

**TYPICAL RECEIVER DIAGRAMS
AND HOW TO
ANALYZE THEM**

REFERENCE TEXT 17X



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TYPICAL RECEIVER DIAGRAMS AND HOW TO ANALYZE THEM

SCHMATIC circuit diagrams of radio receivers can tell you many highly practical facts once you learn how to analyze these diagrams. The complete story of a radio receiver is condensed into its circuit diagram, with every path for signal currents and supply currents clearly shown. One glance at a diagram is enough to tell you how many tubes there are in the receiver. With a bit more study, you can find out how many other parts there are and what the electrical size of each part is.

Practice Makes Perfect. There are only two simple requirements for acquiring the ability to analyze circuit diagrams. The first is a clear understanding of common radio circuits, and this you are rapidly acquiring as you master the lessons in the Fundamental Course. The second requirement is practice in analyzing these diagrams, and the purpose of this reference book is to give you *exactly that practice which you need.*

In regular N.R.I. lessons you have studied a large number of different individual radio circuits. Now you will see how these circuits work together in radio receivers.

That ancient Greek philosopher, Diogenes, had the right idea 2300 years ago when he said, "Practice makes perfect." The more circuits you analyze, the easier will it be for you to analyze each new circuit.

Don't Let Big Diagrams Scare You. First impressions don't mean a thing when it comes to circuit diagrams. No matter how complicated a diagram may seem the first time you look at it, you will generally find upon careful study that it is simply a combination of simple and familiar basic radio circuits.

In practical radio work, men rarely if ever attempt to analyze a complete circuit diagram at one time. Such a procedure is entirely unnecessary, because radio men are invariably interested only in one small section of the receiver—the section in which trouble has developed. They use the circuit diagram merely as a rapid means of finding out what is in the suspected section, and as a guide for locating various parts in that section.

It is the ability to read a complete diagram, however, which makes it possible to concentrate on one section, stage or circuit of a receiver and still appreciate its relationship to the rest of the receiver.

You Get Concentrated Experience. In this reference book, typical receiver circuit diagrams are shown and analyzed completely. Since each diagram contains at least a dozen individual signal and supply circuits, this one book gives you practical experience equivalent to that normally obtained by using circuit diagrams for repairing a large number of radio receivers. With so much practice, obtained in such an interesting manner, you cannot help but develop skill in analyzing receiver diagrams.

What Diagrams Tell You. Each part in a receiver is represented on the diagram by a small but familiar and easily recognizable symbol, and electrical connections between the parts are represented by lines. Notations alongside the symbols either give electrical values of parts directly or refer to parts lists containing these values. These notations will give you a general idea of what resistor and condenser values you can expect in each type of circuit.

One important fact to recognize is that schematic circuit diagrams give electrical connections without showing actual positions of wires. Two parts which are close together on a schematic diagram may actually be at opposite ends of a receiver chassis, even though the electrical connections on the chassis are exactly the same as those on the diagram.

Although a schematic diagram is drawn without regard for actual positions of parts on a chassis, it enables you to find any part on a chassis because it indicates easily-located parts or terminals to which the leads of the desired part are connected. With the practice which you will get from studying the diagrams in this book, you should quickly learn how to find any desired part on an actual chassis.

A knowledge of what stages are in a particular receiver and how these stages operate is oftentimes highly important in the

speedy servicing of the receiver. This means that while you are developing your ability to analyze circuit diagrams through the study of this reference book, you are also developing your ability to service radio equipment speedily. Actually, this reference book teaches you how to make schematic circuit diagrams become one of your most valuable servicing tools.

How The Diagrams Were Chosen. In choosing the diagrams for this book from the N.R.I. file of over 12,000 different radio receiver diagrams, both old and new circuits were carefully considered. Each diagram finally chosen for detailed analysis is typical of one group of receivers encountered in radio work. This means that by studying the few carefully selected circuits, you will actually become familiar with the general features of hundreds of different receivers.

The diagrams in this book are arranged so that you progress logically from simple circuits to more advanced circuits. You start with a simple t.r.f. circuit which was extremely popular some years ago and is still used in some midget table model receivers, but you soon get to the modern superheterodyne circuits which are the leaders in popularity today.

Diagram Styles. Each receiver manufacturer has his own style of drawing radio symbols and circuit diagrams. In order to make you familiar with these different styles, the diagrams in this book are presented almost exactly as they appear in the service manuals of the respective manufacturers. For this reason, many of the symbols in this book will look quite different from the symbols you have become so familiar with in regular N.R.I. lessons.

Curiously enough, you will find that no matter how the various radio symbols are drawn, you will be able to recognize them almost instantly. Sometimes their positions with respect to other parts will identify new symbols even though they appear entirely different from standard symbols. A comparison of the different ways in which tube symbols are drawn is itself a fascinating study.

General Outline. The analysis of the first receiver circuit in this book is divided into the following seven sections. The same general treatment is followed for the other circuits in the book, except that sometimes one or more of the sections are omitted to avoid repetition of basic facts which have already been covered.

1. Identifying Tubes. Identification of each tube stage by noting its position in the diagram with respect to the antenna, the loudspeaker, the power pack and other parts, followed by identification of the general type of receiver.

2. Tracing Signal Circuits. Study of the signals in each circuit, starting from the antenna and working to the loudspeaker. You deal with signal flow, signal voltages and signal currents now, without considering electrons and the direction of electron flow at all.

3. Tracing Supply Circuits. Tracing circuits to see how each tube electrode gets its d.c. operating voltage. You are concerned with the direction of electron flow only when it is necessary to determine the correct polarity for d.c. measurements.

4. Voltage Measurements. Explanation of voltage values given by the manufacturer.

5. Continuity Tests. Suggestions for finding breaks in circuits.

6. Expected Performance. What can be expected in the way of tone quality, volume, distant-station reception, and ability to separate stations.

7. Servicing Hints. Common defects which can occur in the receiver circuits, with clues for recognizing them and suggestions for clearing up the trouble.

Plan To Review Later. In your study of this reference book, you will occasionally encounter circuits and technical phrases which have not yet been taken up in your regular lesson texts. In such cases, simply pass over the things you cannot understand, with the thought that you will review this reference book after you have completed your FR Course and mastered all of the fundamental radio principles and basic radio circuits. Such a review will more than double the value of this reference book to you.

Rather than attempt to study this entire reference book at one time, it is suggested that you spread the study of this book out over several lessons. In other words, study only one diagram after a lesson. In this way, your mind can concentrate upon the essential information in one receiver diagram without mixing it up with other circuits.

BELMONT Series 40A Four-Tube T. R. F. Receiver

IDENTIFYING Tubes. We recognize the type 80 tube as the *rectifier* tube, for it is connected directly to *T*, the power transformer.

We next locate the tuning circuits which are controlled by the gang tuning condenser. There are only two: L_2-C_1 and L_4-C_2 , so the type 58 tube which is between these tuning circuits is an *r.f. amplifier* tube.

The output tube always connects to the loudspeaker through an iron-core output transformer, so the type 47 tube must be the *audio output* tube.

Now there is only one tube left to identify. We know that it receives an r.f. signal from the second tuning circuit (L_4-C_2), and that it must deliver an a.f. signal to the type 47 audio output tube, so we naturally conclude that the type 57 tube is the *detector*.

We thus have one r.f. amplifier stage, a detector, an audio output stage and a rectifier. There being no oscillator tube and no i.f. amplifier stages, we can say definitely that this Belmont receiver is of the tuned radio frequency type.

Tracing Signal Circuits. Instead of antenna and ground terminals, a short length of *tan* wire serves for the antenna lead-in connection, and a similar length of black wire serves for the ground wire connection.

When a modulated r.f. signal current is picked up by the receiving antenna, it flows through primary winding L_1 to ground, inducing a corresponding modulated r.f. voltage in secondary L_2 .

At the same time, some modulated r.f. current will flow directly from the antenna to coil L_2 through capacity C_A . This capacity is provided by a short length of insulated wire connected to the "hot" end of L_1 (the end farthest from ground), and wound partly around L_2 to give capacitive *link coupling*. More uniform transfer of r.f. signals over the entire tuning range is obtained by using both inductive and capacitive coupling in this way.

Tuning in a station (by turning the tuning knob) makes sections C_1 and C_2 of the gang tuning condenser have the correct values to bring both tuning circuits (L_2-C_1 and L_4-C_2) to resonance. The tuning circuits thus provide resonant step-up of the desired signal voltage and provide rejection of undesired signals.

The modulated r.f. signal voltage existing across L_2 and C_1 is applied between the control grid and cathode of the 58 r.f. amplifier tube, with the path to the cathode being

completed through the chassis and r.f. bypass condenser C_9 .

This voltage causes the plate current of this tube to vary above and below its normal direct current value at an r.f. rate. This r.f. plate current flows through coil L_3 , which is *weakly* coupled inductively with coil L_4 in the second tuning circuit. The flow of r.f. plate current through L_3 induces the modulated r.f. signal voltage in L_4 , and this undergoes resonant step-up in the second tuning circuit.

There is also some transfer of signals to tuning circuit L_4-C_2 through coupling condenser C_8 , in such a way as to make the performance of the receiver more nearly uniform over the entire broadcast band.

The modulated r.f. voltage across L_4 and C_2 is applied between the control grid and cathode of the 57 tube, with C_6 and the chassis completing the path from cathode to C_2 .

Bias resistor R_4 has a value of 25,000 ohms, which is high enough to make the 57 tube act as a detector. C_4 provides a shunt path to the cathode for r.f. signals in the plate circuit, so that the energy of the r.f. signal is dissipated in the tube, and only the desired audio signals flow through plate load resistor R_5 .

The a.f. voltage across R_5 is applied to resistor R_6 through coupling condenser C_5 and power pack filter condenser C_{11} . Both have low reactance at audio frequencies.

The a.f. voltage across R_6 is applied between the control grid and filament (acting also as cathode) of the 47 output tube, with the path from R_6 to the filament completed through R_7 , the chassis and the filament wires which run from terminals *XX* on S_3 to filament terminals *XX* of the 47 tube.

The 47 output tube is a power tube, in that it converts normal grid voltage variations into large variations in the plate current. This a.f. grid voltage causes a large a.f. plate current to flow through the primary of output transformer T_1 on its way back to the filament through C_{11} , R_7 , the chassis, S_3 , and the filament leads of the 47 tube.

The induced voltage in the secondary of this step-down transformer T_1 sends a large a.f. current through the voice coil of the loudspeaker.

Tracing Supply Circuits. Since our receiver has a power transformer, it is an a.c. receiver. The table of *VOLTAGES* specifies 115 volts for the *LINE* voltage, but a receiver like this will work satisfactorily on line voltages anywhere between about 105 volts and 125 volts a.c.

Neither filament voltages nor complete filament circuits are shown on the diagram, but if we look up the 58, 57 and 47 tubes on a tube chart, we find that they all have rated filament voltages of 2.5 volts. This means the filaments of these tubes could be connected in parallel, and the *XX* markings on the filament leads and on secondary winding S_3 indicate that parallel connections are used.

According to tube charts, a type 80 rectifier tube requires a filament voltage of 5 volts. A special secondary winding S_1 is provided for the filament of the 80 tube.

The output terminals of the power pack are 1 (+) and 2 (-). From terminal 1, we trace electron flow to the filament of the 80 tube, from there to whichever plate is positive at the time, through one half of secondary S_2 to the center tap, then through choke coil *CH* (also serving as the loudspeaker field coil) to point 2. Resistor R_7 and the various tube circuits complete the path for electron flow from 2 to 1.

For the plate supply circuit of the 58 tube, electrons flow from 2 (the negative output terminal) through R_7 to the chassis, through the chassis to the grounded movable contact of R_1 , through one section of R_1 to the cathode of the 58 tube, from the cathode to the plate, and from the plate through L_3 to 1 (the positive output terminal).

Note that resistors R_7 , R_1 , R_2 and R_3 are all in series between 1 and 2, thus forming a voltage divider. The voltage across R_2 is the screen grid voltage for the 58 tube, as the cathode and screen grid are connected to opposite ends of this resistor.

For the plate supply circuit of the 57 tube, electrons flow from 2 through R_7 to the chassis, through the chassis to the lower end of cathode resistor R_4 , through R_4 to the cathode of the 57 tube, from the cathode to the plate, then through plate load resistor R_5 to terminal 1.

For the screen grid supply circuit, electrons flow from 2 through R_7 to the chassis, through R_4 to the cathode, then to the screen grid and back through R_3 to 1.

For the plate supply circuit of the 47 tube, electrons flow from 2 through R_7 to the chassis, through the chassis to the center tap of S_3 , through the filament leads to the filament of the 47 tube, then to the plate and through the primary of output transformer T_1 to 1. The screen grid supply circuit is the same as the plate supply circuit of this tube, except that the screen grid current does not go through the output transformer.

Voltage Measurements. In the table of voltages alongside the circuit diagram, all d.c. values are to be measured between the specified point and the chassis, with the black (negative) lead of the d.c. voltmeter

going to the chassis. Measured values which are about 10% above or below the specified values can usually be considered satisfactory.

The first value in the table, 240 volts between the *RED* lead and chassis, is the power pack d.c. output voltage (between 1 and 2) less the small voltage drop across R_7 . Ten per cent of 240 is 24, so a measured value 24 volts above or below the normal value of 240 volts does not indicate trouble.

Moving to the *BLUE* plate lead of the 47 output tube, we measure its plate voltage and should get 230 volts, because there is a d.c. voltage drop of about 10 volts across the 500-ohm resistance of the primary of output transformer T_1 .

The value of 140 volts between the *YELLOW* lead and the chassis represents the d.c. voltage drop across R_7 and choke *CH*.

The 16-volt value between the *GREEN* lead and the chassis is the voltage drop across R_7 , which provides the C bias voltage for the 47 output tube. For the last two measurements, the voltmeter test probes must be reversed, with the positive probe going to the chassis.

When measuring between the plate of the 57 tube and the chassis, an ordinary d.c. voltmeter (having a sensitivity of 1000 ohms per volt) will read only 105 volts. A higher-resistance voltmeter would read a much higher d.c. voltage, higher than the screen grid voltage but still less than the power pack output voltage because of the drop in plate load resistor R_5 .

The screen grid-to-chassis voltage of 110 volts for the 58 tube also applies to the 57 tube. This screen grid voltage is established by voltage divider network $R_1-R_2-R_3$. Since R_1 is a part of this network and since it is variable, all voltage measurements should be made with R_1 fully advanced (for greatest sensitivity and hence greatest volume). Under this condition, R_1 has a minimum resistance of about 250 ohms, which is necessary to prevent the C bias voltage of the 58 tube from becoming zero.

No value is given for the plate voltage of the 58 tube, since it is essentially the same as the voltage between terminal 1 and the chassis (240 volts). The d.c. voltage drop across L_3 is negligibly small.

A measurement between the cathode of the 58 tube and chassis indicates 2 volts; this is the minimum negative bias provided by R_1 . As the volume control setting is reduced, this bias voltage is increased correspondingly.

Continuity Tests. When lack of expected voltage indicates absence of continuity, the radio technician makes continuity tests with an ohmmeter while the power cord plug is

out, bearing in mind the following two important rules for an a.c. receiver:

1. There should be continuity between all positive tube electrodes, such as plate and screen grid, and the cathode of the rectifier tube.

2. There should be continuity between all negative tube electrodes (such as the cathode and control grids) and either of the plates of the rectifier tube.

Having located the defective supply circuits by means of voltage measurements, you start a continuity test by attaching one ohmmeter lead to the common power pack terminal (the plate or the cathode of the rectifier tube).

Now place the other ohmmeter lead on the tube electrode terminal. (A reading will not be obtained because the circuit is defective (open) at some point or part between the ohmmeter leads.) Move this ohmmeter lead step by step toward the rectifier tube until the break is located. This is indicated when you get a reading. The circuit path which was just eliminated by moving the probe toward the rectifier tube is open.

Expected Performance. With only one r.f. stage, we should not expect great sensitivity or loud volume on distant stations.

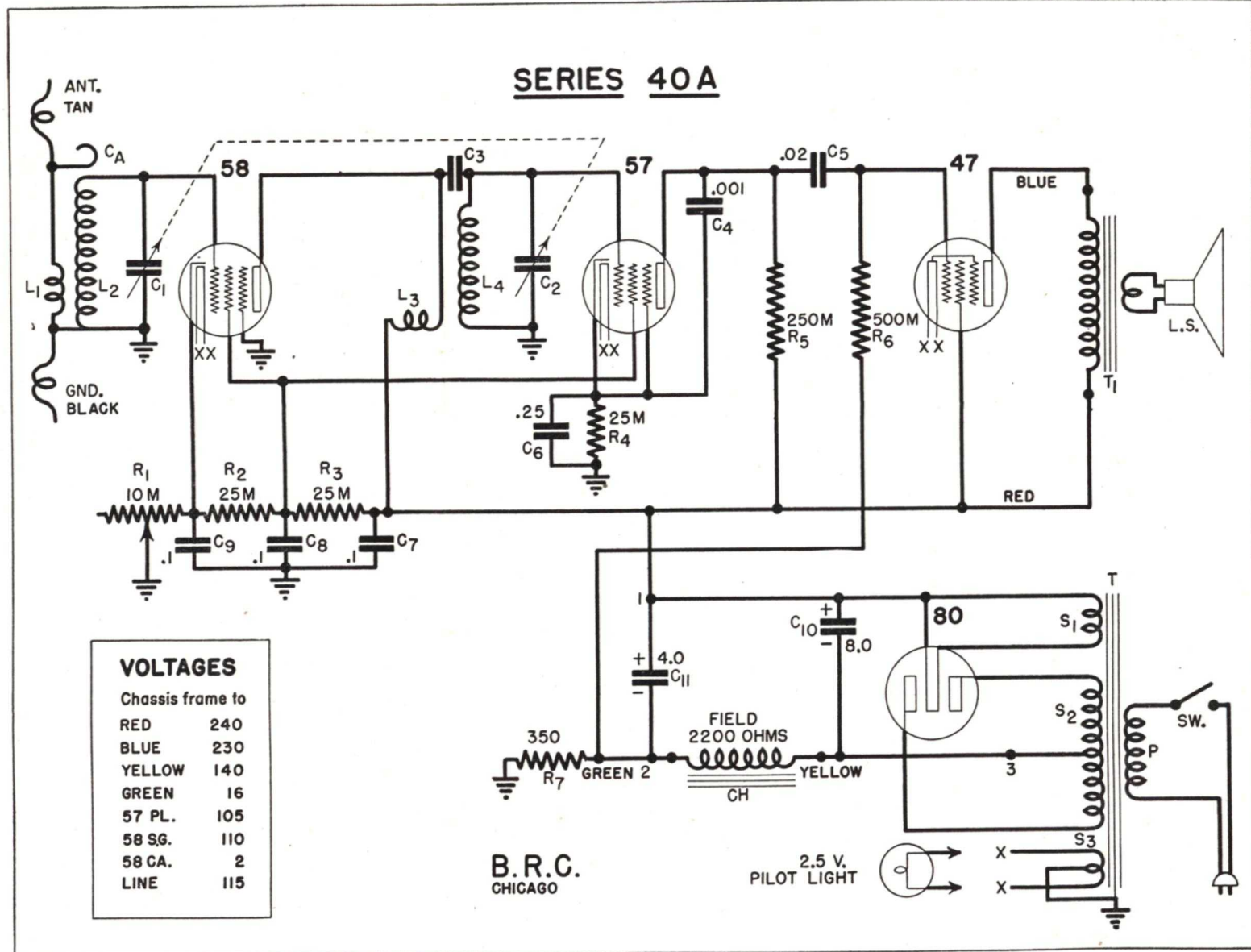
Reception of distant stations can be improved by using a long antenna, but with only two tuning circuits in the receiver, the selectivity will be poor (there may be interference between several stations when tuned to one of them).

The quality of reception can be reasonably good with a receiver of this type. The larger the receiver cabinet and the better the loud-speaker, the better will be the quality.

Servicing Hints. *Hum.* If this receiver has a loud hum, you naturally suspect the filter system of the power pack first. Check electrolytic filter condensers C_{10} and C_{11} by placing other condensers of about the same size across each of them in turn. If this does not change the hum, you know that the existing condensers are all right. You then check the 57 tube in a tube tester for cathode-to-heater leakage, and check for an open in the control grid return circuit of either the 57 or 47 tube.

Squealing. After making sure that tube shields are in place, check screen condenser C_8 by shunting it with a condenser of similar value.

Check the screen grid voltage of the 57 and 58 tubes next, because excess screen grid voltage could cause squealing. If the screen grid voltage is excessively high, R_2 may be open, so check it with an ohmmeter.



Hot Resistor. Suppose resistor R_7 is hot and smoking—what would you do? First you would examine the diagram to see what could cause excessive current to flow through R_7 . A short in C_{11} could not do this, but a short in C_7 could.

You wouldn't have to unsolder C_7 to make an ohmmeter check—simply measure the resistance between the rectifier filament and chassis. This resistance should be about equal to R_2 plus R_3 (volume control all the way on and the set disconnected from the power line). If you obtain a reading much

lower than the 50,000-ohm normal value, you would test C_7 thoroughly.

Conclusion. These examples show you how radio servicemen use circuit diagrams to aid in locating trouble and making repairs in radio receivers. You are not expected to be able to make an analysis of this nature for a long time yet, but as you become familiar with the various circuits in common use and as you secure practice in reading and analyzing circuit diagrams, you will eventually find yourself able to get equally as much information from a circuit diagram.

Fig. 1. Schematic circuit diagram of Belmont Series 40A t.r.f. receiver. Numbers alongside resistors represent resistance in ohms; thus, R_7 is 350 ohms, and R_3 is 25,000 ohms. (The letter M after a resistance value represents "thousand.") Numbers alongside capacitors represent capacity in microfarads; thus C_4 is .001 mfd., and C_{10} is 8.0 mfd. Solid black dots represent connections or terminals; no dots at cross-overs of lines mean no connections. An antenna 50 to 75 feet long will probably give best results in rural locations, but in cities a short antenna is usually best.

EMERSON BA-199 FIVE-TUBE A.C.-D.C. T.R.F. RECEIVER

THIS Emerson model BA-199 receiver consists of one r.f. amplifier stage using two tuned circuits, a detector and an audio output stage, all receiving d.c. operating voltages from a half-wave rectifier.

Tracing Signal Circuits. This receiver is referred to in the diagram as a 5-tube a.c.-d.c. receiver, on the basis that ballast tube *R3* is a tube. Calling a ballast a tube was once considered proper, but today only tubes in signal and supply circuits, operating by virtue of electron emission, are considered as tubes. Actually, this is a 4-tube radio receiver.

This receiver is a midget of the portable type and can be taken from room to room or to any location where 115-volt a.c. or d.c. power is available. A flexible insulated wire, permanently connected to the receiver, serves as the antenna. This wire can be hung around the room or connected to a heating radiator or some metal object in the room. This is information not given in the diagram, but worth knowing when you run across a.c.-d.c. receivers.

This antenna connects to primary winding *L1* of antenna transformer *T1* through condenser *C3*. The other end of *L1* is grounded to the receiver chassis, which in turn connects to one end of the power line through switch *SW*. The power line is used as the ground. As a rule, one of the power line wires is grounded somewhere in the house; even if it were not, its long length and its proximity to the earth would make it highly suitable for a ground.

We now realize that the chassis is connected to the power line. This means that to avoid a possible serious shock, you must keep your hands off the chassis whenever the receiver is in operation.

Condenser *C3* prevents winding *L1* from burning out if the antenna wire touches some grounded object. Without this condenser, the line plug might be inserted into the wall outlet in such a way that the chassis connects to the ungrounded side of the line. Then *L1* would be directly across the power line and would be burned out.

The r.f. current in *L1* induces an r.f. voltage in *L2*. The voltage across *L2* is stepped up due to resonance when *C1* is tuned. (Condensers *C4* and *C5* are trimmer condensers.) Capacitive link *C15* helps equalize gain over the tuning range.

The 6D6 tube amplifies the r.f. signal, so that the r.f. current in the plate circuit is greater than the r.f. current in *L2-C1*. This r.f. current is stepped up by the second r.f. transformer, and the r.f. voltage across *C2* is greater than across *C1*.

As a detector, the type 6C6 tube demodulates the modulated r.f. signal, producing an audio voltage across *R6*. Radio frequency signals resulting from detection are kept out of *R6* by by-pass condenser *C14*.

Observe that one end of *R6* goes to the chassis through condenser *C13*, a 16-mfd. electrolytic condenser. Resistor *R7* terminates at the chassis, with its other end going to the grid of the 25L6 pentode output tube and to the plate of the 6C6 tube through condenser *C9*. Thus, at all but low audio frequencies *R7* shunts *R6*.

The audio voltage across *R7* is fed to the 25L6 output tube. The cathode of the 25L6 tube goes to the chassis through *R8*, thus completing the grid circuit.

Audio current flowing in the plate circuit of the output tube passes through the primary of output transformer *T3*, flows to the chassis through *C13*, and returns to the cathode through *R8*. Transformer *T3* couples the loudspeaker to the output tube, and is designed to furnish the loudspeaker with maximum possible undistorted power.

Beam power output tubes have high plate resistance, which makes them unstable when the load (the loudspeaker) is subject to a great range in load conditions. Leakage inductance, which is especially high in an expensive output transformer, will cause feed-back and produce undesirable oscillation, often inaudible.

Condenser *C10* is used between the plate and cathode of the 25L6 beam power output tube to by-pass higher audio frequencies. This suppresses oscillation and prevents unstable operation, since the plate load is made capacitive at those frequencies at which oscillation might occur.

Undesired signals getting into the plate circuit produce across *R8* a voltage which, being out of phase with the grid signal voltage, cuts down the undesired signals by degeneration. The desired signal is also partially weakened, but its original strength is sufficient to permit degeneration. Distortion is greatly reduced by degeneration, for undesired harmonics of the signal are attenuated.

Noise signals coming over the line are by-passed by *C11*, and do not get into the power supply and the receiver output.

Tracing Supply Circuits. All items in the lower part of the diagram are in the power pack. In this power supply, terminals 1 and 2 serve as the high-voltage d.c. source for all positive tube electrodes in the main receiver circuit.

The 25Z5 tube is a twin rectifier tube used as a single diode by connecting corresponding electrodes together. Electrons will flow only from the cathodes to the plates through this tube. For a d.c. outlet the plug must be inserted in a wall outlet so that the plug prong marked + is in the + terminal of the wall outlet. The other prong is then —, as indicated.

Note that during d.c. operation the chassis is connected through switch *SW* to the negative terminal of the source, and the plate of the rectifier tube is connected to the + terminal. All circuit terminals will thus be positive with respect to the chassis.

Some voltage is dropped in rectifier tube and in choke *CH*, but most is dropped in the receiver circuit itself, which may be considered a load connected to 1 and 2.

Terminal 1, being nearer the + terminal of the source, is the + terminal of the power pack. As you trace from 1 through the receiver (for example, through *R6*, through the plate-cathode of the 6C6 tube, and through *R4* to the chassis), the positive potential with respect to the chassis diminishes. Point 3 is therefore positive with respect to point 4, a condition essential for operation of the 6C6 tube.

If you insert the plug incorrectly into the outlet of a d.c. source, 5 will be negative with respect to chassis, hence 5 will be negative with respect to 6, and electrons will not flow through the rectifier tube. The pilot lamp and tubes glow but the receiver will be "dead"; reversing the plug remedies the condition.

With an a.c. power source, 5 is alternately positive and negative with respect to the chassis. During the half cycle that 5 is positive, the 25Z5 tube is conductive and is furnishing the receiver with a high d.c. voltage. During the other half cycle, the tube is not conductive.

Most of the ripple in the resulting rectified current is eliminated by filter choke *CH* and filter condensers *C12* and *C13*. Note that the filter choke is also the field coil of the dynamic loudspeaker.

Starting with the first tube, let us trace the d.c. supply circuit through the tubes. Imagine, of course, that the tubes are operating, hence conducting.

Assuming that the negative prod of a d.c. voltmeter is on chassis, you can place the positive prod on the cathode of the 6D6 tube, the plate, and terminals 1 and 6 in rotation, and get a voltmeter reading each time. As you progress in this order the reading will become higher.

When you place the d.c. voltmeter be-

tween the cathode of the 6D6 tube and the chassis, you will find that the voltage varies as you adjust *R1*; in fact, as the receiver volume decreases this voltage increases. Here we have a volume control using variable C bias as the means of control. The grid gets this C bias from a chassis connection through coil *L2*.

Note that section *b* of *R1* shunts *L1*, for one end of *L1* and the movable contact of *R1* are connected to each other through the chassis. *R1* provides a shunt path for part of the signal current which would otherwise flow through coil *L1*. As *R1* is turned so the resistance in section *a* increases, the resistance in section *b* decreases.

Both sections of *R1* thus contribute to a reduction in volume, for increasing the resistance in section *a* increases the C bias voltage, and decreasing the resistance in section *b* increases the shunting effect across *L1*. Condenser *C6* always shunts *R2* and section *a* in *R1*, and prevents degeneration in the r.f. stage.

In the 6C6 tube stage, terminal 4, terminal 3 and the junction point of *R5* and *R6* are increasingly more positive with respect to the chassis. The plate-cathode voltage is equal to the main supply voltage (between 1 and 2) less the drop in *R6* and *R4*.

The drop in *R4* serves as the C bias voltage; note that the chassis end of *R4* goes to the grid through *L4*.

The screen grid voltage is obtained from the main d.c. supply but is reduced by the drop in *R5*; only the screen grid current flows through *R5* to produce this drop. R.F. screen grid current returns to the cathode through *C8* and cathode by-pass condenser *C7*.

A technician would recognize the 6C6 as a detector by the *R6-C9-R7* coupler in the plate circuit and by resonant circuit *L4-C2* in the input; this is a typical r.f. to a.f. coupling arrangement. Furthermore, *R6* is 500,000 ohms, *R5* is 2 megohms and *R4* is 25,000 ohms, indicating low plate and screen grid voltages and a high C bias voltage, all of which are essential for operation as a detector.

In the output stage, the plate supply circuit starts with chassis, continues through *R8*, then goes from cathode to plate, through the primary of *T3* and from 1 through the power pack to 2 and chassis.

The filaments are connected in series to the 115-volt supply, and will function with either a.c. or d.c. power. Let us trace this filament circuit by starting at the + terminal of the power cord plug. From here we go to

prong 8 of the ballast tube, through one resistance section to prong 8, through the other resistance section to prong 7, then through the filaments of the 25Z5, 25L6, 6D6 and 6C6 tubes in series. One filament lead of the 6C6 tube is grounded to the chassis, and switch SW completes the filament circuit from the chassis to the other side of the power line.

The total voltage required for the filaments is $25 + 25 + 6 + 6$, or 62 volts. The ballast drops the difference between 115 and 62, or 53 volts. Since the tube filaments and the ballast are self-regulating to a reasonable degree, increases and decreases in line voltage have little effect on the cathode emission of the tubes.

The pilot lamp shunts that portion of the ballast resistor between prongs 7 and 8. The resistance of this portion is so chosen that the lamp normally gets 4 volts; a 6.3-volt Mazda lamp is used, hence it will burn dimly. When the power is first turned on, however, the tube filaments have low resistance until they heat up; this causes a large current to flow, but it is partially "cushioned" by the ballast.

During the heating-up period, the voltage across the pilot lamp will be high, and the lamp will burn brightly. A 6.3 lamp normally operating at 4 volts thus provides a degree of safety from burn-out. In receivers which use this arrangement, you can expect the pilot lamp to glow brightly initially, and then dim down to a subnormal glow.

Checking Continuity in A.C.-D.C. Receivers. Bear in mind that continuity tests are made with an ohmmeter while the receiver is turned off. In fact, with a universal a.c.-d.c. receiver be sure to pull the power plug out of the wall socket. Ohmmeter tests can then be made from tube terminals or socket prong clips, for the tubes are not conductive when power is off.

In checking this receiver you will find that all positive tube electrodes, such as the screen grid and the plate, trace to the cathode of the rectifier. This rule applies to a.c.-d.c. as well as a.c. receivers. To prove this basic servicing rule, select one tube, the 6C6 detector; trace from the plate through R6 and CH to the cathode of the 25Z5.

All negative tube electrodes, such as the control grid, suppressor grid and cathode, should trace to the receiver side of the on-off switch.

Another important reference point is the cathode of the tube in the stage under test. You can place one prod of the ohmmeter on the cathode of the 6D6, the other prod on the control grid, and expect continuity. You should find continuity between other points in the grid circuit and the cathode; for example, from the movable contact of R1 or from the junction of R1 and R2.

To check for continuity in the filament supply circuit, connect the ohmmeter to the two power plug prongs and turn the switch to the ON position. A resistance much lower than 300 ohms (approximately the hot resistance of this circuit) will usually be measured.

Servicing Problems in A.C.-D.C. Receivers. Quite often electrolytic condensers C12 and C13 dry out, lose their normal capacitance and acquire a higher power factor; that is, they act as if a large resistance is in series with the capacity. When this occurs, the filter loses its ability to remove ripple, and hum is quite evident.

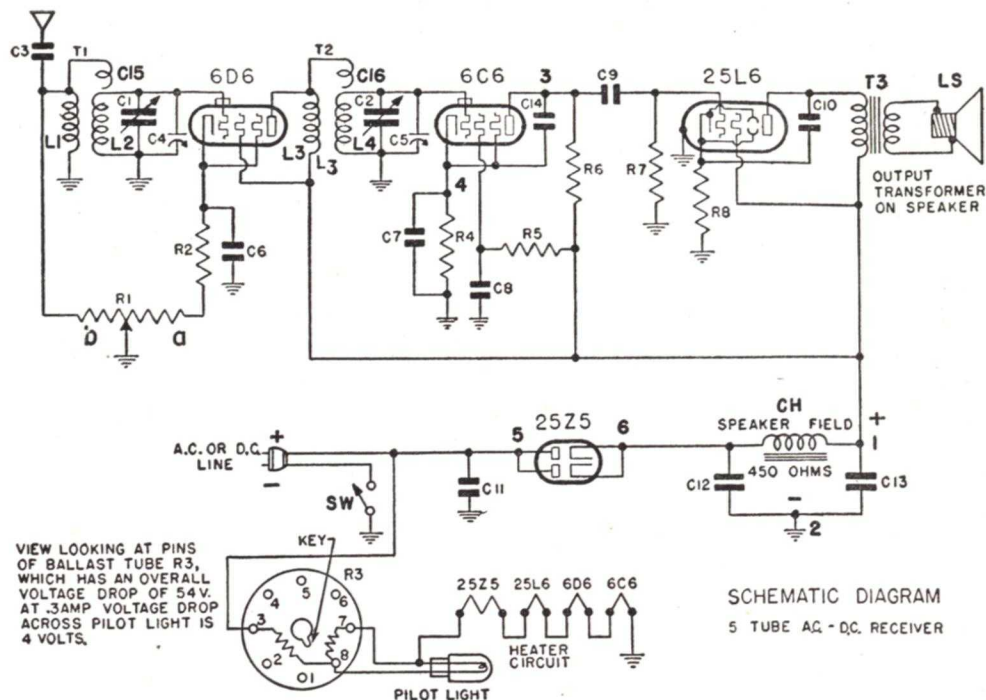
Reduction of input capacity lowers the over-all output d.c. voltage, and low volume may exist along with hum. When hum and low volume exist, try new electrolytic condensers. A short or excessive leakage in an electrolytic condenser gives the same effect, hum and low volume, and may lower the emission of the rectifier tube. Try a new rectifier tube, but before inserting it test the electrolytic condensers for resistance (each one should be substantially above 50,000 ohms when not shunted by any other part such as the field of a dynamic loudspeaker).

When you encounter distortion in an a.c.-d.c. receiver, check the filter condensers, particularly the output filter condenser, then look for gas in the output tube and for a leaky coupling condenser just ahead of the output tube (C9 in this circuit). In either case, current will flow through the grid return resistor (R7), placing a positive bias voltage on the control grid of the output tube, and linear (distortionless) operation will no longer exist.

The test for gas or a leaky coupling condenser is easily made with a vacuum tube voltmeter or a high-resistance voltmeter. Connect the meter across the grid resistor, with the positive prod on the grid end. There should be no reading. If a reading is obtained, unsolder the coupling condenser. A reading now indicates a gassy output tube, and no reading now indicates a leaky coupling condenser. (In an a.c.-d.c. receiver it is necessary to unsolder the coupling condenser, because removal of the output tube would interrupt filament current and make the entire receiver inactive.)

When a tube is operated with an a.c. potential between filament and cathode, leakage resistance between the cathode and filament can give rise to serious hum. When operated from a 110-volt a.c. wall outlet, all tubes in this receiver circuit will have an a.c. voltage between cathode and filament (normally the capacity between these two electrodes introduces negligible ripple current).

Imagine, however, that the cathode of the 6C6 tube is leaking to the filament. One side



VIEW LOOKING AT PINS OF BALLAST TUBE R3, WHICH HAS AN OVERALL VOLTAGE DROP OF 54 V. AT .3-AMP VOLTAGE DROP ACROSS PILOT LIGHT IS 4 VOLTS.

SCHEMATIC DIAGRAM
5 TUBE AC-DC RECEIVER

of the filament will be grounded, so if it leaks little hum results; should the other side of the filament leak to the cathode, then the 6 volts across the 6C6 filament will be across R4, and an a.c. voltage gets into the grid and plate circuits.

Note that one end of the filament circuit is grounded, hence those tubes which are connected farthest away from the ground end will introduce a greater a.c. voltage. The detector tube is most affected by cathode leakage, hence its filament is connected nearest to ground.

The output stage will give the least amplification of a.c. leakage voltage so its filament is placed third from the ground. Tubes should be checked in a tube tester for cathode filament leakage when you encounter hum troubles.

Should squeals or oscillations exist, shunt C13 with a condenser of similar value to see if this cures the trouble. If it does, the original C13 is open and should be replaced. Be sure the full length of the antenna is used because a short pickup will not sufficiently load the input circuit, and the least amount of feed-back will cause oscillation. Also, be sure to check C8 and C14 by substitution or by shunting with equivalent capacities.

Fig. 2. Schematic circuit diagram of Emerson Model BA-199 five-tube universal a.c.-d.c. receiver. The parts list for this set is given below, essentially as it appears in the manufacturer's service sheet. Note that this manufacturer uses the abbreviation mf. for microfarads, in place of mfd.

- | | |
|----------|--|
| T1 | Broadcast antenna coil |
| T2 | Broadcast detector coil |
| T3 | Output transformer |
| R1 | Volume control—75,000 ohms, with line switch SW |
| R2 | 240-ohm, 1/2-watt wire-wound resistor |
| R3 | Plug-in ballast tube |
| R4 | 25,000-ohm, 1/4-watt carbon resistor |
| R5 | 2-megohm, 1/4-watt carbon resistor |
| R6, R7 | 500,000-ohm, 1/4-watt carbon resistor |
| R8 | 110-ohm, 1/2-watt wire-wound resistor |
| C1, C2 | Two-gang variable condenser |
| C3 | .001-mf., 600-volt tubular condenser |
| C4, C5 | Trimmers, part of variable condenser |
| C6, C8 | .1-mf., 200-volt tubular condenser |
| C7 | .25-mf., 200-volt tubular condenser |
| C9 | .02-mf., 400-volt tubular condenser |
| C10 | .05-mf., 400-volt tubular condenser |
| C11 | .1-mf., 400-volt tubular condenser |
| C12, C13 | Dual 16-mf., 100-volt dry electrolytic condenser |
| C14 | .002-mf., 600-volt tubular condenser |
| C15, C16 | Gimmicks |
| LS | Loudspeaker (electrodynamic) |

RCA T5-2 Five-Tube A.C. Superheterodyne

GENERAL Description. This is an a.c.-powered superheterodyne receiver employing five tubes: an 80 rectifier, a 6A7 frequency converter, a 6D6 i.f. amplifier, a 6B7 second detector-a.v.c. and audio amplifier, and a 41 power output amplifier. The circuit is conventional in most respects.

Tracing Signal Circuits. In analyzing this receiver we will trace the essential sections of a superheterodyne, namely, the pre-selector, frequency converter, i.f. amplifier, second detector and audio amplifier.

Preselector. A simple input circuit is used, consisting of a tuned transformer and an i.f. wave trap. The antenna signal sets up a current in primary coil L-1. Should interference at the i.f. value of 460 kc. be present, the wave trap consisting of L-15 and C-47

will present a high resistance and thereby reduce the interference current in L-1.

The r.f. current flowing in L-1 induces a voltage in coil L-2. Trimmer condenser C-45 in shunt with tuning condenser C-6 is connected to coil L-2 through condenser C-5. C-45 has a capacity of 3-25 mmfd. and hence is a trimmer, while C-6 has a capacity of 16-410 mmfd.; the arrow indicates it is a tuning condenser. C-5 has a capacity of .05 mfd. (50,000 mmfd.), more than 100 times that of C-6. For this reason we may say that the reactance of C-5 is negligible with respect to C-6, and L-2 and C-6 with trimmer C-45 form the basic tuning circuit.

As we shall see later, the grid return of L-2 is not directly grounded, in order that the a.v.c. voltage can feed through it to the grid of the 6A7 tube. As far as r.f. currents

are involved, the grid return of L-2 and the rotor of C-6 are at r.f. ground potential.

At resonance the voltage in L-2 is stepped up, presenting to the grid-cathode of the first tube an r.f. voltage substantially greater than the voltage across L-1 in the antenna circuit. Voltage gains of 10 times may reasonably be expected.

Frequency Converter. A pentagrid tube (one with five grids, penta meaning five) is used as an oscillator-mixer-first detector—the frequency converter of a superheterodyne receiver. Its first grid connects through condenser C-8 to coil L-4 and to chassis (or r.f. ground) through C-11 in shunt with C-40.

Coil L-4, C-11 and C-40 are shunted by tuning condenser C-9 and its associated trimmer C-44 to form a resonant circuit in the oscillator circuit. This arrangement is widely used in superhet receivers in order to make the oscillator frequency, always 460 kc. (the i.f. value), different from the preselector

frequency (the incoming signal frequency).

To illustrate the action of the frequency converter, let us assume that the receiver is tuned to a 1000-kc. broadcast station. Tuning condenser sections C-6 and C-9 are ganged together, so that when C-6 tunes preselector resonant circuit L-2 and C-6 to 1000 kc., C-9 will cause the oscillator to generate a 1460-kc. signal. The oscillator frequency is thus 460 kc. higher than the incoming signal frequency, and this relationship exists at all settings of the tuning dial.

At the very high broadcast band frequencies, C-44 is adjusted during alignment to give the desired frequency difference and is called the high-frequency trimmer. At low broadcast band frequencies, C-40 is adjusted and is called the low-frequency trimmer or paddler.

From the second grid, trace through L-6, then through R-5 to the voltage supply (considered later) and through C-16 to ground. Coil L-6 inductively links to L-4 and thus produces feed-back from the second grid to the first grid circuit.

If you consider that the second grid of the 6A7 tube is an anode, or oscillator plate, you will see that we have a tuned grid, tickler type feed-back oscillator circuit. The intensity of oscillation is automatically controlled by the grid bias produced by grid current flow in R-3. Condenser C-8 serves as the filter condenser for the grid resistor and helps to reduce the r.f. ripples of the grid bias voltage.

The cathode, the first grid and the second grid, with their associated circuit components, set up beyond the second grid an electron cloud that is varying in intensity in accordance with the oscillator frequency. Technicians call this cloud the "virtual" cathode for the remaining tube elements, because the electrons flowing to these remaining elements come from this cloud.

The electrons which leave the virtual cathode are speeded toward the plate by the third and fifth grids (connected together internally to form the screen grid), since these electrodes are at a positive potential with respect to the virtual cathode. At the same time, the signal from the preselector is "injected" into the tube by the fourth grid, and introduces a new variation in the electrons flowing from cathode to plate.

Thus, both the preselector and local oscillator signals are mixed in the 6A7 tube. Detection takes place in the mixer section because the tube is operated as a detector and a strong beat signal (the i.f. signal) appears in the plate circuit.

Coil L-9 and adjustable condenser C-17 form a parallel resonant circuit in the plate circuit, absorbing power at its resonant frequency and acting as a low-reactance path for all other frequencies. The plate r.f. and

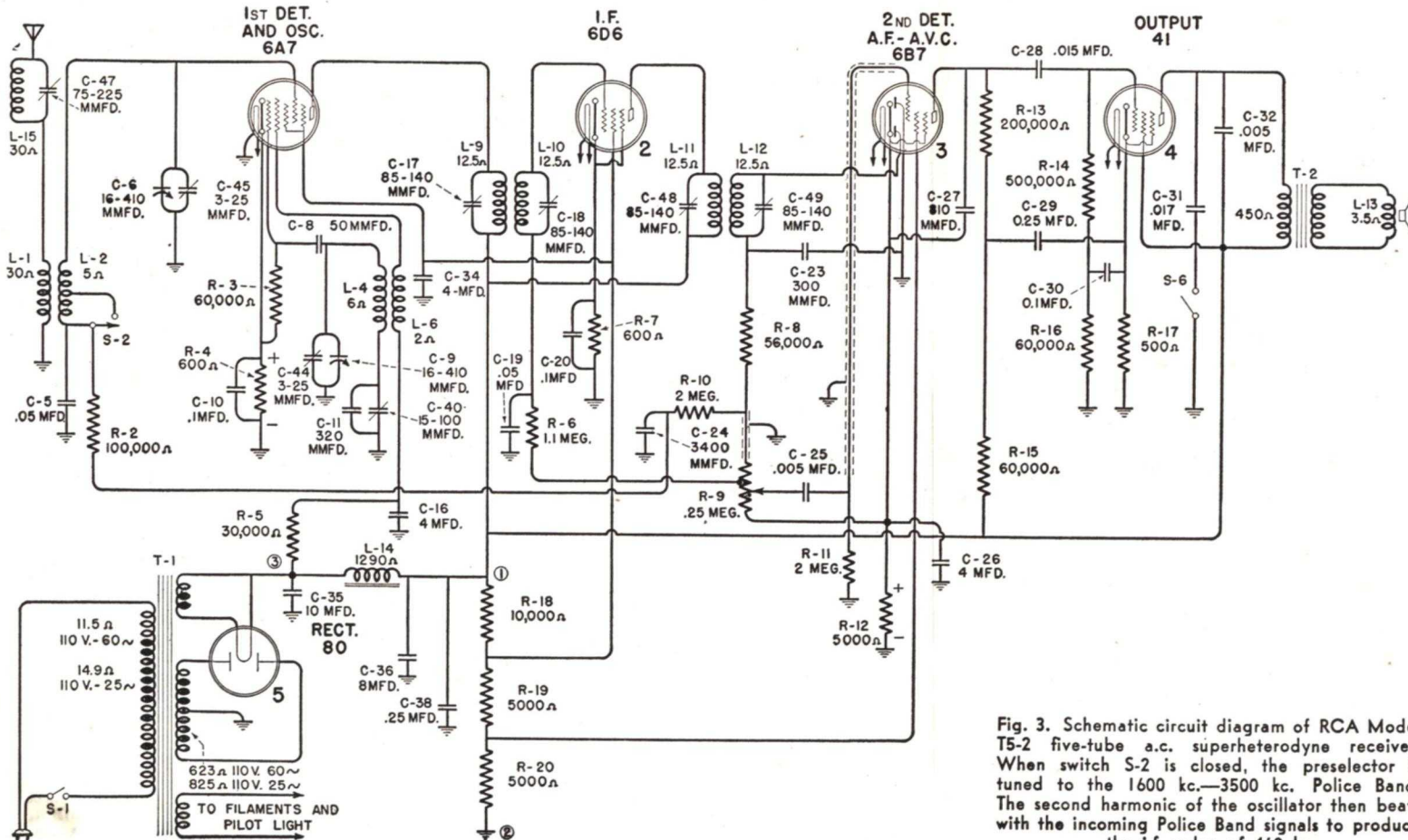


Fig. 3. Schematic circuit diagram of RCA Model T5-2 five-tube a.c. superheterodyne receiver. When switch S-2 is closed, the preselector is tuned to the 1600 kc.—3500 kc. Police Band. The second harmonic of the oscillator then beats with the incoming Police Band signals to produce the i.f. value of 460 kc.

i.f. current returns to cathode through the parallel path formed by C-38 and C-36, through the chassis, and then through C-10.

I.F. Amplifier and Second Detector. In a parallel resonant circuit, a large current flows in the coil-condenser circuit, hence in L-9 a large i.f. current induces in L-10 a corresponding i.f. signal voltage.

L-10 and C-18 form a resonant circuit which boosts this induced voltage, and a larger voltage appears across C-18 than that induced into L-10. However, the voltage across L-10 is slightly less than that across L-9, as some energy is lost in the primary and secondary resonant circuits.

The voltage across C-18 is applied to the input of the 6D6 tube through a direct connection to the grid of the 6D6 tube and a cathode connection through C-19 and C-20.

As the 6D6 is a high-gain amplifier, a large i.f. voltage is developed across the plate parallel resonant circuit, L-11 and C-48. The return i.f. path to cathode for this resonant circuit is through C-38, C-36 and C-20.

The i.f. current in L-11 induces an i.f. voltage in L-12. By tuning C-49 to resonance, a large i.f. voltage appears across C-49; this is less than the voltage across L-11 but many times greater than the voltage across L-10.

Because of the voltage step-ups in the pre-selector, frequency converter and i.f. stage, the voltage across C-49 is high enough for demodulation. This voltage is rectified by one of the diodes in the 6B7 tube. The other diode is not used, and is connected directly to the chassis.

Trace from the lower diode plate through L-12, R-8 and R-9 to the cathode of the 6B7 tube. Because of rectification a pulsating d.c. current flows through this circuit, with its amplitude following the original modulation. In the detector circuit, R-9 is the diode load across which the a.f. voltage is produced. Condenser C-23, resistor R-8 and the capacitor formed by the shield over the lead which connects R-8 and R-9 all act together as an i.f. filter. Only the desired a.f. voltage and a d.c. voltage appear across R-9.

Audio Amplifier. Because of the d.c. voltage drop across R-9, a direct connection to the input of the first a.f. amplifier cannot be made, and a d.c. blocking condenser is therefore required. Note that the movable contact of R-9 connects to the grid of the pentode section of the 6B7 tube through d.c. blocking condenser C-25. The grid also is connected to the chassis through resistor R-11.

For all audio frequencies except the very lowest, very little of the a.f. voltage is dropped in C-25. Most of this a.f. voltage is developed across R-11 and is hence available for audio amplification. Varying the position of the movable contact of R-9 controls the amount of a.f. voltage fed to the audio ampli-

fier, and therefore serves as the volume control.

The connecting lead from C-25 to the grid is shielded so that stray electric field pick-up will be kept out of the audio amplifier. The signal at this point is at a very low level, so stray a.f. signals entering at this point will give the greatest interference.

From the grid of the 6B7 tube, trace through R-11 to chassis and from chassis through R-12 to the cathode, thus establishing the grid to cathode path. Actually, however, a.f. signals will take the C-26 path from chassis to cathode instead of going through R-12.

A pulsating d.c. current (a.f. on d.c.) will flow in the plate of the 6B7 tube. The d.c. current will be forced to take the path through R-13 and R-15 to the +B supply, as all other paths are blocked by condensers. A.F. currents will flow through R-13, C-29 and R-17 to chassis, and from this point through C-26 to the cathode of the 6B7 tube. R-13 has a high ohmic value, which means that a large a.f. voltage will appear across this resistor due to the a.f. current flowing through it. Since the a.f. reactances of C-28, C-29 and C-30 are negligible, resistor R-14 is essentially in parallel with R-13 and most of the a.f. voltage across R-13 is also across R-14. It is the a.f. voltage developed across R-14 that excites the grid and cathode of the 41 tube.

Any i.f. signals getting into the plate of the 6B7 are by-passed from the plate load circuit by condenser C-27.

In the plate circuit of the 41 pentode output tube we find output transformer T-2 coupling the pentode tube to the loudspeaker. Condenser C-32 is shunted across the primary to prevent parasitic oscillation in the output stage, by making the plate load substantially capacitive for high frequencies. The condenser reduces the high-frequency response, but when more bass emphasis is desired C-31 is shunted into the circuit by switch S-6, thus giving the output a boomy or bass response. S-6 is hence a one-step tone control.

Now let us trace the a.f. signal path from the primary of T-2 to the cathode of the 41 tube. Follow the lead connecting T-2, C-32 and the screen grid to C-38 and C-36 in the power pack, go through the filter condensers and go from the chassis through R-17 to the cathode of the 41 tube.

Power Supply Circuit. A full-wave type 80 rectifier is used in the power pack. Power transformer T-1 may be designed either for 60 or 25 cycles, but not for both.

Note that the 25-cycle transformer has higher primary and secondary resistance, this being the result of more turns in each section. Because of the low frequency, more core flux must be obtained with more turns

to provide normal induced voltage. The 25-cycle transformer is larger and heavier than a 60-cycle transformer with the same voltage rating.

One low-voltage secondary supplies power to the filament of the 80 rectifier, and the other low-voltage secondary feeds all other tube filaments in parallel. Note the usual method of leaving out the filament connections, but indicating connections by ending short leads in arrows.

Note also that the left-hand filament lead of the 6A7 tube does not terminate in an arrow, but goes to ground. Though there is nothing to show it, this lead connects to the low-voltage winding just as do the others. You can assume this because every filament circuit in a receiver must be complete. The ground symbol is not a mistake, however, for one side of the filament is grounded to prevent r.f. pick-up.

The ends of the high-voltage secondary go to the plates of the 80 rectifier tube, while the center tap is connected to the chassis.

Choke coil L-14 (the field of the loudspeaker), and condensers C-35 and C-36 are the power pack filter which terminates in the voltage divider, consisting of R-18, R-19 and R-20.

Note that condenser C-36, an electrolytic condenser, is shunted by C-38, a .25-mfd. capacitor which is a paper condenser. (The capacity values are the clue to the condenser type.) Electrolytic condensers lose effectiveness as the frequency goes up. At high audio and radio frequencies, C-36 may not be a good capacitive shunt on the voltage divider. Including a paper condenser insures low reactance at these frequencies.

The voltage divider serves to furnish the lower electrode voltages, but the plate-chassis voltage supply for all tubes terminates across the total voltage divider (terminals 1 and 2).

Tracing Supply Circuits. Let us trace the d.c. supply voltages to terminals 1 and 2 for each stage in turn.

6A7 Converter. Starting with the plate, trace through L-9 to point 1 in the power pack output. From point 2, the chassis, continue through resistor R-4 in the cathode circuit of the 6A7 to the cathode of this tube.

The voltage drop across R-4 is used to bias the detector section of the 6A7 tube. The grid connection is made from the chassis end of R-4 through R-12, R-9, R-10, R-2 and L-2 to the fourth grid of the 6A7 tube.

The a.v.c. voltage across R-9 is added to the normal C bias voltage developed across R-4. The voltage across R-12, serving as C bias for the 6B7 pentode section, is included in this circuit and has an opposite polarity, hence the voltage across R-4 must be made

great enough to compensate for it and give the fourth grid a net negative bias with respect to its cathode even when the a.v.c. is not working.

Grid 2 is the anode for the oscillator section of the 6A7 tube. Trace through L-6 and R-5 to point 3 in the power pack. At point 3 the voltage is positive with respect to the chassis, and higher than point 1 by the drop in coil L-14. Considerable ripple exists at 3, but is eliminated by filter R-5 and C-16. R-5 also reduces the oscillator anode voltage to the desired value.

Grid d.c. voltage is secured by self-rectification of grid current, with the current building up the d.c. voltage across R-3. Ripple is filtered out by C-8, which connects back to the cathode end of R-3 through L-4, C-11 and C-10. In this way the grid-cathode of the oscillator section receives its C bias. Since there is no conductive path for the voltage developed across R-4 (it is blocked by C-8 and the low-frequency padder), this voltage in no way influences the operation of the oscillator.

6D6 I.F. Amplifier. Here the plate connects directly to point 1 through coil L-11. Point 2 connects to the cathode through resistor R-7, which supplies the minimum C bias for the i.f. amplifier. The grid return is through L-10, R-6, R-9 and R-12. Again the bias established by R-7 must be large enough to overcome the opposing voltage across R-12.

Since the screen grid voltage should be less than the plate voltage, it is connected directly to a tap on the voltage divider, at the junction of R-18 and R-19. (The screen grid of the 6A7 tube is likewise connected to this point in the voltage divider.) C-34 serves as the screen by-pass, and also prevents any power pack ripple voltage from being applied to the screen grids.

6B7 A.V.C. Detector and First A.F. From the pentode plate, trace through resistors R-13 and R-15 to point 1 of the power pack. With 260,000 ohms in the plate circuit, the net plate-cathode voltage is lower than the power pack d.c. voltage. Resistor R-12 in the cathode circuit furnishes the C bias for the pentode section of the tube. The grid return is through R-11.

Screen voltage for the 6B7 is obtained by a connection to the junction of R-19 and R-20 in the voltage divider. Note the lack of a screen by-pass condenser. Normally one would be used, but since the circuit is stable it has been omitted.

41 Power Output Tube. The plate connects to point 1 through the primary of the output transformer T-2. The screen grid connects directly to point 1. Resistor R-17 develops the C bias voltage as the result of screen and plate current flowing through it; its nega-

PHILCO 37-84 Four-Tube A. C. Superheterodyne

SO you can see the diagram in Fig. 7 while studying this receiver, proceed as follows: Turn this page so pages 19, 20, 21 and 22 are in view. Now fold page 19 so that it covers page 20.

General Description. The Philco model 37-84 is a four-tube a.c.-operated superheterodyne receiver. It uses a type 6J7G as the oscillator-mixer-first detector, another 6J7G as the second detector, a 6F6G output tube and a 5Y4G rectifier.

In the receiver, r.f. voltage gain is obtained by resonant step-up in the tuned secondary of the antenna coil and regeneration, while most of the i.f. gain is the result of conversion gain in the detector-oscillator and regeneration in the second detector. A.F. gain is due to amplification of the audio signal in the second detector and the amplification afforded by the 6F6G output tube.

An examination of the schematic shows this receiver to be unique in that it does not use a stage of intermediate frequency amplification. This circuit is typical of a great number of midget superheterodyne receivers. The output of the first detector feeds through an i.f. transformer into the input of the second detector. Both the first and second detectors are regenerative, which tends to make up for the loss in sensitivity due to omission of the usual i.f. stage.

Signal Circuits. Signals picked up by the antenna cause a current to flow through the 20,000-ohm volume control, marked 1 in the diagram. By adjusting the position of the slider on the control, any amount of the signal voltage may be taken off and fed to the primary of the antenna transformer marked 2 in the diagram.

By mutual induction a voltage will be induced into the secondary transformer, and only the signal tuned in will undergo resonant step-up. The resonant circuit consists of the secondary coil, the tuning condenser, and trimmer condenser 5 shunting it. The signal is applied to the grid and cathode of the *DET.-OSCILLATOR* tube, the cathode connection being through oscillator feed-back coil 10 and through by-pass condenser 7.

Regeneration is obtained by means of condenser 3, with the feed-back path being from terminal 4 of the oscillator pick-up coil through condensers 7 and 3 to the primary of antenna coil 2.

All i.f. oscillator and r.f. signals between terminals 4 and 1 of coil 10 are fed back to the primary of coil 2 through condensers 7 and 3. These signals are induced into the secondary, but the secondary is tuned only to the r.f. signal. Other signals do not under-

go resonant step-up, and hence effective feed-back occurs only at r.f. values.

Condenser 3 is known to radio men as a "gimmick," as it consists simply of two insulated wires twisted together.

Advancing the volume control for greatest volume has the effect of producing more regeneration.

The oscillator is of the tuned plate type. The oscillator energy is fed to the tank coil through i.f. trimmer condenser 11. The tank (coil winding 2-1 of 10, the tuning condenser and trimmer 13) is coupled to the cathode circuit by mutual induction through pick-up coil 4-1 of coil 10. The voltage induced into this coil causes the grid-cathode bias of the tube to vary at the oscillator frequency. In this way, oscillation is maintained.

The incoming signal and the local oscillator signal are mixed inside the tube. As a result, we also have the intermediate frequency of 470 kc. existing in the plate circuit. Since the primary of i.f. transformer 14 with its associated trimmer 11 offers a high impedance at the intermediate frequency, we have a large i.f. voltage existing across the primary.

At the intermediate frequency, the oscillator tuning coil acts as a low-reactance path. The connection between i.f. primary trimmer condenser 11 and the white lead of the i.f. primary is through oscillator tuning coil 10 to chassis and then through condensers 28 and 29.

An i.f. voltage is induced into the secondary of i.f. transformer 14. Note that the i.f. transformer secondary (having a *BROWN* lead and a *BLACK & WHITE TRACER* lead) is tuned to resonance by trimmer condenser 15.

The signal is now applied between the grid and cathode of the second detector, the grid connection being through the 4-megohm grid resistor marked 16. The gimmick shown connected to the grid of the second detector forms a capacity across resistor 16, thus more effectively coupling the resonated signal to the grid, and at the same time making the 6J7G an ordinary grid leak-condenser type detector.

The second detector tube will amplify the i.f. signal applied to its input. Resistor 19 acts as the i.f. plate load, the end connected to a.f. plate load 22 being at chassis potential as far as i.f. signals are concerned because of .001-mfd. condenser 20. This has low reactance at i.f. values and high reactance at a.f. values.

The i.f. signal across resistor 19 is fed back through regeneration control conden-

ser 17 and the lower tapped portion of the i.f. secondary. The phase of the feed-back voltage induced into the tuned secondary is such that it aids the original signal. This greatly strengthens the signal applied to the grid-cathode input of the second detector. In other words, we have regeneration of the i.f. signal.

Condenser 17 is adjustable, so we can feed back into the grid circuit more or less of the energy developed across resistor 19. Increasing the capacity of 17 results in more feed-back and increased regenerative effects. Too great an increase will cause oscillation and receiver squealing, however.

With the strengthened i.f. signal applied to the input of the second detector, satisfactory rectification will take place in the grid circuit. When the signal makes the grid positive, electrons flow from the cathode to the control grid, through the 4-megohm resistor and back through the secondary of the i.f. transformer to the chassis and cathode. As a result, we will have audio signal voltage appearing across the 4-megohm resistor. I.F. variations are by-passed across the resistor by means of the gimmick condenser.

This audio voltage, as you can see, is in the grid input circuit of the second detector. The tube amplifies the audio signal, and large variations occur in the plate current at an audio rate.

The amplified audio signal voltage appears across plate load resistors 19 and 22, and all i.f. variations are by-passed around load 22 by the .001-mfd. condenser marked 20. The audio signal voltage across 19 is not transferred to the 6F6G tube, and hence is wasted or lost. Resistor 22 is 24 times larger than 19, hence will have 24 times as much a.f. across it. The a.f. loss in resistor 19 is thus relatively small and can be neglected.

The audio signal across plate load resistor 22 appears across the 6F6G grid resistor, marked 23 in the diagram. The signal is applied across this resistor through .015-mfd. audio coupling condenser 20 and through the 4-mfd. output filter condenser marked 29. The voltage across resistor 23 is applied directly to the 6F6G grid and cathode through by-pass condenser 28.

Variation in the grid voltage of the 6F6G output tube causes a large variation in plate current through the primary of output transformer 25. This transformer has the correct turns ratio to match the loudspeaker voice coil impedance to the plate resistance of the output tube. The voltage induced into the secondary causes a large current flow through the voice coil and, as a result, the voice coil and attached cone moves in and out, producing sound.

Condenser 24, connected to the plate of the output tube, by-passes around the plate

load high audio frequencies which otherwise might feed back into the control grid circuit and cause audio oscillation. Condenser 28 completes the connection between condenser 24 and the cathode.

Tracing Supply Circuits. The bias voltage for the first detector-oscillator tube is obtained by means of a drop occurring across cathode bias resistor 6. The end of the resistor connected to terminal 4 of the oscillator pick-up coil is at d.c. chassis potential, and is negative with respect to the end connected to the cathode. Therefore, the control grid of the tube, which is at d.c. chassis potential, is negative with respect to the cathode.

When we say a part or point is at d.c. chassis potential we mean that there is no d.c. voltage between that point and chassis. In other words, a d.c. voltmeter connected between the point in question and the chassis would read zero d.c. volts.

The screen voltage for the detector oscillator tube is obtained from a voltage divider which consists of resistors 12 and 8. The screen of the tube is kept at r.f. ground potential by means of screen by-pass condenser 9 because this condenser acts as a short circuit as far as r.f. and i.f. are concerned.

The plate of the tube is supplied from the output of the power pack through the primary of i.f. transformer 14.

Self-bias, due to grid current flow, is employed in the second detector circuit. When no signal is tuned in, the control grid of the second detector receives an initial negative bias due to convection current caused by electrons striking the grid and flowing through the grid circuit instead of passing on to the plate.

These electrons then flow through resistor 16, producing a voltage drop across it. The number of these electrons is few but the high value of resistor 16 makes the result appreciable.

When an i.f. signal is applied to the tube input, the grid draws current whenever the signal makes the grid positive with respect to the cathode. The grid current will vary with the strength of the signal. The greater the grid current flow, the more negative the grid-cathode voltage becomes. This current and the voltage produced by it will have an average value, and this determines the grid voltage and the operating point of the tube.

The screen grid of the second detector tube is supplied through resistor 18. The screen is kept at r.f. ground potential by means of the .09-mfd. condenser which, like the first detector screen by-pass, is marked 9. Thus we know that the two .09-mfd. screen by-pass condensers for the first and second detectors are in the same container, since they have the same identifying number.

the 1-megohm screen supply resistor to burn out, since its value is so high that even the full voltage of the power pack could not cause a great deal of current to flow through it. However, if the condenser is not shorted, resistor 18 should be checked with an ohmmeter. The resistor may be open.

Lack of plate voltage on the second detector would lead you to suspect resistors 19 and 22 and the .001-mfd. plate by-pass condenser marked 20. Regeneration control condenser 17 might also be shorted.

Screen voltage on the output tube but no plate voltage would be due either to a short in plate by-pass condenser 24 or to an open in the primary of the output transformer. If by-pass condenser 24 breaks down to the point where it has no resistance, the power pack may be damaged or the output transformer primary may burn out. Power pack damage would be limited to the rectifier tube and the power transformer.

Lack of d.c. voltages at any point, when the rectifier, power transformer and filter condensers are in good condition, would be due either to an open in the loudspeaker field or an open in C bias resistor 30.

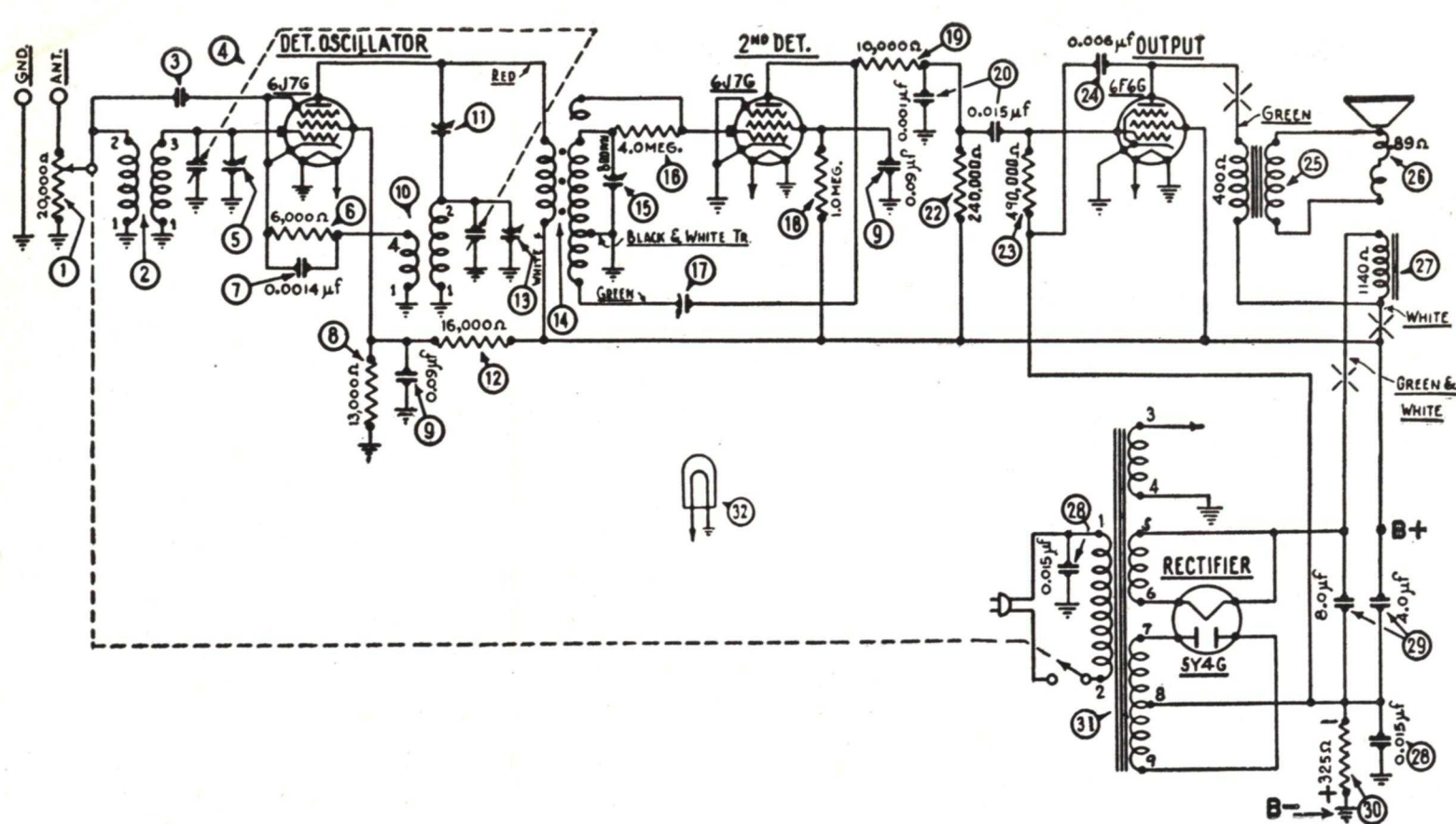
Continuity Tests. In your study of previous diagrams, you have learned that all tube electrodes at a positive potential should trace back to the rectifier filament, while those at a negative potential should trace back to either plate of the rectifier.

Here is how you can secure valuable practice: On each receiving tube, trace all screens and plates back to the rectifier filament, and all control grids, cathodes and suppressor grids back to one plate of the rectifier.

Expected Performance. The performance of this type of receiver is remarkable considering the number of tubes employed. Its good sensitivity and selectivity may be attributed to regeneration in the first and second detectors. Lack of a.v.c. makes it impractical to listen to distant stations whose carriers fade in and out.

Since the receiver is placed in a small cabinet, the loudspeaker is necessarily of the midget type, which cannot give good reproduction of the low audio frequencies. Regeneration with consequent side-band cutting reduces the high-frequency audio response. To sum up, you may expect sets of this type to give acceptable rendition of programs on local and semi-distant stations. Tone quality is passable but cannot be compared to that expected from a console type receiver.

Common Causes of Typical Troubles. The common troubles encountered in receivers of this type are low operating voltages due to defective filter condensers, and intermittent reception due to a change in value of the volume control (disconnect the slider and



check the volume control with an ohmmeter). Oscillation is generally due to excess capacity (caused by incorrect adjustment) in regeneration condenser 17, although screen bleeder 8 sometimes opens up, as does the detector-oscillator screen by-pass condenser.

A more than average amount of trouble is encountered in oscillator circuits of this type. Frequently, the oscillator refuses to function at the low-frequency end of the dial. The first thing to do is to try a new detector-oscillator tube or interchange this one with the second detector which is of the same type. When the gain of the tube falls off due to loss in cathode emission, it is harder for the oscillator to work at the low-frequency end of the dial.

When a new tube does not clear up the trouble, excessively high bias is indicated. This can be corrected by reducing the value of cathode bias resistor 6 to approximately 4000 ohms. The rule here is to use a replacement resistor having about one-third less resistance than the original.

If continued trouble is experienced, go

over all connections in the oscillator circuit with a hot soldering iron. Where bolts are used to hold the stators of the tuning condensers in place, loosen and tighten these bolts one at a time, as a high-resistance joint sometimes occurs at this point and movement of the bolts will eliminate the corrosion which caused the high resistance.

If the oscillator refuses to function at the high-frequency end of the dial, this in practically every case indicates moisture absorption by the oscillator coil. The remedy is to install a new oscillator coil.

It is a good idea to draw a picture diagram showing the connections to an old coil. This will prevent you from making a mistake when installing the new coil.

A loud audio squealing heard in the receiver loudspeaker may be due to opening up of the 6F6G plate by-pass marked 24 or the C bias by-pass condenser marked 28, connected across bias resistor 30.

Distortion in this receiver is often due to leakage in the a.f. coupling condenser marked

Fig. 7. Schematic circuit diagram of Philco Model 37-84 four-tube a.c. superheterodyne receiver. Note the use of the Greek letter "mu" following condenser values. This Greek letter represents "micro," and "f" stands for "farads," so this is just another way of abbreviating "microfarads."

20, having a capacity of .015 mfd. Check for leakage at this point by measuring for voltage across resistor 23. A d.c. voltage will not normally exist across this resistor. If it does, remove the output tube to see if it is gassy. If the voltage drops with the tube out of the circuit, gas did exist in the tube. If d.c. voltage remains, even with the tube removed, the coupling condenser is leaky.

As indicated in the diagram, the .001-mfd. plate by-pass and .015-mfd. coupling condensers are in a single container. Either can be replaced with a separate condenser, while the remaining good section can be left in the circuit.

TRUETONE D746 Five-Tube Auto Radio

GENERAL Description. The Truetone model D746 is a five-tube superheterodyne receiver having a turning range of 530 kc. to 1550 kc. It operates from a 6-volt storage battery and uses the automotive type 6.3-volt tubes. The B supply is obtained from a vibrator and a tube rectifier.

Additional data in the factory manual states that the receiver is of the single-unit type, no flexible shaft being used. The entire radio and automatic mechanical tuning mechanism is self-contained.

Five levers are provided for accurate and convenient automatic station selection, plus the conventional manual tuning control. This makes full tuning range coverage available at all times without any switching device from automatic to manual tuning.

The tube complement consists of a type 6A8 pentagrid converter, a type 6K7 remote cut-off pentode used as an i.f. amplifier, a type 6Q7 duplex diode triode used as a second detector, a.v.c. and first audio, a type 6K6 pentode output amplifier, and a type 6X5 high vacuum rectifier with indirectly heated cathode.

This set derives r.f. gain from its frequency converter and one stage of i.f., and obtains a.f. gain from one voltage amplifier and the output a.f. stage.

Tracing Signal Circuits. The signal picked up by the antenna causes a current to flow through condensers C2 and C3. Condenser C3 is not only in the input circuit but also in the first tuned circuit feeding the frequency converter tube. This is capacity coupling to the antenna, in contrast to the more usual inductive coupling found in home receivers.

The voltage applied to C3 is stepped up by resonance. The resonant signal appearing across tuning condenser C is applied directly between the control grid (grid No. 4) and cathode of the 6A8 type tube.

Frequency Converter. The local oscillator produces a signal for frequency conversion. The oscillator electrodes in the 6A8 tube are cathode (pin 8), control grid (pin 5) and anode (pin 6).

When the oscillator is working, we have a variation in the electron stream passing through the oscillator anode to the screen and plate electrodes. When the incoming signal voltage is applied to the mixer grid (top cap G), the electron stream is again caused to vary, this time at the signal frequency. Mixing of the two signals takes place in the tube.

The oscillator frequency is always above

the frequency of the incoming signal by the amount of the intermediate frequency, which in this case is 465 kc., as noted on the diagram.

Because of the curvature in the E_s-I_s characteristic of the tube operating as a detector, a beat frequency is produced in the plate circuit. The resulting 465-kc. beat builds up a large circulatory current and a high voltage in the primary of transformer T3. All other frequencies, such as the sum of the oscillator and incoming signal frequencies, the oscillator signal alone and the incoming signal alone, are by-passed around the primary coil by the first i.f. trimmer condenser. All signals, including the i.f. signal, are returned to the cathode through condenser C6.

I.F. Amplifier. By mutual induction, an i.f. signal voltage is induced into the secondary of transformer T3, and the resonant i.f. signal voltage appears across the secondary coil and its trimmer condenser. This signal is applied between the control grid and cathode of the 6K7 tube, the cathode connection being through condenser C8.

Because the primary circuit of T4 presents a large impedance in the plate circuit of the 6K7 tube, the latter produces an i.f. voltage across the primary of T4, greatly amplified with respect to the input signal. A signal voltage is induced into the secondary of T4 and after resonant step-up is large enough for rectification.

Second Detector. The upper diode plate in the 6Q7 is used for detection. When it is positive, electrons flow from the cathode to this plate, through the secondary of transformer T4, and through volume control R6 back to the cathode. R6 therefore acts as the diode load resistor, and a rectified signal appears across it. This is a combination of d.c. and the a.f. signal. Condenser C9 serves to remove the i.f. from the diode output, so it does not appear across the volume control.

First A.F. Stage. The audio signal is fed from the variable tap on the control through condenser C10 to the control grid of the 6Q7 tube. The signal is developed across resistor R9 in this circuit, the low-potential end of R9 being connected to the tube cathode and the cathode end of the volume control through condenser C14.

The resulting audio variations in the 6Q7 plate current cause a large audio signal voltage to be built up across resistor R12. C13 serves to remove any i.f. signal which may have gotten into the plate circuit, by-passing it around the plate load and through resistor R7 to the cathode. The amplified audio sig-

nal is now applied across R13 through condensers C15 at the grid end and through C11, R7 and C16 at the other end.

Power Output Stage. The signal voltage across R13 is applied to the control grid-cathode of the 6K6 tube, the cathode connection being through C16.

The 6K6 tube then amplifies the signal voltage across R13, and we now have a very large signal current flowing through the primary of output transformer T6. The turns ratio of the transformer matches the voice coil impedance to the tube plate impedance. The voltage induced into the secondary and the resultant current flow through the voice coil causes the voice coil and attached cone to move in and out in step with the audio signal, and in this way the cone produces sound waves.

Signal Circuit Features. We will now consider some of the signal circuit features in this set. First, from the diagram we see that the oscillator is not equipped with a low-frequency padding condenser. We may therefore assume that the oscillator tuning condenser has specially cut plates in order to obtain tracking over the entire band. In addition, and this is peculiar only to some auto receivers, condenser C3 serves as an r.f. padding condenser and has the duty of helping make the preselector track or follow the oscillator by the i.f. frequency difference.

Condenser C1 has a capacity of only .00002 mfd. and consists only of two flat metal plates separated by mica. A condenser of this construction will maintain its capacity even at the high frequencies produced by the auto ignition system—in other words, it is an excellent by-pass. Condenser C2 is of the usual wound wax paper type. Because of its construction, it actually becomes a coil at ultra-high frequencies.

Ignition interference is modulated on ultra-high frequencies. When it enters the input circuit, C2 acting as a coil with relatively high reactance forces this signal to take the C1 path to ground. Broadcast signals will be by-passed by C1 to some extent, but will mainly be capacitively coupled through C2 to the resonant circuit by condenser C3. At broadcast frequencies C2 and C3 form the low-reactance path.

Condenser C4 serves to couple the oscillator tank circuit to the oscillator control grid, and also serves (together with condenser C in the oscillator circuit) as a by-pass across resistor R2, thus smoothing out the r.f. across this resistor.

Resistor R3 is used to cut down on the voltage to the oscillator anode, and condenser C5 is an r.f. by-pass condenser. Condensers C5, C6 and resistor R3 also serve to keep any variations in the power supply cir-

cuit from being applied to the oscillator anode, as this might result in hum modulation.

Condenser C6, which has a capacity of .05 mfd., is also the plate supply by-pass condenser for the 6A8 and 6K7 tubes. Condenser C7, having a capacity of .1 mfd., is the screen by-pass condenser for the first detector and i.f. tube. Resistor R4 serves to reduce the plate supply voltage to the correct amount for the screens of these two tubes.

Condenser C13, besides acting as an i.f. by-pass in the plate of the 6Q7 tube, also reduces the high-frequency audio response of the receiver, thus raising the bass response.

Condenser C18, connected between the plate and cathode of the output tube, prevents parasitic oscillations in the output stage. The plate load, because of this condenser, is essentially capacitive at the high audio frequencies at which such oscillation would normally occur.

The A.V.C. System. There is nothing unusual about the a.v.c. circuit. The mixture of d.c. and audio voltage developed across resistor R6 is filtered by resistor R5 and condenser C8 for application of d.c. voltage only to the control grid of the 6K7 i.f. tube. Further filtration is afforded by resistor R1 and condenser C3 for the control grid of the first detector tube. The minimum bias for these tubes is 2.2 volts and is obtained across resistor R7, in the main power supply system.

When no signal is tuned in, no voltage exists across R1, R5 and R6, and the control grids and cathodes of these tubes are essentially connected across R7. Naturally, when a signal is tuned in, the a.v.c. voltage appears across R6 and, being in series with R7, determines the new operating bias.

When the incoming signal increases in strength, the i.f. voltage applied to the cathode and diode plate 5 of the 6Q7 tube increases. This results in increased diode current and a greater voltage across R6. This in turn increases the negative bias of the 6A8 and 6K7 tubes, and reduces the receiver sensitivity.

When the strength of the incoming signal decreases, the rectified voltage across R6 decreases. Since this reduces the negative bias of the 6A8 and 6K7 tubes, the receiver sensitivity increases, thus enabling us to have an automatic control of the volume.

No a.v.c. system is 100% efficient, and a change in the incoming signal strength will result in some change in the output sound level from the loudspeaker. For slight changes in signal strength, the sound level will not change perceptibly. Even for large changes in signal strength, the output level changes far less than if a.v.c. were not used.

The A.V.C. Gas Gate. You will note that diode plate 4 of the 6Q7 tube connects to the grid return to the 6K7 tube at the junction of resistor R5 and condenser C8. This arrangement is known as a gas gate. If the 6K7 tube happens to become gassy, electrons will flow up through resistors R6 and R5 to the control grid of the 6K7 tube. This tends to make the grid of the tube positive by an amount equal to 4,000,000 ohms (R5 + R6) multiplied by the gas current in amperes.

When diode plate 4 becomes positive due to gas in the 6K7, current will flow from the 6Q7 cathode to this diode plate, lowering the effective resistance of R5 and R6 and therefore lowering the voltage drop produced across them by the gas current.

Tracing Supply Circuits. In this, or in any other auto receiver, we only have the 6-volt storage battery in the car as a source of power. We can feed the tube filaments and loudspeaker field directly from the battery since they are designed for 6-volt operation. We must also feed the tube electrodes with the correct d.c. voltages, which in some cases will be as much as 200 volts.

D.C., as you know, cannot be stepped up. Therefore, we use a non-synchronous vibrator to interrupt the d.c. from the battery, thus changing it for all practical purposes to a.c. This a.c. may be stepped up by a power transformer, rectified by a high-vacuum rectifier tube, and the pulsating d.c. from the rectifier filtered just as in an a.c. set. The rectified and filtered d.c. is then ready to be applied to the various tube electrodes.

The diagram shows that the vibrator is used solely to interrupt the d.c. flowing through the primary of power transformer T5. It causes the supply current to flow first through one section of the primary and then through the other, giving the same effect as an a.c. current.

The hot (ungrounded) A lead connects to the center tap on the primary of the power transformer through switch S1 and choke L1. Normally, the vibrator armature connects to terminal 2, being held in place by spring tension.

When the set is turned on, current will flow through the armature coil of the vibrator, connected to terminals 2 and 4. The current flow is through the coil to vibrator terminal 2, and through the armature in contact with terminal 2 to the chassis. This will pull up the armature, causing it to make contact to terminal 3, and breaking the contact of the armature coil to ground through terminal 2 and the grounded armature. Then the current flowing to the center tap on the primary passes through the upper section of the primary to terminal 3, and through the armature contact to terminal 1, which connects to the other side of the storage battery.

The breaking of the circuit through the armature coil allows the spring to return the armature to terminal 2 on the vibrator. The current then flows through the lower half of the power transformer primary through the contact at 2 and to the other side of the storage battery. The armature coil is also re-energized to pull the armature over again for another round trip. This action occurs as long as the receiver is turned on, and we have current flowing first through one half of the primary and then through the other half.

As a result of feeding the primary with alternating current, a large voltage is developed across the secondary of T5 and is applied to terminals 3 and 5 of the rectifier tube.

Since B- is the center tap on the secondary of T5, the B supply electron path is from the center tap through bias resistors R11, R8, R7 to the 6A8, 6K7 and 6K6 cathodes (in the case of the 6Q7 cathode, the path is through R11 and R8), then through the tubes to the plates and other positive electrodes, back to the rectifier cathode and across to rectifier plate 3 or 5—whichever one is positive.

Resistor R15 is used to prevent excess voltage from being developed across the primary. Condenser C17 is a smoothing or buffer condenser and helps to remove any irregularities in the peaks of the secondary voltage. It is also important to use the right size of condenser at this point, so that the vibrator will work smoothly and with a minimum of sparking.

The cathode currents of all tubes flow through resistors R7, R8 and R11 (with the exception of the 6Q7, which skips R7), and develop a voltage across these resistors. The end connected to the power transformer secondary center tap is negative, while the end connected to the chassis is positive, thus forming the bias voltages.

Filter Circuits. You will note from the diagram that the vibrator coil and the heater of the rectifier tube are fed through choke L1. To avoid vibrator interference, the filaments of all but the rectifier tube are fed in parallel directly from the ON-OFF switch, as is the pilot lamp. The loudspeaker field is also fed from this point, and these parts are isolated from the interference produced by the vibrator by the filter consisting of condenser C19 and choke L1.

Condenser C19 serves to prevent any low-frequency interfering vibrator signal from feeding back through choke L1. The two condensers marked SP are called spark plate condensers and are essentially similar in construction to condenser C1 in the antenna circuit. Since they do not have any

inductive effects at ultra-high frequencies, they prevent any ignition interference produced at the car motor from entering the receiver by way of its B power supply.

By this time you have probably noticed that a filter choke is not used in the power pack system. We do have, however, two filter condensers marked C12 and C11. These are 8-mfd. electrolytic condensers, and their positive leads connect together and to the cathode of the rectifier. Between their negative leads we have resistors R8 and R11. These two resistors therefore have the additional duty of replacing the more familiar filter choke. The condensers have a reactance of approximately 80 ohms each at the ripple frequency. The frequency of the voltage applied to the plates of the rectifier is approximately 120 cycles, due to the vibrator design, and the rectified ripple frequency will be twice this or 240 cycles.

It is possible to use resistors R8 and R11 as resistive filters instead of using a regular filter choke, since their combined ohmic value is quite high compared to the reactance of C11 and C12 while still being low enough not to seriously reduce the d.c. supply voltage. Furthermore, as high fidelity is not a feature of this set, the a.f. section of the receiver is so designed that low frequencies of the order of 240 cycles or less are not reproduced very well.

Bias Considerations. Resistor R2 is the oscillator grid resistor. The rectified current flowing through this resistor automatically furnishes the correct negative bias for the oscillator.

The grid bias for the triode section of the 6Q7 tube is obtained by means of the voltage drop across resistor R8. The grid connection, made through resistors R9 and R10 to the junction of R8 and R11, is approximately 1.4 volts negative with respect to the cathode, which connects to the junction of R7 and R8. There may be voltage variations across resistor R8, and these are filtered out by means of resistor R10 and condenser C14.

The grid bias for the 6K6 type tube is obtained by means of the voltage drop across resistors R7, R8 and R11. This is approximately 15 volts. Resistor R14 and condenser C16 serve to prevent bias voltage variations and hum across the bias resistors from getting into the grid input circuit of the output tube.

Voltage Measurements. While you will normally check the electrode voltages at the tube socket terminals, the manufacturer has indicated in the diagram strategic points at which the main supply voltages may be checked.

First, you will see the notation "200V" appearing on the plate supply line for the 6A8 type tube. This means that all points con-

nected to this line, such as the cathode of the 6X5 or the screen of the 6K6, should measure 200 volts when the voltmeter probes are touched to either one and the chassis. The plate of the 6Q7 will be considerably less than this, due to the drop in resistor R12, while the voltage between the plate and chassis of the 6K6 will be approximately 15 volts less than B+ due to the drop in the primary of the output transformer. The screen to chassis voltage of the 6K6 tube will be 200 volts, since the screen is fed directly from the line marked 200 V.

The screen voltage for the first detector and i.f. tubes is approximately 95 volts, as marked on the diagram. The C bias voltages for the 6K6 and 6Q7 tubes are approximately 15 volts and 3.6 volts respectively, as measured between the points indicated and the chassis.

The actual bias on the 6Q7, as pointed out previously, is not 3.6 volts since it only consists of the voltage drop across resistor R8, which is 1.4 volts. However, if the voltage from the junction of R8 and R11 is 3.6 volts, the voltage across R8 will be correct. The initial bias for the 6A8 and 6K7 tubes is approximately 2.2 volts, and exists across resistor R7.

Continuity Tests. With the set turned off, we can check the various supply circuits for continuity with an ohmmeter.

As you already know, those points supplied with a positive potential should show continuity back to the cathode of the rectifier, the most positive d.c. point in the set. As an example, place one ohmmeter probe on the plate of the 6Q7 and the other on the cathode of the 6X5 rectifier. Continuity will be indicated through resistor R12 and we will read a value of approximately 250,000 ohms on the ohmmeter.

A check between the screen grid (electrode 4) of the 6A8 and the rectifier cathode will give us continuity through resistor R4, with a reading of approximately 25,000 ohms. A check between the oscillator anode (pin 6) and the rectifier cathode will give us a resistance reading of approximately 30,000 ohms. The plate winding of the oscillator coil has a resistance of only 5.5 ohms and this would be negligible with respect to the value of R3. If you suspect a defect in this winding, it must be checked individually with a low ohmmeter range.

We can now trace the continuity between those terminals supplied with a negative potential and either plate of the rectifier, the common reference point. Put one ohmmeter test probe on the top cap of the 6A8 tube, and the other probe on one of the rectifier plates. We will then obtain a reading through T1, R1, R5, R6, R8, R11, and one-half of the power transformer secondary

winding. The cathode of the 6Q7 traces back through resistors *R8* and *R11* and one-half of the power transformer secondary. The control grid of the 6K6 traces back through resistors *R13*, *R14* and the power transformer secondary to one 6X5 plate.

Alignment. The i.f. alignment of this receiver is quite conventional. As an output indicator, we could connect a vacuum tube voltmeter across diode load resistor *R6* or we could connect a low-range copper-oxide rectifier-type a.c. voltmeter across the voice coil. All adjustments are to be made for maximum output. The i.f. is 465 kc., as marked on the schematic.

The output of the signal generator, tuned to 465 kc., is connected between the top cap of the 6A8 type tube and the chassis. A reading will then be observed on the output meter, and all four of the i.f. trimmers, starting with the two on the second i.f. transformer, are to be adjusted for maximum output.

It doesn't matter whether we adjust the primary trimmer first or whether we start with the secondary trimmer. To be on the safe side, you can go over the adjustments two or three times. When a peak is finally obtained, the i.f. amplifier is correctly adjusted and the trimmers are not touched again.

The output of the signal generator is then connected to the antenna post and the receiver chassis. For best results, a dummy antenna which takes the place of the regular aerial may be used in series with the output lead of the test oscillator. This could consist of a 175-mmfd. (.000175 mfd.) condenser, as specified in the factory manual. One lead of the condenser may be connected to the antenna terminal of the receiver, and the remaining lead to the ungrounded signal generator output lead. The variable condenser of the receiver is tuned to its minimum-capacity position (plates entirely out of mesh), and the signal generator is adjusted to 1550 kc. The oscillator trimmer on the variable condenser gang is then adjusted for maximum output. The signal generator is then shifted to 1400 kc. and the signal is tuned in by rotating the receiver tuning condenser. The antenna trimmer which is mounted on the condenser gang is then adjusted to maximum output. (The antenna and oscillator trimmers mounted on the condenser gang are not shown in the diagram.)

The signal generator is next set to 600 kc., and this signal is tuned in for maximum output at about 600 kc. on the receiver dial. The padding condenser marked *C3* in the diagram is then adjusted for maximum output.

Now go back and check the antenna trimmer only at 1400 kc. If an adjustment is made, recheck *C3* again at 600 kc.

Servicing Hints. Let us suppose that the receiver is distorted and that by touching the top cap (control grid) of the 6Q7 and the chassis with your hand the distortion clears up. This definitely shows that excess bias is being applied to the 6Q7, and points to leakage in *C15* as the cause of the trouble.

As we have already found out, the bias is due to the voltage drop across resistor *R8*. A study of the diagram shows that the cathode currents of all tubes flow through this resistor. Immediately we suspect some tube of drawing excessive plate current, since the voltage drop is excessive across *R8*. The 6K6 is the most likely offender, since it draws the most plate current.

The diagram shows that leakage in condenser *C15* would cause the plate current of the output tube to be excessive. We may check for this by connecting a voltmeter across resistor *R13*, with its positive probe going to the control grid of the tube. If voltage is measured, we withdraw the 6K6 type tube. If this causes the voltage to disappear, the tube is gassy. If the voltage is still present it is definite proof that *C15* is leaky. Normally, no voltage should exist across resistor *R13*.

You might think that a positive bias on the grid of the 6K6 would of itself cause distortion. Such is not the case, for the increase in plate current increases the voltage across resistors *R7*, *R8* and *R11* and maintains more or less normal bias for the grid of the tube. The increase in voltage across *R7*, *R8* and *R11* offsets to a certain extent the positive bias developed across *R13* and *R14* by leakage in *C15*.

It is interesting to see why touching the 6Q7 top cap and chassis lets us diagnose the trouble as excess bias. Your body has resistance and between the fingers touching the top cap and chassis there is about 50,000 ohms. Connecting the top cap to the chassis through 50,000 ohms or so simply reduces the voltage between the control grid and cathode because the voltage divides between *R9*, *R10* and your body. The voltage across *R9* and *R10* is considerably greater than the drop which acts as the bias voltage and which occurs across your body.

If the receiver squeals when a station is tuned in, we immediately suspect oscillation in the i.f. amplifier or the mixer. A glance at the diagram shows that this would most probably be due to an open in condenser *C7*. We check for this condition by letting the set squeal and by connecting another condenser across *C7*, or from pin 4 on the 6K7 tube to the chassis. If this stops the squealing, it's definite proof that *C7* is open and should be replaced. There is a possibility that an open in the plate by-pass condenser *C6* could cause

the same trouble, and it is checked in the same manner as *C7*.

If excessive hum is heard, we should be on the lookout for cathode-to-heater leakage in some of the tubes, and for drying up of electrolytic filter condensers *C11* and *C12*. These two condensers should be checked by substitution, being sure to observe the polarity markings of the test condensers by connecting their positive leads to the 6X5 cathode.

Motorboating or noise originating in the a.f. section of the set (check on this by removing the 6K7 type tube to see if the noise is still present) would cause us to suspect an open in condensers *C14* and *C16*, the a.f. decoupling capacitors. They should be checked for an open by substitution. Hum might also result if these condensers are open.

Distortion and audio oscillation may be due to an open in condenser *C18*.

Excessive noise may be caused by worn vibrator contacts. In cases where it is not practical to remove the vibrator housing to see if sparking occurs at the contacts, a new vibrator should be tried, after checking condenser *C17* by replacement and measuring the value of *R15*. One terminal of this resistor must be disconnected when checking it with an ohmmeter, so that a misleading reading will not be obtained through the power transformer primary.

The spark plate condensers seldom if ever give trouble, although some vibrator hash may get into the receiver if *C19* is open.

Weak signals coupled with distortion would lead you to believe that the loud-speaker field was open. This wouldn't affect the application of correct voltages to the tube electrodes. A quick check may be made on the field by holding a screwdriver near the metal pole piece. If the field is energized there will be a pull on the screwdriver. If it is not, the field should be disconnected and checked with an ohmmeter.

If the receiver is dead and a circuit disturbance test shows all stages to be alive, you would immediately suspect failure of the oscillator. This would most probably be due to lack of plate voltage on the oscillator anode grid, pin 6 in the diagram.

Immediately you would suspect a short or leak in condenser *C5*, with perhaps opening up of resistor *R3*. If these points proved to be in good condition, you would check the 5.5-ohm winding of the oscillator coil to see if it was open.

Trouble sometimes is experienced with this type oscillator if the oscillator grid resistor changes in value. A value lower than 50,000 ohms for *R2* will frequently cause the oscillator to be dead at the low-frequency end of

the dial. Sometimes a value as high as 75,000 ohms may be used. If the resistor is made too high in value, the oscillator will intermittently block, particularly at the high-frequency end of the dial.

High-resistance connections in the oscillator circuit will cause the oscillator output to be poor at the low frequencies. If the oscillator stops functioning at the high frequencies, the oscillator coil probably has absorbed moisture, and it would be best to install another. When another cannot easily be obtained, the oscillator coil can be baked in an oven to drive off the moisture.

Tracking failure of the oscillator and pre-selector, if not due to incorrect adjustment or a defect in condenser *C3*, is probably due to the i.f. being aligned at the wrong frequency.

Blasting and distortion on strong local stations would indicate lack of a.v.c. voltage, and this in turn would probably be due to a short in a.v.c. filter *C8* or to a short between diode plate 4 and the cathode of the 6Q7 type tube.

Automatic Tuning Set-Up. This receiver has a mechanical automatic tuning system. There are five levers on the dial by means of which five stations may be selected, as indicated in Fig. 9. The procedure for setting these automatic tuning levers is as follows:

Make a list of local stations you tune in regularly; any number up to and including five.

Any order of grouping can be used, either by assigning call letters for the levers alphabetically or arranging them to correspond with the calibration on the dial scale.

Loosen the special locking screw ("O" in Fig. 9) which is located on the left side of the tuner dial assembly.

Press DOWN ALL THE WAY any one of the automatic tuner levers. Holding it down FIRMLY, tune in by means of the tuning knob (No. 1) the station you have assigned to this lever. Turn the tuning knob very slowly back and forth (while still holding lever in downward position) until the signal is clearest. The station will then be accurately tuned in. Release the lever.

Press down another automatic tuner lever. Holding it down FIRMLY, carefully tune in the station assigned to this lever. Release this lever.

Follow this procedure until you have selected all of your favorite stations.

Now rotate the tuning knob (No. 1) to the right (clockwise) as far as it will turn, and tighten the special locking screw ("O").

It is VERY IMPORTANT that this locking screw is turned until it is ABSOLUTELY TIGHT.

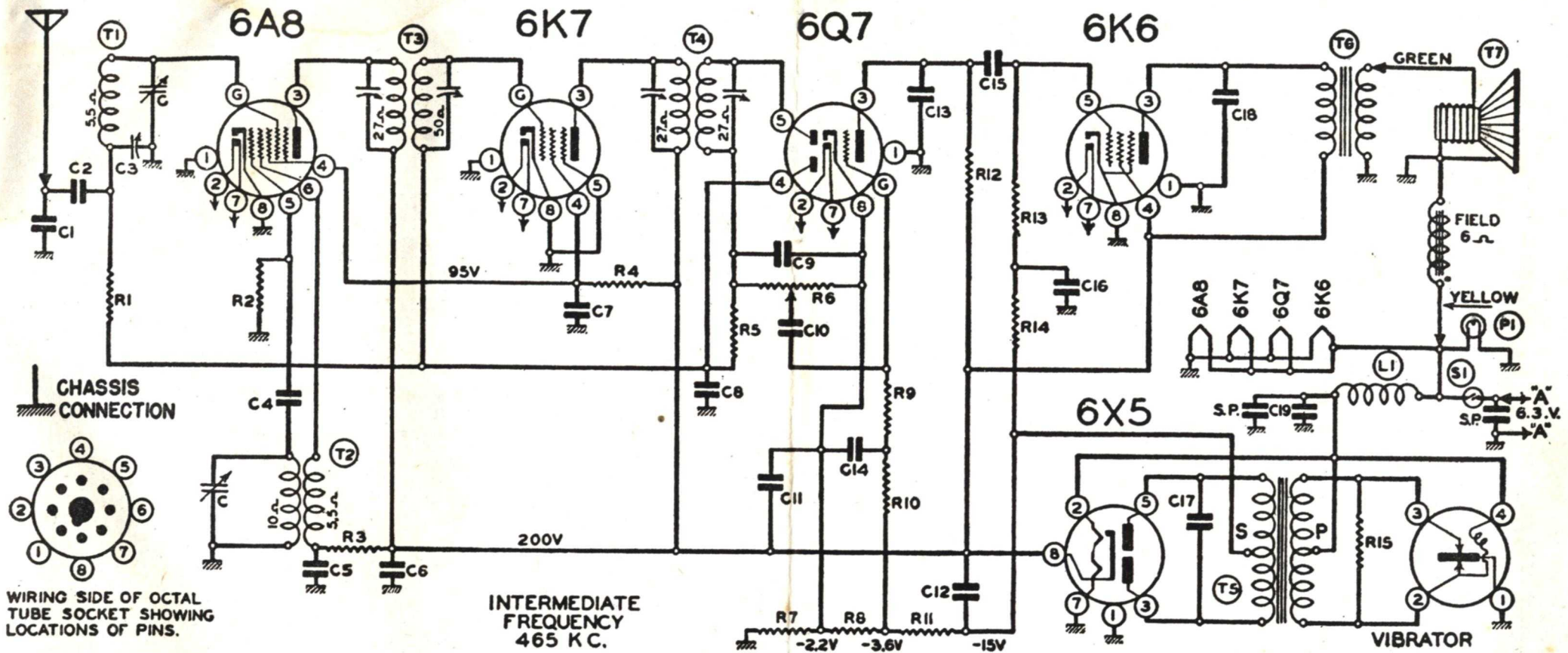


Fig. 8. Schematic circuit diagram of Truetone Model D-746 five-tube auto radio receiver. The parts list for this set is given below. Voltage values on the diagram represent d.c. voltages to chassis. All condenser values are assumed to be in microfarads. Percentages after values indicate the percent of tolerance which is permissible in the values of replacement resistors or condensers. The abbreviation w. stands for "watts."

- R10 1 megohm—1/3 w. 20%
 R11 250 ohm—1 watt 10%
 R12 250M ohm—1/10 w. 20%
 R13 250M ohm—1/10 w. 20%
 R14 250M ohm—1/10 w. 20%
 R15 200 ohm—1/3 w. 20%

- C13 .0005 Mica 20%
 C14 .01 x 200 v. 25%
 C15 .01 x 400 v. 25%
 C16 .006 x 600 v. 25%
 C17 .005 x 1200 v. 10%
 C18 .01 x 600 v. 25%
 C19 .5 x 120 v. 50-10%
 C11 and C12 in same unit

CONDENSERS

- C 2-gang variable condenser
 C1 .00002 Mica 20%
 C2 .01 x 400 v. 25%
 C3 Antenna Trimmer
 C4 .00025 Mica 20%
 C5 .1 x 200 v. 25%
 C6 .05 x 400 v. 25%
 C7 .1 x 200 v. 25%
 C8 .05 x 200 v. 25%
 C9 .0001 Mica 20%
 C10 .01 x 200 v. 25%
 C11 8. mfd. Electrolytic
 C12 8. mfd. Electrolytic

RESISTORS

- R1 250M ohm—1/10 w. 20%
 R2 50M ohm—1/10 w. 20%
 R3 30M ohm—1/2 w. 20%
 R4 25M ohm—1 watt 10%
 R5 3 megohm—1/10 w. 20%
 R6 1 megohm volume control
 R7 50 ohm—1/3 w. 10%
 R8 30 ohm—1/3 w. 10%
 R9 2 megohm—1/3 w. 20%

PARTS

- T1 Antenna coil complete
 T2 Oscillator coil complete
 T3 Input I.F. 465 kc.—complete
 T4 Output I.F. 465 kc.—complete
 T5 Power Transformer
 T6 Output Transformer
 T7 5" Dynamic Speaker
 L1 "A" Filter Choke
 PI 6.8 v. pilot light
 SI Off-on Switch on Volume Control
 SP Spark Plates

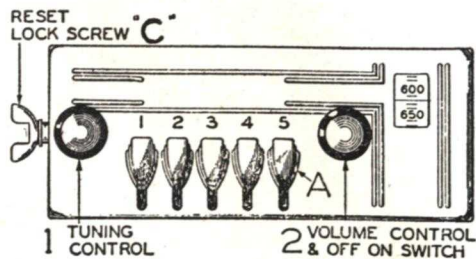


Fig. 9. Front view of Truetone Model D-746 receiver, showing automatic tuning levers. Locking screw "C" will lock in place all the stations you have selected on the automatic tuner levers. If you should desire to change any station you selected to another, loosen the locking screw "C" one or two turns, and select the new station as explained. Be sure to retighten the locking screw, otherwise the stations you have selected will not stay adjusted to the levers.



THE VALUE OF KNOWLEDGE

Knowledge comes in mighty handy in the practical affairs of everyday life. For instance, it increases the value of your daily work and thereby increases your earning power. It brings you the respect of others. It enables you to understand the complex events of modern life, so you can get along better with other people. Thusly, by bringing skill and power and understanding, knowledge gives you one essential requirement for true happiness.

But what knowledge should you look for? The first choice naturally goes to knowledge in the field of your greatest interest—RADIO. Become just a little better informed about radio than those you will work with, and your success will be assured.

It pays to know—but it pays even more to know how to use what you know. You must be able to make *your* knowledge of value *to others*, to the rest of the world, in order to get cash for knowledge.

The N. R. I. Course gives you radio knowledge, and in addition shows how to use what you learn. Master thoroughly each part of your Course, and you'll soon be getting cash for *your* knowledge.

J. E. Smith