minimum capacity for all wavelengths below this. The regular tuning condensers are used for the actual tuning.

The midget condensers may be mounted directly on the sides of the shields; their rotors will then be automatically "grounded" to the framework of the set. Run wires from the stator posts to the stator posts of the No. 1611 tuning condensers, and the job is complete.

K-113 AMPLIFIER WITH K-112 POWER PACK



The hook-up of the K-113 push-pull amplifier. Both the Pilot Twin Screen-Grid 8 and the K-113 were described in the Fall issue of "Radio Design". Full-size blueprints may be obtained for 10 cents each.



THE question, "How high is up?" enters the intelligent category of "What time does the five fifteen arrive?" Both questions were intended, originally, to be foolish ones. Unfortunately, because the train never arrived on time, the five-fifteen gag became a legitimate question: and no aviator, noting that his barometric altimeter shows an altitude of five thousand feet, knows how high he really is above ground. All that he does know is that the plane is five thousand feet above the field he started from *if* he remembered to set the needle at zero before he took off and *if* the weather hasn't changed.

It is rarely indeed that one may set the needle of an altimeter to zero at the point of departure and find it with a hundred feet of zero at the end of the flight. The discrepancy is generally in the neighborhood of five hundred to a thousand feet. A pilot flying from New York to Albany will find that his altimeter shows a height of nine hundred feet when the plane is on the ground at the Albany airport. Albany is nine hundred feet higher up than Roosevelt Field, New York. And as he taxis up to the hangar at his home port the next day he may be surprised to note that, theoretically, at least, he is still five hundred feet in the air. The barometric altimeter functions with changes in atmospheric pressure, which, in turn, vary with altitude and weather conditions.

These changes are not particularly bothersome in clear weather, but in fog or rain they have, in a woeful number of instances, been fatal. Almost every crash into a mountain or hill in thick weather can be directly attributed to an unwise dependence upon a barometric altimeter.

A pilot will seldom fly above clouds, when it is at all possible to fly under them. When flying above the clouds there is the added danger of becoming lost, and the more direct hazard of having to come down through them into an unknown terrain that may extend up into the comfortable looking billows. He prefers to skirt along just under the ceiling, particularly when he knows his country—knows that the highest altitudes he has to pass over are, say four thousand feet, and according to his altimeter and observations he has a forty five hundred foot ceiling. But a five-hundred foot leeway with a barometric altimeter is most treacherous, and more than one transport ship, depending upon an inaccurate altitude, has crashed into the side of a mountain peak that just shouldn't have been there.

ABSOLUTE ALTITUDE

The obvious need is for an instrument that will indicate absolute altitude: the actual altitude of the plane above the ground immediately under it. The necessity for such a device has long been recognized in army and commercial flying circles, and it becomes particularly urgent as it now remains the only obstacle to consistent flying regardless of weather conditions. With multi-motored engines, the possibility of a forced landing becomes remote. It is possible by means of the radio beacon to guide a plane exactly to its destination through the thickest fog. The development of the airplane gyroscope eliminates the hazards of blind flying. It only remains to put the plane down on a fog covered field, a fog that may hug so closely to the ground as it blankets it completely from a height of ten feet.

NAUTICAL DEPTH INDICATORS

An absolute indicator of depth, or nautical "altitude," is employed by all large oceanic vessels when coming in through a heavy fog. A sound signal is transmitted through the hull of the ship, by means of an audio oscillator, and the time period between the transmission of the impulse and the return of the echo from the ocean bed is noticed. The speed of sound through water being known in thousands of feet per second, this speed multiplied by the number of seconds it took for the sound impulse to travel from the ship to the bottom of the sea and back again, gives the number of thousands of feet the sound traveled. Dividing this by two we have the depth.

Unfortunately it would be difficult to apply this exact and simple system to the determination of airplane "depth", or rather altitude, though C. Francis Jenkins is working on just such an arrangement. The air is a much less efficient medium for the transmission of sound than water, and the cabin of a plane is, almost fundamentally, a noisy place.

THE RADIO ECHO

Nevertheless, it is an echo system that has been most successfully employed in the absolute altimeter systems so far developed. However, a radio wave is used instead of a sound wave. This rather obviously complicates matters, for radio waves travel 930,000 times as fast as sound waves. It is impossible by direct means to measure the time interval between the transmission of a radio signal and its reflection from any object, such as the ground, five thousand feet away. It would traverse this return journey in one ninety-three-thousandth of a second. However, it is possible to measure much smaller time intervals by indirect means. Many of the readers of RADIO DESIGN will recall the simple experiments with light by which interference bands are created, which, virtually, constitutes a measurement of time intervals of perhaps trillonths of a second. So, after all, the job of measuring the period of a radio echo is not so difficult a matter.

Curiously enough, the system employed for measuring this time interval was discovered, accidently, by Dr. Alexanderson, when experimenting with a different and apparently more simple form of radio altimeter. His original altimeter idea consisted of a local oscillator, and a secondary oscillator connected to an open antenna system on the plane. The two oscillators were tuned sufficiently close, so that, by listening to telephone receivers plugged in the second oscillator, a beat note, or squeal, could be heard. It seemed logical that, as the plane neared the earth, the capacity of the antenna system would be increased, the frequency of the second oscillator lowered, with a noticeable difference in the beat note. This happened. But the changes in the beat note did not follow in accordance with the changes to be expected from purely capacitative variations. There were periodic leaks that were not covered at all by the original theory of operation. It was later proved, by exhaustive tests, that these unusual variations were caused by a reflected wave from the ground varying the frequency of the oscillator on the plane!

THE LOCKING EFFECT

In other words, the frequency of an oscillator is governed wholely by the capacity and inductance of the circuit *only when it is influenced by exterior oscillations* of almost the same frequency or the same frequency with a phase difference. This influence of one frequency upon another can be observed in tuning to a zero beat. It is possible to run the entire gamut of beat frequencies from the highest audio frequencies down to about fifty or forty cycles, by varying the capacity or inductance of one circuit. However, at this lower point, the two frequencies "lock" (even though the capacitative or inductive values of the two circuits are slightly different) and a zero beat results.

As the altitude of the plane varies, the phase of the reflected wave, in respect to the

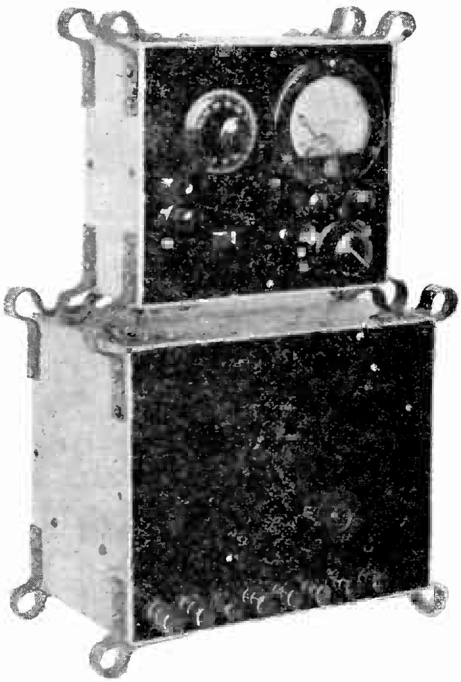
A view of the new monoplane just purchased by the Pilot Radio and Tube Corporation for use as a flying laboratory in the development of radio altimeters and other aircraft radio equipment. This plane, powered with a 300 h.p. engine, replaces the other ship described and pictured in past numbers of "Radio Design."

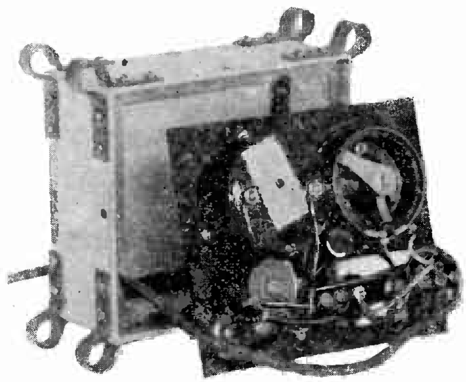
wave leaving the ship, varies. At an altitude equal to half the wavelength, the reflected wave, received back on the plane, is in phase with the outgoing wavelength. At an altitude equal to three quarters wavelength the two oscillations will be bucking. At an altitude of one wavelength the reflected wave will again be in phase with the local oscillations. We therefore have periods, varying with fractions of a wavelength at which the return signal either bucks or assists the generated signals. *These varying conditions change the frequency of the oscillator.* When the returned oscillations are assisting we have a higher frequency, or a maxima, when they are in opposing phase, the frequency is lowered, and we have a minima, a half wavelength of altitude covering a complete cycle. Employing a wavelength of 100 meters there will be a maxima every fifty meters (approximately 160 feet), the maximas and minimas becoming less pronounced as the altitude increases. However, they have been definitely observed as high as four thousand feet above the nearest ground. These maximas have been made to actuate lights and meters calibrated in feet as positive instrumental indicating devices.

By employing two transmitters, it is possible to obviate any confusion as to which maxima is being observed. For instance, length will have maximas in multiples of ten and thirteen meters, but only one *common* "altitude point" (within reasonable flying altitudes) at two thousand feet. By using ten and thirteen meters, each wave-varying altitude until both receivers show a maxima simultaneously, the plane will be brought to exactly two thousand feet above the ground immediately beneath it.

HOW PLANES WILL FLY BLIND

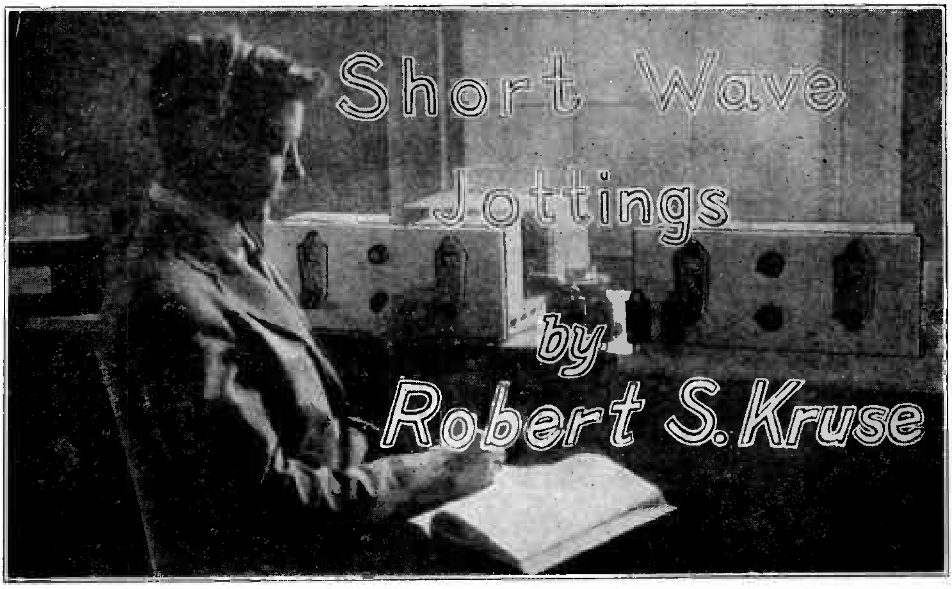
The plane, with its cargo of passengers and mail, is guided to the field by radio beacon, in a combination, let us say, of night and fog. Over the field, the pilot sets a sensitive barometric altimeter, reading in units of five feet, against his radio altimeter. The barometric altimeter will now be exact, for this field, until weather conditions materially change. He circles the field, picks up a radio beacon course showing him the direction of the longest runway. (There is next to no wind with heavy fog.) A marker beacon tells him that he is three thousand feet from the field. He notes that his altitude is three hundred feet—enough to clear obstructions. A second marker beacon flashes a half minute later on the instrument board before him. This means he is five hundred feet from the border of the field, all obstructions behind him. He quickly loses altitude, cutting the gun, while the gyroscope keeps the plane on an even keel. The altitude drops—two hundred, one hundred fifty, thirty, twenty, ten feet. He slowly pulls back on the stick, watching the altimeter. He eases up on the control at the slightest tendency of the plane to rise. Shortly the wheel is back against his chest, the plane settles, the wheels touch, and the plane is down, in the perfect and proverbial three-point landing.





Left: Radio altimeter equipment arranged in compact form for spring suspension in aircraft. The lower box contains the oscillator transmitter-receiver, the upper one, the registering apparatus. Top: View of the inside of the registering apparatus.

—Photo Courtesy of "Aero Mechanics Magazine.



THIS department must apologize. Some part of Mr. Fred S. Beach's Moscow-and-Khabarovsk-to-Portland reception either didn't happen or else didn't happen as related in the last issue. We are not at all clear on the matter. However, Mr. Beach feels that too much credit has been given him, therefore, 15% of it is hereby withdrawn and replaced by a compliment on his good sportsmanship.

PUSH-PULL DETECTION

SEVERAL have written me of late to raise once more the question of push-pull detection as applied to short-wave receivers, suggesting that it might afford better fidelity or larger output.

Neither advantage seems to me likely of attainment. The lack of fidelity which is so often associated with short-wave signals is not manufactured at the receiver but in the transmission mediums which we are pleased to call "ether" and which we suppose to occupy the space thru which the signal came to the receiver. The signal having been damaged in transit, it is unfair to expect any detector to perform both demodulation and correction of etheric distortion. Assuming that the signal did avoid damage en route and arrived in good order, there still seems to be no reason why a special detector is desirable.

For "small signals" a leak-and-condenser detector is admittedly more sensitive than the bias detector. In a broadcast receiver this advantage is mostly lost because the low resistance of this sort of detector damages the performance of the preceeding R.F. transformer. However, in short-wave receivers we almost invariably provide regeneration, which permits us to wipe out this loss entirely, leaving the leak-and-condenser detector with a clear margin of advantage.

The power capacity of the leak detector is limited and one may come on the thought that if it is preceeded by a stage of tuned R.F. (as in the Super-Wasp receivers) the detector may be overloaded. It is certainly quite possible to overload the detector—but it will not be done. Quite a long ways before the detector is overloaded we will find the 2nd audio tube so overloaded that the listener will reduce the signal to protect his sensibilities. Putting it differently, a 227 leak-and-condenser detector can very nicely supply enough audio output so that one stage of 227 first audio will in turn provide ample input to a final stage of 227 to overload the last tube hopelessly. This statement hold even though the last tube is operated at 300 volts and the inter-stage coupling devices are of low-ratio or resistance type.

There is another good reason for using leak detection. This is that it permits the direct grounding of the cathode and thereby materially reduces the tendency toward A.C. hum, always a major problem with a regenerative detector.

If one is to handle a large signal the obvious device is the bias detector (I like the British term "anode bend" detector) with high enough plate and cathode voltage to handle the signal. There are commercial receivers to show that good fidelity may be maintained while operating the detector at such a level that its output is sufficient to operate a push-pull pair of 245 tubes without the aid of any first audio stage whatever. Unless one is near a short-wave station the signal necessary to operate such a system will not be available. An attempt to create it by means of several stages of tuned R.F. will prove interesting and also troublesome. Doubtless, there will be such receivers later on, but at present a high-gain 20 meter amplifier is somewhat of a laboratory proposition, especially if it is to raise the signal to 5 volts R.F. to operate the detector just mentioned.

The push-pull detector is also inconvenient when renegeration is to be used; and regeneration is almost always used at short waves because of the comparative difficulty of outright R.F. amplification which was just mentioned. A push-pull regenerative arrangement with controllable regeneration becomes rather messy and the tubes show a discouraging tendency to operate unevenly. It is usually quite impossible to secure as much output as when one tube is removed. (This statement does not apply to the push-pull amplifier, either radio or audio.)

If there be needed argument as to the undesirability of push-pull detection, it is furnished by the inconvenience of coupling to the first audio tube, no entirely suitable device being available.

PUSH-PULL AUDIO WITH SIMPLE EQUIPMENT

WHILE still on the subject of push-pull, let me pass on a rather clever circuit arrangement of Paul Mueller. It is useful where push-pull equipment is lacking, or has been damaged, also as a temporary expedient to determine whether push-pull will be of advantage. The circuit for separate heater tubes is shown in Fig. 1A; for 171A or 245 power tubes in Fig. 1B.

TR is a perfectly normal audio transformer, preferably of good grade and with a ratio of 3 to 1 or thereabouts. It is provided with an artificial center-tap by use of the two ¼ megohm resistors, R1 and R2. The bias resistor R3 of the cathodes must, of course, have half the resistance which would be used for a single tube. If preferred, two resistors may be used, each of the proper value for one tube and each having its own by-pass, though that may be left off with no special harm. The plates are fed thru two chokes, CH1 and CH2. These can be almost anything, as long as the two are alike and have the same inductance. A pair of audio transformer primaries, a pair of filter chokes, a pair of output chokes, or whatever else is at hand and has an inductance of 30 henries or more, will answer. In an extreme pinch it is even possible to use a pair of resistors with a value around 10,000 ohms each, though that requires a "B" voltage about twice that normally needed for the tubes, or even 2½ times. The resistors must, of course, be able to carry the plate current. The output is taken from plate to plate as shown. If one prefers not to be killed by the plate voltage, it is best to put a 2 or 4 microfarad condenser in each lead.

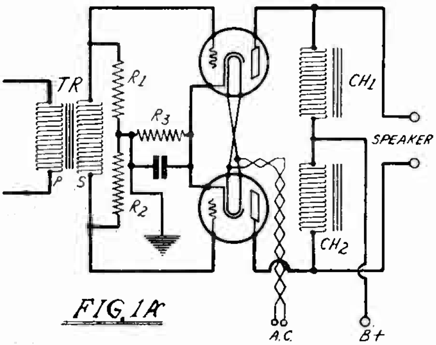


FIG. 1A

Trying push-pull audio amplification without push-pull transformers, with heater type tubes.

SUPER-WASP CHANGES

TWO simple alterations are possible in the Super-Wasp which are of advantage, respectively, in very good and very bad locations.

In the very good locations, where there is little local interference, it is helpful to be able to cut out the antenna series condenser readily when working in the broadcast band, where the reactance of this condenser is high and therefore cuts down the signal from even a large antenna. The thing is done easily by turning over a small corner of one rotor plate (Fig. 2) so that the condenser shorts when turned to the "all in" position. The main defect of the arrangement is that the volume jumps greatly when the switching arrangement takes place, which is alright with a loud speaker but rather tremendous with a headset.

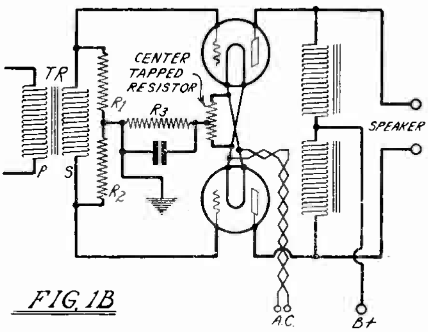


FIG. 1B

The same idea as Fig. 1A but with 171A or 245 tubes in the push-pull stage.

In the very bad locations, where there is very bad local interference, a quite surprising improvement may be made by shielding the screen grid tube inside its stage shield. The change does not help particularly in most locations, only where the intereference is so intense that several coils of the set are rendered useless. For instance, at one location a 50 kilowatt broadcast station, three miles away, completely blanketed the blue, green and yellow coils, and even created a background on the orange coil. An aluminum tube shield, sold at the chain stores under the name of "Twin Coupler," was dropped into place over the tube, grounded to the main stage shield by an inch of wire (Fig. 3) and the stage-shield cover replaced. The interfering station disappeared completely from the orange, yellow and green coils, also from the lower half of the blue-range coil. Even longer wave stations like WEAF could now be received decently. The wire grounding the tube shield needs to be short

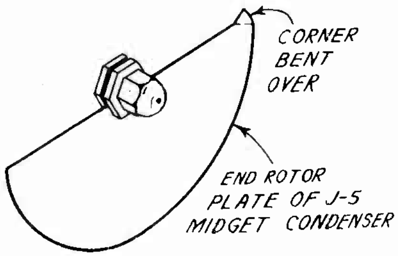


FIG. 2

With the corner of the rotor plate bent as shown, the J-5 condenser may be shorted out of the antenna circuit.

and was accordingly run from one of the screws in the stage shield to another screw passed thru the top of the tube shield. At the same time, the latter was being drilled for a few extra holes were made (v, v. v) thru the top of the tube shield to aid in cooling the tube. The improvement was certainly worth 30c.

"CODE INTERFERENCE"

THE usual winter crop of complaints as to "code interference" has begun to arrive, and as usual it comes mainly from the cities.

That it should be a winter complaint is natural, for the winter brings longer receiving ranges, puts more stations of all sorts on the air for more hours a day and finally causes the listener to be at his set more so that he becomes aware of the tangle in the ether. Just why the city man should feel worse about it than the small towner is not so clear; why should a little interference worry a man whose nerves have been blunted by daily exposure to the appalling din of the subway or elevated?

None the less, worry there is, and a demand for relief. Very well, let us first be sure who or what is actually causing the interference. First, we must call in some one who can read the code well and have

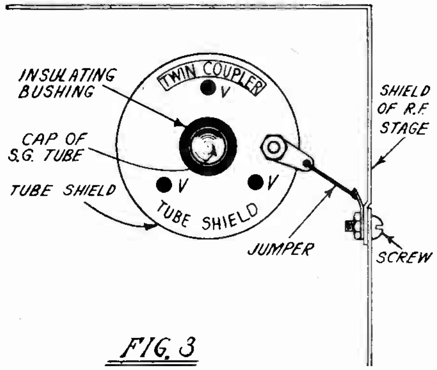


FIG. 3

A Twin-Coupler tube shield connected as shown often helps the screen-grid tube along.

him spend several hours identifying the interfering station or stations—remembering that his time is worth money, the same as anyone else's. If the troublesome signal does not appear when he is there, take his telephone number, provide yourself with a headset and a cord long enough to reach the phone and when the signal next appears call him, clap the headset over the mouthpiece and have him listen in this way. Do NOT use a loudspeaker, for the result is a mere jumble of noise at the other end of the phone line.

If it turns out that the "station" is a bad light in the bathroom or a defective lighting line nearby, take the matter up with the electrician or the power company. If it is a commercial radio telegraph station write the operating company a courteous letter and have it signed by as many neighbors as have the same difficulty. It isn't a bad idea to get acquainted with one's neighbors. Quite likely also it will help to visit the station (if it is accessible) and talk to the operating staff, remembering that a grin and a cigar produce more power-reductions than a scowl and a demand. If the station is an amateur one, visit it and talk with the operator for the purpose of determining if his transmitter or your receiver be at fault, or if the condition is unavoidable. The right sort of amateur, although it is no way his duty, will go to much trouble to improve your receiver or to avoid operation during the evening hours.

Not until these peaceful means have failed is it time to use force. The only authority to use such force resides in the office of the Supervisor of Radio for your district, of which there are nine in the country. Your radio dealer can tell you where your supervisor's office is located. The supervisor is invariably a man of long years of radio training, but he is neither a magician nor an absolute monarch. He cannot *and must not* interfere with a station simply because someone says that the station is a nuisance; this would be about equivalent to telling the Chief of Police to arrest Jones because "nobody around here likes him." As yet we do not jail people simply because they fail to please everyone they meet, nor do we take stations off the air simply because their appeal isn't universal.

KEEP A LOG

If the station, or stations, seem to be troublesome to a degree not covered by any of these things, it may indeed be time to sharpen the axe and hand it to the supervisor for use. Call in the code man again, secure the cooperation of as many neighbors as are troubled with you, and with a good supply of paper start keeping records in the shape of proper radio logs. Each sheet must carry your name and address and the date, the left margin must at frequent intervals show the time by a reliable watch and the bulk of the page is to be filled with copious notes as to the time and nature of the interference, the wavelength at which the tuner was set and any unseemly things the transmitter appears to be guilty of, especially excess calls and needless signals. Ten pages of such material, spread over several weeks, confirmed by several other observers and accompanied by letters stating the type of tuner, antenna, etc., used, will give the supervisor's office both ammunition and a target.

WHAT ONE HAS A RIGHT TO HEAR

WE have all heard that short-wave signals do not behave like long-wave signals, but instead go up into the air, miss many miles of territory and come down at a more distant point, where they can be heard again.

Most of the explanations of the performance seem to me to be too complicated for any good use. After all, the ordinary person does not care what the scientific explanation is; he merely wants to know how he may know what it is possible to hear and what isn't worth trying for. The curves herewith show what one may expect to hear, summer and winter, day and night.

The charts are not complicated and no explanation for their use need be given beyond saying that if you know the wavelength and distance of a station you may look at the proper one of the four charts and see at once if there is a reasonable prospect of hearing the station. If it falls well within the "Ground Wave" area you will very probably hear it quite regularly unless the station is weak or your location badly shielded by buildings or hills. If the station falls into the "Sky Wave" region, you may hear it at the time of day and year for which the chart is made, screening now being less deadly since the wave comes slanting down at your antenna. Finally, if the station lies near the right-hand edge of the "Sky Wave" area, you are in the position of having to try your luck.

If the weather, the sunspots, and the station, itself, are all working properly, you will hear it even tho it lies outside the area a bit. On the other hand, if weather, sunspots or transmitter are adverse, you may miss it entirely, even tho it lies somewhat to the left (inside) of the right-hand border of this area. Since this edge is the final and permanent "fadeout" of the signal it is naturally somewhat hayy and variable, easily affected by all sorts of things.

WHAT THE CURVES MEAN

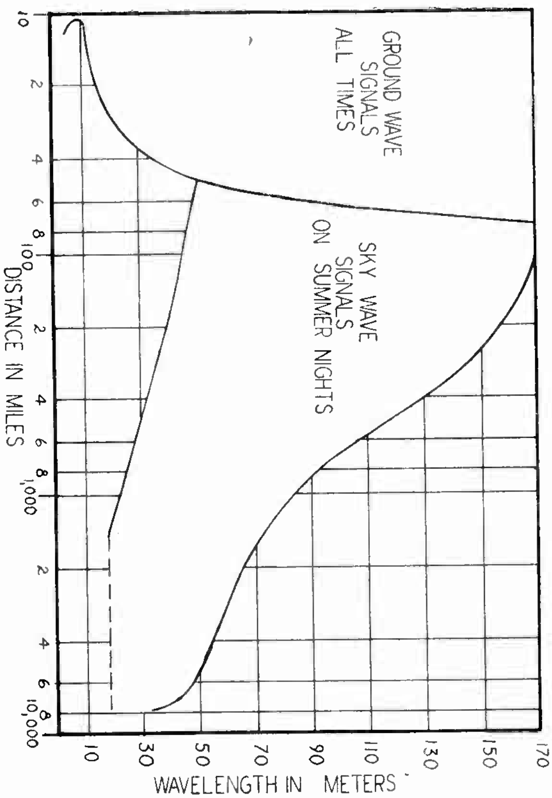
It will be noticed that the end of the "Sky Wave" territory is shown by a dashed line instead of a solid one. This means simply that one must expect a great deal of variation here, for one is "on the edge" as to both wavelength and distance and the limits are hazy. Thus, the Summer-day "Sky Wave" territory is shown as having two sorts of endings, simply because it was not posible to get an agreement between the information of various observers at this rather indefinite point.

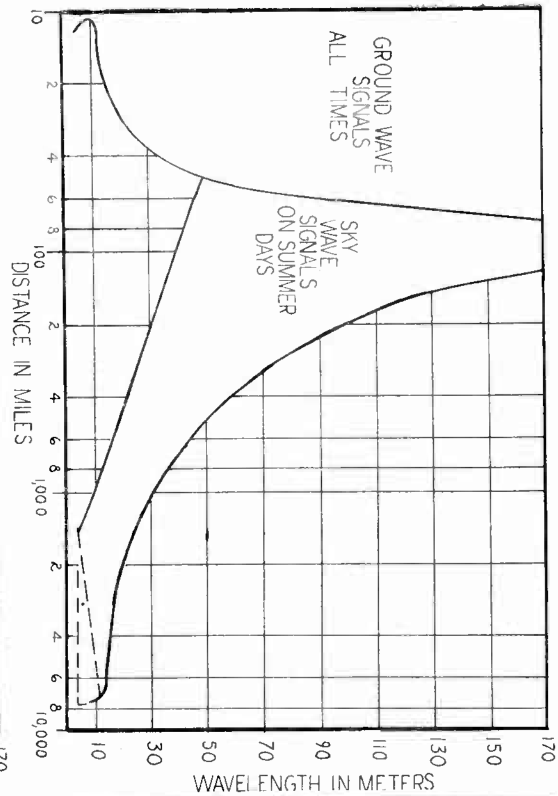
It will also be seen that the area of Ground Wave Signals is shown as having a sort of reverse kink below 10 meters, the reliable range of 6 and 5 being a bit better than that of 10. On this point observations do not agree entirely, but for the present, there are few stations at that wave to bother about, and fewer receivers that can tune to it.

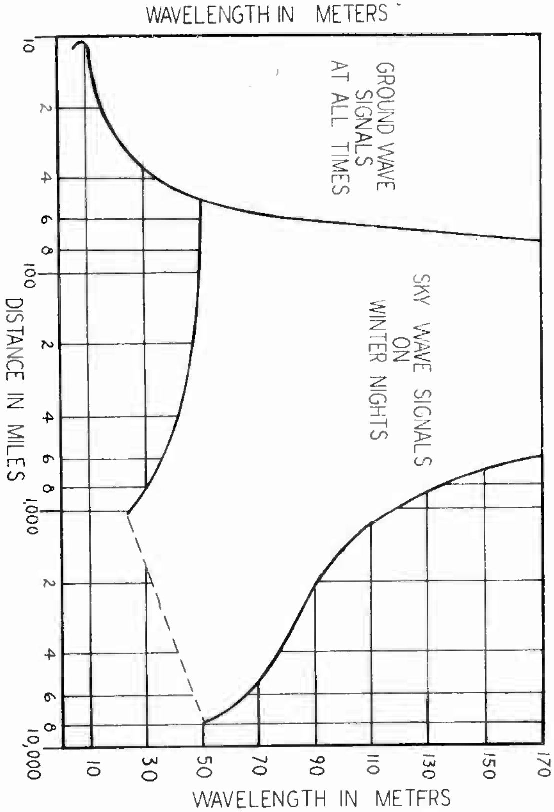
The general shape of the curves results from the average of three sets of reliable observations, each of which embodies many thousands of transmissions. The most veight has been given to the figures orignating at the Naval Research Laboratory, because more work of this sort has been done there than elsewhere, and over a longer period.

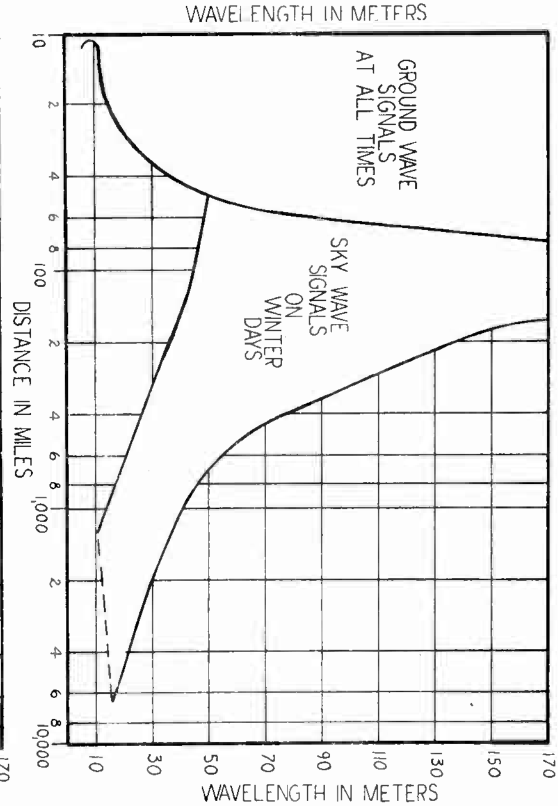
EXCEPTIONS, OF COURSE

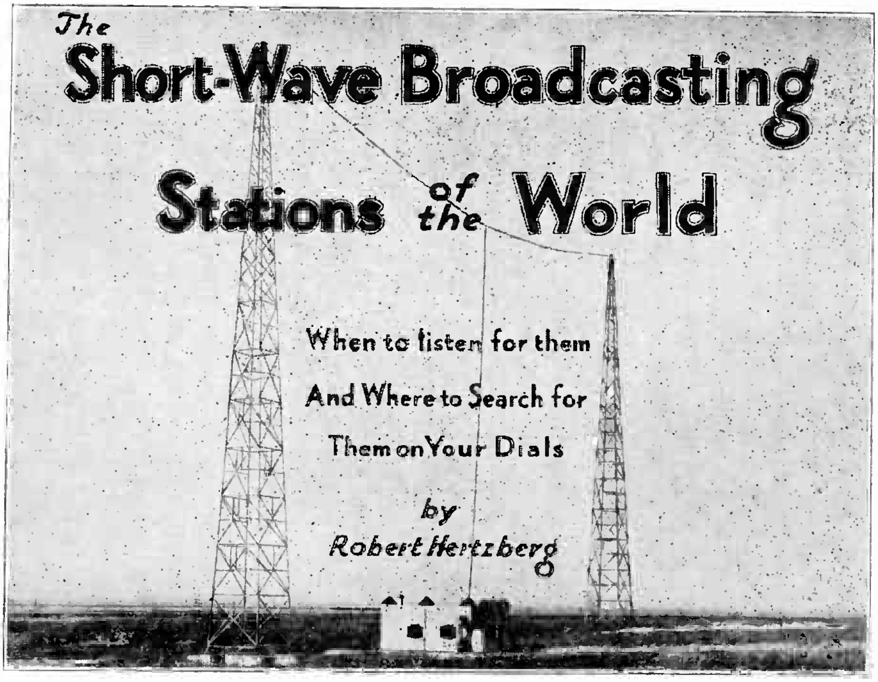
Exceptions: Practically never will signals act *exactly* as the curves say they shall, just as it would be nearly impossible to find an "average man" who was of exactly average height, weight, intelligence, health, wealth, strength, complexion, etc. None the less, a signal which acts very much different is a freak, just as a seven-foot man is a freak. On the other hand, one may quite easily find a time or a place where signals consistently violate some part of the chart with the same regularity as Sweden produces men of more than average size.


GROUND WAVE SIGNALS ALL TIMES
SKY WAVE SIGNALS ON SUMMER NIGHTS
DISTANCE IN MILES
WAVELENGTH IN METERS


GROUND WAVE SIGNALS ALL TIMES
SKY WAVE SIGNALS ON SUMMER DAYS
DISTANCE IN MILES
WAVELENGTH IN METERS


GROUND WAVE SIGNALS AT ALL TIMES
SKY WAVE SIGNALS ON WINTER NIGHTS
DISTANCE IN MILES
WAVELENGTH IN METERS


GROUND WAVE SIGNALS AT ALL TIMES
SKY WAVE SIGNALS ON WINTER DAYS
DISTANCE IN MILES
WAVELENGTH IN METERS



The above photo shows the antenna system and transmitting house of station WABC.

MOST owners of short-wave receivers are able to pick-up foreign broadcasting stations without any trouble if they just happen to listen in at the right time. However, many short-wave fans do not seem to hit the right moments, and will sometimes listen half a dozen or so times a week without hearing anything outside of KDKA. They have frequently written for definite operating schedules, so RADIO DESIGN presents herewith what it believes is the most complete and most authentic list of the short-wave broadcasting stations of the world ever published. Where the actual operating hours are known, they are given in Eastern Standard Time, so that listeners may "fish" for them with some assurance that the transmitters are actually on the air.

It must be emphasized that most short-wave stations are purely experimental in nature, and in many cases their owners cannot give operating schedules because they have no fixed hours.

We'll start with the United States, and proceed to the other countries. If you learn to tune in the American stations, and record their dial readings, you will have a pretty good idea where to search for stations of lower or higher wavelength.

UNITED STATES

WABC-W2XE, station located at Cross Hassock Bay, L. I. (on road leading into the Rockaways); owned and operated by the Columbia Broadcasting System, office 485 Madison Avenue, New York, N. Y. Wavelength, 49.02 meters, or 6120 kilocycles, power 500 watts. Transmits the same programs as WABC. Is on the air without interruption every day from 8 a. m. Eastern Standard Time to 1.00 a. m. the following morning. W2XE is the most active short-wave station in the world, operating continuously 17 hours a day. Station is readily identified because announcer always says "These are stations WABC and W2XE". Will soon have a 20,000 watt transmitter operating on any one of three wavelengths for international broadcasting: 19.63 meters (15,280 kc.), 25.34 meters (11,840 kc.), and 49.02 meters, (6120 kc.). Reports from listeners desired.

WGY, Schenectady, N. Y. General Electric Company. Operates a whole group of experimental short-wave stations. These are W2XAF, 31.48 meters (9530 kc.); W2XAD, 19.56 meters (15,340 kc.); and the following stations which are licensed to operate on any one of the frequencies listed afterward: WXO, W2XAH, W2XAK, W2XAZ, W2XH, W2XK, and W2XAC. Frequencies: 1604, 2398, 3256, 4795, 6425, 8650, 12,850, and 17,300 kilocycles. W2XAW is licensed for the same eight frequencies and in addition may use 23,000 kc. and above, or 13 meters and below. These stations broadcast the regular programs of WGY during the periods they are on the air.

Evening programs are transmitted by W2XAF on Monday, Tuesday, Thursday and Saturday, and by W2XAD on Monday, Wednesday, Friday, Saturday and Sunday. See your local newspaper for any National Broadcasting Company program for exact hours. Afternoon schedule: W2XAD, Sunday, 2.30 to 5.40 p. m.; Tuesday, 12.00 to 5.00 p. m.; Thursday, 12.00 to 5.00 p. m.; Friday, 2.00 to 3.00 p. m.; Saturday, 12.00 to 5.00 p. m. W2XK, Tuesday, Thursday, Saturday, 12.00 to 5.00 p. m. Where two stations are listed for the same time, it means they are both broadcasting the same program.

Every Monday night from 8 to 9.30 p. m., the English announcements are translated into Spanish, for the benefit of South American listeners.

Other special features: Early morning programs from W2XAF, 6.00 a. m. to 7.00 a. m., daily except Sunday, for benefit of Australian and New Zealand listeners. Television license, W2XACW, 139.5 meters, 2100 to 2200 kilocycles. Experimental airplane license, W2XCH, frequencies of 2302 and 3076 kc. Alternate Saturday nights, special programs to Commander Byrd, beginning at 11.00 a. m., by W2XAC on 34.5 meters in addition to W2XAD.

W2XAL - WRNY, Aviation Radio Station, Inc., Coytesville, N. J. Wavelength 49.9 meters (6040 kc.) On the air at 11.30 a. m., 3.30 p. m. with weather reports, aviation news. Also 11.30 p. m. to 12.30 midnight every night, testing.

W9XF, WENR, Chicago, Ill. Wavelength 49.83 meters, power, 5000 watts. Relays all the WENR programs except daytime broadcasts on week-days between 9.00 a. m. and 5.00 p. m. Sunday morning programs are broadcast. (Data taken from newspaper clipping. Station probably on air throughout evening from 6.00 p. m. to about midnight.)

KDKA-W8XK, Westinghouse Electric Mfg. Co., East Pittsburgh, Pa. 25.4 meters (11,814 kc.) and 62.5 meters (4800 kc.) Known to be on the air every evening, but station does not answer letters or telegrams requesting information. 62.5 meter transmitter a stand-by for testing receivers, as it is very reliable in the United States.

WLW-W8XAL, Crosley Radio Corporation, Cincinnati, Ohio. Wavelength, 49.50 meters. Another powerful and consistent short-waver, but its owner evidently wants to keep its schedule a secret. Heard regularly during the evening hours.

W6XN-KGO, Oakland, California. 23.35 meters, Relays the regular programs of KGO. Tuesday, Wednesday, Friday, 12.30 to 4.00 p. m. Also after 9.00 p. m., experimental transmissions. Delivers a powerful signal in the East. Handles NBC chain programs, so don't be fooled by the New York or Chicago announcers Wait for the announcements at the end of each 15-minute period, so that you can hear the KGO announcer tell you that you are listening to California.

W2XCR, Jenkins Television Corporation, Jersey City, N. J. 107 meters (2800 kc.). Week days from 3.00 to 5.00 p. m. and 8.00 to 10.00 p. m. Also, W3XK, same firm, Washington, D. C., 142.5 meters, daily except Sunday, 8.00 to 9.00 p. m.

Various call books list a large number of American short-wave broadcasting stations, but the great majority of them are not on the air. If you hear or read about any new ones, please let us know.

There are also a number of short-wave telephone stations along the Atlantis seaboard, engaged in radio-telephone service with Great Britain. These are private stations, and are not to be classified as broadcast transmitters. Similarly, the English telephone stations are private in nature, and little data on them is available. It is quite easy to hear the English end of the circuit. The wavelengths skip all over the scale; down about 16 or 18 meters during the day and up in the neighborhood of 30 during the evening.

SUPER-WASP OWNERS!

You can help the short-wave game greatly by reporting to RADIO DESIGN *the short-wave broadcasting stations that you pick up. Tell us the dial readings, wavelength or frequency, if announced, the nature of the announcement, and the time you accomplished the reception. The more information of this kind you send in, the more pleasure will you obtain from your receivers, as we will publish the "dope" for the benefit of everybody. A post card with the facts on it is enough. Address,* RADIO DESIGN, *103 Broadway, Brooklyn, N. Y.*

CANADA

CJRX, Winnipeg, Manitoba, James Richardson and Sons, Ltd. 25.6 meters, 2000 watts. All programs from CJRW, as follows: Daily, except Sunday, 5.30 p. m., to 8.30 p. m., music, talks. Sunday, 11.30 a. m. to 1.00 p. m., sacred and classical music, 10.00 to 11.00 p. m., Royal Alexander Hotel Concert. Tuesday, 5.30 to 10.30 p. m., music, talks. Thursday, 5.30 to 11.00 p. m., music, talks. Saturday, 5.30 p. m. to midnight, music, talks. French lessons on Tuesdays and Fridays, 7.50 p. m. to 8.00 p. m. CJRX is another powerful and reliable station, and you will find its programs very interesting.

There are a number of radio-telephone stations in Canada working with England. Like the American stations, these are private undertakings, and have nothing to do with broadcasting, although the telephone conversations can be picked up without much difficulty. The wavelengths are subject to change without notice.

ENGLAND

G5SW, Chelmsford, England. 25.53 meters, 15,000 watts. 2.00 p. m. to 7.00 p. m. daily, silent Saturday and Sunday. Experimental transmissions 7.00 to 9.00 p. m. Monday and Wednesday and 7.30 to 8.30 a. m., irregular intervals. Tests with American W2XO Monday and Thursday, 12.00 to 1.00 p. m. Heard quite regularly in the United States. Famous for its transmission of the midnight chimes of "Big Ben" when it signs off at 7.00 p. m. Eastern Standard Time, it then being midnight in London.

HOLLAND

PCJ, Philips Radio, Eindhoven, Holland. 31.4 meters, 27 kilowatts. Latest schedule is Thursday, 1.00 p. m. to 3.00 p. m. and 6.00 p. m. to 10.00 p. m. Friday, 1.00 p. m. to 3.00 p. m., 7.00 p. m. to 1.00 a. m. Saturday morning.

Announcements are made in six languages: Dutch, English, French, German, Spanish and Portuguese, according to the country to which the particular program is dedicated. As a rule, English is always used, in the form of this announcement: "Hello, this is station PCJ of Philips Radio, Eindhoven, Holland, broadcasting on a wavelength of 31.4 meters to the Argentine, Australia etc."

PCJ was one of the first short-wave broadcasting stations, and is probably the most widely heard. It is heard regularly in the United States and can be tuned in quite easily.

Associated with PCJ are a number of other transmitters, mainly engaged in a telephone service to the Dutch possessions in the East Indies, but also heard broadcasting regular programs. Notable among them is PHI, Huizen, Holland, on 16.88 meters. Monday, 8.00 to 11.00 a. m.; Wednesday, Thursday, Friday, 7.00 a. m. to 11.00 a. m.

The stations in Java are also heard frequently. There is PLE, Bandoeng, on 15.74 meters, and PLF, Malabar, 17.7 meters. PLE is on the air Wednesday, 7.40 a. m. to 9.40 a. m.; PLF, from 9.00 a. m. to 11.00 a. m. There is also a station PCK, in Kootwik, Holland, on 16.3 meters, broadcasting at 11.00 a. m. daily.

FRANCE

The French short-wave stations are just beginning to be heard in the United States. Reports on them are very much desired.

Station at Nancy, France. 15.5 meters, (19,754 kilocycles) 5.00 p. m. daily, news and weather reports.

Station at Ste. Assise, France. 24 meters (12,500 kc.) 6.00 a. m. to 8.00 a. m. daily.

Eiffel Tower, Paris. 49 meters, (6122 kc.) 7.30 a. m. to 7.45 a. m., 2.15 p. m. to 2.30 p. m., 7.15 p. m. to 7.45 p. m., daily.

New Experimental station in Paris. 31.65 meters (9479 kc.), 5.00 p. m., and 6.00 p. m. daily.

Paris-Vitus. 33 meters, (9091 kc.), 3.30 p. m. daily.

Agen, France. 38 meters, (7894 kc.) 8.40 a. m. daily.

Rugles, France. 55 meters, (5455 kc.) with 500 watts. 9.30 a. m., and 5.00 to 8.00 p. m. daily.

GERMANY

Koenigswursterhausen, (Berlin) Germany. 31.88 meters. The Reichs-Rundfunk Gesellschaft, Berlin, Germany, would like reports on this station. On the air daily from 9.00 to 9.55 a. m., 11.30 a. m. to 2.30 p. m., 3.00 p. m. to 5.00 p. m., 5.00 p. m. to 10.00 p. m.

RADIO DESIGN is greatly indebted to Mr. Karl Stegman, of 254—92nd Street, Brooklyn, for the accurate data on the French and German stations, and for much of the information about the other European short-wave broadcasters.

PORTUGAL

Oporto, Portugal, Apolo Theatre. 25 meters (12,000 kc.) Daily from 8.00 to 9.00 a. m., 3.00 to 4.00 p. m., 6.00 p. m. to 9.00 p. m.

SPAIN

EAR, Madrid, Spain. 43 meters (6976 kc.) Monday and Friday, 5.30 p. m. to 7.00 p. m.

A station EAM in Spain has been reported by listeners as far away as the Hawaiian Islands, but we have no details on it.

DENMARK

Lyngby, Denmark. 31.6 meters (9494 kc.) On the air daily at 2.00 p. m., 3.55 p. m. to 4.15 p. m., and 5.00 p. m. to 6.00 p. m.

SWITZERLAND

EH9XD, Zurich, Switzerland. 32 meters, (9375 kc.) 4.00 to 6.30 p. m., daily.

SWEDEN

Motala, Sweden. 49.9 meters (6012 kc.) Daily at 1.00 p. m.

BRITISH EAST AFRICA

7LO, Nairobi, British East Africa. 31.4 meters (9554 kc.) 12 noon to 2.00 p. m. daily. This station has been heard in the United States, and in many other parts of the world.

AUSTRIA

UOR2, Vienna, Austria. 49.4 meters (6075 kc.) Daily at 12 noon, and 5.00 p. m.

OHK2, Vienna, Austria. 70 meters, (4285 kc.) Sundays, for 15 minutes at the beginning of each hour from 12 noon to 7.00 p. m.

CENTRAL AMERICA

NRH, Costa Rica, operated by Amando Cespedes Marin. 30.3 meters, every evening 10.00 p. m. to 11.00. One of the most unique of all the short-wave stations because it uses only 7½ watts of power and is heard all over the world. Mr. Marin runs it just for fun, and is a most interesting character.

AUSTRALIA

2ME, Sydney, Australia. 28.8 meters (10,410 kc.) On Wednesday after 6.00 a. m., but also on at irregular hours. Usually heard in the Eastern United States after 4.00 a. m. Reported by dozens of Super-Wasp owners.

6AG, Perth, Australia. 42 meters (7124 kc.) Daily at 5.30 a. m. and 10.00 a. m.

Melbourne, Australia. 31.55 meters (9509 kc.) Daily from 5.00 to 6.00 a. m.

SIAM

HS1PJ, Bangok, Siam. 16.9 meters. Sundays, 7.00 a. m. to 9.30 a. m., and from 1.00 p. m. to 3.00 p. m.

HS4PJ, Bangok, Siam. 37 meters. Tuesdays, 8.00 to 10.00 a. m. and 1.00 to 3.00 p. m.; Friday, 8.00 to 10.00 a. m.

Announcements from these two stations are made in English, French, German and Siamese. Reports welcomed. Address, Radio Chief, Bangok, Siam.

UNION OF SOVIET SOCIALISTIC REPUBLICS (RUSSIA)

RA97, Khabarovsk. 35 meters. Daily at 3.00 a. m. Announcement in Russian, Chinese and English. Programs end with playing of the "International". This information comes direct to RADIO DESIGN from the station itself. RA97 has been heard in the United States on numerous occasions.

RFN, Moscow, 50 meters. Tuesday, Thursday, Saturday, 7.00 to 10.00 a. m.

RFM, (city?) 70.1 meters. Also during the morning hours.

OTHER STATIONS

News about other scattered stations has drifted in from one source or another, and we are presenting herewith. We believe most of it is reliable. If you hear any of these stations, please write and give us the details.

Manila, Phillipine Islands. 48 and 31.3 meters, daily at 9.00 a. m.

DHC, Nauen, Germany. 26.22 meters, 15 kilowatts. Thursday, Friday, Saturday, Sunday about 2.00 p. m.

DGW, Germany, 14.83 meters, about 7.30 a. m.

AGC, Nauen, Germany. 17.20 meters, 20 kilowatts.

FZT, Madagascar. 13.4, 24.4, 30.5 and 39.1 meters. FZU, same place, 16.7, 20.3, 59.5 meters. FZV, on 12.2, 15.4, and 34.8 meters.

According to "Amateur Wireless", a British magazine, the Royal Society of Great Britain has instituted a series of calibration signals. On the second and fourth Sundays of each month the Society's Cambridge station will send out calibration signals at 5.00 a. m. and 5.05 a. m. At 4.58 the letter X will be followed by a telephonic announcement that the service is about to start. At 5.00 a. m. will come RSGB RSGB de G5YK, in morse, followed by a two-minute dash on 42.75 meters. At 5.05 a. m. the procedure will be repeated, on 41.38 meters. This same magazine says there is a reliable station in Doberitz, in Europe, on 67.25 meters.

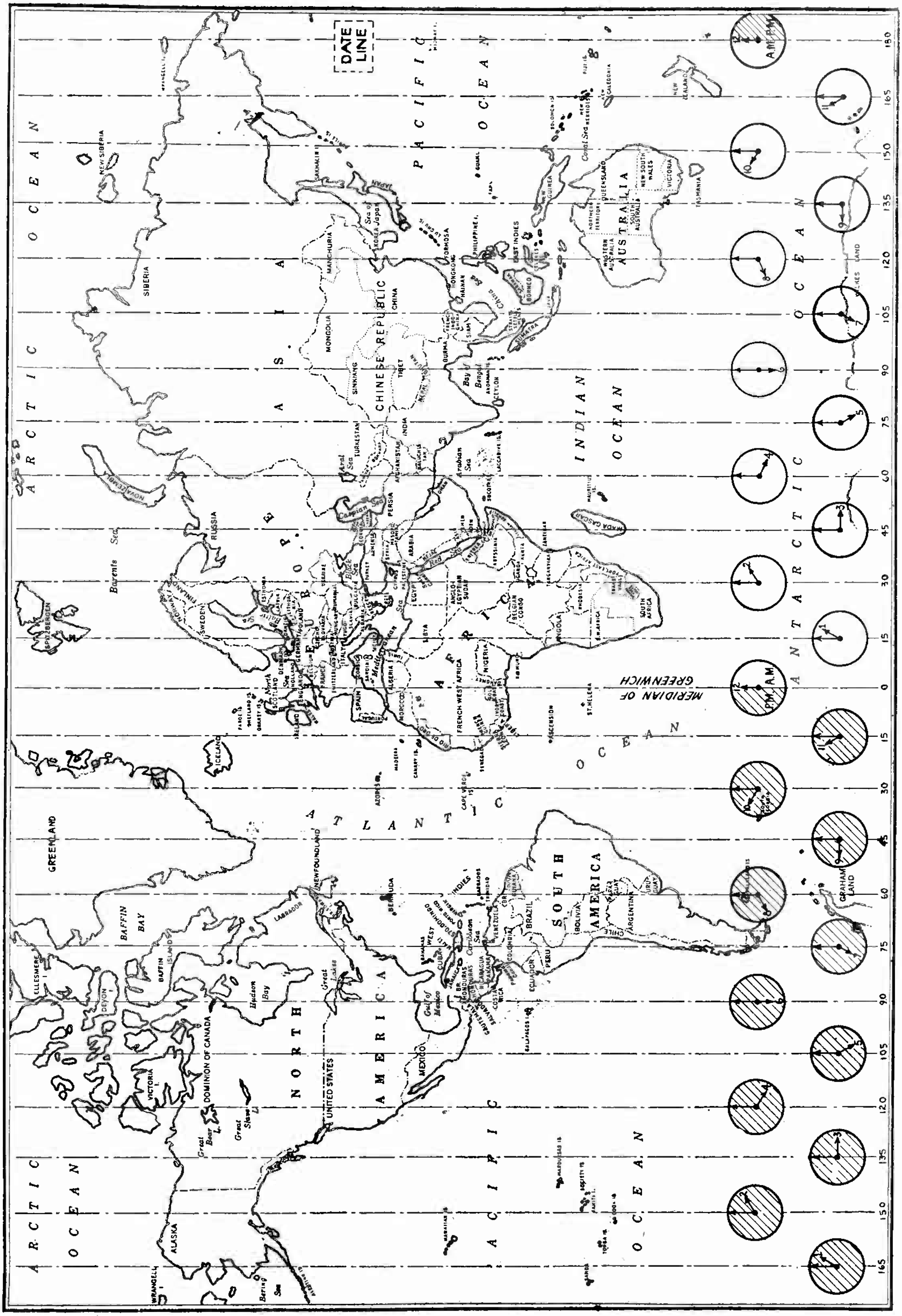
"Wireless World" says that experiments in "Fultograph" picture transmission are being conducted in Vienna over a short-wave transmitter working on 41.42 meters, with announcements in voice. The telephony schedule is from 4.20 to 4.30 a. m.

An English station GBX on 27.86 meters has been reported working with Sydney, Australia, on a telephone circuit. Also, a New Zealand listener reports having heard stations VUC and VUV in India, and JOAK, JOHK and JOGK, in Japan. JOAK has also been reported by American listeners, but we have no dope on its wavelength or hours.

Mr. Leon Tosi, P. O. Box 2066, Seattle, Wash., using a Super-Wasp, reports a station LON, in Buenos Aires, South America. Mr. Douglas A. Dane, Beaver Cave, Vancouver, Island, B. C., is the fan who heard JOAK.

We have incomplete data on many other stations, but we are not publishing it because it would be of little value.

In looking for any of these foregoing stations on your dials, record the readings for dependable stations like KDKA, CJRX, the WGY group, PCJ, G5SW, W6XN, and NRH, and you will have a fairy good idea where the others should be. Remember that the Super-Wasp tunes in steps from 15 to 26 meters, 26 to 50, and 50 to 100 meters, on the three short-wave coils. After you've spotted a few stations you'll find it easy to hear others.


DATE LINE
MERIDIAN OF GREENWICH
ARCTIC OCEAN
PACIFIC OCEAN
ATLANTIC OCEAN
INDIAN OCEAN
ANTARCTIC OCEAN
ASIA
EUROPE
AFRICA
NORTH AMERICA
SOUTH AMERICA
AUSTRALIA
SIBERIA
CHINESE REPUBLIC
RUSSIA
GREENLAND
DOMINION OF CANADA
UNITED STATES
BRAZIL
ARGENTINA
ALASKA
ICELAND
NEWFOUNDLAND
Hudson Bay
BAFFIN BAY
AM
PM

TELLING TIME

One very important thing that all owners of short-wave receivers must learn is that time is different in different parts of the world. Remember that song entitled, "When It's Night Time in Italy It's Wednesday Over Here"? Well, it wasn't as crazy as it sounded. When it's Wednesday over here it's actually to-morrow in New Zealand.

The accompanying full page map of the world shows how time differs. For purposes of reckoning time, the world has been divided into 24 zones, each representing a time change of one hour and each equal to a slice of the earth's surface 15 degree of longitude wide. The meridian of longitude which runs through the little town of Greenwich, England, is the starting point, and international time is usually expressed as Greenwich Mean Time, familiarly abbreviated into the letters G. M. T.

The sections west of the Greenwich line are earlier than Greenwich, and those east are later, an hour in each direction for each 15 degrees. If we travel half way around the earth in each direction away from Greenwich, we will have passed twelve time zones in each direction, as the earth is a globe and represents a geometrical total of 360 degrees. When we reach this point twelve zones or 180 degrees away (diametrically opposite Greenwich), we come to another imaginary line which we call the International Date Line. In going across this line from east to west, we actually lose a complete day; in the other direction, we actually gain a complete day. That is, at the same instant a place just east of this date line is one day later than a place just west of it.

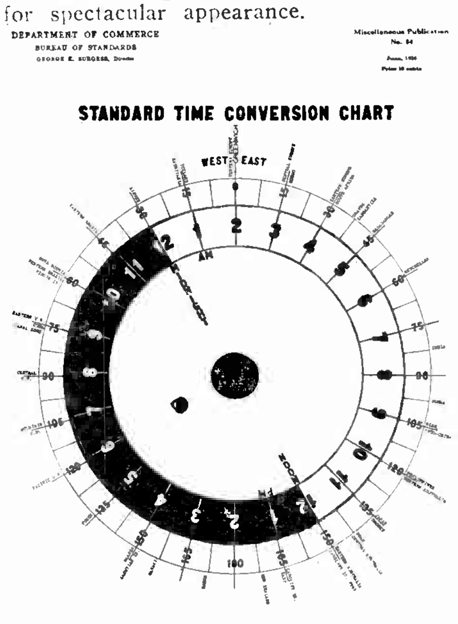
The little clocks on the map are shaded to indicate time between noon and midnight, and left white to show time between midnight and noon. You can see that when it is 8.00 a. m. in western Australia it is 2.00 a. m in Egypt. Our own United States is divided into four zones: Eastern, Central, Mountain, and Western, which represent zones five, six, seven and eight hours earlier than Greenwich. When it's 6.00 p. m. in Boston, New York, Philadelphia and Miami, it is 5.00 p. m. in Chicago, St. Louis, Little Rock and New Orleans, 4.00 p. m. in Butte, Denver and Albuquerque, and only 3.00 p. m. in Seattle, San Francisco and San Diego.

All this explains why you have to get up at 4.00 in the morning to hear Australia, and why you hear the midnight chimes from London through G5SW when you've finished your supper in New York. Time differences are very confusing at first, but after you've studied the subject a little, you will find it is very simple and obvious.

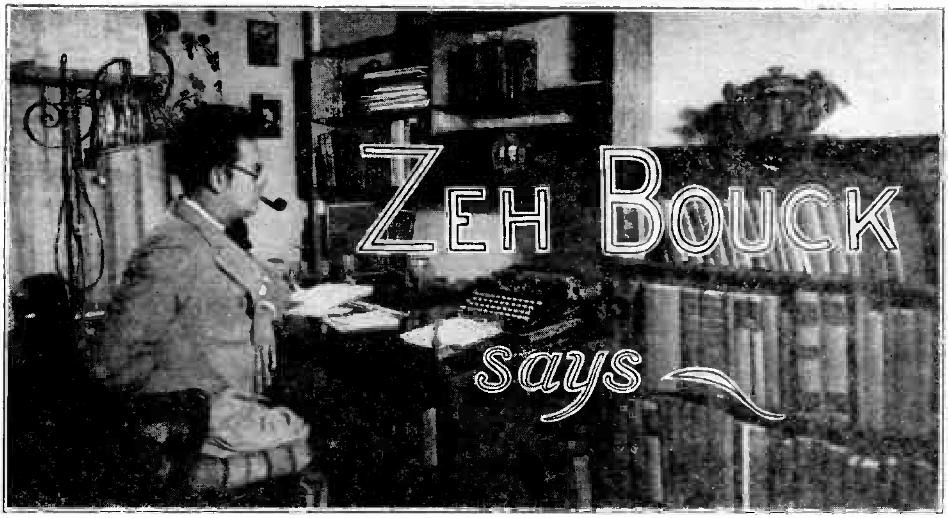
Instead of trying to remember all these details, the best thing to do is to write to the Government Printing Office, Washington, D. C., for a copy of Miscellaneous Publication No. 84, entitled, "Standard Time Conversation Chart". A reduced reproduction of this handy chart is shown at the bottom of this page. The inner circle is a separate disc of cardboard, which can be turned with the finger. To find the time any place in the world when it is a certain time in any other place, you simply adjust the disc and read off the answer directly on the chart. There is no calculating to be done. This chart costs only ten cents (do not send stamps) and is an education in itself. Every owner of a short-wave receiver should have one.

Another good thing to have is a small globe. Since the earth is a globe, a flat map gives a distorted idea of its appearance, and makes distances particularly hard to figure. You'll learn some astonishing things about distance with a globe by stretching a string between any two points you want to measure. On a flat map you get one figure, but on a globe you get the true distance, which is something altogether different.

You'll learn that some foreign stations are nearer than some American ones, and that some countries are located in the most unexpected places. Your whole conception of the earth will change, for the better, if you have a globe. Small globes can be bought as cheaply as $2.00. Buy one, stick colored pins in it to represent the countries you have heard, and you will have a DX "log" that beats everything else for spectacular appearance.



Send ten cents in coin to the Government Printing Office, Washington, D. C., for one of these highly valuable time conversion charts.



PROFITS FOR SERVICEMEN

THE servicing of a radio receiver is a proposition that is unusually profitable as a side line or as a major trade. An interesting survey recently made by the National Radio Institute of Washington shows that a large percentage of radio retail merchants throughout the country employ the services of independent servicemen rather than equip and maintain a service department themselves. The serviceman in such a case is generally a local expert working under some arrangement with the dealer—the basis usually being that he buy all replacement parts through the dealer.

The readers of Radio Design are particularly well fitted for this type of work, and should have no hesitancy about getting into it if they have the time and a reasonable amount of experience.

The serviceman should possess a fundamental knowledge of electricity and radio, a general familiarity with the more popular receivers, a certain amount of mechanical ability and experience, and a fairly well equipped shop. His primary piece of electrical equipment will be a test set, and if he is going into the business seriously, the serviceman will find it worth while purchasing a reliable testing outfit such as the Weston or Jewell. While these sets come high, many servicemen have expressed their opinion to the writer that they are worth their weight in gold.

The readers of Radio Design interested in servicing undoubtedly have the technical situation well in hand. However, the economic aspects of the job are equally important; and the writer's long association with servicemen has brought out several points worth observing.

Get in touch with your own radio dealer and offer to take over his entire service trade on a mutually agreeable basis—generally as outlined above. Offer to refer your own service customers to this dealer for accessories and new equipment. Have it distinctly understood, however, that you will receive a commission on all parts sold equal to the difference between the list price and the reduced price to which you are entitled as a trade courtesy—usually about twenty-five percent.

Do all work on a strictly cash basis. Charge a flat rate for service calls—from one to three dollars depending on the locality—regardless of the amount of work done. Charge for time—a dollar and a half per hour plus the list price for any new parts.

The major portion of your profit on all small jobs will be your commission on parts. This will be the greatest, of course, when the parts are standard and cheapest. However, under no condition sacrifice quality for a larger profit. Pilot parts are particularly to be recommended for service work. They admit the greatest possible profit compatible with a quality job, are standard in every respect, and as every part for every possible set is manufactured by Pilot, the problem of securing the correct parts is simplified. Also Pilot parts are readily available all over the world.

Always guarantee your work for a reasonable period of time.

Keep a precise record of all work done, and follow it up from time to time. You can generally do a lot of work for old customers just before big fights, world series games and other broadcast events of unusual importance.

Read three magazines regularly: Radio Broadcast, Radio Design and Radio Retailing.

FOUR CAUTIONS

THE majority of radio service calls are for tube troubles. These can be avoided for the greatest part by observing the following four cautions:

Don't jar tubes. While jars seldom break the filaments, they often derange the relative positions of the elements sufficiently to alter the amplification characteristics of the tube.

If tubes are consistently short lived in any one set, check the "A", "B" and "C" voltages.

Be sure all tubes are in the correct sockets.

Unless you are quite sure of yourself, do not turn on the set with one or more tubes missing.

TO BE OR NOT TO BE

THE R.M.A. has come out with another one of its jokers. There seems to be some question in the minds behind this ultima dicta of radio manufacturing that might be queried, "When is a screen grid set not a screen grid set?" According to the R.M.A., a screen grid receiver is not a screen grid receiver unless it has more than one screen grid tube in it. If your set has two or more screen grid tubes in it, fine and dandy, and you have a screen grid receiver. However, if it has only one screen grid tube, it is no such thing!

This foolishness reminds us of Harry Stevens, who every once in a while used to fly over to Mitchel Field for medical examination in an eternal effort to break into the U. S. Army flying service. He was invariably turned down for some obscure reason, the medical officer always telling Harry, "You can't fly." Whereupon Harry would walk away disgusted, climb into his plane and return across the road to Curtiss Field.

THE BETROTHED

(With the very liberal assistance of Rudyard Kipling)

"Claims a Breach of Promise Over Radio Set—Refused to Give Up Radio For Love."
—*Recent News Headline*

Turn on the Radiola and twist the dials about
For things are running crossways, and Maggie and I are out.
We scrapped about this radio—(with other things to boot)
And I know she is exacting, and she says I am a brute.
Turn on the juice and Listen—Let me consider a space
In the lilting strains of the Gypsy Hour a vision of Maggie's face.
Maggie is pretty to look at—Maggie's a loving lass
But the prettiest cheeks must wrinkle, the truest of loves must pass.
There's peace in this good old set—exceptin' now and then
The Prophylactics get my goat, and such occasions when—
I tune it to something more my taste—a degree or two up or down
But I couldn't detune Maggie, for fear o' the talk of the town!
Maggie, my wife at fifty, gray and down and old,
With never another Maggie to purchase for love or gold!
And the light of the days that have been the dark of the days that are—
A program too often repeated to wrangle the nerves and jar!
A program you've heard till you're sick repeating the dose till it gags
Like the "Waters of Minneton‹ka›" once tuneful now shredded to rags.
Tune in the Sieberling Singers—let me consider a while
Here is a pretty good program—there is a wifely smile.
For Maggie has written a letter—for all my love or no—
Her wee little whispering love and the great god Radio!
Which is the better portion—bondage bought with a ring
Or a life full of song and music (Maggie can't even sing!)
Family life—well what of it? I have the Capitol gang if I choose
Major Bowes and the Family—and I won't have to buy them shoes.
"Cheerio" will wake me as I tumble each day from my couch
Maggie's face in the morning may disclose a yawning grouch.
And I have been servant of Love for barely a twelve month clear.
But I have been priest of programs a matter of seven year.
And the still of my bachelor days yet echoes with notes on high
Thanks to the NBC and WSAI!
And I turn my eyes to the future that Maggie and I must prove,
But the only light on the marshes is the Will-O-The-Wisp of love.
Will it see me safe through my journey, or leave me bogged up in the mire
Since a program or two can damp it, shall I follow the fitful fire?
Tune in another jazz band—let me consider anew—
Old friend, and who is Maggie that I should abandon you?
Tune me another station—I hold to my first sworn vows
If Maggie will have no rival, I'll have no Maggie for a spouse!
What? No music? I'll bet the darn tube is blown!
And nothing to do all evening—I wonder if Maggie is home?

An Audio "Booster Unit" for the A. C. Super-Wasp

by FRANK T. SULLIVAN

WHEN we first brought out the Super-Wasp receiver, we emphasized its superiority as a short-wave receiver, and mentioned, more or less incidentally, that it was also a broadcast receiver. As it uses only one screen-grid stage, and only four tubes altogether, we knew it could not be compared with more expensive broadcast receivers, using three or four screen-grid tubes, or a total of seven or eight tubes, and we stated frankly that while it was certainly the best short-wave outfit we knew of, it was not the best broadcast receiver.

AN EFFECTIVE BROADCAST SET

All the people who have built Super-Wasps agree with us entirely on our first claim, but a surprisingly large number of them disagree with us most emphatically on the second. They tell us that their Super-Wasps in many cases work fully as well on the broadcast band as larger factory-built sets, and in some respects even a little better. They pull in stations by the score, their only complaint being that the set hasn't quite enough "kick" in the audio end on distant stations. They do not want to substitute a 171A power tube in the last stage in place of the present 227, because that would mean an increase in hum on the short waves, and they have suggested that we bring out a small booster unit that will pep up the set a little for broadcast reception without affecting its operation on the short waves.

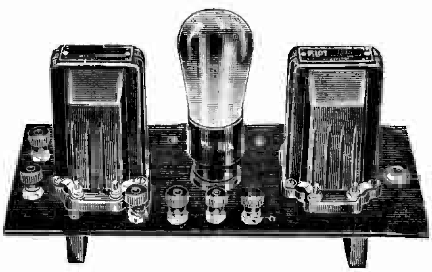
As such a booster unit is quite easily constructed at little expense, John Geloso, chief engineer of the Pilot Radio & Tube Corporation, worked out a design for one and had several experimental models built. As expected, they all worked very well in different locations with different A.C. Super-Wasps, so we are glad to present the details of the construction for the benefit of the many Super-Wasp boosters who want a booster for their sets.

The booster unit consists merely of a single stage of transformer coupled audio amplification, using a P-171A output tube. This combination will give the Super-Wasp a tremendous "kick", probably more than is really needed in most locations, but, of course, it is a single matter to reduce the volume by adjusting either the regeneration condenser or the little aerial coupling condenser mounted on the left side of the antenna stage shield. The unit will more than satisfy the demands of enthusiastic Super-Wasp owners for more audio amplification, and will make the set equal to many pretentious broadcast receivers.

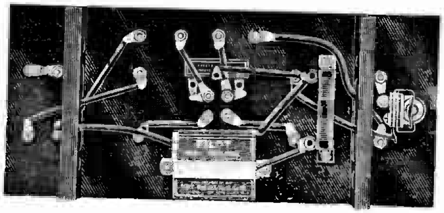
All the parts for the booster unit are available in the form of a small kit, which you will find convenient if you have no loose parts around. The following Pilot parts are needed for the unit, and are the ones supplied in the kit:

PARTS REQUIRED

1—Bakelite base panel, 10 by 4½ inches
2—Mounting feet for base panel
1—No. 391 audio amplifying transformer, 3½:1 ratio
1—No. 394 output transformer
1—No. 214 four-prong socket



Appearance of the completed Booster Unit, with a P-171A in place. Note how the terminals of the transformers are bridged to the mounting screws by means of lugs.



Under view of a completely assembled and wired Booster Unit. Note that the two outer terminals of the center-tapped resistance are soldered directly to the filament binding posts of the tube socket.

1—No. 1165 phone jack
1—No. 275 phone plug
1—No. 356 center-tapped resistance, 50 ohms
1—No. 951 biasing resistance, 2250 ohms.
1—No. 806 by-pass condenser, .6 mf.
6—Binding posts: P, B+, B—, 5v. A.C., 5v. A.C., B+ 220v.
Connecting wire, insulating tubing, mounting screws, etc.

The wood cuts on page 46 and the picture wiring diagrams on page 48 clearly show the simple layout of the parts. On the top side of the base panel are the two transformers, the tube socket, the phone jack and the binding posts. On the under side are the two resistances, the by-pass condenser, and the "works" of the phone jack.

ASSEMBLY

If you do not buy the kit, but wish to use spare parts that you have on hand, you can easily drill a piece of bakelite in accordance with the layout on page 48.

In assembling the booster unit, first screw the two bakelite mounting feet in place, passing the screws in from the top side of the base panel. Place the tube socket with the two filament posts facing the long edge that has the binding post holes drilled in it, and fasten it on the under side with nuts and lock washers, first slipping soldering lugs over the screw terminals.

Now mount the No. 806 condenser on the under side of the base panel by means of two screws and the small strap supplied with it. Have the terminals face the tube socket. Mount the binding posts as shown, with soldering lugs under all of them. Also fasten the phone jack in place.

MOUNTING THE RESISTOR

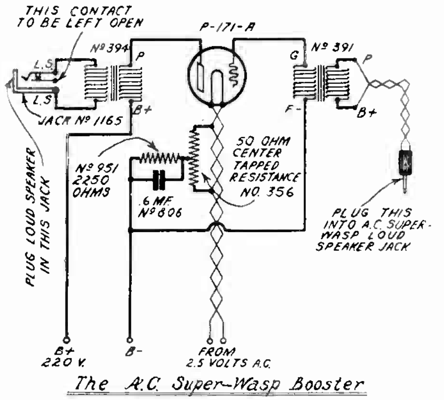
The next thing to mount is the No. 951 resistance, which is held on the under side of the base panel merely by two screws, the holes for which must be countersunk on the top side of the panel. The latter operation is necessary because the screws will be covered by the No. 394 transformer.

The No. 391 transformer fits next to the two binding posts marked "input"; the No. 394 fits at the other end, next to the phone jack. In fastening them down, put double-end lugs (you will find them in the kit) under the heads of all the screws, and bridge these lugs to the adjacent binding posts on the transformers. On the under side of the base panel, put soldering lugs over all the screws.

WIRING IS EASY

This completes the assembly work, and you can start the wiring. The connections are obvious, and you can follow them with the aid of the schematic and picture diagrams. Note that the center-tapped resistance is soldered directly to the F terminals of the tube socket; it needs no other support. On the phone jack, note that only the frame and the outer spring are used.

The method of using the booster unit is very simple. Connect the B— post to the frame of the Super-Wasp itself, or to the B— post on the K-111 power pack. Run a pair of twisted wires from the 5v. A.C. posts to terminals number 1 and 2 on the K-111, to obtain five volts for the 171A filament. Run a single wire from the B+ 220 v. post to the correspondingly marked post on the K-111.



Complete schematic wiring diagram of the A.C. Super-Wasp Booster Unit. The connections are simple and will give no trouble.

From a piece of old lamp cord, cut a three-foot length. Skin one of the pairs of ends, and stiffen the wires with solder so that they will hold in the phone plug. Connect the other ends to the input posts.

To use the booster unit on the A.C. Super-Wasp, merely insert the plug in the jack on the front panel of the receiver, and plug the loudspeaker into the jack on the booster. That's all there is to it. If you want to use the set for short-wave reception, put the earphone plug in the jack on the set.

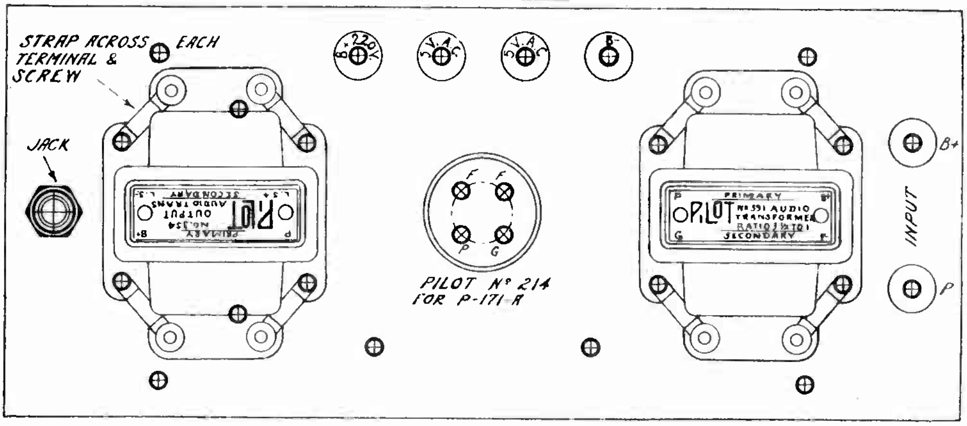
As there is no filament switch on the booster, the best thing to do when not using the unit is to remove the P-171A from its socket. This safely shuts off both filament and plate circuits. If you want to, you can install an extra filament switch, but this is hardly necessary, because you will connect and disconnect the unit probably only once during an evening. Removing the tube takes only an instant.

PLACING THE UNIT

The booster unit may be placed anywhere near the Super-Wasp. As it is very small, it can be made to fit inside the same cabinet holding the set. Its exact placement depends, of course, on how your particular set is laid out.

Many owners of the battery-type Super-Wasp will inquire if they can use the

TOP VIEW



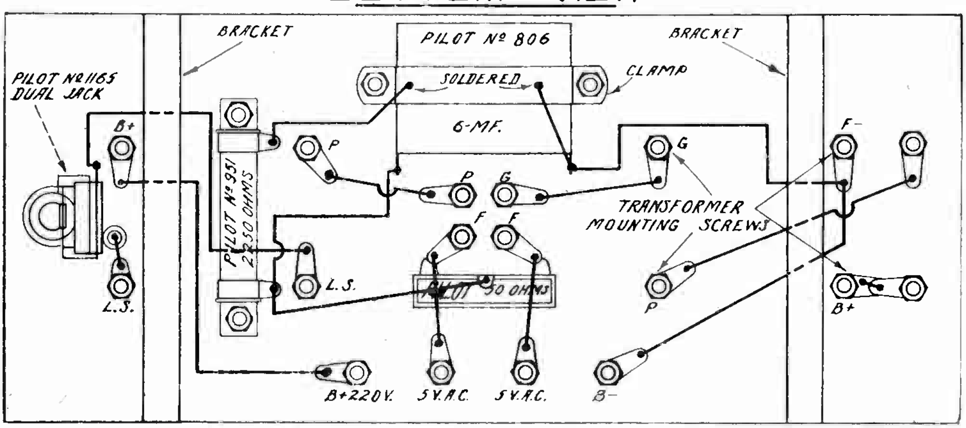
Top view of the Booster Unit, showing placement of the parts. As this base panel is supplied with the kit already drilled, no drilling instructions are included, but the arrangement is so simple you can easily drill a panel of your own, if you want to do so. The dimensions are 10 by 4½ inches.

booster unit with their sets. It can be done, but since the battery model Super-Wasp already has two transformer-coupled stages, the addition of a third may cause trouble, due to interstage feed back. For battery operation, remove the center-tapped resistance and the No. 951 biasing resistor, and connect a 40 volt "C" battery with the minus post going directly to F— on the No. 391 transformer and the plus post to the minus side of the "A" battery. The filament of the P-171A must be run through a rheostat or other filament ballast device, so that it obtains five volts instead of the full six volts of the "A" battery.

Booster Unit Parts Supplied in Kit Form

All the parts required for the construction of the Booster Unit described in the foregoing article are supplied in Pilot kit number K-120. This includes the drilled basepanel and two special molded bakelite mounting feet, and also wire, "spaghetti' and incidental hardware.

BOTTOM VIEW



Bottom view of the Booster Unit, showing all the wiring. Use soft tinned copper wire, with "spaghetti" tubing slipped over it to prevent short circuits.

Selectivity and the Screen Grid Amplifier

A Consideration of Some Little Understood Factors in R.F. Circuit Design, Leading Up to the "Pre-Selector" or Band Pass Filter Idea

by DAVID GRIMES

SELECTIVITY has ever been a major problem in the design of radio receivers and this is not a new discovery either! For long before the present broadcast era, radio telegraph engineers were concerned with the same dilemma. In fact, most of the present fundamental inventions which are used to obtain selectivity in our modern sets date back long before broadcasting was ever conceived. For instance, the now famous Alexanderson tuned radio frequency circuit was developed and patented over a dozen years ago and almost as long before that again we find selectively coupled circuits fairly well worked out by John Stone. You see, selectivity in the commercial radio field means even more than in the broadcast business; so we had a lot of experience from which we could draw when radio entertainment receivers became widely used.

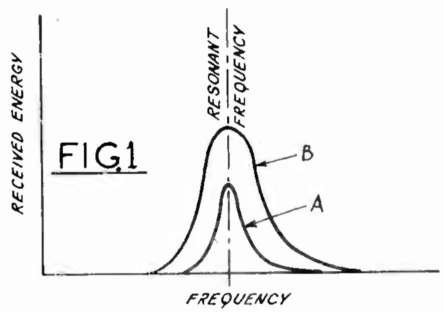
ALL KINDS OF SELECTIVITY

All of which brings us down to the issue at hand:—that of the continual demand for increased selectivity. Now this is rather an elusive subject, because there are many variable factors which enter into the considerations. It is the latter that have spelled the doom of many a pioneering soul who has dared to attempt the new and different. Selectivity is one thing and apparent selectivity is quite another. Then still again, we have harmonics and "cross modulation" or, what have you, to confuse an otherwise simple situation. The reason for this present pre-selector band-pass receiver is really most easily explained by a little history of the art.

The old single tube regenerative sets and the fixed radio frequency receivers were very efficient on pick-up, but were notoriously bad when it came to selectivity. This one thing alone accounted for their decline in popularity in favor of the more elaborate and costly tuned radio frequency combinations. The reason for the broadness of these war horses was the fact that they had only one tuned circuit and the reason for the increased sharpness of the tuned radio frequency sets which followed them and have remained ever since, in one form or another, is the fact that they have more than one tuned circuit. In general, the greater the number of tuned circuits in a receiver, the greater is the selectivity of that instrument. This is one of the first fundamentals and should be kept constantly in mind. This rule is even more important than appears on the surface, because the selectivity increases in proportion to the SQUARE of the number of tuning circuits—other things being equal. This means in simple language, that a receiver employing three tuned circuits is nine times as selective as the set using only one tuned arrangement.

As multi-stage tuned radio frequency amplifiers became better understood and the design consequently became more efficient, more tuned stages were incorporated with the sole desire for greater selectivity. Now, modern engineering decrees that four such tuning stages are just about right; so we see most of the present day sets using a four gang tuning condenser. This was all very well as long as the low "mu" UY-227 tubes were utilized for the R.F. amplifiers. Several types of receivers were quite successful with such tubes even when a fixed, untuned radio stage was placed ahead of the tuning to couple the first tube to the antenna. The real troubles started with the introduction of the screen grid radio amplifier tube. This tube has done more, and is doing more to change radio design than any other development in a long, long while.

Our story starts at this point. Curve A in Figure 1 shows a standard tuning, or

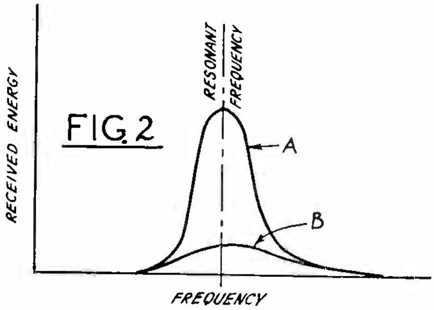


Illustrating the difference between actual and apparent selectivity.

resonance, curve. The sharpness of the peak of this curve is a direct indication of the selectivity of the circuit. You see, selectivity in simple terms is just how much will the circuit receive of the desired station to which it is tuned and how little will it receive of the undesired station to which it is not tuned. Obviously, the higher the resonance curve at the center and the more rapidly it decreases to zero at the sides, the sharper and more selective will be that particular circuit. Now take curve "B" in the same Figure 1. The curve is identical in every respect to the smaller curve. It has the same general shape and the ratio between the peak and the wideness at the bottom is the same in the two cases. Yet Curve "B" is much wider at the bottom, even though it is higher at the top. These two circuits, represented by the two resonance curves, have the same ACTUAL selectivity, but the larger of the two has what is known as APPARENT broadness. Evidently, the apparent broadness of a receiver increases as the amplification increases, providing that the number of tuned stages has remained the same! This simple observation is important, especially with the screen grid tube! This high power tube has more radio amplification than the old standard 227 and with the same number of tuning circuits, would have apparent broadness.

RADIO FREQUENCY GRID SWING

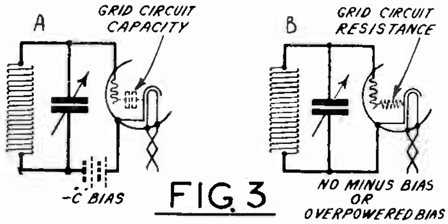
The next point that has to be considered is radio frequency grid swing. This has a very important bearing on the sharpness of tuning. You will soon begin to conclude that there are several things which affect tuning besides the number of tuning circuits and in this you will be absolutely correct. You will note that we stated in the third paragraph, at the beginning of this article, that the selectivity "increases in proportion to the SQUARE of the number of tuning circuits—other things being equal." But that last reservation is a "wow". The other things referred to are so seldom equal. For instance, the resistance in the tuning circuit plays a tremendous part in the selectivity. Reference should here be made to Figure 2.



Curve B shows what happens to an otherwise selective circuit when resistance is added to it.

Curve "A" in this case once more represents the standard resonance curve with the average amount of resistance in the circuit. Curve "B" shows about what happens when only a small amount of resistance is added in the circuit. It certainly raises havoc with the sharpness of the curve. It was this very thing that led to such a lot of talk several seasons ago about low loss coils and low loss condensers. Such design precautions are evident and there is not a set to-day that does not employ good low loss coils and condensers. But losses may creep into the tuning circuit in other ways not so apparent on the surface and, as you have already seen from the curves, it doesn't take much loss to ruin the tuning. The most insidious loss is that introduced by excessive grid swing.

Figure 3 now enters into the picture. Here is shown a regular tuned circuit con-



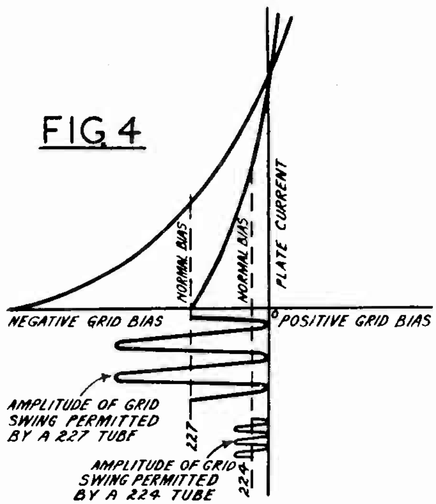
The grid-to-filament path of a tube may act as a capacity or as a resistance.

sisting of a tuning coil and a variable condenser. Of course, the grid and filament of the associated tube are shown connected across the tuning condenser. Now if this tube circuit represents nothing more than a small fixed condenser, such as is shown in sketch "A" in this figure, all will be well; but the only way to bring this to pass is to put a definite amount of negative "C" bias on the grid to prevent it ever running positive even under operating conditions. This means that the bias shall at all times exceed the amount that the grid is swung positive at any instant by the incoming signal. If the grid swings over this margin and becomes positive, it will act as a small plate and wlil draw current. The grid-filament circuit then becomes a resistance during the time that the grid remains plus. This resistance is directly across the tuning circuit and acts like a very poor, leaky, high-loss tuning condenser. So what is the use of going to all the trouble of inserting low loss apparatus in the tuning circuit if we deliberately allow the grid to become positive during the reception of the signals? See sketch "B" in this figure.

Now in the old days with the standard 227, or other type of low mu tube, we used a very much larger permanent grid bias. For instance, the 227 tube calls for a 14 volt negative grid voltage when it is operated as an amplifier with 180 volts on the plate. Such a negative bias would permit a 14 volt maximum grid swing in the radio frequency tuned circuits before the grid swung positive and became a resistance which would broaden the tuning. Let us take a peak at the new 224 high mu tube, which has become so popular of late as a radio frequency amplifier. The recommended negative grid bias for this tube, when operated on the same identical 180 volts plate battery, is between 1½ and 2 volts. This means that this tube could stand only a 2 volt grid swing before broadness and other things covered a little later on would give trouble. And there is some difference between 14 volts and 2 volts when it comes to grid swing.

224 NOT A POWER TUBE

Let us look at this with a little more care and see the upset in design caused by this wonder tube. Figure 4 shows the plate-current, grid-voltage characteristics of both the old 227 and the new 224 types.



These curves show that the 227 tube can handle much more power than the 224.

Only a glance is necessary to comprehend the enormous difference in the amount of signal strength which the 227 will handle within the limits of its grid bias as compared with the screen-grid 224 tube. Then why the 224? Well, because its amplification factor is much greater and because it has much less tendency to oscillate. The whole purpose of the radio frequency amplifier is to pick up weak signals and amplify them to the point where the detector will function and reproduce the program thru the audio amplifier. Naturally, the better the radio amplifier, the weaker the signal which will be picked up. In other words, a screen-grid radio amplifier will receive much greater distances.

For another thing, the extra grid mounted in the tube between the regular grid and the plate affords an effective shield to prevent currents in the plate circuit from feeding back onto the grid circuit to cause oscillations. Whenever a device can be produced that will deliver more with less instability, then that device is sure to prove in. The 224 in one form or another is here to stay. But it must be remembered that it is only capable of producing more when weak signals are considered. It will actually produce less on powerful stations. But that is neither here nor there, except as it creates new troubles for us if we do not remember that very point.

In considering some of these troubles, we must retrace our steps a little. One of the essential things to know about a vacuum tube is that it is never, under any circumstances, a perfect amplifier. To be such, it must amplify both halves of the incoming carrier wave to exactly the same extent. A study of the characteristic curve of a tube will reveal than only a straight line would enable such a state of affairs to exist. And the characteristic curve of a vacuum tube is never a straight line. Reference should here be made to Figure 5. No matter where

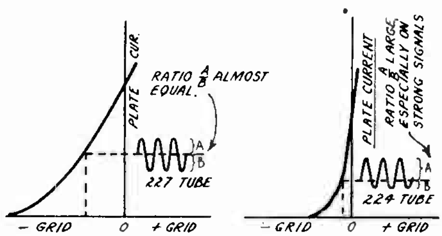


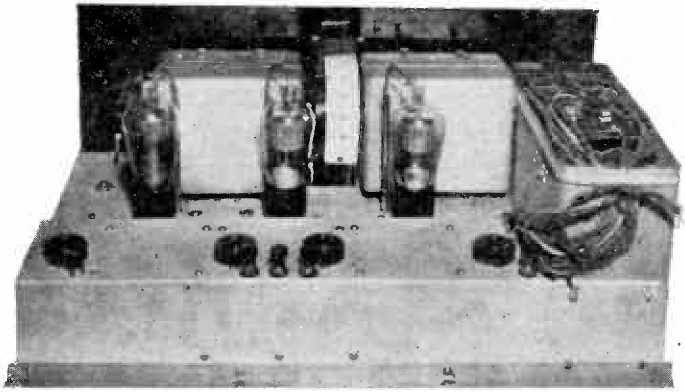
FIG. 5A FIG. 5B

The steeper characteristic curve of the 224 means somewhat uneven amplification.

the operating permanent grid bias is placed, the positive sides of the incoming signal wave will always receive a greater boost than the negative sides. To this extent, the standard amplifier will perform other tricks than mere amplification! It will be obvious from the two curves drawn in this last figure that the curve with the steepest slope will give the greatest amount of UNequal amplification. This steeper curve is the signature of the new 224 screen-grid tube. What are its other tricks?

MORE AMPLIFICATION

We have already learned that the greater amplification of the 224 creates an apparent broadness in tuning merely by virtue of increasing the height of the resonance curve without decreasing the width of its base. For a given number of tuning stages, the 224 results in more amplification and so all stations come in with more strength. It is just as if you suddenly moved your present receiver up nearer to all broadcasting stations. In addition to this, we have cov-



Back view of an experimental model of the "Pre-Selector" receiver mentioned in the accompanying article. This set, which marks a new departure in receiver construction, will be described in great detail in the next number of Radio Design.

ered the fact that you get an actual broadness in tuning if the incoming signal is of sufficient strength to overpower the negative bias on the grids of the R.F. tubes. This happens very easily on the screen-grid tube with its smaller value of permanent bias. The remedy for both of these conditions is the operation of the set on a much smaller aerial. In fact, the real commercial advantage of the new screen-grid tube, aside from its inherent stability, lies in the permissable use of a small pick up antenna, thus replacing the cumbersome and awkward long outside aerials of the past.

NECESSITY FOR SINGLE CONTROL

But even this doesn't help us much in avoiding those other tricks to which we referred. At this point another observation is required. Modern radio set design demands a one control tuning device. This became inevitable as the number of tuning circuits increase. Two controls weren't so bad. Even three controls were tolerated for awhile. But four and five controls were impossible. Hence, one control on the tuning stages became a necessity and a reality. To make such a set possible, it was imperative to eliminate all circuits which would in any way cause any variations in the tuning condensers. It is obvious that all of the tuned circuits must run together. The antenna tuning circuit was the biggest source of trouble. The maker of the set could not prescribe a standard antenna. The electrical characteristics of such an installation depends on the local conditions. The tuning of the antenna in many receivers was dispensed with as a result of this.

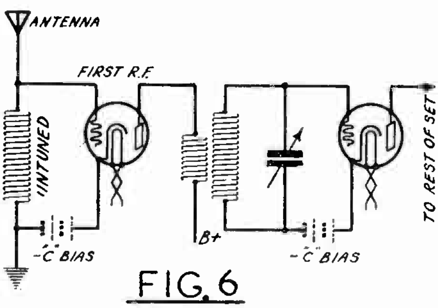


FIG. 6

An untuned R.F. amplifier like the one diagrammed above causes considerable trouble.

What happens under these conditions? We have no control over the signals entering the first tube. All of the broadcast stations picked up by the aerial actually enter onto the grid of this tube all at once. Such an untuned antenna circuit is shown in Figure 6. It must be kept clearly in mind that no matter where the tuning circuit is set, the grid of the first tube is at all times receiving everything with little or no discrimination. This, combined with the curved characteristics of the tube, forms the crux of the entire matter. The difficulties can best be made clear by citing actual conditions. Suppose, for instance, that we wish to pick up a 250 meter station and there is a high powered local operating on 500 meters. We will hear bad heterodyning if the 250 meter station is on the air, or we will hear the local very clearly and sharply tuned at this wave length if the 250 meter station doesn't happen to be on at the time. Oftentimes, this has been blamed on the 500 meter station. Many people believe that this pseudo-harmonic is coming from the 500 meter broadcaster and they blame everything but the real miscreant. That harmonic of the local long wave station is coming from no other place than your first untuned stage. We will see in a minute why this is. Of course, if the low wave station is also on the air, heterodyning is bound to take place between its wave, and the harmonic of the higher wave station, no matter where that harmonic is created. Thus, the excessive howling and harmonics on the waves below 275 meters are often the fault of the receiver itself, if that receiver employs an untuned stage in the antenna.

Before proceeding to the explanation of this phenomenom, let us cite still another trouble that is already very familiar to the owner of the untuned antenna set. Once more, we must remember that the grid of the first tube receives all stations at all times, no matter where the tuning condensers are set. Thus, a strong powerful local broadcasting station may be pounding onto the grid of the first tube with sufficient signal strength to actually cause rectification in the plate circuit of that tube. We already know that any rectification or detection will create audio currents which represent the program on the carrier wave. In fact, this is the entire action of the ordinary detector tube and any tube, no matter how operated, will detect to some extent when the carrier signals are of sufficient strength. This detection in the first tube actually occurs and in appreciable amount when the set is located under the eaves of a local station. Well, what happens then? We experience what we have chosen to call "cross modulation". The local program may be tuned out all right on its own wavelength, but it will reappear riding in on the carrier waves of all other stations tuned in. This will be in addition to the harmonic waves generated in this tube and discussed above. Some mess!

CREATION OF HARMONICS

But let us pass onto to the theoretical considerations involved so that you will understand why all of this takes place. For those of you who have actually experienced such troubles, no explanation will be necessary, except in the nature of enlightenment. For the rest, we do not want you to take this story for granted. It sounds too impossible. So impossible is it, superficially, that many engineering departments of radio set manufacturers made that mistake of the untuned antenna connection when designing a one control radio set. But on to the explanation!

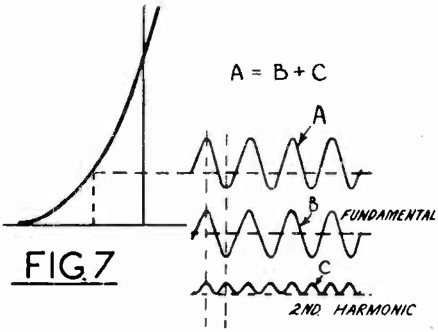
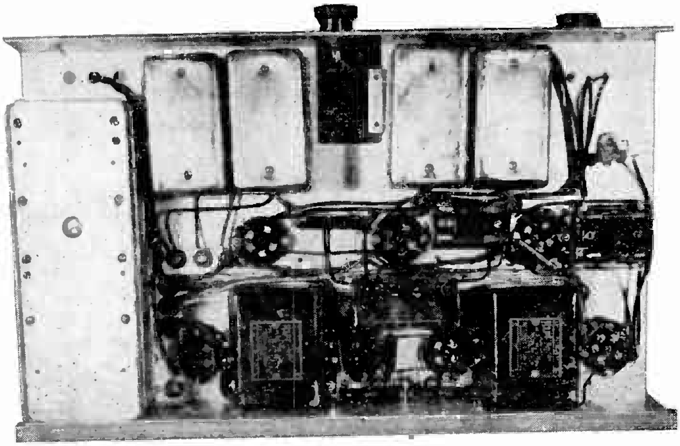


FIG.7

Action of harmonics in screen grid amplifiers.

We are now already familiar with the fact that the curved characteristic produces an unequal amplification of the positive and negative halves of the incoming carrier wave. This was brought out by Figure 5. This produces a lopsided amplified wave in which the upper half is greater than the lower half. This is illustrated by Curve A in Figure 7. Such a wave can be resolved into two waves, both of which are equally balanced waves. One has the proper frequency of the incoming signal and the other has twice the frequency. This is known as the harmonic. This second wavelength, which is just half of the proper one, is actually created in the tube and the amount of it, for a given strength of signal, depends on the steepness of that characteristic curve shown in Figure 4. Obviously, the new 224 screen-grid tube is a much more prolific source of second harmonic disturbance than the 227. In many locations where the signals were not excessively strong, the old 227 "got by" in the untuned antenna combination, but not so with the screen-grid. The untuned antenna is out of the picture as far as it is concerned. A detailed study of Figure 7 will show that Curve A, which is the actual one produced in the plate circuit of the tube, may be

Bottom view of the experimental "Pre-Selector" receiver pictured on the preceding page. The large can at the left is the K 112 power pack. The four small cans hold the R.F. coils. The circuit of this set, which will be described further in the next issue of Radio Design, is shown on page 56.



built up from a fundamental curve with the second harmonic added to it. The fundamental wave is shown as Curve B, while the harmonic wave is represented by Curve C.

"CROSS MODULATION"

Cross modulation is a very close relative to the above family. It has to do with this same unbalanced amplification with the exception that it is merely carried to the point where detection is appreciable and audio currents in the radio frequency plate circuit exist in measurable quantities. Continue to keep in mind that the first tube, with untuned antenna, at all times receives everything. A strong local may be coming in with sufficient strength to cause rectification in the first tube. Thus we have the program of that station actually present in the form of audio currents in the plate of that first tube at all times no matter where we are tuning the following stages.

These audio currents vary the plate voltage on this fixed R.F. amplifier and thus increase and decrease its amplification efficiency. All of the radio frequencies passing thru this tube are accordingly increased and decreased by the varying amplification efficiency of this first tube and this efficiency is controlled entirely by the strength of those audio currents which have been created by the rectification of the strong local station. Thus the local program appears as a modulation on all the other stations received.

All of these troubles taken together certainly rule out the use of a fixed radio stage on the antenna and the employment of the screen-grid tube has caused us to go still further in this regard. The tendency toward harmonics and cross modulation is even greater in the case of the 224 than with the 227. Hence, we must not only definitely discard the untuned antenna, but we must go a step further and incorporate a double tuned antenna. This double tuning is called pre-selection and makes doubly sure that nothing but the desired station reaches the grid of the first tube with any amount of energy. Such a pre-selector is shown in Figure 8.

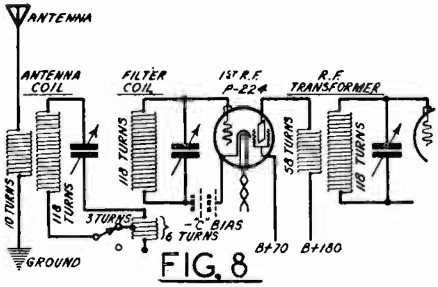


FIG. 8

Diagram of a "Pre-Selector" circuit used with a screen-grid amplifier.

This rather long-winded explanation has been given to convince you that the modern set should employ pre-selection and that the tuned filter ahead of the first tube has not been added to the receiver merely to be different. It has a very definite use which is inherently associated with the new screen-grid amplifier. Yet it calls for no

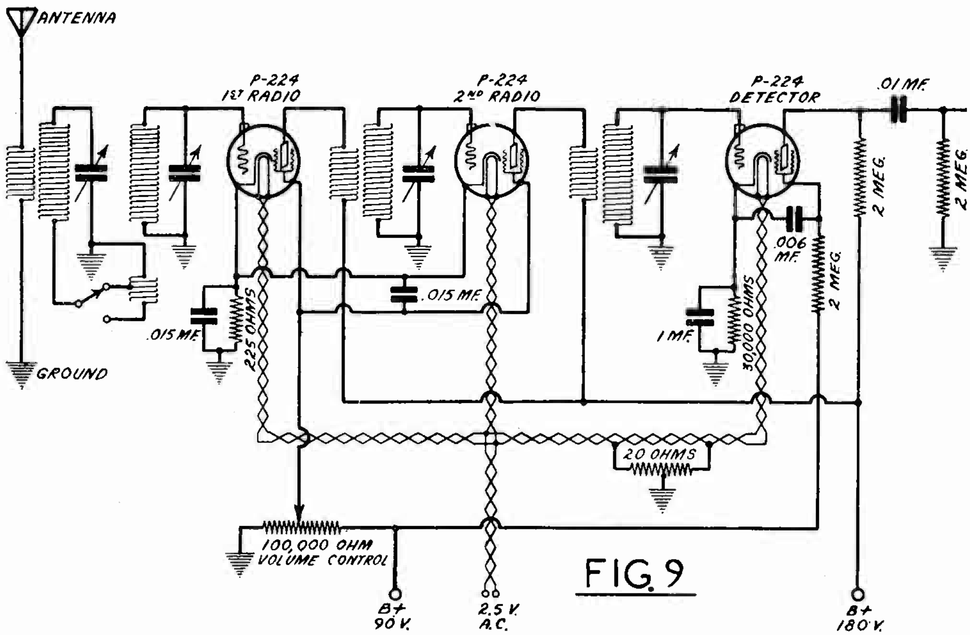


FIG. 9

Fig. 9: Complete radio-frequency and detector circuit of "pre-selector" receiver.

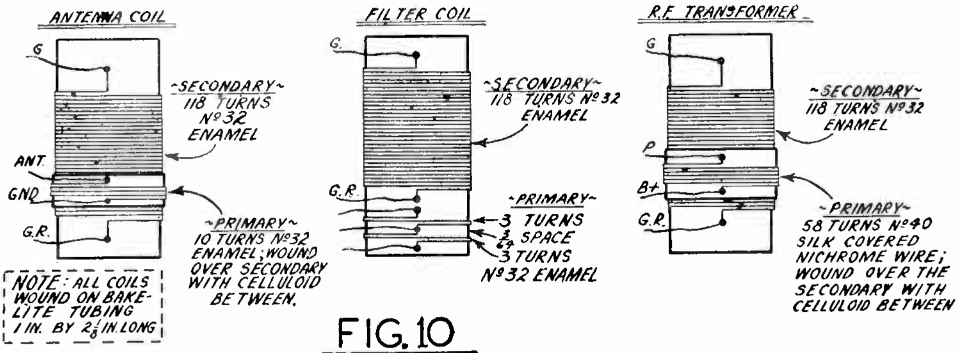


FIG. 10

Details of the coils used in the "pre-selector" circuit.

complicated equipment. This pretuner requires no increase in the number of tuning condensers over that which would ordinarily be required to give proper selectivity. If four tuned circuits are the standard, these four may be located before, after, or in between the amplifying tubes. Just because we are accustomed to seeing the tuning circuits arranged between the R.F. amplifying tubes is no reason why they will not function equally as well somewhere else. So we submit for your consideration the radio frequency circuit shown in Figure 9.

The details of coil design for both the pre-selector and the intermediate stages are presented in Figure 10.

USE OF RESISTANCE WIRE

The resistance wire is incorporated in the primary winding as a damping device. It tends to stabilize the circuit as a whole and prevents over-all feedbacks from reaching oscillating proportions. It acts in the same manner as the old grid suppressors, but much more effectively in that there is no broadening of the tuning as was so noticeable with the grid suppressors, particularly on the low waves. The resistance, when used in the grid, actually appears in the tuning circuit and is bound to broaden the tuning, as shown in Curve B in Figure 2. Furthermore, nothing much was to be gained with the 227 by placing the resistor in the plate circuit, as this circuit was coupled thru the capacity of the tube to the grid circuit.

Things are quite different with the screen-grid tube, as the plate circuit is completely isolated from the grid with no coupling between. The damping resistance added in the plate in this new circuit doesn't broaden the tuning in the previous plate. Of course, it almost goes without saying that everything must be fairly well shielded and that a small added capacity must be connected across the first pre-selector tuning circuit to represent the grid capacity of the tubes which are to be found across the other tuning circuits by virtue of the tubes connected thereto. If this precaution is not taken, the ganging will not run true thruout the circuits.

About the only thing left of importance to discuss is the detector circuit with its associated audio coupling. This feature of the receiver is also novel and worth considering. As soon as the screen-grid tube came onto the market, it was generally predicted that it would be a great detector. Several attempts were immediately made to incorporated it, but with little or no success. This lead to a premature conclusion that it could not be used as a detector. The entire fault lay in the previously mentioned fact that its small grid bias did not permit it to handle any too much energy. In other words, it was very easily overloaded. We have overcome this limiting feature by a power detection circuit which automatically varies the amount of "C" bias in proportion to the strength of incoming signal. This detector circuit is shown in sufficient detail in Figure 9, so we will discuss its operation directly by reference thereto.

OBTAINING "C" BIAS

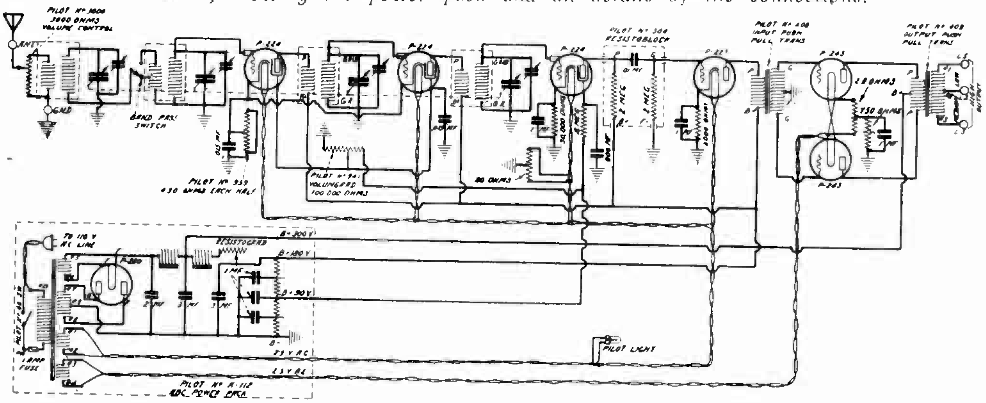
The secret of the success of the scheme lies entirely in the creation of the "C" bias for the tube by means of the average plate current flow. This is accomplished by the 30,000 ohm resistor in series with the cathode to ground circuit. The method of obtaining the grid bias by this arrangement is similar to that used in the rest of the A.C. heater type of tubes, where resistors are placed between the cathode and ground so that the plate current flow makes the cathode positive with respect to the grid circuit. Making the cathode positive to the grid is identical to making the grid negative with respect to the cathode. The only reason that the screen-grid acts as an efficient detector in one case and a good amplifier in another is because of the relation of plate and grid voltage values. In the detector, the plate voltage is made low by means of the high resistance in the plate circuit. At the same time, this two meg leak acts as a very good coupling resistance from the high internal impedance of the detector to the grid of the succeeding amplifier. Then, the screen-grid voltage is proportionately reduced by a different tap on the eliminator in addition to the five meg leak placed in series thereto. Of course, both the screen-grid and the plate circuit contribute some current to the drop in the cathode resistor, and these have been taken into account when 30,000 ohms were decided upon. This latter resistance must be by-passed by a good audio by-pass condenser, such as the 1 mf. shown in the sketch, because audio currents flow in this plate circuit, which must not affect the grid potential.

As the average plant current tends to increase upon tuning in on a local program, the grid bias is also increased, so that the detector hovers about the lower knee of the characteristic curve, no matter what the strength of station. Rapid audio changes which takes place during the actual program, are effectively by-passed by the 1 mf. condenser around the cathode resistance so that nothing changes to affect the program. The five meg screen-grid resistor may vary between 4 and 8 megs, while the plate resistor may change between one and three megs. The 30,000 ohms may also have fairly large limits between 25,000 and 35,000 ohms. The entire arrangement is not very critical and takes full advantage of the wonderful high amplification factor of this tube without its overload limitation.

The audio circuit represents the modern trend in design for this part of the radio receiver. The first stage consists of the high resistance coupling, just mentioned, and a push-pull audio transformer output. The output secondary is provided with a combination of taps so as to match almost any range of loudspeaker, from the lowly magnetic to the complicated and efficient dynamic. This is an important feature where the set will be operated on speakers beyond the control of the set manufacturer and yet this is often the weak link in the chain.

Figure 11 shows the over all circuit and is sufficiently clear so that no additional information is necessary for elaboration on the schematic.

Fig. 11 (below): This is the complete circuit diagram of the Grimes "Pre-Selector" broadcast receiver, showing the power pack and all details of the connections.



IN THE NEXT NUMBER

In the foregoing article Mr. Grimes has described in admirably clear language the theory of screen-grid amplifier design, and we are sure our readers have learned much from it. In the next number of Radio Design, he will describe in detail the construction of his "pre-selector" receiver, the circuit of which is shown above. This set will mark a departure in broadcast receiver construction from the standpoint of the radio constructor, and will prove one of the oustanding developments of 1930.

How Pilotron Radio Tubes Are Made

No. 4 of a Series of Trips Through the Largest Radio Parts Plant in the World.

by ALFRED A. GHIRARDI

THE news of the advent of the Pilot Radio and Tube Corporation into the radio tube field came as a pleasant surprise to many old friends who have long been users of Pilot radio parts. To others it came almost as the answer to long felt desire to see the greatest radio parts manufacturing plant in the world manufacture tubes on the same scale of high quality precision poduction that has characterized the many Pilot radio parts which are used all over the world.

Although the tube plant has been on a production basis for only a short time, the Pilot engineering staff, headed by Mr. John Geloso, has already made several important contributions to the art of tube design and manufacture. The production of the new Pilotron 227 tube, which was developed as a result of the intensive study of the problem of A.C. short-wave reception by the Pilot engineers, is a notable example. The story of the development of this tube was told by David Grimes in his article on the A.C. Super-Wasp in the Fall issue of RADIO DESIGN.

This unique situation of the largest radio parts manufacturing company in the world manufacturing both parts and tubes under the supervision of one staff of highly trained engineers cannot help but result in many new developments in both the tube and set field, for these men know the tube requirements desired in actual practice and are determined to produce the very finest tubes possible.

Before continuing further, we advise you to read Chapter 7 of the Radio Physics Course, which appears in this issue of RADIO DESIGN. You will then have an understanding of the construction of a vacuum tube and will understand the many processes involved in tube manufacture more easily.

TYPES OF TUBES MADE

At the present time the facilities of the new tube plant are being concentrated on the production of 112A, 222, 201A, 224, 226, 227, 245, 280 and 171A types of tubes. The manufacturing operation can be roughly divided as follows:

(a) Making of all elements and glassware; (b) Assembly of elements on flared tube; (c) Sealing of flared tube to outer bulb; (d) Evacuation of tube and bombardment; (e) Assembling base on tube; (f) Ageing; (g) Testing; (h) Packing. Inspection and testing is, of course, carried on throughout the various processes.

The various parts of a Pilotron 227 tube are shown in Fig. 1. Throughout this article reference will constantly be made to the letters of the individual parts of this tube.

MAKING THE PARTS

The first step is to prepare the glass bulb which acts as a support for the tube elements. The glass stems are cut off to proper length from long rods of glass tubing about ½-inch in diameter. The short pieces of tubing are then placed in a special machine, which contains four heads rotating slowly in gas flames. One flame preheats the end of the glass tube, the next heats it to a red heat and softens it. Then the operator flares out one end of the softened tube, as shown at I, by inserting a special tool in it.

MAKING THE STEM

The next operation is to place in position and seal into the flared tube the grid, plate, cathode and filament lead and support wires, and the smaller diameter glass tube through which the air will later be exhausted, as shown at I. If you will inspect a Pilotron tube closely you will notice that there are six of these wires sealed into the stem of the tube. Five of them are lead-in wires for the elements and one is a blind wire, used merely for supporting one end of the plate. Each of these wires consists of three parts, electrically welded together. The element support wire is made of nickel; the part of the wire sealed in the glass stem is a special wire having practically the same expansion coefficient as the glass, so that it will expand and contract just exactly the same amount as the glass does as the tube heats and cools off. This prevents opening of the seal or cracking of the glass (which would allow air to enter the tube later and ruin it). The lower part of

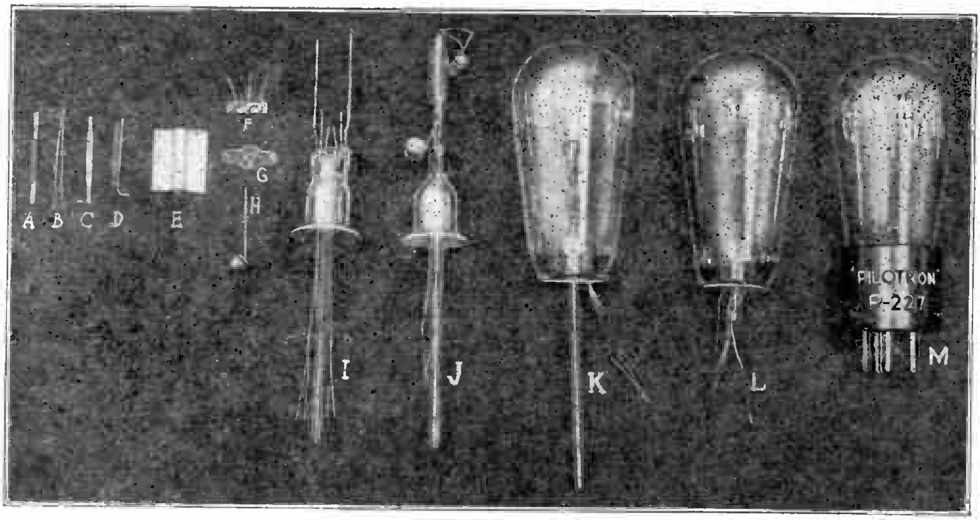


Fig. 1: This photo will help you in following the assembly operations involved in the construction of the Pilotron P-227. The lettered parts are referred to in the accompanying text.

the wire, which goes to the tube base prongs, is made of soft copper, so it can stand being bent back and forth many times during the manufacture of the tube without breaking.

The parts are all assembled in a special jig, which holds each part in its proper position. The stem machine, which has eight such jig fixtures arranged on a circular table, seals these wires into the glass. Each jig revolves constantly and the entire circular table is revolved in steps to bring the jigs to specially designed gas flames which heat the glass in successive heating stages. As the glass softens, it closes up at one end and seals the wires in. At the same moment two clamping arms are automatically pressed into the heated glass to flatten it and make a tight seal around the wires, as shown at I and J. The small glass tube for air exhaustion also seals into this at this time.

As the stems are removed from the jigs, the parts are very hot. If they were allowed to cool suddenly in the open air, mechanical strains would be set up in the glass parts, which would cause cracking later on. To prevent this, the stems are placed in an annealer, which contains a series of gas jets. These are arranged in steps so they are further apart at one end than at the other, thus making one end of the annealer much cooler than the other. As the stems pass thru this from the hot to the cool end they are gradually and slowly cooled to room temperature.

The stem assemblies are then inserted in a special press, which springs out the two plate supports slightly, cuts off and shapes the two grid and two filament support wires, and flattens them all out, so they will be in the same plane. This completes the operation on the stem, and it appears as shown at I.

MAKING THE BEAD

The small glass bead which holds the filament support at the top of the tube is made next. Long glass rods are cut up into the small lengths, which are then placed in the bead machine. In this, the operator feeds in the small glass pieces and the machine softens the glass and automatically pushes the three small nickel wires into the soft glass. There are six beads on this machine, so that the operation is continuous. The beads are then put in a press which contains a special die which bends the two outside wires over and out, the inside wire in, and trims all three to proper length in one operation. The bead is shown at the top right in J, Fig. 1.

MAKING THE PLATE

The machine which makes the nickel plates is a very ingenious one. A roll of nickel strip feeds into the machine at each end, to make the two halves of the plate. The machine contains a special die, which automatically punches the two halves of the plate, pierces them and fastens them together. The plates come out completely formed as shown in E.

MAKING THE GRID

The grids are wound of Molybdenum ("Moly") wire on two nickel supports, to which they are welded by a spot welding machine.

The small metal "Mag" cups for the small magnesium ribbon (described later) are formed in a press from a nickel sheet. The nickel support wires are then spot welded on to the cups, as shown at H.

This completes the manufacture of all the metal elements for the tube.

DE-GASSIFYING THE ELEMENTS

To the naked eye, all of the metal parts of the tube seem to be perfectly smooth. However, if they are observed under a high powered microscope, the many pores in the metal are readily seen. These pores, or irregularities in the surface, entrap tiny bubbles of air and other gases, which must be removed if a perfect vacuum is to be obtained in the tube later. This is done by heating the plates, grids and mag cups in a hydrogen furnace for about 40 minutes at a temperature of 1400° F. The heating causes the metal to expand and the pores to enlarge, and these tiny gas bubbles expand and burst, thus freeing the gasses. As they do so, they are swept away by the swirling stream of hydrogen, and thus de-gassified.

FILLING MAG CUPS

The magnesium used as a "getter" in the tube comes in strip form about ⅛-inch wide. It is cut up into four-millimeter lengths. A piece is dropped into each mag. cup and spot welded to the bottom of the cup. The magnesium melts to the cup and the spot of the weld, but does not burn up.

The filament wire for heater type tubes is made of tungsten, covered with a special enamel to give it the necessary mechanical strength to stand all the handling incidental to its preparation for filament use. A machine bends the filaments into V-shape, as shown in B. A girl then scrapes both ends of each piece off clean for the spot-weld connection to the filament support wires.

The hollow nickel cathode, which has a special oxide coating over its surface for electron emission, is then fastened to the little nickel U pin at one end, as shown at C.

MOUNTING THE ELEMENTS

The operator assembles the grid, plate, cathode and filament elements in a fixture which holds all of the parts firmly in their proper positions and exactly centered. They are then spot welded to the lead-in wires which were previously sealed into the glass flare.

The next girl places the small mica element spacer (G.) on top, places the glass bead on and welds its two outside wires to the plate supports. She then places the filament through the hole in the tiny ceramic insulator tube (A, Fig. 1) and inserts these in at the top of the cathode. She then welds the filament to the support wires.

The next girl puts the hooked tungsten wire under the V end of the filament to support it and welds this to the middle wire on the glass bead. She also welds the "mag" cup support wire to the dummy plate support wire. The cup is mounted in an inclined position, for a special reason to be explained later. The next girl lines up and assembles the entire element assembly, which now looks like J. A general view of a section of these assembly tables in the Pilot tube plant is shown in Fig. 5.

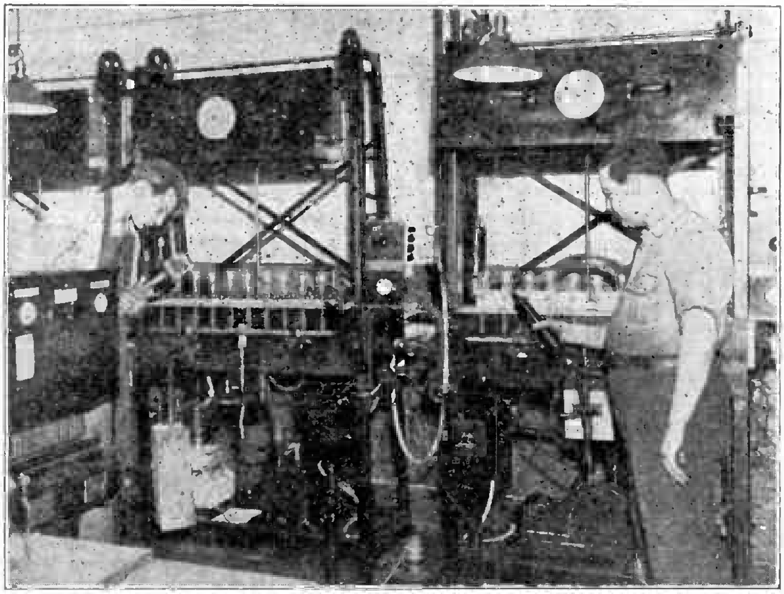


Fig. 2: A corner of the Pilot tube laboratory, showing how experimental tubes are exhausted and "degassified".

Fig. 3: An "ageing rack" used in the experimental tube laboratory. Here different tubes are subjected to different loads and their behavior observed.

Fig. 4: A testing outfit used in the experimental laboratory to check the characteristics of special tubes. Mr. Ghirardi (directly under the light) and Mr. Geloso are in the background.

ASSEMBLING OUTER BULB

The next step in the manufacture of the tube is the sealing of the element assembly into the outer glass bulb, as shown in K, Fig. 1. This is done in an automatic sealing machine, shown at the lower right hand corner of Fig. 6. In this machine the sealed-in element assembly in placed inside of the outer glass bulb. A number of gas flames are directed on the glass at the various positions to heat and soften it gradually.

In the first step the gas jets preheat the glass. In the second step the heating is continued and concentrated so as to soften the bottom of the outer glass bulb and draw it in partly by gravity, due to the weight of the apron below it. In the next step, the bulb is drawn in altogether and a special etching solution, which has previously been placed on top of the tube with a stamp, acts on the glass due to the heat and etches the Pilotron trademark on it.

In the next step, the flare and outside bulb have been sufficiently softened so they join together forming a seal, and the lower apron of the outer bulb is cut off. This completes the operation and the tube is now ready to be inspected again and evacuated.

The tubes are evacuated by drawing out the air inside the bulb through the small glass tube which extends up inside the flare. This is clearly shown in K, Fig. 1.

The tubes are first placed with their evacuating stems fitting tightly into rubber tubing leading to the exhausting pumps. Two small evacuating machines used in the Pilot tube laboratory for exhausting experimental tubes, are shown in Fig. 2.

When the tubes are in position, the rotary motor-driven vacuum pumps are turned on for about one minute. Some of these are shown at the left of Fig. 6. These are used for the rough pumping to take out most of the air. The tubes are then tested by bringing the discharge from a high voltage spark coil (held by man at right of Fig. 2) close to the glass bulb. If the inside of the bulb lights up with a reddish glow it indicates that a large proportion of air still remains inside the tube. If it lights up with a bluish glow it indicates that most of the air has been drawn off.

If a blue glow is obtained at this point the rotary prongs are shut off and the mercury pumps are turned on for doing the final pumping and creating the high vacuum in the tubes.

A gas heated oven (shown at the top of each machine Fig. 2) is then lit and lowered over the tubes. This heats all the glass parts of the tubes while the exhaustion is going on, to free all occluded air and gas from the walk of the glass (de-gassifying). The spark coil test is applied to the glass portion of the exhaust manifold to indicate the presence of gas in the exhaust line. This tells whether gas is still being taken out of the glass parts of the tube. If a yellow glow is produced it indicates that everything is O. K. If a red glow is obtained, it indicates that a tube has developed a crack, admitting air. This tube must then be located by individual test and removed.

After about fifteen minutes, the oven heat is shut off and the tubes are allowed to cool slowly so the glass does not crack. Then a terminal board, just back of the tubes, is folded down (left machine in Fig. 2) and wires are clipped on to the filament terminals of all the tubes. The filaments are now lit up at various voltages. At a certain time in this process the tubes are "bombarded" by the bombarder. This is an induction furnace, consisting of a coil of heavy copper strip through which a high frequency current is passing. This is held over the tube by the operator, as shown at the left of Fig. 2. This sets up eddy currents in the metal parts of the tubes which heat them to a red heat, without affecting the glass. This drives off the last residue of gas which may be occluded in the pores of the metal. As the mercury pump is still on, it draws all these gases out as soon as they are freed from the metal.

The filament voltages are then raised above normal and the bombarder is again placed around the tube, only this time it is placed down lower, so it heats the "mag" cup red hot and the magnesium strip is "flashed". Magnesium combines very readily with oxygen, so that the magnesium vapor being thrown against the glass walls, due to the inclined position of the "mag" cup combines with any remaining traces of air. This vapor condenses on the walls of the glass bulb and forms the familiar colored coating on the tube. The glass exhaustion tubes are now sealed off by a small gas burner and the pumps are stopped. The tubes now appear as in L, Fig. 1.

BASING OPERATION

A special cement is smeared around the inside of the Bakelite tube base and the tube is pressed down into it with the lead wires protruding through the proper base prongs. The bulbs together with the bases are then placed in an inverted position in the basing machine, one of which machines is shown in front of the operator at the left of Fig. 6. Heat is applied by gas flames to covers which fit over the bases. The heat bakes the cement at 300° F. while pressure is applied between the tube and base so that the glass bulb is held firmly to the base and resists being pulled out when tubes are placed in and out of sockets.

The lead wires which protrude thru the base prongs are then cut off and soldered to the prongs.

AGEING

The tubes are then "aged" that is, operated with and without filament, plate and grid voltage combinations, according to a special schedule developed by the Pilot engineers. The tubes are placed in sockets which are all wired up to permit of control of all voltages. One of the "ageing" racks used in the Pilot experimental tube laboratory is shown in Fig. 3. The ageing process not only ages the filaments and permits cleanup of any slight residual gas which may be in the tube but also serves as a test to indicate shorted cathodes, grids or plates. A 15 volt incandescent lamp is connected in series with the grid of each

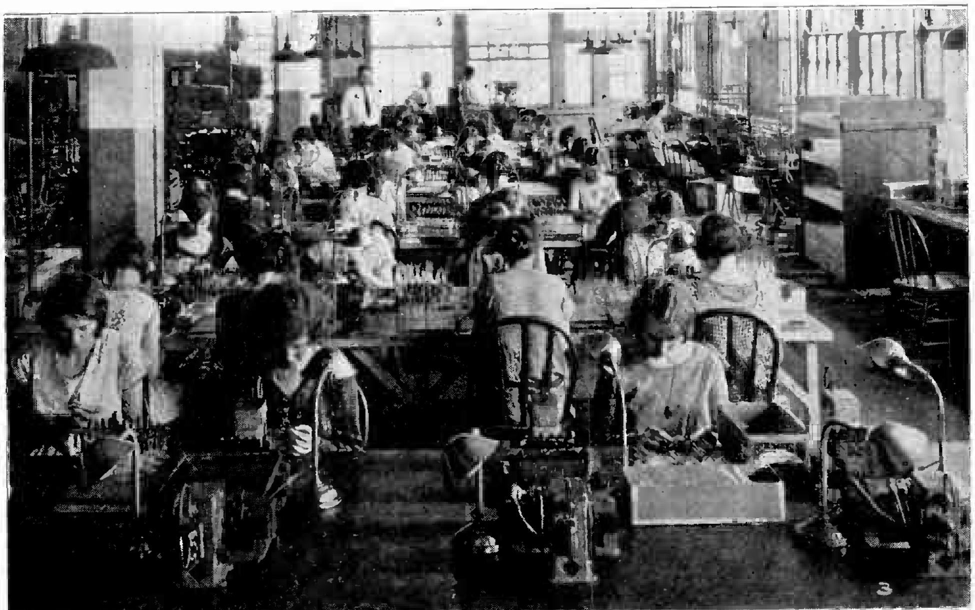


Fig. 5: A view of one corner of the assembly division of the Pilot tube factory, where Pilotrons are made.

Fig. 6: A corner of the exhausting, sealing and basing department of the Pilot tube factory.

tube and a 25 watt lamp is connected in series with the plate of each tube. If a short circuit exists in either the grid or plate circuit of a tube the particular lamp will light up.

The operator immediately destroys the tube. The incandescent lamp is shown on the vertical board before the operator. The filaments are lit for nearly 30 minutes at various voltages during the ageing process. Any gas which may be occluded in the filament or cathode is driven out by the heat to the glass walls during this process.

FINAL TESTS

After being aged the tubes are tested for filament current, plate current, total emission, amplification factor, mutual conductance and plate impedance. Fig. 4 shows the testing outfit used in the experimental tube laboratory. This equipment is adapted to test any type of tube from a 199 to a 50-watt transmitting tube. The total emission test is made by the special instrument on the left. Tubes which fail to meet the high standards set by the Pilot engineers are immediately destroyed. These standards are at least ten per cent above those of other manufacturers.

The Pilot engineers have also devised a unique tube life testing machine. This automatically opens and closes the filament circuit of the tubes on test continuously. The tubes are on about 20 minutes and off three minutes. Thus they are subjected to the same expansions and contractions due to alternate heating and cooling of the elements that they receive in actual service. Ten tubes are taken from each day's production of tubes, and are tested in this life tester until failure occurs. Readings are taken on the tubes at regular intervals so that an exact record of the behavior of the tube during its life is obtained.

All tubes which pass the Pilot specification have their bases branded with the name "Pilotron". The apearance of a completed tube is shown in M, Fig. 1. They are then packed in special shock-proof cartons for shipment, to be used in radio receivers of all kinds in the four corners of the earth.

Educational Department

How Instructors of Electricity in High Schools Can Arrange a Radio Course That Will Be Both Interesting and Instructive for the Students.

by ALFRED A. GHIRARDI

SINCE the publication of the first article in the Educational Department in the Spring issue of RADIO DESIGN, we have received many letters from both radio teachers and students in high schools all over the country. This is encouraging, for it indicates a healthy interest in the service we are trying to render for the benefit of the teachers and the thousands of boys who are interested in radio and are just learning what it is all about.

We received so many commendatory letters from boys and teachers alike, who had constructed the "Little Pal" receiver described in the Spring issue, that we designed "The A.C. Three", a simple three-tube electrically operated set somewhat similar to the "Little Pal". This was described in the Summer issue. The "Workshop Special" short-wave receiver described in the Fall number has also become very popular and many boys are abe to receive Europe on it regularly. Although most school work was at a standstill during July and August, numerous boys constructed this set. Many boys vacationing at summer camps took to radio set construction as part of their camp science project work.

With the opening of the fall school term, school radio work entered another year. Set design and construction has changed somewhat since last year, due to the introduction of the A.C. type of screen-grid tube. Sets are now being built almost entirely with metal chassis construction, and most receivers are of the one-dial type. The dynamic speaker seems to have come to stay, since many refinements in design and construction have brought it to the fore among the speakers. Push-pull audio amplification and power detection have also become very popular.

This season radio courses will have to include a great deal of material on screen-grid tube theory, power detection, push-pull amplification, dynamic speakers, single control, etc., if they are to be up-to-date. The Radio Physics Course textbook, which is now on sale, was completely revised during the past summer and we believe it presents all of this material in the most complete up-to-date form possible. We have even included chapters on television and the "talkies", as we felt that the great popular interest in these subjects warranted the space devoted to them.

Electricity, physics and radio instructors who have examined this book have all been highly enthusiastic over its possibilities and have expressed their desire to use it in their courses. Many have already ordered copies from RADIO DESIGN.

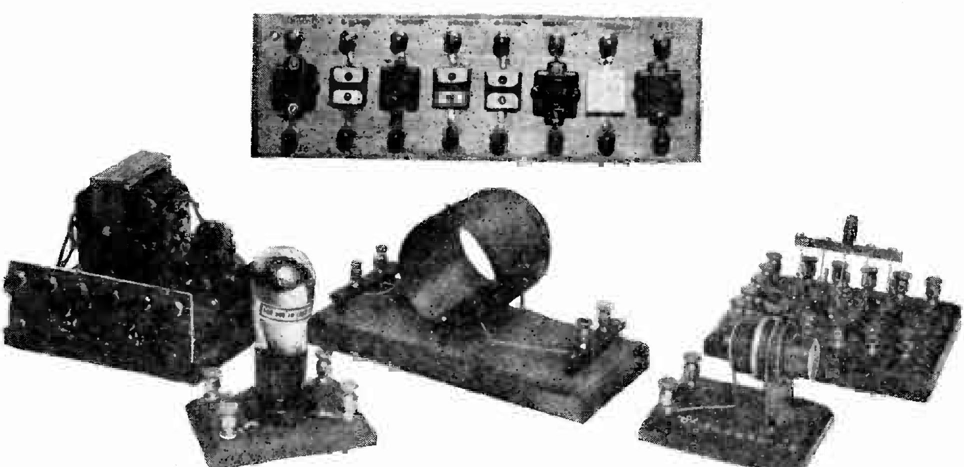


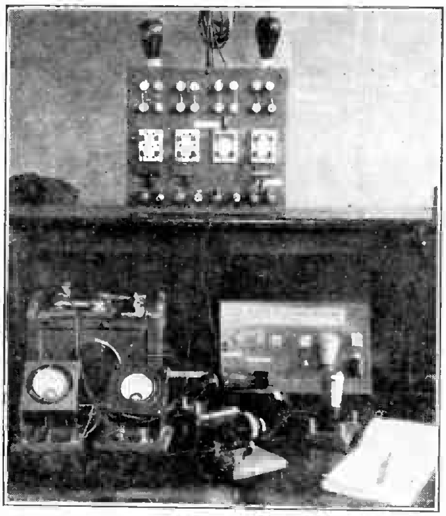
Fig. 1: Some typical radio instruments made up in very convenient form for instruction purposes in the school laboratory. Top: fixed condensers. Bottom, left to right: Filament transformer, vacuum tube, R.F. transformer, Resistograd, switch.

GETTING STARTED

MANY instructors of electricity have written us for advice on starting a radio course. We will attempt to outline a procedure for this, leaving most of the individual ideas as to experiments, apparatus and laboratory arrangements, etc., up to the instructor. Naturally, every teacher has his own ideas on the subject of laboratory arrangement and procedure, and we believe more or less in accordance with the other laboratories in the school.

Several years of experience in teaching applied electricity and radio has convinced us of the fact that radio should be taught to a student only after he has mastered the principles of electricity. You cannot take a green student and teach him the numerous intricacies of the radio art unless he already has a good foundation of physics and electricity. If one stops for a moment and considers how much modern radio, with its electric operation, power amplifiers, vacuum tubes, coils, condensers, resistances, transformers, etc., depends upon physical and electrical laws and principles, he cannot fail to realize the importance of these subjects in radio instruction. Radio work is really merely a specialized branch of electricity.

To take a concrete example, the writer teaches in a private technical school offering a three-year course for boys. Radio is taught as one of the specialized subjects in the senior year. The term is from September to June and approximately thirty hours per week are spent in school. From September to the end of December the radio class spends two hours per day in the laboratory. During this time no radio work is done at all. Regular experiments on electro-magnetism, induction, resistance, D. C. motors, D. C. dynamos, batteries, A. C. circuits, A. C. motors and generators, transformers, etc., are performed. The experiments are written up in laboratory notebooks and corrected and marked in the usual way. This prepares a firm foundation for the radio work, which is given approximately four hours a day from January until June. Classroom lectures and recitations form a regular part of the work.



Obtaining the characteristics of a tube with a set-up of instruments in a school laboratory.

While no radio work is done at the beginning of the term, every opportunity for illustrating how the electrical principles apply in radio work is utilized. Problems in resistance, inductance, capacity, transformers, etc., are given from the radio viewpoint. Thus by the time the students get to the radio work they are all prepared and anxious to delve deeper into the subject with some degree of intelligence.

The order of the work given closely follows the Radio Physics Course. Experiments on vacuum tubes are followed by those on coils, condensers, tuning, detection, R. F. amplification, regeneration, audio amplification, loud speakers, "B" eliminators, A. C. tubes and electric sets, screen-grid sets, trouble shooting, servicing, etc. The students are urged to deliver lectures on radio subjects before the school radio club, and every effort is made to assist them in arranging clear, understandable lectures with apparatus and demonstrations.

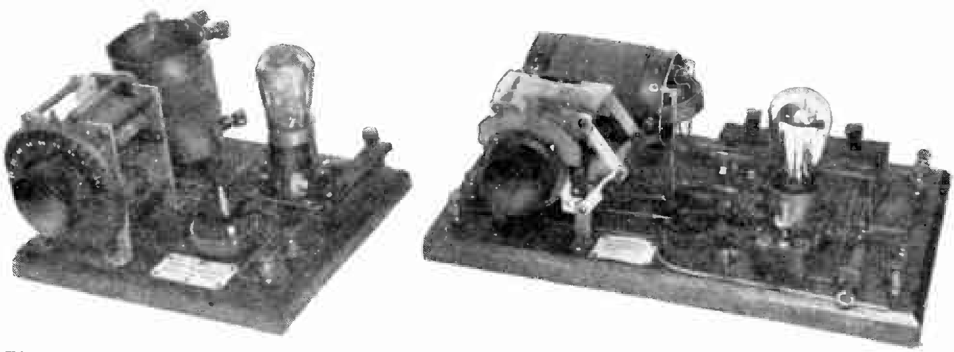


Fig. 2: These "breadboard" R.F. and detector units help the student to visualize complicated circuits and aid him in learning their principles of operation.

RADIO INTERNATIONAL GUILD INC.

New members join by the thousand as radio fans learn about the Guild; letters show widespread interest in organization.

by ALBERT L. RUDICK,

Executive Secretary, Radio International Guild

RADIO INTERNATIONAL GUILD got off to a flying start at the Radio World's Fair in Madison Square Garden, New York, during the week of September 23rd, 1929. The Guild's booth at the show was literally swamped during the entire week. At times it was necessary for applicants for membership to form in line and wait their turns, so great was the interest in and enthusiasm to join the Guild. When the final returns were in after the show came to a close, it was found that several thousand radio experimenters, custom set builders, amateurs and fans had enrolled. Many signed up for their friends also.

With this wonderful contingent as a nucleus, the Guild has been making rapid strides daily ever since. Not a day goes by that we do not receive between 50 and 100 members into the fold. Right now the membership consists of many thousands and at the present rate of incoming applications we hesitate to hazard a guess as to just how large the membership lists will be when the next Radio World's Fair rolls around.

Ordinary radio fans owning factory-built receivers who visited the show at the "Garden" marveled at the activity around our booth, where a group of well-known engineers, headed by John Geloso, David Grimes, Alfred A. Ghirardi and Robert Hertzberg, was kept busy every minute answering questions for twelve hours a day during the entire week. These fans couldn't understand why the Pilot—Radio Design—Radio International Guild booth was the busiest at the entire show and why crowds flocked around it continuously. However, to the initiated, such as the custom set builder and the experimenter, this was no mystery. The interest in custom built sets is greater than ever.

As a matter of fact, the interest was so great that David Grimes was compelled to adjourn to the ballroom of a large hotel across the street from Madison Square Garden, where the famous Walthal organization of New York, was holding a radio show of its own. Here Mr. Grimes gave ten-minute talks and demonstrations on his new "110 Volt D.C. New Yorker", which was described in the Fall number of RADIO DESIGN. Visitors were compelled to wait their turns to get into these lectures, so great was the crush.

Perhaps the most interesting feature of the show was the fact that so many people came from far distant points. Nearly every state in the Union was represented, besides Mexico, Porto Rico, Cuba, South America, Canada and even Europe. This is not merely a haphazard statement, but an actual fact, for the Guild signed up members from these far away lands.

The spontaneous support given the Guild upon the announcement of its formation in the Fall number of RADIO DESIGN was most heartening. Hundreds of letters, full of expressions of good-will and commendation were received. The avalanche of renewals of subscriptions to RADIO DESIGN, which automatically make the readers members of the Guild, was most flattering.

MANY LETTERS ARRIVE

Many letters containing valuable suggestions have been coming in. One that brought immediate action was from Leslie F. Satterly of Blue Point, N. Y. Mr. Satterly requested permission to start a local chapter of the Guild in his town, and as this was in line with our plans, we very happily granted his request. He has already interested many of the foremost radio experimenters and custom set builders in his community and now has several members in the Blue Point chapter.

Chapters of the Guild are being formed in all parts of the country. Enthusiastic members are gathering their radio friends together and acquainting them with the aims and objects of the Guild. The benefits to be derived from personal contact, such as a local chapter offers, are unlimited and we will give every encouragement and assistance to those desirous of undertaking the establishment of such chapters in their own cities.

Our international secretary, Mr. E. Manuel, reports the initiation of hundreds of members in South America, Mexico, Cuba, Porto Rico, Australia, Africa, Asia and throughout Europe. Certificates and membership cards have been printed in Spanish for the members speaking that language. As evidence of the interest in foreign lands, we reprint a letter from Senor Pedro de la Rosa, Jr., of Havana, Cuba.

Havana, Cuba,
October 18th, 1929

Mr. Albert L. Rudick;
Executive Secretary,
Radio International Guild,
325 Berry St., Brooklyn, N. Y.
Dear Sir:—

In a letter I've recently received from Mr. E. Manuel, General Export Manager of Pilot Corp., that gentleman notified me of the formation of the Radio International Guild and of the appointment of RADIO DESIGN as its official organ.

Being a radio fan and experimenter, I would like to become a member of Radio International Guild. Will you please state to me how to reach my wish?

Thanking you in advance, for the favor I hope to receive from you, I remain,

Yours faithfully,
Pedro de la Rosa, Jr.,
San Joaquin 87, moderno
Havana, Cuba.

Many other letters have been reaching us and we have selected a few that show the general trend of this correspondence.

October 28th, 1929
Seabrook, New Hampshire

Albert L. Rudick, Executive Sec'y.,
International Guild,
325 Berry St.,
Brooklyn, N. Y.

My dear Sir:

Inclosed you will find postal money order for fifty cents for which please send to my address for one year the RADIO DESIGN, also certificate, identification card and pin of the Radio International Guild.

Emery N. Eaton

I take this opportunity to tell you that RADIO DESIGN is the best Radio magazine on the market today. Through a friend I secured the Fall edition and believe me, from now on my workshop won't be complete without the latest copy.

Respectfully yours,
Emery N. Eaton.

Radio Guild,
Gentlemen:

At the recent Radio World's Fair I became a member of the R. I. G. Now I am desirous of some information in radio construction. At present I have a five-tube set, employing push-pull amplification 171-A's. This set works on an "A" eliminator. My question is concerning the "B" eliminator. Enclosed find a diagram of such up to the resistor section. This is where I would appreciate very much if you could give me the correct values of the resistors to be used in this circuit. The main difficulty lies in obtaining the correct *grid bias* for the 171-A's in push-pull. Am using Pilot No. 387 power transformers, Mershon condenser of 36 Mfd., 3 Pilot by-pass condensers, 1 choke, 1 resistance.

Vincent Campbell

Hoping you will oblige, if possible, I am,

Member,
Vincent Campbell.
464 — 73rd Street,
Brooklyn, N. Y.
October 9th, 1929

P. S. Here's wishing you lots of luck in the plan of the R. I. G. Am waiting for first development.

(EDITOR'S NOTE: Technical questions of this kind are answered by the hundred every day by the staff of the Guild and RADIO DESIGN.)

October 15th, 1929.

Mr. Albert L. Rudick, Sec'y.,
Radio International Guild,
325 Berry Street,
Brooklyn, N. Y.
Dear Sir:

I have been a regular subscriber and reader of the RADIO DESIGN for the past year and always look forward to receiving my copy. It truly is a wonderful paper, interesting to the experimenter, very helpful to the dealer and a blessing to the set builder.

I am enclosing 50c to take care of another year's subscription (I don't know when my present subscription is up), but the main idea of this letter is to put my application in for membership to the Radio International Guild. If I am accepted, I certainly would appreciate all the credentials to show that I am a member.

Would also appreciate any other information as to this new organization, how it functions and its purpose. I have read your article in the Fall issue of RADIO

DESIGN just received, but if there is any other information to be had, I would like to have it.

Very truly yours,
Edward Roth,
1358 Wholesale St.,
Los Angeles, Calif.

Galien, Ohio
October 8, 1929

Mr. Albert L. Rudick,
Radio International Guild,
Brooklyn, N. Y.,

Dear Sir:

Through a friend I received a copy of RADIO DESIGN and regret that it was the first one I have ever seen. I was surprised at the first hand information it contained.

J. P. Vanderkoy

First of all, it differs from the average run of radio magazines in that it is not all filled with advertisements from one or the other firm, and also in that the descriptions it contains are simple in wording.

Most any novice can read and understand what the writer is trying to bring out, without an education from a college in "Siberia" or some such place.

Allow me to express my sincerest wishes for the continued success of RADIO DESIGN and please enter my name on your membership list.

Yours respectfully,
J. P. Vanderkoy,
446 N. Market Street,
Galien, Ohio.

Radio Design Publishing Co., Inc.,
103 Broadway,
Brooklyn, New York

Gentlemen:

On November 12th I wrote you asking you to look up my subscription which I sent to you in the early part of October. Please disregard that letter, as the next day I received my receipt and the membership certificate in The Radio International Guild.

I want to compliment you on the wonderful magazine you publish. I have been fortunate enough to have received every copy since the first one published, and I want to say RADIO DESIGN is worth twice what you ask for it.

I also want to thank you for the beautiful membership certificate and button, and want to say I am very proud of them both.

Yours truly,
L. E. Giezendanner,
616 West 30th Street,
Indianapolis, Ind.
November 14, 1929.

October 8th, 1929
Blue Point, N. Y.

Dear Sir:

Kindly send me four copies of the constitution to give to friends. I would like to start a local branch of the Guild here in Blue Point so that as a body, we may experiment with radio. How many members must I get to get a charter? Enclosed find \$1.50 for three memberships and subscriptions for Charles Stroh, Anthony Petroske and Harold Kershaw.

You will please send me their memberships and I will deliver them, as they all live nearby. Thanking you in advance I remain,

Yours sincerely,
Leslie Satterly.

P. S. I obtained my membership from you at the Radio World's Fair.

October 3, 1929.

Dear Sir:

As a member of the Radio Guild (I became one at the Radio Show), I have started to enlist my friends. Up to now I have seven new members. A few more yet to come. I would like to know if I should put their names and addresses on plain paper or if you will send me blanks to fill out. Kindly let me know as soon as you can.

W. C. Davis

Yours truly,
W. C. Davis,
109 Passaic St.,
Garfield, N. J.

How to Join the Guild

Membership in the Radio International Guild costs only fifty cents a year, or a dollar for two years, and this includes one (or two) year's subscription to "Radio Design". You will receive a handsome blue and gold membership button that you can wear on your coat, a beautifully engraved membership certificate, and an identification card. Merely fill out the form on page 68 of this number and mail it to Albert L. Rudick, Executive Secretary, Radio International Guild, 323 Berry Street, Brooklyn, N. Y.

Read what BIG money these fellows have made in the RADIO BUSINESS

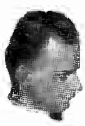
$375 One Month Spare Time

"Recently I made $375 in one month in my spare time installing, servicing, selling Radio sets. And, not so long ago, I earned enough in one week to pay for my course."
EARLE CUMMINGS,
18 Webster St., Haverhill, Mass.

$1597 In Five Months

"The N. R. I. is the best Radio school in the U. S. A. I have made $1597 in five months. I shall always tell my friends that I owe my success to you."
HENRY J. NICKS, Jr.,
302 Safford Ave.,
Tarpon Springs, Fla.

$1164 Spare Time Profits



"Look at what I have made since I enrolled, $1,164—money I would not have had otherwise. I am certainly glad I took up Radio with N. R. I. I am more than satisfied."
HENRY R. HEIKKINEN,
123 W. Erie St., Chicago, Ill.

Over $1000 In Four Months

"My opinion of the N. R. I. course is that it is the best to be had at any price. When I enrolled I didn't know a condenser from a transformer, but from December to April I made well over $1000 and I only worked in the mornings."
AL. JOHNSON,
1409 Shelby St., Sandusky, Ohio.

I will show you too how to start a spare time or full time Radio Business of Your Own *without capital*

J. E. SMITH *Pres.*

Radio's amazing growth is making many big jobs. The world-wide use of receiving sets and the lack of trained men to sell, install and service them has opened many splendid chances for spare time and full time businesses.

Ever so often a new business is started in this country. We have seen how the growth of the automobile industry, electricity and others made men rich. Now Radio is doing the same thing. Its growth has already made many men rich and will make more wealthy in the future. Surely you are not going to pass up this wonderful chance for success.

More Trained Radio Men Needed

A famous Radio expert says there are four good jobs for every man trained to hold them. Radio has grown so fast that it simply has not got the number of trained men it needs. Every year there are hundreds of fine jobs among its many branches such as broadcasting stations, Radio factories, jobbers, dealers, on board ship, commercial land stations, and many others. Many of the six to ten million receiving sets now in use are only 25% to 40% efficient. This has made your big chance for a spare time or full time business of your own selling, installing, repairing sets.

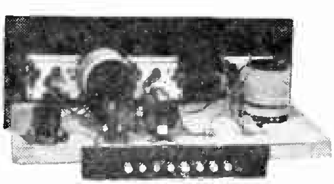
So Many Opportunities You Can Make Extra Money While Learning

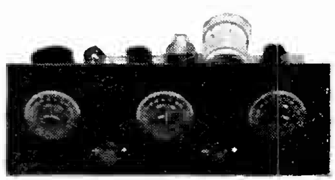
Many of our students make $10, $20, $30 a week extra while learning. I'll show you the plans and ideas that have proved successful for them—show you how to begin making extra money shortly after you enroll. G. W. Page, 1807-21st Ave., S., Nashville, Tenn., made $935 in his spare time while taking my course.

I Give You Practical Radio Experience With My Course

My course is not just theory. My method gives you practical Radio experience—you learn the "how" and "why" of practically every type of Radio set made. This gives you confidence to tackle any Radio problems and shows up in your pay envelope too.

You can build 100 circuits with the Six Big Outfits of Radio parts I give you. The pictures here show only three of them. My book explains my method of giving practical training at home. Get your copy!





I Will Train You At Home In Your Spare Time

I bring my training to you. Hold your job. Give me only part of your spare time. You don't have to be a college or high school graduate. Many of my graduates now making big money in Radio didn't even finish the grades. Boys 14, 15 years old and men up to 60 have finished my course successfully.

You Must Be Satisfied

I will give you a written agreement the day you enroll to refund your money if you are not satisfied with the lessons and instruction service when you complete the course. You are the only judge. The resources of the N. R. I. Pioneer and Largest Home-Study Radio school in the world stand back of this agreement.

Get My Book

Find out what Radio offers you. My 64-page book, "Rich Rewards in Radio" points out the money making opportunities the growth of Radio has made for you. Clip the coupon. Send it to me. You won't be obligated in the least.

This Book points out what Radio offers You Get a copy!

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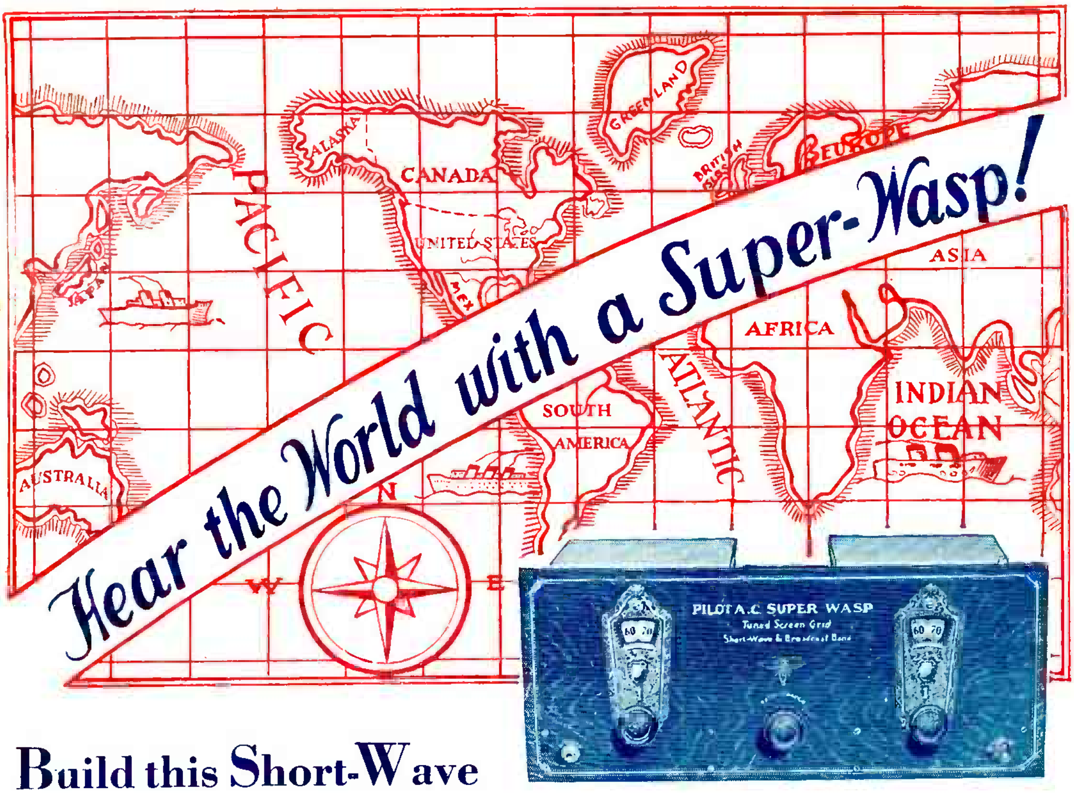
National Radio Institute
Washington, D. C.

This coupon is good for a FREE copy of my Valuable Book Mail it NOW

J. E. Smith,
President,
Dept. O A 4
National Radio Institute, Washington, D. C.

Dear Mr. Smith: Send me your book. I want to know more about the opportunities in Radio and your practical method of teaching at home in spare time. This request does not obligate me to enroll and I understand no agent will call on me.

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



Build this Short-Wave Receiver *with the* 10,000 *Mile Range!*

[Also covers the entire broadcast band from 14 to 500 meters, by means of interchangeable plug-in coils]

A. C. Operated Kit K-115

$34.50

(Power Pack Extra)

This combination short-wave and broadcast receiver, designed by Grimes, Geloso and Kruse, utilizes the super-sensitive screen-grid tube and specially developed Pilotron 227. Thousands of fans attest the world-spanning ability of this four-tube short-wave wonder! Made for both A.C. and battery operation. (With the A.C. job use power pack K-111.) You, too, will get more "kick" per dollar from international short-wave reception with the Super-Wasp than from anything else in radio!

BATTERY OPERATED KIT K-110

$29.50

If your nearby radio dealer is not yet supplied, write direct to

PILOT RADIO & TUBE CORP.

World's Largest Radio Parts Plant
Established 1908

Trade Mark

323 Berry Street
Brooklyn, New York