HOW TO USE CIRCUIT DIAGRAMS AND LOCATE CHASSIS PARTS

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Study Schedule No. 32

For each study step, read the assigned pages first at your usual speed, then reread slowly one or more times. Finish with one quick reading to fix the important facts firmly in your mind, then answer the Lesson Questions specified for that step. Study each other step in this same way.

☐ **1. What a Circuit Diagram Tells; Principles of Radio Servicing — Pages 1-7**

Circuits need not be completely analyzed; two groups of receiver defects; Surface Defects; Dead Receiver; Improperly Operating Receiver; trouble-locating questions; Distortion at High Volume Levels; Hum; Alignment Procedures; Subjects for Further Study; example for study is Philco Model 38-7 receiver. Answer Lesson Questions 1, 2 and 3.

☐ **2. Identifying Stages on a Schematic Diagram; Analyzing Each Stage on a Schematic Diagram - - - - - - - - Pages 7-12**

Read diagrams from left to right; identifying clues on diagrams; stage-identifying examples: Oscillator-Mixer-First Detector; I.F. Amplifier; Second Detector; A.V.C. Tube; First A.F. Amplifier Stage; Output Stage; Power Pack. Answer Lesson Questions 4 and 5.

☐ **3. Identifying Stages on the Chassis - - - - - - - - - - Pages 12-20**

Use of tube layout diagrams; identifying the circuit; locating the rectifier tube and a.f. output tube; identifying other tubes; General Suggestions. Answer Lesson Question 6.

☐ **4. Locating Parts with a Pictorial Diagram; Locating Parts Without a Pictorial Layout Diagram; Tracing Tube Electrode Circuits - - - - - - - - - - - - - - - - Pages 20-24**

Locating electrolytic filter condensers and identifying their leads; locating a resistor; use of circuit diagram alone for locating parts and checking continuity; Plate Circuits; Screen Grid Circuits; Control Grid Circuits; Suppressor Grid Circuits; Diode Detector Circuits. The important thing in this step is to refer to the diagrams as you study, so as to get practice in locating parts quickly with the aid of diagrams. Answer Lesson Question 7.

☐ **5. General Rules for Checking Continuity of Electrode Circuits in A.C. Receivers; How to Locate Trimmer Condensers; Appraising Receiver Performance; Schematic and Chassis Wiring - - - - - - - - - - - - - - - - - - Pages 24-29**

Rule for positive electrodes; rule for negative electrodes; rule for diodes; identification of trimmers; General Trimmer-Locating Suggestions; how performance is affected by the number of tuned stages, number of tubes, type of circuit, use of r.f. stage, type of loudspeaker and presence of band-pass circuits; practical chassis wiring. Answer Lesson Questions 8, 9 and 10.

☐ **6. Mail your Answers for this Lesson to N.R.I. for Grading.**

☐ **7. Start Studying the Next Lesson.**

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How To Use Circuit Diagrams and Locate Chassis Parts

What a Circuit Diagram Tells

AS YOU know, a schematic circuit diagram is a symbolic means for showing the electrical connections in a radio set. A schematic diagram tells very little about the construction of each part, how the parts should be adjusted, where the parts are located on the actual chassis, or how the connections are actually made between various points; nevertheless, to a man possessing the fundamental training in radio theory and practice which you are now acquiring, this diagram can yield information of great value in connection with the servicing and maintenance of radio equipment.

There is no more need for a Radiotrician to analyze a complete receiver circuit diagram when repairing a defect, than there is need for a carpenter to study the complete building plans for a new home when repairing the front porch railing. Once you become familiar with the general principles of radio servicing, you will agree that a circuit diagram is a "reference text" rather than a "study text."

Principles of Radio Servicing

When you tackle a defective receiver, you know that it must belong to one of the two general trouble groups in which all defective radio receivers can be placed: *1, the receiver is dead*—it does not play at all; *2, the receiver plays improperly*—it may howl, squeal, distort, lack selectivity, lack sensitivity, be noisy, have a faulty automatic tuning or A.F.C. system, or have any one of a host of other defects which are considered elsewhere in the Course.

Surface Defects. Occasionally the trouble which results in a dead or improperly operating receiver is not in the chassis at all, but on the outside or on the *surface*, where it can be readily seen and corrected. Obviously you will want to check for surface defects before removing the chassis.

The practical radio serviceman generally starts in by checking the antenna system and the power line cord, making sure that all tube caps are in position and not touching the shields, making sure that all extension wires and cable plugs are in place, and noting whether any tubes are obviously defective. He may even remove each tube and check it in a tube tester, to see if a simple replacement of a defective tube will clear up the trouble.

Making a continuity test between the top caps of two tubes on the Philco model 38-7 receiver, using the multimeter section of a combination signal generator and multimeter.

When a check for surface defects in this manner proves unsuccessful, one trouble-locating procedure is followed for the case of a dead receiver, and an entirely different pro-

cedure is chosen for an improperly operating receiver. In both of these procedures the schematic circuit diagram is brought into use.

Dead Receiver. When anything goes wrong, the natural first step is to ask yourself what the trouble could be. This applies to any machine, to any human being, and to any action, as well as to the radio receivers under discussion. We therefore ask: "Why does a receiver become dead?" There are a number of answers—one or more tubes may be defective, some part in the power pack or in the voltage supply system for the receiver may have opened up or become shorted, a signal circuit part may have opened or shorted, or a connection may have opened somewhere.

With a dead receiver, then, our first task is the locating of the defective tube, part or connection. Do we have to check all parts and connections until we find the one which is defective? Not if we reason out this problem a bit first. You know that a carrier signal modulated with an intelligence signal enters the antenna circuit of a receiver, with this intelligence signal working its way through a chain of stages to the loudspeaker. The receiver is dead because one or more links in this chain have failed. Radio men say that one or more stages have become defective; once they locate this defective stage, they have limited the task of locating the defective part to a smaller portion of the receiver.

As you will learn elsewhere in your Course, there are two ways of locating the defective stage in a dead receiver; we will present them here only briefly. In the *dynamic stage-by-stage elimination test,* a modulated signal generator is connected to the input of the second detector; if the modulation signal is heard in the loudspeaker, you know immediately that the detector and the audio amplifier are free of trouble. If no signal is heard, headphones are connected in turn to the output of the detector and to the output of each following audio stage. Failure to hear the output signal in the headphones at any stage identifies that stage as being defective, assuming that the power supply has been checked and found to be performing properly.

If the detector and the stages following it are found to be operating properly, the signal generator is advanced toward the antenna one stage at a time; the signal should become louder as this is done. Failure to hear the signal identifies the defective stage.

The simplest and speediest test for isolating the defective stage in a dead receiver is the *circuit disturbance test.* This depends upon the fact that when a tube is pulled out of its socket and quickly returned, or when the grid of a tube is touched or shorted to the chassis, or when the grid cap connection to a tube is removed and returned, a sharp change in the plate current for the tube takes place. This sudden change or shock is relayed through the receiver and is heard in the loudspeaker as a click, a thud or a squeal provided that all stages in the path of this disturbance are operating properly. Starting at the last audio stage and working toward the antenna stage, one of these methods for producing a disturbance is employed on each tube in turn. When you reach a tube which produces no indication in the loudspeaker while being shocked, you have isolated the trouble to that stage.

Once the defective stage is isolated, it is given a thorough check either with an ohmmeter or a voltmeter in a manner explained elsewhere in the Course, after making sure that the tube is good. Supply voltages for the tube are usually checked first.

Obviously you must know something about the circuit of a receiver in order to be able to isolate the defective stage and then isolate the defective part in that stage. You must be able to identify the second detector tube, which is the usual starting point for a stage isolation procedure. You must be able to locate the first, second and power audio tubes so you can follow the chain of stages in the proper order from the second detector to the loudspeaker; likewise you must be able to locate the I.F. and R.F. amplifier tubes in their proper order from the second detector to the antenna. You should know where to connect a voltmeter in order to check the main power supply. Once the defective stage is located, you must be able to locate and identify the various parts in the grid, plate, screen grid and suppressor grid circuits of the tube. You may be able to determine all these things by a study of the chassis itself, but this will take time; a schematic circuit diagram gives this information far more readily. If the service manual of the receiver also contains a tube layout diagram, showing the positions of the various tubes on the chassis and identifying their functions, your task is further simplified.

Improperly Operating Receiver. Expert Radiotricians will tell you that a dead receiver is generally easier to service than an improperly operating receiver. The true value of theoretical training, modern technique and practical experience becomes evident when it is necessary to service a receiver which squeals (oscillates), blocks, distorts, hums, is noisy, cuts off intermittently, lacks selectivity, lacks sensitivity, or lacks output volume. The value of circuit diagrams becomes increasingly more evident as servicing problems become more complicated.

A customer may bring in a receiver for repair, complaining that he can't understand the announcements or speeches as reproduced by the loudspeaker. After making sure that surface defects are not the cause of this distortion, a Radiotrician will automatically ask himself these questions:

1. Under what conditions of receiver operation does distortion ordinarily occur? Does the receiver distort only when the volume level is high, only when the volume level is low, or at all volume levels and all settings of the receiver controls?

2. What are the general reasons for distortion which occurs under the conditions noted?

3. What are possible causes, in this particular receiver, for the type of distortion observed? (Reference text "Radio Receiver Troubles—Their Cause and Remedy," which was sent you some time ago, covers many of the common causes for various types of distortion. This reference text will help you develop an ability to reason from observed effects like distortion to the logical causes.)

When a serviceman cannot answer these questions, he is compelled to test all stages and parts, using some systematic method of defect isolation. The checking of operating voltages for all tubes is an important part of this procedure; the correct voltages are usually given in the service manual.

Distortion at High Volume Levels. Let us assume that the receiver in question distorts only when the volume level is high. If it is an inexpensive midget table model receiver, this distortion may be natural and unavoidable, especially if it is most serious when powerful local stations are tuned in. Experience is a great help in determining whether or not an actual defect exists. Reference to the circuit diagram of the receiver will

often tell whether or not the receiver is capable of handling high volume levels. If you decide that the receiver is operating as well as can be expected for that particular type of circuit, you will have to explain the situation to the customer and point out that the volume level should be kept below the point at which distortion begins.

If the receiver is of normal design and you decide that it should handle the maximum volume level without distortion, the next question to answer is: What can cause distortion when the volume level is high? The Radiotrician knows that possible causes for this effect are overloading of the detector, overloading of the audio output tube, overloading of the loudspeaker, weak tubes (low emission), low supply voltages, or a defective loudspeaker. With these probable causes in mind, you should now proceed to eliminate them one by one until you reach the true cause of the trouble. Test the tubes first of all, then check the main supply voltage and the individual supply voltages for each suspected tube. You may have to refer to a circuit diagram in order to determine where the voltmeter connections should be made for each test.

Plate and screen grid supply voltages are usually measured between these electrodes and the cathode of the tube, while a C bias voltage is measured between the cathode and the chassis, as a rule. Quite often, manufacturers will specify, in service manuals, all electrode voltages with respect to the chassis. Reference to the schematic circuit diagram will tell you exactly where connections can best be made to measure a particular voltage.

Can you quickly locate the plate, screen grid and cathode terminals on an actual tube? Few people can, for there are hundreds of different types of tubes in use today, each with different connections between the electrodes and the terminal prongs. Receiver manufacturers sometimes show tube sockets in pictorial form in the service manual, either on the schematic circuit diagram itself or on a separate chassis diagram. Tube manufacturers likewise supply socket connection diagrams for all tubes, so there should be no trouble in securing a tube diagram to serve as a guide.

When there are two or more stages in a receiver employing the same type of tube, how can you locate one of these tubes on the circuit diagram? The answer is quite simple; examine a few of the parts in the chassis which are connected to the tube in question, then determine which tube in the schematic diagram has these same parts connected to it.

Now you can check the values of each part in the defective stage against the values specified on the circuit diagram; check for changes in the resistance of a part and for shorted or leaky condensers, as any of these defects will alter the supply voltage enough to cause distortion when the volume level is high.

If you have followed the servicing procedure up to this point without locating the defect, refer to the schematic circuit diagram and determine whether the receiver has A.V.C. If the volume control is connected into the input of the audio system, you can be pretty sure that some of the preceding I.F. and R.F. amplifier stages are A.V.C controlled. Assuming this to be the case, you can be fairly certain that R.F., I.F., and second detector signal and supply circuits are all in order since there is no distortion at low volume levels on the particular receiver being analyzed.

You think a bit—could there be

overloading of an audio amplifier stage? As soon as you think of a reasonable cause of trouble, check up on it. An easy way to locate the overloaded stage is to turn up the volume control while tuned to a strong local station, so that distortion is clearly evident, and then connect headphones across the output of each audio stage in turn, starting with the second detector and ending at the loudspeaker terminals. Reference to the schematic circuit diagram and perhaps to the pictorial layout diagram will tell you where to make the headphone connections. The stage at which distortion is first noticed in the headphones will very likely be the overloaded stage. If no distortion is first noticed in the headphones up to the loudspeaker, then you can be pretty certain that there is a defect in the loudspeaker or its input circuit.

Hum. Now let us consider a receiver which has excessive hum. Naturally you turn on the set and make the usual inspection for surface defects. Let us assume that while doing this you note one tube with a blue glow between the cathode and plate. By noting the number of this tube, by referring to the parts layout diagram in the service manual, or by noting that there are no grid electrodes between the cathode and plate in the tube, you identify it as a rectifier. Obviously you have located a surface defect, for these tubes (with the exception of mercury vapor rectifier tubes) should not glow when operating properly; there is no sense in looking farther for other causes of hum until this trouble is cleared up.

A blue glow inside a vacuum type rectifier tube indicates the presence of gas; we say that the tube is *gassy*. The question is: Why did the tube become gassy? A logical answer is normal aging of the tube with constant use, for rectifier tubes are often operated very nearly at their maximum capacity in receivers. On the other hand, there may be a short in the power pack which is making this rectifier tube deliver higher than normal current. It would not be safe to insert a new tube until the power pack has been examined for possible defects. Again you would refer to the circuit diagram, noting what parts are in the power pack circuit and noting what their values should be. From your study of condensers, you know that paper condensers should have very large resistances, above 20 megohms, and electrolytic condensers should have resistance above at least 250,000 ohms when properly tested. Since filter condenser failure is a very common cause of hum, and excess rectifier tube current, you check these first, then check the electrical values of other parts in the power pack or in the power supply system.

But suppose that the inspection for surface defects gave no sign of the trouble. In this case the Radiotrician would turn to the schematic circuit diagram with one thought in mind: What part of circuit in this particular receiver could become defective and cause hum? As he glances over the power section of the circuit diagram, he may notice a tuned filter; knowing that even small changes in the values of the condenser and choke coil can result in hum, he checks these parts carefully with his multimeter. Or he may notice a hum bucking coil indicated in the schematic symbol for the loudspeaker; this could well be the cause of the hum, so a careful check of this part is made. There are electrolytic condensers in the power pack, and they have an unfortunate tendency to become leaky with age, so he checks them next. There are resistance-capacitance filters in grid circuits for application of a C bias

voltage, so he checks these for leaky condensers and shorted resistors.

But this is not intended to be a lesson telling how to service a radio receiver; we have briefly considered these actual examples of servicing problems primarily to illustrate correct service technique and to show how the schematic circuit diagram and the other information contained in service manuals can be of help in servicing. You are becoming acquainted with the process of figuring or reasoning out probable causes of trouble when certain effects are observed—a process which we call "effect-to-cause reasoning."

A knowledge of how radio circuits work is one essential requirement for successfully applying effect-to-cause reasoning; this knowledge you are now acquiring in your Fundamental Course. Experience with actual radio apparatus and continued reference to schematic circuit diagrams will eventually make effect-to-cause reasoning become second nature to you.

Alignment Procedures. We have by no means exhausted the Radiotrician's uses for circuit diagrams. One highly important use, in connection with the alignment of tuned circuits in a receiver, deserves particular attention, for it is often desirable to realign a repaired receiver to secure maximum selectivity and sensitivity.

In a conventional superheterodyne receiver having peak-tuned circuits, the I.F. stages are aligned first and then the oscillator is made to track the preselector. In an all-wave receiver the preselector-oscillator tracking adjustment must be made for each band. Before any of these adjustments can be made, however, you will first want to know how many trimmers there are to be adjusted, where each one is located, and what it does. A study of the schematic circuit diagram will give you this information. Furthermore, this analysis of the diagram will reveal if there are any image rejection circuits, harmonic or code interference traps, A.F.C. circuit trimmers, or fidelity-equalizing trimmers. Once you spot these on the circuit diagram and note their functions, you can mentally omit them from your alignment procedure and concentrate upon the true circuit-aligning trimmers. You may note that certain oscillator coils have adjustable iron cores; this establishes the fact that they are the low-frequency oscillator adjustments.

The circuit diagram may reveal the presence of variable-selectivity I.F. transformers and band-pass circuits which can be adjusted either for peak response or for broad (band-pass) response. It would be difficult to determine the presence of a band-pass circuit from mere study of the receiver chassis, yet the schematic circuit diagram and your knowledge of circuit operation immediately suggests the correct aligning procedure. If you know radio theory and the usual design practices, there will be no need for you to follow detailed alignment instructions as given in service manuals.

Once you have determined what the correct alignment procedure should be, you must locate the trimmer condenser adjusting screws or nuts on the actual chassis; again the schematic circuit diagram can be of great help in identifying each trimmer. If a pictorial layout is available, do not overlook it during an alignment procedure; this diagram often reveals the exact locations of the various trimmers.

Subjects for Further Study. The preceding brief outline of the technique of radio servicing has shown you many uses for circuit diagrams and the associated information prepared by receiver manufacturers in the form of service manuals. We will now consider in some detail how these service manuals can be used to best advantage in radio servicing, and how the information needed for servicing

can be obtained directly from the receiver chassis when no service manual is available. The important subjects for further study are therefore:

1. How to identify the various stages on a schematic circuit diagram.
2. How to analyze each stage of a schematic circuit diagram.
3. How to identify the various stages on the actual receiver chassis.
4. How to locate various parts on the chassis with a pictorial layout diagram.
5. How to locate parts when no pictorial layout is available.
6. How to trace each tube electrode circuit with and without the help of a schematic circuit diagram.
7. How to locate the alignment trimmer condensers.
8. How to appraise the performance of a receiver.
9. Important differences between schematic diagrams and actual chassis wiring connections.

For the purpose of illustrating the various points covered in this lesson, we have selected a popular model of a well known receiver (Philco Model 38-7) and have reproduced, in the center pages of this lesson, the following material pertaining to this receiver: Fig. *1*—the schematic circuit diagram as it appears in the service manual of the receiver; Fig. *2*—the pictorial layout diagram for parts underneath the chassis, as given in the service manual; Fig. *3*—pictorial layout of parts on the top of the chassis, as given in the service manual; Fig. *4*—tube socket connections as seen when looking at the bottom of the chassis, and electrode operating voltages; Fig. *5*—reproduction of an actual photograph of the top of the chassis, corresponding to the diagram in Fig *3*; Fig. *6*—reproduction of an actual photograph of the bottom of the chassis, corresponding to the diagram in Fig. *2*.

For convenience in referring to these diagrams while studying this lesson, it is suggested that you pry up the staples holding this lesson together, carefully remove the inside four pages (13, 14, 15 and 16), and bend back the staples again. When you have completed your study of this text-book, you can replace these diagrams in the same manner.

Identifying Stages on a Schematic Diagram

When a Radiotrician first takes up a schematic circuit diagram, he makes a general survey before attempting to locate any individual circuits or parts, in order to determine the general line-up of stages in the receiver. When looking at Fig. *1*, for example, he would immediately identify the circuit as that of a two-band superheterodyne receiver which is A.C. operated and has a simple tuned input circuit feeding directly into a pentagrid converter tube which acts as oscillator-mixer-first detector. He notices that this is followed by a single I.F. amplifier stage which feeds into a double-diode detector in which one section acts as the actual demodulator and the other serves as the A.V.C. tube. The diode demodulator feeds into a single audio amplifier stage which in turn feeds a pentode power output amplifier stage. He notes also that the power pack employs a full-wave rectifier tube. An experienced man could make this identification of stages almost at a glance, for familiarity with the tubes and circuits employed enables him to omit a great many of the steps in the reasoning process now to be described.

Circuit diagrams are invariably arranged so they can be read from left to right when tracing the path taken by intelligence signals from the antenna to the loudspeaker. We therefore start at the upper left of the dia-

gram in Fig. *1*, where we find a terminal strip having provisions for two antenna connections and one ground connection. Observe that the signals pass through R.F. transformer *1*, the secondary winding of which is tuned by one section of a ganged variable condenser. This tuned circuit feeds into a type 6A8G tube having five grids. Although on this particular diagram the designation *DET.-OSC.* identifies this stage as the detector-oscillator, you will find many circuit diagrams in which only the tube type numbers are given. We know, however, that the first stage must be either an R.F. amplifier stage or the first detector; we trace from the plate of this tube into I.F. transformer *13*, and we know that tubes having five grids (pentagrid conveters) are almost invariably used as combination oscillator-mixer-first detector tubes, so we feel safe in identifying this stage as the mixer-first detector of a superheterodyne circuit.

Another glance at input R.F. transformer *1* reveals that each of its windings is in series with the winding of another R.F. transformer marked *2*, and that there are switches for shorting out one secondary winding. Clearly, then, we have a two-band receiver. Verification of this can be secured by tracing from the first grid of the 6A8G tube, which we know must be serving as the grid of the local oscillator; this goes to two tuning coils, *5* and *6*, and one of these can be shorted out with a switch.

The second tube in our receiver line-up, a 6K7G, is fed by the secondary of the first I.F. transformer and feeds into the primary of the second I.F. transformer; it must therefore be an I.F. amplifier stage. We know that this second I.F. transformer (*19*) must feed either into a second detector or into another I.F. amplifier stage. The tube in question is a 6J5G triode, and triodes are seldom if ever used as I.F. amplifiers. We must examine this circuit more carefully to determine its true function (assuming that the *2ND DET-A.V.C.* designation is not present). Note that the secondary voltage of second I.F. transformer *19* is applied between the grid of this triode and ground, with the cathode of the tube directly grounded. This looks much like an ordinary diode detector circuit, with the control grid of the triode serving as the diode plate. Resistors *20* and *21* are in the circuit, and now we note a volume control potentiometer connected across resistor *21*, with condenser *24* in series to block direct currents. The plate and cathode of this triode tube must therefore be serving as the A.V.C. diode, since the plate is also fed by the second I.F. transformer through D.C. blocking condenser *23*.

From the movable contact of the volume control we trace our signal path to the grid of a 6K5G triode, which can only be a first audio amplifier stage since it follows a diode second detector. This tube in turn feeds into a pentode type 6F6G tube having a loudspeaker as its plate load, and consequently this is the power output stage.

One glance at the *power transformer symbol* in the power pack circuit in Fig. *1* is sufficient to identify our circuit as that of an A.C. receiver, for power transformers are never used in universal or D.C. sets.

There are a great many other clues which will prove useful in identifying each stage when you first go over a circuit diagram to get the general line-up, and consequently you will seldom if ever have any difficulty in identifying a stage even though its function is not indicated on the diagram.

Analyzing Each Stage on a Schematic Diagram

When the servicing procedure has advanced to the point where the defective stage is isolated, it is often

necessary to refer to the circuit diagram and analyze in detail that particular stage. Since all of the stages in a receiver are subject to failure, you should know how to analyze any one of the stages when necessary. To show how simple this can be when the analysis is made in the proper manner, we will go through the process for each stage in turn in the circuit of Fig. *1*.

Oscillator - Mixer - First Detector. Below the sketch of band-changing switch *48* is a note indicating that this switch is shown in the broadcast band position. Comparison of this diagram with the individual switches in the R.F. input and oscillator coil circuits shows that these separate switch symbols are also in the broadcast band position. For the broadcast band setting, then, the short across the primary of antenna coil *1* makes this coil inactive. Signals picked up by the antenna (the RED terminal) thus pass through the primary of antenna coil *2* and through switch contacts *A1-A2* to ground, inducing in the secondary winding an R.F. voltage which is applied through the inactive secondary of antenna coil *1* to the fourth grid of the 6A8G tube. The fact that the secondary of antenna coil *2* has a higher D.C. resistance than the secondary of antenna coil *1* verifies the fact that coil *2* serves for the broadcast band (a higher resistance usually indicates more turns of wire, giving the higher inductance required for the lower-frequency bands).

The only switch in the oscillator circuit, that for contacts *A3-A4*, is open during broadcast band operation, and consequently oscillator coil *6* acts in series with oscillator grid coil *5* in the oscillator tuned circuit. The feedback voltage required for oscillation enters this circuit through oscillator plate coil *5*, which is in the second grid (oscillator plate) circuit of the 6A8G tube. The oscillator section of the gang tuning condenser connects between the first grid and ground, and consequently is shunted across both coils in the tuned circuit.

For the short-wave setting of the band-change switch, contacts *A1-A2* are open, making antenna coil *1* effective, and contacts *A6-A7* are closed, shorting the secondary of antenna coil *2* and thereby making this transformer ineffective. Switch contacts *A3-A4* in the oscillator circuit are connected together, shorting oscillator coil *6* and thus reducing the inductance in the oscillator tuned circuit to the value required for the higher - frequency band.

Condensers *7* and *8* acting with resistor *9* furnish the automatic C bias for the local oscillator. Condenser *7B* is simply an oscillator coupling condenser, which serves to feed A.C. plate current into the tuned grid circuit during broadcast band operation. Condenser *7* also serves as the low-frequency padder in the oscillator circuit for broadcast band operation. Trimmer condenser *7A* is the oscillator high-frequency trimmer for the broadcast band, and trimmer condenser *4B* is the oscillator high-frequency trimmer for the short-wave band. There is no oscillator low-frequency padder on the short-wave range. High-frequency trimmer *4A* is the only input circuit alignment adjustment; consequently we can assume that the input circuit or preselector is quite broad in frequency response on the short-wave band, and is adjusted only for the broadcast band.

The pictorial diagrams of the antenna and oscillator coils, at the lower left in Fig. *1*, give coil connection information which is often helpful in tracing continuity through the coil circuits. The small numbers on these coil sketches correspond to the numbers on the schematic symbols for the corresponding coils.

I.F. Amplifier. We recognize the 6K7G I.F. amplifier tube as a pentode,

and learn from a tube chart that it is a super-control amplifier tube which can be A.V.C.-controlled. Tracing from the control grid or first grid of this tube through the secondary of the first I.F. transformer, we find the circuit to be through one-megohm resistors *15* and *27* to a tap on the voltage divider in the power pack, and then to ground. This means that the tube receives an initial negative C bias from the power pack. From the common connection of resistors *15* and *27* we note a lead which can be traced to ground through one diode section of the 6J5G tube (that formed by the plate and cathode), which means that the tube also receives an A.V.C. voltage.

There is a third winding on the first I.F. transformer, which places the suppressor grid at D.C. ground potential. The secondary of this I.F. transformer induces in this coil a signal voltage which can produce either regeneration or degeneration, depending upon the manner and upon the phase relationship of the secondary coil current with respect to the coil voltage. This third coil is connected in such a way that whenever the circuit tends to oscillate (regenerate), a degenerating voltage is applied the suppressor; likewise, when the circuit tends to degenerate during off-tune conditions, a regenerating voltage is applied to the suppressor. The third winding thus serves to stabilize the circuit during off-tune conditions.

Following the 6K7G tube is the second I.F. transformer, of conventional design. Trimmer condensers *13A, 13B, 19A* and *19B* permit peak adjustments of the two I.F. transformers.

Second Detector. The output voltage of the I.F. amplifier is applied to the grid and cathode of the 6J5G triode, with resistors *20* and *21* serving as the load for this diode detector circuit. Resistor *20* also acts in combination with condensers *19C* and *19D* as an I.F. filter. Rectified diode current flowing through resistor *21* develops across it an A.F. voltage which is transferred through D.C. blocking condenser *24* to potentiometer *26*. Resistor *32* and condenser *38*, connected between a tap on this potentiometer and ground, provide automatic bass compensation. Switch *39* has one contact for shorting out condenser *38* when automatic bass compensation is not desired, and other contacts for tone control circuits. The movable contact on volume control potentiometer *26* feeds A.F. signals through condenser *28* to the grid of the 6K5G first audio amplifier tube.

A.V.C. Tube. The output voltage of the I.F. amplifier also acts upon the plate of the 6J5G triode tube through condenser *23*. The grid and cathode of this tube thus serve as one diode, while the plate and cathode form another diode section which acts as the A.V.C. tube. Resistor *27* (trace down from the plate of the 6J5G tube) serves as the load for this second diode; the D.C. voltage required for A.V.C. purposes is developed across this resistor. The circuit from resistor *27* to ground is through the 8-ohm and 35-ohm sections of voltage divider *43*, and consequently the D.C. voltage drop across these sections is applied to the A.V.C. controlled tubes in the form of a constant negative C bias, as well as a delay voltage for the diode A.V.C. tube. The A.V.C. voltage is applied to the two A.V.C.-controlled tubes (6A8G and 6K7G) through an A.V.C. filter made up of resistor *15* and condenser *3*.

First A.F. Amplifier Stage. A tube chart tells us that the 6K5G tube is a high mu triode designed especially for use in resistance - capacitance coupled audio amplifiers. Resistor *36*, coupling condenser *34* and grid resistor *35* make up the resistance-capacitance coupling network through which this tube feeds into the output

stage. A negative C bias for the first audio tube is obtained from tap *2* on voltage divider *43*, with resistor *33* and condenser *30* serving as a filter.

Output Stage. According to a tube chart, the 6F6G tube in the output stage is a power amplifier pentode. The entire voltage drop across voltage divider *43* serves as the negative C bias for this tube, and likewise the entire output voltage of the power pack is applied to the plate of the tube through the primary winding of output transformer *41*. Note that condensers *37* and *40* are connected in series between the plate of the output tube and ground, with the common connection of these condensers going to one contact on tone control switch *39*. When the switch is set at this contact (at its extreme right-hand position), condenser *40* is shorted out and condenser *37* then by-passes the higher frequency components of the intelligence signal to ground, giving the effect of a boost in bass notes. When switch *39* is at some other setting, the extremely low capacity of condenser *40* (.008 mfd.) makes the reactance of this shunt path to ground so high that there is very little attenuation of any signal frequencies.

The voice coil of the dynamic loudspeaker, marked *42*, is connected across the secondary of output transformer *41*. The single-loop coil symbol drawn in series with the voice coil but in the opposite direction represents a hum bucking coil.

Power Pack. Obviously we have a full-wave rectifier circuit here, since the two plates of the 5Y4G rectifier tube are connected to the outer ends, *5* and *7*, of the high voltage secondary winding on power transformer *46*. Center tap *6* on this secondary winding is therefore the negative or B— terminal of the power pack; it traces through resistor *43* to the chassis and ground, making terminals *2*, *3* and *4* on this resistor increasingly more negative with respect to point *1*, the chassis.

Point *3* on the rectifier tube filament winding is the high-voltage terminal of the rectifier system, so we will find the power pack filter network connected between this point and either the B— terminal or ground. The main filter employs condenser input (*45*) with loudspeaker field coil *44* serving as a choke and condenser *11A* serving as the output filter condenser. The symbols indicate that condensers *45* and *11A* are of the electrolytic type. The common terminal of field coil *44* and filter condenser *11A* is the B+ or high-voltage output terminal of the power pack, and feeds directly to the plate of 6K7G I.F. tube, the 6K5G audio amplifier tube and the 6F6G output tube through the plate load of each tube.

A separate filter system is employed for the 6A8G pentagrid converter, however; this is made up of filter resistor *12* and electrolytic condenser *11*. A voltage divider network (resistors *16* and *22*) is connected between the output of this filter and ground, with the higher output voltage being fed through resistor *10* and the oscillator feed-back coil to the second grid (oscillator plate) of the 6A8G tube. The plate of the 6A8G tube receives this same high output voltage through the primary of the first I.F. transformer. A lower voltage is applied from the common junction of resistors *16* and *22* to the screen grids of the 6A8G and 6K7G tubes, with condenser *14* serving as the screen grid by-pass condenser.

Filament connections are indicated but not completed on this diagram. Observe that terminal *8* of the filament winding on power transformer *46* is grounded and that one filament terminal of each tube except the rectifier is likewise grounded. The other filament terminal for each tube is terminated in an arrow, as also is the

other filament winding terminal; this of course, indicates that all these terminals are connected together. All tube filaments except the rectifier are thus connected together in parallel across the filament winding having terminals *8* and *9*.

Observe that two condensers, marked *47*, are connected in series across the 110 volt A.C. power line, with their midpoints grounded. These condensers shunt to ground any noise interference signals which might otherwise enter the receiver.

The extreme left position of switch *39* is the off or open position for the receiver on-off switch which is in series with the primary of the power transformer. This power switch is closed for all other positions of switch *39*. Moving this switch one contact to the right shorts out automatic bass compensation condenser *38*, providing normal receiver operation. Moving the switch one more contact to the right places this condenser in the circuit, and the final position of the switch to the right shorts out condenser *40*, giving a bass-boosting effect together with automatic bass compensation.

A note at the bottom of the schematic circuit diagram indicates that on some receiver models employing this circuit, a shadowgraph indicator is inserted in series with the plate supply lead to the I.F. amplifier tube, with a .05 mfd. condenser connected between the plate side of this meter and the chassis to keep R.F. current out of the meter. The small diagram at the lower right of the circuit diagram indicates that pilot lamp *49* is connected in parallel with the tube filaments across the filament winding on the power transformer. A note indicates that an extra pilot lamp (*49X*) is used on one model to operate a shadowgraph tuning indicator.

Remember that it will seldom if ever be necessary for you to analyze a complete receiver circuit as we have just done. Modern servicing techniques isolate the trouble to a particular stage or section, making it necessary to analyze that one small part of the receiver circuit. Furthermore, do not expect to be able to analyze a diagram or even a part of a diagram completely right from the start. As you acquire additional knowledge and experience, you will find it easier and easier to secure the information which schematic diagrams can give you.

Identifying Stages on the Chassis

By including top-of-the-chassis layout diagrams along with the schematic diagrams in some service manuals, receiver manufacturers have made it quite easy to identify each tube and its function. A typical diagram of this type, in which the position of each tube is clearly indicated with respect to easily recognizable parts such as the power transformer and the tuning condenser, is shown in Fig. *3*. With this layout at hand, it is a simple matter to perform either a dynamic stage-by-stage elimination test or a circuit disturbance test when hunting for the defective stage.

A tube layout diagram has other uses in radio servicing. Since octal-base tubes are used in practically all modern receivers, any tube will fit into any socket. The sockets on the chassis are ordinarily not marked for the proper tubes, and consequently the tube layout diagram serves as a valuable guide for replacing tubes when all are removed for testing, or in order to clean the chassis. The wise Radiotrician usually does not depend upon a tube layout diagram, however; he removes only one tube at a time, returning it or replacing it with a new tube before testing the next tube.

But how do we go about identifying the stages on the chassis when no schematic diagram and no tube layout diagram are available? All we

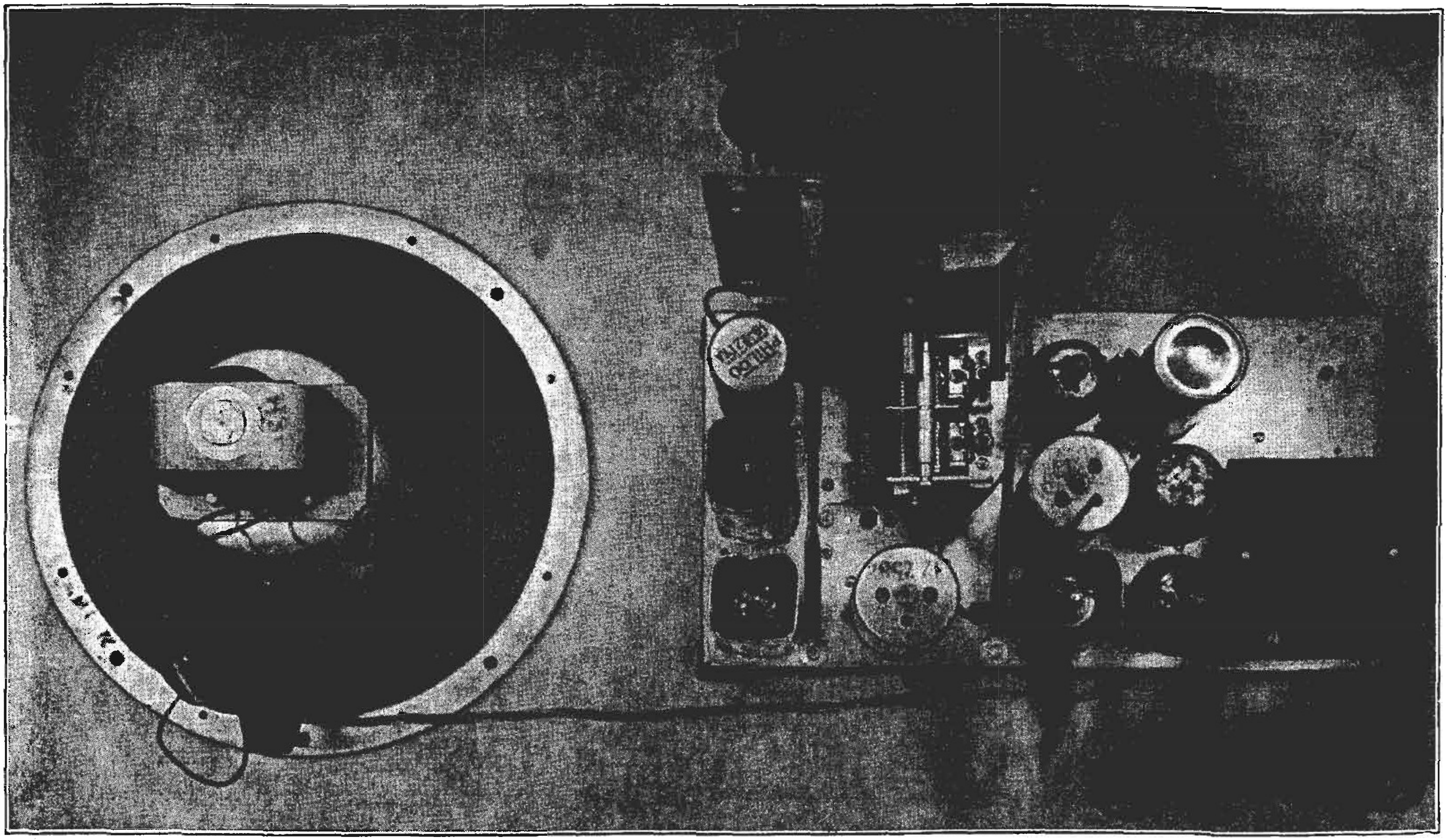
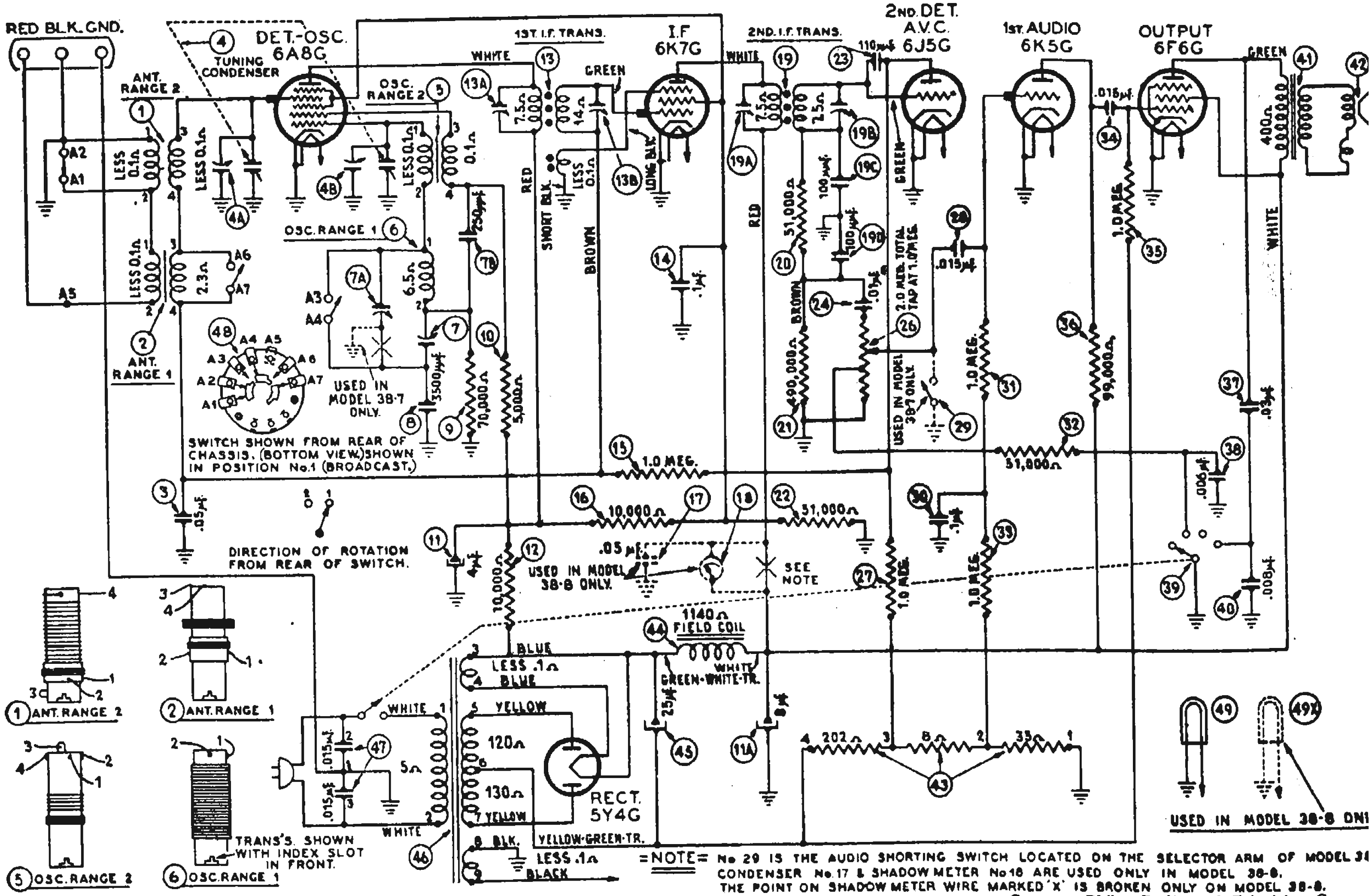


FIG. 5. Top of chassis of Philco model 38-7 receiver



=NOTE= No 29 IS THE AUDIO SHORTING SWITCH LOCATED ON THE SELECTOR ARM OF MODEL 3
CONDENSER No. 17 & SHADOW METER No 18 ARE USED ONLY IN MODEL 38-8.
THE POINT ON SHADOW METER WIRE MARKED 'X' IS BROKEN ONLY ON MODEL 38-8.

Courtesy Philco Radio and Television Corp.

FIG. 1. Schematic circuit diagram of Philco model 38-7 two-band superheterodyne receiver. A dot at the intersection of circuit lines indicates a connection; when two c cuit lines cross and there is no dot at the intersection, there is no connection between them. NOTE: For convenience, lift up the staples and remove these four cen

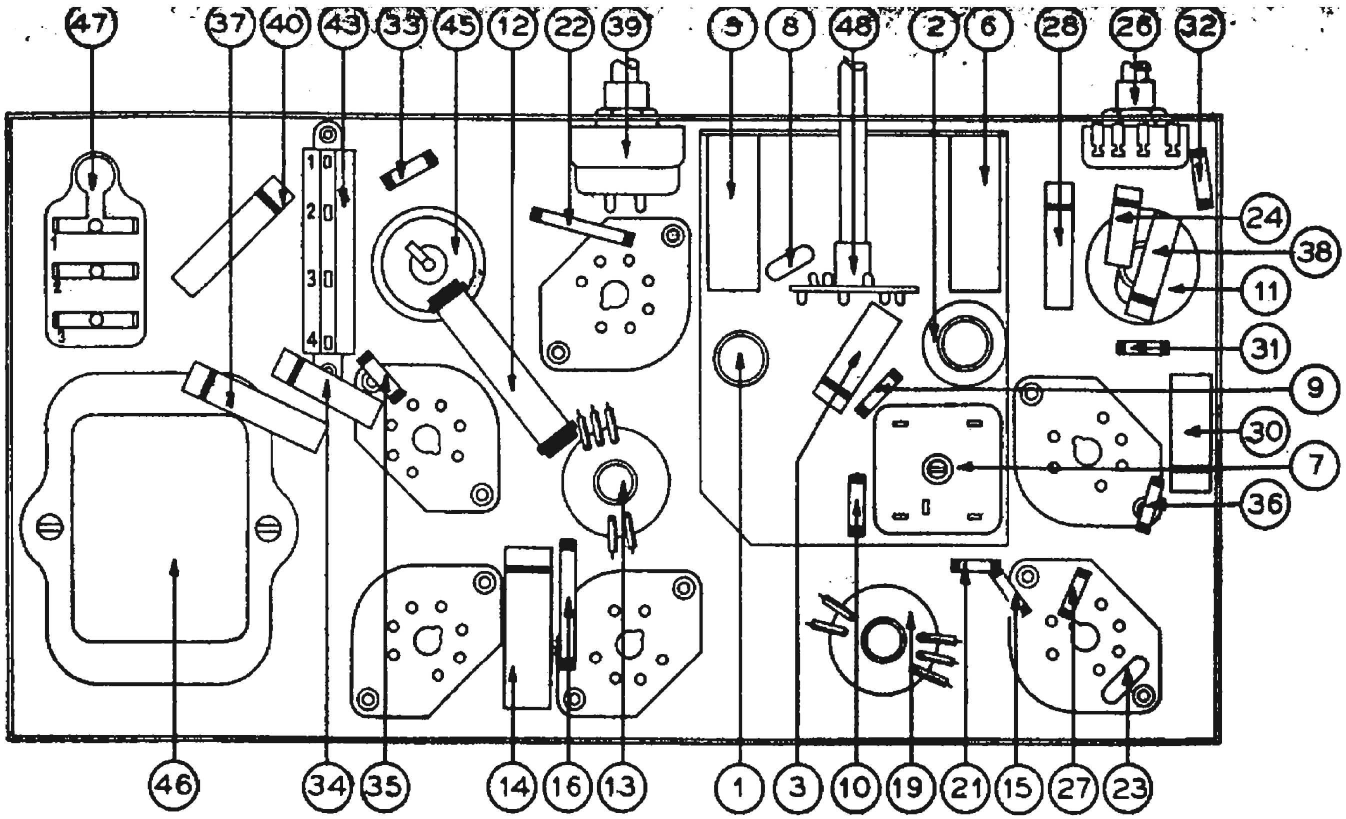


FIG. 2. Pictorial layout diagram for parts under chassis of Philco model 38-7 receiver. The parts list on this page serves as a guide when ordering replacement parts for this receiver.

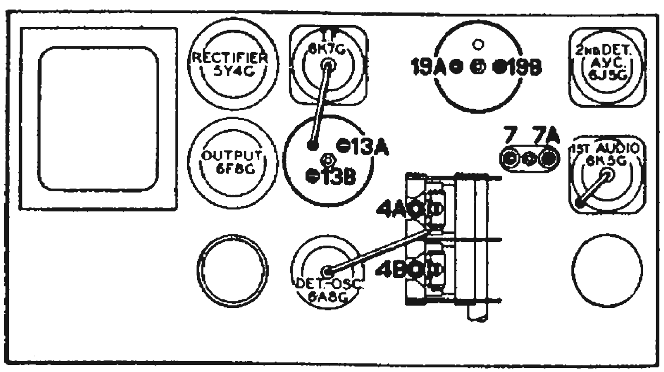


FIG. 3. Pictorial layout diagram for parts above chassis of Philco model 38-7 receiver.

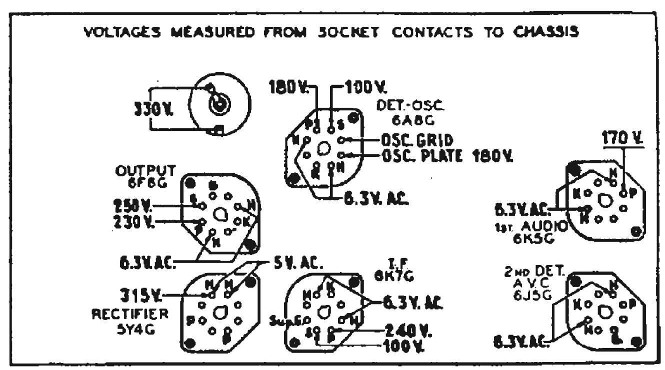
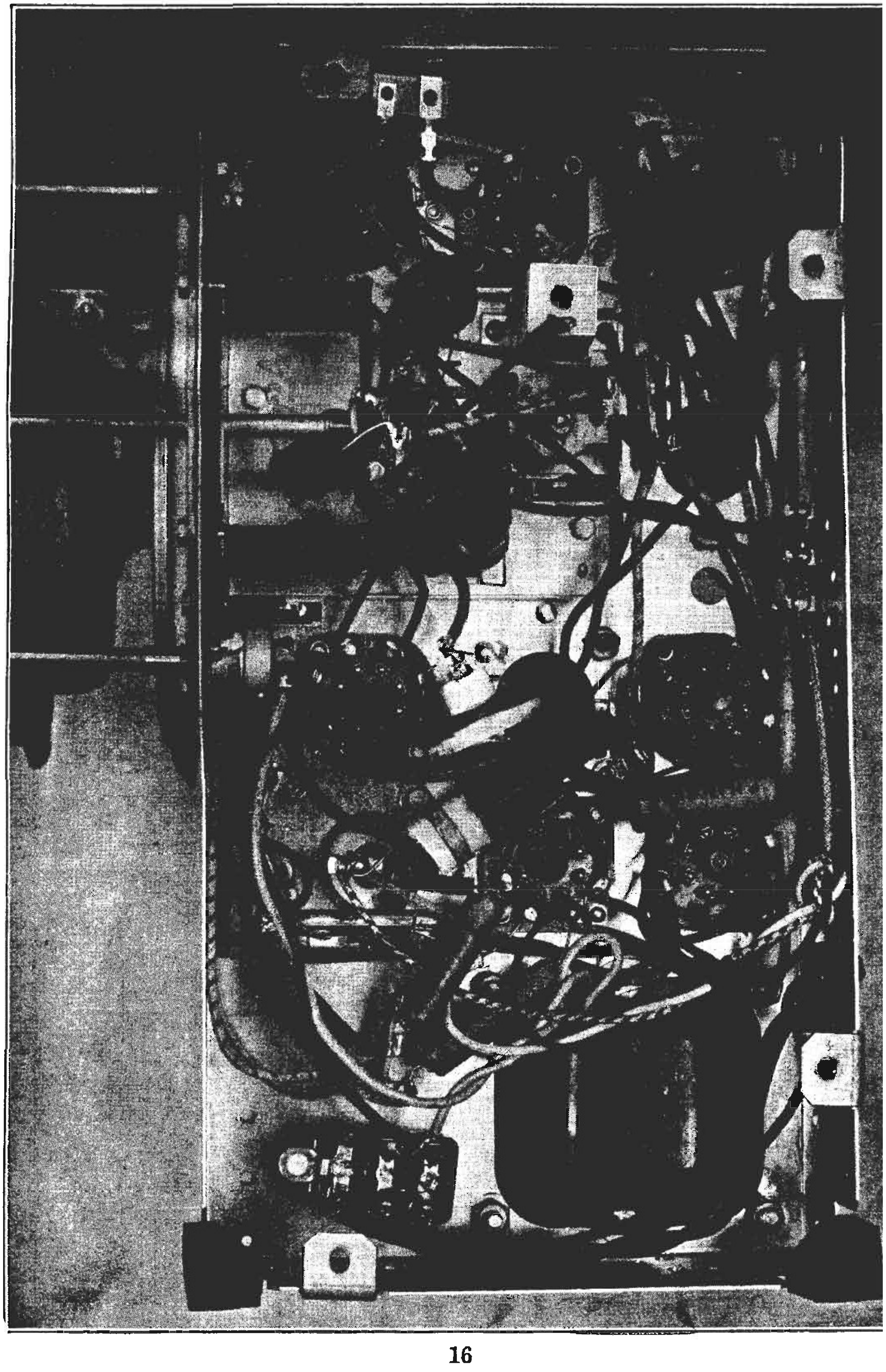


FIG. 4. Tube socket connection diagram and electrode voltages for Philco model 38-7 receiver.

Schem. No.	Description	Part No.
1	Antenna Transformer—Short Wave	32-2558
2	Antenna Transformer—Broadcast	32-2557
3	Condenser .05 mf.	30-4519
4	Tuning Condenser, Models 8 and 9	31-2026
	Tuning Condenser, Model 7	31-2040
5	Osc. Transformer—Short Wave	32-2560
6	Osc. Transformer—Broadcast	32-2559
7	Compensator Dual Models 8 and 9	31-6188
	Compensator, 580 KC. (Model 7)	31-6195
7A	Compensator Model 7 (1500 KC.)	31-6196
8	Condenser 3500 mmf. mica	30-1094
9	Resistor 70,000 ohms (½ watt)	33-370339
10	Resistor 5000 ohms (½ watt)	33-250339
11	Condenser, Electrolytic Dual (4 and 8 mfd.)	30-2217
12	Resistor 10,000 ohms (3 watt)	33-310639
13	1st I. F. Transformer	32-2580
14	Condenser .1 mf.	30-4455
15	Resistor 1.0 meg. (½ watt)	33-510339
16	Resistor 10,000 (1 watt)	33-310439
17	Condenser .05 mf. (38-8 only)	30-4454
18	Shadowmeter (38-8 only)	45-2307
19	2nd I. F. Transformer	32-2582
20	Resistor 51,000 (mounted in 19)	33-351339
21	Resistor 490,000 ohms (½ watt)	33-449339
22	Resistor 51,000 ohms (1 watt)	33-351439
23	Condenser, mica, 110 mmf.	30-1031
24	Condenser .01 mf.	30-4479
25	Removed Prior to Production	
26	Volume Control	33-5216
27	Resistor 1 meg. (½ watt)	33-510339
28	Condenser .015 mf.	30-4358
29	Audio Shorting Switch (38-7 only) Part of Selector Crank	
30	Condenser .1 mf.	30-4499
31	Resistor 1.0 meg. (½ watt)	33-510339
32	Resistor 51,000 (½ watt)	33-351339
33	Resistor 1.0 meg. (½ watt)	33-510339
34	Condenser .015 mf.	30-4515
35	Resistor 1.0 meg. (½ watt)	33-510339
36	Resistor 99,000 (½ watt)	33-399339
37	Condenser .03 mf.	30-4447
38	Condenser .06 mf.	30-4467
39	Tone Control	42-1327
40	Condenser .008 mf.	30-4112
41	Output Transformer (Model 7)	32-7862
	Output Transformer (Models 8 and 9)	32-7019
42	Cone and Voice Coil Assembly (H31)	36-3801
	Cone and Voice Coil Assembly (K41)	36-3174
	Cone and Voice Coil Assembly (HS)	36-3796
	Cone and Voice Coil Assembly (S7)	36-3157
43	Bias Resistor	33-3316
44	Field Coil Assembly (H31)	36-3665
	Field Coil Assembly (K41)	36-3931
	Field Coil Assembly (HS)	36-3690
	Field Coil Assembly (S7)	36-3039
45	Electrolytic Condenser	30-2219
46	Power Transformer, 115V, 50/60 cycle	32-7833
	Power Transformer, 110V, 25 to 40 cycle	32-7827
	Power Transformer, 115/230V, 50/60 cycle	32-7835
47	Condenser .015—.015 mf., 25 mf.	3793DG
48	Wave Switch	42-1325
49	Pilot Lamp, Models 8 and 9	34-2064



have is the chassis itself, which can be represented in this discussion by the photographs in Figs. *5* and *6*. We will concentrate upon Fig. *5*, which shows a top view of the chassis, since you will often want to identify the tubes and stages without removing the chassis from its cabinet.

The power transformer and the two-gang tuning condenser are, of course, easily identified. Likewise you can be pretty sure that the two cylindrical metal cans adjacent to the tuning condenser, each having two adjusting screws, are I.F. transformers. Their presence identifies the receiver as a superheterodyne. The fact that there is a lead coming out of one I.F. transformer to the top cap of a tube is further proof that we are dealing with a superheterodyne, for in tuned radio frequency receivers the top caps of tubes usually go to the stator sections of the gang tuning condenser.

The shapes of the completely enclosed metal cans, one to the right and below the power transformer, and the other at the lower right on the chassis, identify these parts as electrolytic filter condensers; with experience you will be able to spot these at a glance.

Once you have determined the type of circuit, you can proceed to identify the tubes. First of all, look for the rectifier tube, which will have two rectangular electrodes with a heavy filament wire inside each, but no other electrodes. We notice a tube like this, marked 5Y4G, at the upper right of the power transformer (see Fig. *5*); reference to a tube chart verifies that this is a rectifier tube.

Below the rectifier tube and next to the power transformer in Fig. *5* is a tube which is larger than all other tubes except the rectifier. This has a rather large plate, with a cathode and several other elements inside. By counting the elements or by determining its number and referring to a tube chart, we identify this as a pentode; since there is no top cap connection for the control grid, we know definitely that it is not an R.F. pentode. It is logical to assume, then, that we have a power output pentode, a tube widely used in the output stages of receivers. A tube chart would verify this assumption.

To the left of the tuning condenser in Fig. *5* is a tube marked 6A8G; a tube chart identifies this as a pentagrid converter, the fourth grid of which connects to the top cap. We say, therefore, that this tube is for the oscillator - mixer - first detector stage. A lead from the top cap of this tube goes to the upper stator section of the tuning condenser, identifying it as the preselector tuning condenser. The other section of the tuning condenser must therefore tune the oscillator circuit.

At the right of the rectifier tube in Fig. *5* is a tube marked 6K7G; according to our tube chart, this is an R.F. pentode. Since there are only two sections in the gang tuning condenser, one for the first detector input and one for the oscillator, we know that there is no R.F. amplifier stage. This means that the 6K7G R.F. pentode must be used as an I.F. amplifier; the fact that there is a lead coming from the I.F. transformer to the top cap of this tube verifies our assumption. The tube chart also reveals that this is a super-control tube, and since a receiver designer ordinarily does not employ such a tube unless it is to be A.V.C.-controlled, we know that this receiver has A.V.C.

The two tubes at the upper right on the chassis in Fig. *5* still remain to be identified. The upper is marked 6J5G, and reference to a tube chart reveals it to be a triode which can have a number of different uses. The lower tube is marked 6K5G but here the tube chart tells us definitely that

it is a high-gain audio amplifier tube. Since we have not yet located the second detector-A.V.C. tube, with only these two tubes left to identify, we can say that the 6K5G is the first audio amplifier tube and the 6J5G is the second detector-A.V.C. tube. We could verify this by measuring the voltage between the plate and cathode of each tube; we would find that the tube selected as the audio amplifier had a reasonably high D.C. supply voltage, whereas the plate of the 6J5G tube was slightly negative with respect to the cathode. These measurements would tell us that a delay voltage was present in the A.V.C. system.

We have just seen how each tube in this receiver can be identified as to its function without removing the chassis from its cabinet. Naturally a person would not go through this procedure if a tube diagram were at hand, or if a schematic circuit diagram were available, for it is not always possible to determine the function of each tube on a chassis without tracing connections underneath the chassis. On the other hand, with experience you will be able to identify the various tube stages on most receivers almost at a glance, and will not have to refer to diagrams.

General Suggestions. The ability to recognize radio parts by their appearance alone is obviously quite desirable when it is necessary to identify stages on the chassis. For this reason it is important that you keep in touch with new developments as announced in radio magazines and in the latest catalogs of mail order radio supply houses or of your local radio parts distributor.

You can generally secure the latest tube charts from your local parts distributor, or from the manufacturer of the tubes which you handle. These charts will familiarize you with the appearances and characteristics of new and old tubes alike.

The first thing you want to know, when working on a chassis without a service manual, is whether you have a T.R.F. or superheterodyne receiver. Look for I.F. transformers, as they are clues identifying a superheterodyne; if these I.F. transformers are under the chassis, as they often are, look for the screws of their adjusting trimmers on the top of the chassis. If one of the sections of the gang tuning condenser has rotor plates which are shaped differently from those in other sections, you have another clue toward a superheterodyne. A receiver having only two sections in the gang tuning condenser but with six or more tubes can reasonably be assumed to be a superheterodyne. Older radio receivers with three, four and five sections in the condenser gang will generally be T.R.F. sets, but make sure that there are no I. F. transformers before deciding this.

Next you will want to know how the receiver is powered. If there is a multi-lead cable in place of the line cord, it is a battery receiver; if there is a two-wire cord having at its end the familiar two-prong wall outlet plug, you can be sure that it is a socket-powered receiver. But do we have an A. C., D. C., or universal socket-powered receiver? If a power transformer is visible on the chassis, you can be sure it is an A. C. receiver. If there is a rectifier tube but no power transformer, it is a universal A.C.-D.C. receiver. If there is no power transformer and no rectifier tube, it is a D.C. receiver. These rules will enable you to identify practically all receivers, but be on the lookout for exceptions. A few transformerless A. C. receivers have been made; these will have the conventional full-wave rectifier tube, so you will have to check the rectifier con-

nections to make a positive identification. *

Now let us concentrate our attention upon the stages ahead of the I.F. amplifier in a superheterodyne receiver. A two-section ganged variable condenser means that there is no R.F. amplifier stage ahead of the first detector, for one section serves for tuning the oscillator and the other for tuning the input to the first detector. Three sections ordinarily indicate that there is one stage of R.F. amplification ahead of the mixer-first detector, but occasionally you may find a band-pass preselector instead. You may find a pentagrid converter tube or a pentode tube being used as a combination mixer-first detector-oscillator, or there may be a pentode serving as mixer-first detector and a separate triode (or even a screen grid or pentode tube) serving as the oscillator tube.

Most superheterodynes use screen grid or pentode tubes in the R.F. first detector and I.F. stages; this means that the control grid connection for each of these tubes will be to a top cap. In the case of a pentagrid converter, the top cap will be connected to the fourth grid inside the tube, and there will be an external connection from this cap to the stator section of the detector input tuning condenser; with a three-gang condenser the oscillator stator will be at one end, and will not have a connection to a tube cap if a pentagrid converter is used.

Because I.F. transformers require complete shielding, they will be found in metal shields or cans and will usually be mounted on the top of the chassis. The secondary of the first I.F. transformer will always be connected to the control grid of the I. F. amplifier tube; since this will be a screen grid or pentode tube, you can expect to find a flexible lead coming out of the top or side of the I.F. transformer and going to the top cap of the tube.

When there are two I.F. transformers, the second will feed into the second detector, usually by means of an under-chassis connection (only when the second detector is a screen grid or pentode tube will there be a connection from the second I.F. transformer to its top cap).

Since diodes or triodes are ordinarily used as second detectors, you can usually assume that any tube having a top cap connection into an I.F. transformer is an I.F. amplifier tube. If there are three I. F. transformers, look for two I.F. amplifier tubes; in all probability you will find them in line with the mixer-first detector and the second detector.

The second detector has a few peculiarities which permit easy identification. Look for a double diode, a double diode-triode, a double diode-pentode, or a triode following the last I.F. transformer. Occasionally you may run into a screen grid or pentode second detector which will have a lead from its top cap to the last I.F. transformer. When the R.F. and I.F. stages use pentode tubes and there is a pentagrid converter in the line-up, look for tubes such as the 56, 6C5, 6C6, 55, 85, 75, 6B8 and 6H6 serving as the second detector, the second de-

* There is seldom need to make a positive identification unless you isolate a defect to the power pack. In this case you will naturally remove the chassis, and an inspection of rectifier connections will reveal the type of circuit used. If it is an A.C. set with a voltage-doubling power pack circuit, you will usually find that the plate of one diode section is directly connected to the cathode of the other diode section. There will be two electrolytic condensers connected in series, with the negative lead going to the remaining diode plate and the positive lead to the remaining cathode. The common connection of these two condensers goes to one side of the power line, and the other side of the power line goes to the common plate-cathode connection. The circuit for this is given in an earlier lesson in your Course.

tector-A.V.C. tube, or as the second detector-A.V.C.-first A.F. amplifier.

Rectifier tubes in an A.C. receiver are easy to locate, for they are almost always *right next to the power transformer.* Obviously it would not be good design practice to run high voltage A.C. leads any distance through the chassis from the power transformer to the rectifier tube. Look for such tubes as the 80, 25Z5, 82, 83 5Z3, 5Z4 and 6X5, for these are all rectifier tubes. Most of these have glass envelopes, through which you can usually see two long black rectangular or cylindrical anodes, with a thick V-shaped filament inside each.

Output tubes can be recognized by their numbers and by their relatively large size in comparison to all other tubes except the rectifier. Double-triode power amplifier tubes such as the 19, 6N7, 6A6, 79 and 53 are instantly identified as output tubes connected for push-pull or push-push operation. Such tubes as the 45, 47, 2A3, 6L6, 2A5, 59, 43 and 42 are power output tubes which you will find used singly or in pairs for push-pull or push-push operation.

An additional tube, usually a triode, located between the second detector and the power tubes or near them is very likely an audio voltage amplifier tube.

Cathode ray tuning indicator tubes can, of course, be identified on sight. Automatic frequency control tubes, noise-limiting and noise-suppression tubes, A.V.C. tubes and A.V.C. amplifier tubes are not so easy to identify from the top of the chassis. When the circuit contains extra tubes which are not readily identified, it is wiser to secure the circuit diagram and identify these extra tubes by a process of elimination or by comparing tube numbers. With some receivers it is practically impossible to identify all tubes merely by studying the top of the chassis; in these cases it is either necessary to refer to a service manual or remove the chassis and trace tube connections. When metal tubes are used, the tube numbers stamped on the sides of the tubes must serve as your guide.

Locating Parts with a Pictorial Layout Diagram

Let us suppose that the receiver being used as our example in this lesson has developed an annoying squeal. We might logically suspect that a screen grid by-pass condenser is open somewhere; referring to the schematic circuit diagram in Fig. *1*, we see that screen grid by-pass condenser *14* for the 6K7G I.F. amplifier tube is a likely offender. We can make a quick check by shunting this condenser with a good unit of the correct value (.1 mfd.), provided that we can locate condenser *14*. An examination of the underside of the chassis reveals at least nine tubular paper condensers which could be *14;* by referring to the parts layout diagram in Fig. *2,* however, we learn that the condenser under suspicion is near the back edge of the chassis and is between two tube sockets. With this information, it is easily located on the chassis; turn to Fig. *6* and see how quickly you can locate it on the photo. If the squeal stops when we temporarily shunt this condenser with a good condenser, we know that condenser *14* requires replacement.

Now let us consider the case where the receiver has an annoying hum, and an inspection for surface defects reveals that the rectifier tube is gassy (a blue glow can be seen between its electrodes). Before inserting a new tube, we naturally want to check the electrolytic condensers with an ohmmeter to determine if excessive leakage through them was the cause of rectifier tube failure. To

locate these condensers, we first refer to the circuit diagram and determine what numbers are assigned to them. At the right of the rectifier tube in Fig. 1 are two electrolytic condensers, *45* and *11A*, while above the power transformer is another, marked *11*. This numbering indicates that *11* and *11A* are in the same housing, and the fact that only two electrolytic condensers were found on top of the chassis is further proof of this assumption.

We locate condenser *11* on the pictorial layout diagram in Fig. *2*, finding it in the upper right corner of the diagram, near the volume control. An inspection of the connections underneath this chassis would show three leads, colored black, green and red respectively. This means that the two condenser sections must have a common connection; an inspection of the schematic circuit diagram verifies this and shows that the common negative terminal is grounded. The black lead on the condenser itself is grounded, so this must be negative; the red and green leads are therefore the positive leads for these electrolytic condensers. A leakage test is now readily made with an ohmmeter, connecting the plus terminal of the ohmmeter (that terminal which goes to the plus terminal of the ohmmeter battery) to the plus terminal of the condenser. The practical man seldom bothers to figure out condenser polarity, however; he connects both ways and uses the highest-resistance reading, for he knows he will then have the correct polarity. One of the condenser leads is disconnected for this test, as there are usually other parts shunting the condenser.

Let us consider one more case, that where the receiver is dead and the defect is localized to the pentagrid converter by means of a stage-by-stage elimination test. Measurements of electrode voltages on this tube show that there are no D.C. supply voltages; other measurements reveal that there is no screen grid voltage on the I.F. amplifier tube. A study of the schematic circuit diagram reveals that an open circuit through resistor *12* could be a cause of the trouble. The parts layout diagram in Fig. *2* shows that resistor *12* is located under the chassis, between electrolytic condenser *45* and I.F. transformer *13*. Since it is a 10,000 ohm resistor, we have the additional clue that it will have a brown body, black end and orange dot in accordance with the RMA color code for resistors. You should now be able to locate this resistor in Fig. *6;* it is a large carbon resistor, supported at one end by a metal clamp under which is white insulating paper. Naturally you would look for a defect in this resistor or for a break in its connection.

These two examples show the value of the parts layout diagram in bridging the gap between the schematic circuit diagram and the actual receiver chassis.

Locating Parts without a Pictorial Layout Diagram

The procedure for locating on the chassis a part which is indicated on the schematic circuit diagram becomes considerably more involved when no pictorial layout diagram is available. Familiarity with the appearance of various radio parts will speed your search, as also will experience in tracing actual wiring on a chassis. A few examples will illustrate the procedure to be followed.

On the schematic circuit diagram, condenser *14* is shown connected between the screen grid of the 6K7G I.F. amplifier tube and ground; let us see how we would go about locating this condenser on the chassis. First of all we locate the 6K7G tube

on the top of the chassis and determine the position of its socket underneath the chassis. We would find this socket to be at the rear edge of the chassis; almost exactly midway between the sides of the chassis (you can locate it for yourself on Fig. *6* by referring to the socket connection diagram in Fig. *4*).

The next step is the location of the screen grid terminal on this socket; a tube chart will give this information if a socket connection diagram like that in Fig. *4* is not available. We look for terminal *S*, for this letter (as well as the notations G_s or G_2) are used to designate the screen grid terminal. We know that condenser *14* is connected between this terminal and ground, and a careful study of the schematic diagram shows that there is no other condenser connected to this screen grid terminal. We trace each lead in turn from this terminal of the socket until we locate one going to a tubular paper condenser marked .1 mfd.; we note that the other lead of this condenser goes to a soldering lug which is riveted to the chassis, and thus have definite proof that this is condenser *14*.

Here is another example: suppose that the trouble has been isolated to the R.F. input circuit. We suspect an open circuit in one of the windings of R.F. transformers *1* and *2*. A study of the schematic circuit diagram shows that if we connect an ohmmeter between the two antenna terminals marked *RED* and *BLK*, we can check continuity of the primary winding. If the ohmmeter indicates a resistance of about .1 ohms when the band change switch is in the broadcast position (shorting contacts *A1* and *A2*), we know that the primary of R.F. transformer *2* is good. A changeover to the short-wave setting of the switch removes the short across the primary of R.F. transformer *1*, and if the ohmmeter reads about .2 ohm, we know that this primary winding also is good.

Now we study the circuit diagram again to see how we can check the continuity of the secondary coils. Observe that there is a complete conductive path from the fourth grid of the 6A8G tube to the secondary of the first I.F. transformer and control grid (top cap) of the 6K7G I.F. amplifier tube. The diagram further indicates that if we place an ohmmeter between the top caps of these two tubes, we should measure a D.C. resistance of .1+2.3+14, or a total of approximately 16.4 ohms. We do not even have to remove the chassis from the cabinet in order to make this test.

If, when measuring the resistance between the top caps of the first two tubes, we secured an infinite resistance reading, we would know that an open circuit existed somewhere along the path being checked. To make sure that the trouble is an R.F. coil, we could make an ohmmeter test between the top cap of the 6K7G tube and the chassis. The schematic circuit diagram indicates a resistance of a little over 2 megohms (the combined resistance of parts *15*, *27* and a section of *43*) between these two points. Any resistance reading differing greatly from this value, or an open circuit reading, would indicate trouble in the I.F. transformer. If the ohmmeter reads the correct value of 2 megohms, we make the same test between the top cap of the 6A8G tube and the chassis; let us assume that we get an open circuit reading.

To determine which of the R.F. coils is defective, we must locate them underneath the chassis and test each one individually. The sketches at the lower left in Fig. *1*, with each coil connection numbered and the relative lengths of the windings shown, makes

identification of these coils on the chassis quite simple.

Oftentimes, however, these coil pictures are not provided on the circuit diagram. In this event we would trace from the top cap of the 6A8G tube to the input tuning condenser stator, and from there to point *3* on the secondary of R.F. transformer *1*. (Each stator section has two terminals, one above and one below; the R.F. transformers are underneath the chassis, so we look underneath the chassis for a lead coming through it directly under the stator section in question.) We trace through the heavy wire forming the secondary winding to the other terminal, marked *4*, and then in turn trace to point *A6* on the band change switch, to point *3* of the secondary of R.F. transformer *2*, and through this winding to terminal *4*. We can then make a continuity test across this entire circuit or any part of it.

Tracing Tube Electrode Circuits

Once the various tube stages have been identified, the defective stage isolated and the tube in that stage checked, the next logical step is a check-up of the circuits in the defective stage. These tests are simple and easy to make if you recognize that electrode circuits in any receiver can always be traced to certain definite points. It is then a simple matter to make continuity tests of the paths between the tube electrodes and these points. Let us trace the conductive paths from the electrodes in Fig. *1* before considering the general continuity-checking rules which apply to all circuits.

Plate Circuits. Suppose we start at the plate of the 6K7G I.F. amplifier tube and trace a conductive path as far as we can. From the plate we go through the primary of second I.F. transformer *19* in Fig. *1*, down a lead marked *RED* to loudspeaker field coil *44*, and through this coil to the filament of the 5Y4G rectifier tube. Clearly the rectifier filament is one terminal in this path.

Now trace from the plate of the 6A8G pentagrid converter tube through the primary of first I.F. transformer *13* and down another lead marked *RED* through resistor *12* to the rectifier filament. The plate of the 6K5G first audio amplifier tube traces through resistor *36* and loudspeaker field coil *44* to the rectifier filament, and likewise the plate of the 6F6G output tube traces through the primary of the output transformer and through field coil winding *44* to the rectifier filament.

There is a very good reason why the plates of all these tubes should trace to the rectifier filament or to a rectifier cathode. In any rectifier type of power pack the filament is the highest positive voltage terminal, and consequently all electrodes which are supplied with a positive voltage must eventually trace to the rectifier filament.

Screen Grid Circuits. Since the screen grid of a tube is likewise supplied with a positive D.C. potential, you should also expect to trace a conductive path from it to the rectifier filament. We can check this very easily in Fig. *1*. From the screen grid of the 6K7G tube (the middle grid, which is also connected directly to the screen grid of the 6A8G detector-oscillator tube), we trace through resistors *16* and *12* to the rectifier filament. In a similar manner we can trace from the screen grid of the 6F6G output tube through loudspeaker field coil *44* to the rectifier filament.

The only other electrode in this particular circuit which requires a positive D.C. potential is the second grid of the 6A8G pentagrid converter

tube, which serves as the anode of the oscillator. Observe that this traces through *oscillator plate coil 5* and then *through resistors 10* and *12* to the rectifier filament.

Control Grid Circuits. Since the control grid of an amplifier tube must be negatively biased with respect to its cathode, we know that there must be a conductive path between the control grid and the cathode of an amplifier tube. Let us verify this on the circuit in Fig. *1*. The fourth grid of the 6A8G tube is serving as a control grid, so we trace from it through the secondary winding of R.F. transformer *1* and *2* and then through resistors *15, 27* and *43* to the chassis and the grounded cathode. Clearly there is a continuous path here for direct current. The first grid of this tube, serving as the oscillator control grid, likewise traces to the cathode through oscillator grid coil *5*, through coil *6* and then through resistor *9* and the chassis. The control grid of the 6F6G output tube traces through resistors *35* and *43* to the chassis and cathode. A circuit can likewise be traced from the other control grids to their respective cathodes through the chassis.

As you know, the center tap of the high voltage secondary winding on the power transformer (feeding the two plates of the rectifier tube) is the lowest negative D.C. terminal in the power supply. A further study of Fig. *1* will show that the control grids can also be traced to this most negative point in the power pack. This means that in an A.C. receiver you can, after turning the set off, make a continuity test of each control grid circuit by connecting one ohmmeter lead to the control grid and the other to the cathode of the tube, to one of the plates of the rectifier tube or to the most negative point in the power pack. In a universal receiver, where there is no power transformer, the most negative D.C. point will be the receiver side of the main power switch; be sure this switch is open when you make your test.

Suppressor Grid Circuits. When an external prong connection is provided for the suppressor grid of a tube, this will either trace to the cathode of the tube or to some negative supply terminal. For continuity checking purposes, then, you may treat the suppressor grid just as if it were a control grid.

Diode Detector Circuits. Since a diode detector is a rectifier and consequently passes direct current, we know that there must be a conductive path from the plate through the external circuit to the cathode. An ohmmeter connected between the cathode and plate of a diode detector should therefore indicate continuity. (There may be an exception to this rule in the case of a power pack rectifier tube used as a diode rectifier, for the load on this diode may be tubes in the receiver which are conductive only when their cathodes are heated.)

The second detector-A.V.C. tube in Fig. *1* employs two diodes, one for detection and one for A.V.C. purposes, but the plate of each can be traced to the cathode. For example, the actual plate of the tube traces through resistors *27* and *43* to the chassis and then to the cathode, while the grid (which serves as the other diode plate) traces through the secondary of I.F. transformer *19* and through resistors *20* and *21* to the chassis and cathode.

General Rules for Checking Continuity of Electrode Circuits in A.C. Receivers

1. **There should be a conductive path *from the rectifier tube filament or* cathode (the highest positive D.C.**

terminal) *to all tube electrodes which are supplied with a positive D.C. potential,* **such as plates and screen grids.**

2. **There should be a conductive path** ***from the most negative D.C. terminal in the power pack to all control grids and suppressor grids which require zero or negative bias voltages.*** **Likewise there should be a conductive path** ***between the control grid and the cathode of a tube,*** **and** ***between the suppressor grid and cathode of a tube.***
3. **In diode detectors or diode A.V.C. tubes, there should be a conductive path between the plate and the cathode.**

Failure to secure a conductive path in any of the cases mentioned, as evidenced by an infinite-resistance reading of the ohmmeter, indicates a break in the electrode circuit in question. It should then be a simple matter to check the circuit piece by piece to locate the break.

When the schematic circuit diagram and the parts layout diagram are available, all parts suspected of being open can be located first on these diagrams and then on the chassis. Each part is then checked for continuity, making sure that the test includes the connecting leads.

When neither the circuit diagram nor the pictorial layout diagram is available, the circuit must be traced on the chassis for the most likely path between the points in question before making ohmmeter measurements. For example, if you found that there was no continuity between the plate of the 6K5G first audio amplifier tube and the rectifier filament, you would first locate the plate terminal of the audio tube socket. There would be a wire from this terminal running around the front edge of the chassis to a terminal to which a resistor and a .015 mfd. condenser are soldered. Of course, no continuity should be expected through the condenser, so you trace through the resistor to the screen grid of the power output tube and then to the field coil of the loudspeaker. You know that your circuit should trace through this field coil rather than through leads going to the electrodes of other tubes and so you arrive at the rectifier filament. Having traced the circuit, you can then proceed to test continuity of each part and section of it.

How to Locate Trimmer Condensers

As you know, the location and identification of each trimmer condenser in a receiver is essential for alignment purposes. If the manufacturer supplies a circuit diagram like that in Fig. *1* and a trimmer layout diagram like that in Fig. *3,* this task is simple. When no trimmer layout diagram is available, however, the problem becomes more complicated. Let us see how this would be done on the receiver being used as an example if the only service manual data available is the circuit diagram in Fig. *1*.

First of all, we note that there are two holes in the top of each I.F. transformer through which can be seen adjusting screws. Those in the first I.F. transformer we can identify as I.F. trimmers *13A* and *13B,* while those in the second I.F. transformer must logically be I.F. trimmers *19A* and *19B*. We next note that there is a trimmer condenser mounted on each stator section of the gang tuning condenser. That one which is on the R.F. input stator section we identify as high-frequency trimmer *4A;* the trimmer on the oscillator stator section must therefore be oscillator-high frequency trimmer *4B*.

A glance over the circuit diagram in Fig. *1* shows that there are only two more trimmer condensers, *7* and *7A*. Since manufacturers will make all trimmer condenser adjustments

available from the top of the chassis wherever possible, we look for these on the chassis and finally locate the two adjusting screws to the right and a little above the gang tuning condenser unit, near the last I.F. transformer. We must turn the chassis over and trace connections, however, in order to tell which is *7* and which is *7A*. Figure *1* shows that these trimmers have one common connection through condenser *8* to ground, with the other connections going to opposite ends of oscillator coil *6*. Trimmer *7A* also connects to one terminal on oscillator coil *5*, so we can positively identify as trimmer *7A* on the chassis that trimmer which connects to two oscillator coils. The remaining trimmer, which connects to only one oscillator coil, will therefore be *7*.

General Trimmer-Locating Suggestions. For each band in an all-wave superheterodyne receiver there will usually be the following separate trimmers: *1*, one high-frequency trimmer for each preselector stage which is tuned to the incoming R. F. carrier frequency; *2*, a high-frequency oscillator trimmer; *3*, a low-frequency oscillator padder. (The receiver used as an example in this lesson is an exception to this rule, for there is one high-frequency oscillator trimmer for each band but only a low-frequency oscillator padder for the broadcast band. In the preselector, one high-frequency trimmer serves both bands.) In the case of a three-band receiver having one R.F. amplifier stage, there would be four trimmers in the preselector and oscillator sections for each band, making a total of twelve trimmers ahead of the I.F. amplifier. Usually there will be two trimmers for each I.F. transformer, but in the less expensive receivers which have no R.F. amplification and only one stage of I.F. amplification, a high gain I.F. transformer using only one tuned circuit and consequently only one trimmer may be found.

Look for I.F. trimmer adjustment screws either at the top or on the side of the I.F. transformer shield; occasionally, however, you may find them at the bottom of the transformer, visible only from the bottom of the chassis. Some manufacturers mount these trimmers directly on the chassis rather than in the shield, but they will always be located close to the I.F. transformers they tune.

In a conventional broadcast band superheterodyne receiver, all of the high frequency trimmer condensers will be mounted on the stator plates of the condensers which they adjust. The low-frequency padder will be a separate unit, mounted somewhere near the oscillator coil or the oscillator tuning condenser section. If two or more trimmers are found on the chassis of a broadcast band receiver, trace the circuit to each in order to make sure that the one selected as the padder is not a wave trap adjustment or some other special circuit arrangement. The oscillator low-frequency padder will generally be in series with the oscillator coil; sometimes this padder will be shunted by a fixed condenser.

Ordinarily there will be no high-frequency trimmers mounted on the gang tuning condenser of an *all-wave receiver;* these will be located near the coils which they adjust, instead. (The Philco two-band receiver used as our example in the lesson is not considered an all-wave receiver.) Sometimes all of the oscillator circuit coils will be found in a separate aluminum shield can, along with the oscillator high-frequency trimmers, while another shield can will be used for the preselector coils feeding into the mixer-first detector, and one more shield for the antenna coils if an R.F.

amplifier stage is used. There will be one adjusting screw on each of these shields for each band in the receiver; for example, in the case of a three-band receiver there will be three high-frequency trimmer adjusting screws on the side or on top of each preselector and oscillator coil shield.

Sometimes the preselector and oscillator coils are placed below the chassis, completely shielded from each other and from other parts by metal partitions and a metal cover plate. The adjusting screws for the high-frequency trimmers will be accessible through holes in the cover plate.

Low-frequency padder condensers are ordinarily mounted on the chassis, and are usually ganged or grouped together on a common insulating strip. Identification of these in the case of an all-wave receiver can sometimes be made by noting the number of plates in each unit; that padder having the largest number of plates will be for the broadcast band, while the other with the fewest plates will be for the high-frequency band. It is best, however, to identify trimmers by referring to a circuit diagram and to a chassis layout when available. Experienced Radiotricians can often identify the bands controlled by preselector and oscillator trimmers simply by adjusting each in turn and noting the effects; if you attempt to do this, however, be sure to note the original setting of the trimmer so you can restore this setting in case the wrong trimmer is chosen.

Appraising Receiver Performance

When servicing a receiver, it is obviously a waste of time to attempt to secure better performance than was originally intended by the manufacturer. Each receiver is designed to sell for a definite price, and consequently, lower-priced receivers will lack many of the features which are incorporated in the more expensive sets.

Actual experience with the various types of receivers is, of course, the best guide for determining when a receiver is performing in a satisfactory manner, but there are a number of recognizable clues indicating how much can be expected from a particular receiver in the way of selectivity, sensitivity and fidelity.

First of all, the number of tuned stages in a receiver is an excellent guide as to its selectivity and sensitivity, for increasing the number of tuned stages improves both of these performance characteristics.

The presence of more than two tuned circuits between adjacent R.F. or I.F. amplifier tubes indicates improved selectivity, possibly with some sacrifice in gain (sensitivity). Plate and grid connections to taps on tuning coils are signs of improved selectivity; the use of these taps also indicates that the stages in the receiver provide more gain than is considered essential, for the introduction of a selectivity-improving scheme tends to cut down the gain.

The number of tubes in the entire R.F. and I.F. amplifier systems, not including the oscillator and oscillator control tubes, is another rough guide to the amount of selectivity and sensitivity in a receiver. A superheterodyne will give better selectivity and better gain than a T.R.F. receiver having an equal number of tubes, simply because the I.F. amplifier in a super utilizes higher Q factor circuits and more tuned circuits per stage than does a T.R.F. receiver. Furthermore the gain and selectivity will be more uniform over the entire band in a super than in a T.R.F. receiver.

The presence of a stage of R. F. amplification ahead of the mixer-first detector in a super indicates a highly sensitive receiver with a high ratio of signal level to converter noise level. In other words, with an amplifier stage in the preselector, weak stations should be heard with clarity and freedom from converter noise interference.

Do not expect the selectivity and gain of an all-wave receiver to be as good on the higher-frequency bands as on the broadcast band, for the Q factors of the tuning coils are considerably reduced at the higher frequencies.

When checking the selectivity of a receiver, pay no attention to the space on the tuning dial which is covered by a station, but rather, note whether stations which are received at your location with approximately equal intensity can be heard separately even though only 10 kc. apart.

To determine what you can expect from a particular receiver in the way of fidelity, study the loudspeaker and the compartment in back of it carefully. If the design of these indicates a wide range of frequency response, means for suppressing cavity resonance and means for utilizing bass reflection, you can be quite sure that high fidelity performance was intended.

The presence of band-pass circuits in the R.F. and I.F. amplifiers, especially in the preselector circuits, are equally important clues pointing to a high fidelity receiver. The mere fact that I.F. transformers have a tuned primary and tuned secondary is no indication that they are band-passed, but if these transformers are critically coupled or over-coupled (as indicated by your inability to secure a sharp peak response curve with a cathode ray oscilloscope), they are very likely designed for band-pass use. If a receiver employs three or more I.F. transformers, and the design of the preselector appears to indicate a broad response, then band-passing is probably present.

An I.F. amplifier circuit employing variable coupling between the windings of the I.F. transformer is a fidelity control, permitting the customer to choose between high fidelity and high selectivity.

In receivers having automatic frequency control, the regular I.F. amplifier circuits are very likely intended to be band-passed for high fidelity if the discriminator is fed through one or more independent and highly selective tuned circuits.

Schematic and Chassis Wiring

The fact that the actual wiring on a chassis may be considerably different from the connections indicated on the schematic circuit diagram cannot be emphasized too strongly even though the differences between schematic and actual chassis wiring have already been taken up in this Course. Remember that the lines on a schematic diagram merely indicate which terminals of the various parts are connected together *electrically;* these lines are not intended to show how wires actually run from point to point on the chassis, nor do they indicate the relative lengths of the connecting wires.

For example, referring to the first audio amplifier stage in Fig. *1,* notice that parts *34* and *36* are both connected to the plate of this first audio tube. It might be possible to solder the condenser and resistor leads directly to the plate terminal of this tube socket. Actually, however, the resistor is soldered directly to this tube terminal and a long lead run from this terminal to condenser *34,* which is soldered directly to the grid terminal of

the tube socket in the following stage. Experience with actual receivers will show you that other electrical connections indicated on a schematic circuit diagram can be made in many different ways on the actual chassis.

TEST QUESTIONS

Be sure to number your Answer Sheet 32FR-2.

Place your Student Number on every Answer Sheet.

Never hold up one set of lesson answers until you have another ready to send in. Send each lesson in by itself before you start on the next lesson. In this way we will be able to work together much more closely, you'll get more out of your Course, and you will receive the best possible lesson service.

1. Is it necessary for a Radiotrician to analyze the complete circuit diagram of a receiver when repairing a defect? No

2. Into what two general trouble groups can all defective radio receivers be placed? Dead receivers & those which do not play perfectly.

3. What is the simplest and speediest test for isolating the defective stage in a dead receiver? The circuit disturbance test

4. Referring to the schematic circuit diagram in Fig. 1, what symbol identifies the circuit as that of an A.C. receiver. The power transformer

5. Give the numbers of the trimmer condensers in Fig. 1 which permit peak adjustments of the two I.F. transformers.
13A; 13B; 19A; 19B.

6. Near what easily identified part would you expect to find the power pack rectifier tube in an A.C. receiver? The power transformer

7. Through what parts does the second grid (oscillator plate) of the 6A8G tube in Fig. 1 trace to the rectifier filament? The oscillator plate coil 5 & the resistors 10 & 12

8. What is the general rule for checking continuity in the circuits of all electrodes (in an A.C. receiver) which are supplied with a positive D.C. potential? P 24

9. Should there be a conductive path (continuity) between the plate and cathode of a diode detector? Yes

10. Are high frequency trimmer condensers ordinarily mounted on the gang tuning condenser of an all-wave receiver?