ELEMENTARY *RADIO* SERVICING

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by

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PREFACE

This book is intended to serve as a medium of instruction for those who have already mastered some of the principles of radio receiver construction and now wish to apply their knowledge and skills to radio servicing.

It has been expressly prepared to fill the needs of vocational school students, former students in the War Industries Training Program courses, returning members of the armed forces and all others who have received instruction in set building and theory, but have had little or no training or experience in trouble shooting and repairing.

The primary aim is to assist the reader in developing the logical, orderly procedure which is so vital to successful servicing, and to aid him in acquiring familiarity with the steps necessary in isolating, diagnosing, locating and clearing radio troubles. The Introduction outlines the procedure in detail.

As the main objective has been to describe and illustrate these servicing steps in a how-to-do-it fashion, the related theory has been eliminated, so far as is possible and, where theory is introduced, it is kept to a bare minimum. No mathematics is used in any part of the book. It is assumed at the outset that the reader has had sufficient instruction in theory and radio mathematics to enable him to understand the basic principles of the operation of receiver circuits.

The writer has made every effort to present all explanations as simply as possible; in fact, in many cases, oversimplification may have resulted. However, this might be considered a pardonable error if the main purpose of the book is achieved.

W. R. W.

Brooklyn, N.Y.
November, 1946

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INTRODUCTION

How To Use the Book. In the great majority of cases, radio servicing can be conducted according to a plan or sequence of operations, and this sequence, if rigidly adhered to, will eventually result in the disclosure of the defect. There are exceptions, of course, cases in which the trouble is obvious, and in which it is not necessary to apply a series of tests in order to find it. Some examples of this are a burned-out tube, a torn speaker cone, or a broken dial cable. It must also be kept in mind that the experienced service man will in time become so thoroughly familiar with certain makes and models of receivers that he can put his finger on the trouble immediately. Under either of these two conditions, short cuts may be taken to find the defect.

But, if we dismiss those troubles which may be located instantly, we are confronted with the need of using some system to narrow down the possible causes of faulty operation, first to one stage in the set, and then to one part in that stage. To accomplish this, the efficient service man generally proceeds by:

1. Finding out which of the several stages in the set is not functioning properly. This is referred to as "isolating" the trouble. The modern method of isolation is signal tracing.
2. Testing the tube or tubes used in that stage.
3. If tube testing does not disclose the trouble, the next step is determining, by means of voltage and resistance tests, which part in the suspected stage has caused the difficulty. These two operations may be referred to as voltage analysis and point-to-point resistance analysis.
4. Removing the defective part and replacing it with a new one of proper value.
5. Checking the operation of the set with the new part installed.
6. If the operation of the set seems to indicate that all trouble has been cleared, aligning the receiver is the next step.
7. Cleaning the chassis. Some service men prefer to do this before starting work on the set.

Considered separately, no one of these operations is particularly difficult, and they may be learned in a short time. For example, it has been demonstrated that students can learn to make a voltage analysis in a few hours, at a speed which would be accepted in the trade. But knowing when to apply the various tests, and knowing how to apply them in correct sequence and to fit varying conditions, is something that requires a little more knowledge and judgment. This knowledge and judgment can be acquired through proper training and practice.

To help you not only in learning how to perform the required tests, but also to develop a system of using them, the following plan of reading and applying the contents of this book is offered:

1. Read the book through once without giving special attention to any particular section, but with the idea of becoming familiar with the contents in a general way. In so doing you will notice that a separate section has been devoted to testing and making repairs on each stage of a receiver—r.f. amplifier, converter, audio amplifier, etc. There is also a section covering general testing procedures—voltage analysis, signal tracing, etc. Each of the sections covering a specific stage includes one or more job sheets which describe and illustrate an important operation. This form has been used because experience shows that the job sheet is one of the most valuable of instructional methods.

2. Study carefully the chapter devoted to the use of test equipment, and the application of voltage analysis, resistance analysis and signal tracing.

3. With the book readily avilable for reference, apply each of the testing procedures to a number of sets which are in good working condition. You might do this in the following order:

(*a*) Make a complete voltage analysis at every tube socket in the set. List all of the voltage readings and compare with the normal readings to be expected; this information is obtainable from the service bulletin, the tube manual or the Rider manuals. Keep practicing the operation until you feel that you not only know how to do it, but that you have acquired fair speed. You might try timing yourself, as a measure of your progress. Ten to fifteen minutes for a seven-tube set, for example, would be considered good at this stage.

(*b*) Make a number of complete resistance checks on as many receivers as you can obtain. Study the circuit diagrams, follow each of the separate circuits—grid, plate, cathode—and then go through each of these circuits with the ohmmeter. Compare the readings you get with the values shown in the diagram.

(*c*) Set up a receiver in normal operating condition and with the signal generator, go through the set stage by stage, starting from the last audio and working toward the antenna. Follow the instructions given under signal tracing and apply the proper signal to each stage in turn, noting the results obtained. Repeat on several different sets.

(*d*) Get a receiver which does not operate at all, but in which the tubes light normally. Begin by tracing the signal through the generator until you find the dead stage. Then turn to the section of the book which deals with that type of stage and follow the instructions for locating the trouble. You will find that these instructions combine both voltage and resistance analysis tests.

If you have followed the instructions thus far outlined, you will eventually locate the defect. Your first trial may take you some time, but this is something that all service men have experienced. In your first few attempts at locating trouble, have the book and the circuit diagram of the set handy for reference. If you fail to find the trouble, go back and retrace all the steps you have taken. You might have overlooked something or you may have misinterpreted some of your findings. After a number of trials, you will master the general technique; the remainder of the job is only a matter of constant practice and observation.

1

BASIC OPERATIONS VOLTAGE ANALYSIS, RESISTANCE CHECKING AND SIGNAL TRACING

Equipment Needed. The number of hand tools required by the radio service man is relatively small when compared to the number needed by a carpenter or a machinist, but this is more than balanced by the fact that a well-equipped service shop must have a variety of rather expensive test equipment.

A beginner in radio repairing can, of course, eliminate a number of the more expensive items from his initial budget, and get along for a while with only the bare essentials. Many top-notch service men are able to work wonders with a volt-ohmmeter alone, proving that much of the usual run of servicing can be done with just this instrument. But it is also true that more efficient, much more rapid, and, very often, more accurate work can be done if the repairman has access to such instruments as a vacuum tube voltmeter, an oscilloscope and signal tracing equipment.

Just which instruments are indispensable? After a survey of service shops, it may be said without fear of contradiction that the volt-ohm-milliammeter, the signal generator and the tube tester are all absolute necessities, even for the beginner. The tube tester, however, might be eliminated for a while, if one has access to a considerable stock of tubes for substitution.

The Volt-Ohm-Milliammeter. Because this instrument may be used for a considerable number of years, it is just as well to buy the very best one you can afford. There are an infinite number of models to choose from, and since all those made by reputable instrument manufacturers are accurate and dependable, the choice may be difficult and may be determined by the amount you can spend. All leading manufacturers make testers in several price classes. Here are some of the facts you might wish to consider before buying:

(a) **Sensitivity.** The sensitivity of a meter is determined by the amount of current required to produce a full-scale deflection. An instrument using a 100-microampere movement is ten times as sensitive as one using a 1-milliampere movement. If the instrument uses a 1-milliampere meter as a foundation, and is to be used to measure 100 volts, sufficient resistance must be connected in series with the meter to limit the current to 1 milliampere at that voltage. This resistance value would be 100,000 ohms; for a 500-volt range it would be 500,000 ohms, and so on. The series resistance value divided by the voltage range gives us 1000 ohms in series for each volt on the scale. Such a meter is referred to as a 1000-ohms-per-volt meter. If a 5-milliampere meter were used instead, the series resistance for 100 volts would only have to be 20,000 ohms, because the current then would only have to be limited to 5 milliamperes. Dividing the series resistance by the voltage range in this case we get 200 ohms per volt.

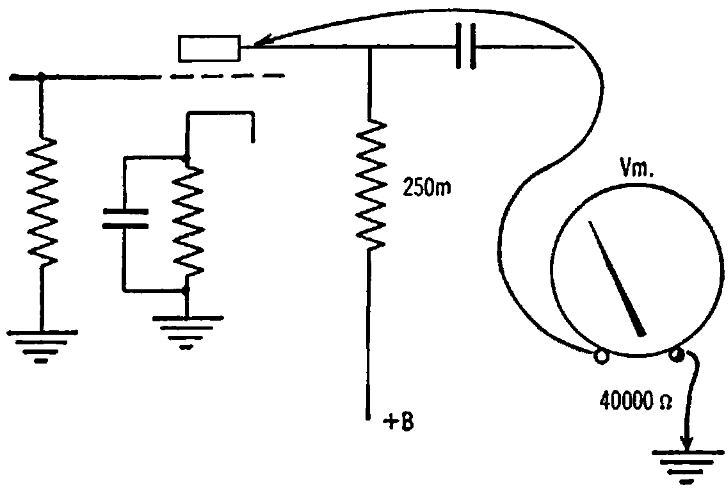
The term "ohms per volt" is an indirect statement of the sensitivity of the meter. The higher the ohms-per-volt rating, the more accurate will the readings be, because connecting a meter with a relatively low resistance in series across a high resistance source will naturally result in a serious current drain, a drop in the voltage and, consequently, inaccurate readings. An example of this is in measuring the plate voltage of a resistance-coupled amplifier, as illustrated in sketch "A." Here the load resistance of the tube is 250,000 ohms, but the total meter resistance is only 40,000 ohms. Because the meter resistance is so low, considerable current will flow through the meter. This will cause the voltage to drop, and the reading on the meter will be much lower than the true value. The ideal meter, of course, is one which does not draw any current at all from the source being measured, and this may only be realized through the use of an electronic instrument.

At one time, 1000 ohms per volt was considered adequate for all servicing, but meters have constantly been improved, until, at the present time, many meters are available with a sensitivity of 20,000 ohms per volt or more. Naturally, the higher the sensitivity, the higher the price, and this must necessarily be a determining factor in the purchase; but remember that meters having a sensitivity lower than 1000 ohms per volt are of practically no use in modern servicing.

The limitations of the ordinary voltmeter have led to a wider use of the vacuum tube voltmeter.

This instrument is available in a wide variety of forms, and it is also possible for the service man to build his own. Constructional details appear from time to time in radio periodicals.

An electronic meter is one in which voltage variations are impressed upon the grid of a vacuum tube, either directly, or through a voltage



A

divider. These voltage variations cause plate current changes in the tube which are indicated by means of a milliammeter connected in the plate circuit of the tube. This milliammeter is calibrated in terms of volts.

The most important advantage of this instrument is that, since it draws practically no power from the source to be measured, measurements may be made without disturbing the conditions present in such circuits. The V.T.V.M. may be constructed to read either a.c. or d.c. voltages and may be made independent of frequencies, within certain limits.

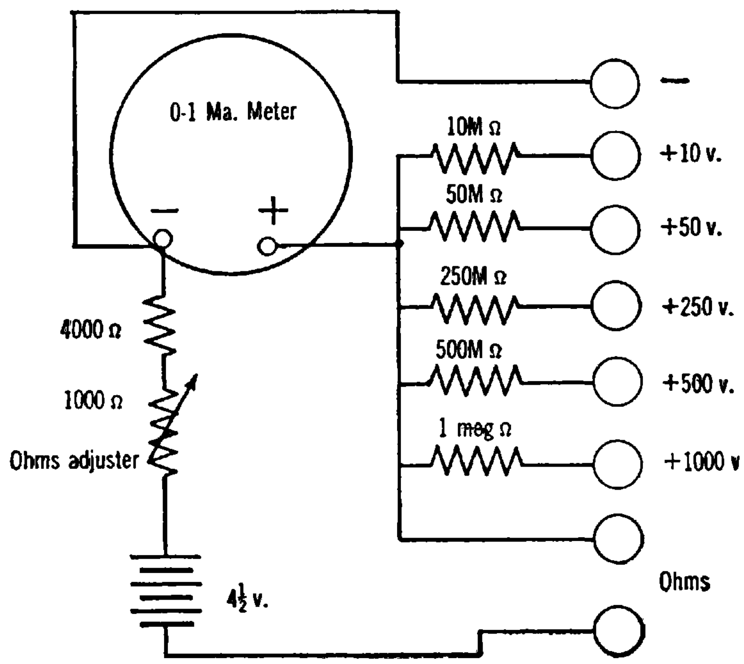
The importance of this instrument cannot be overemphasized in the measurement of voltages in circuits where absorption of any considerable amount of power from the source would result in incorrect readings, such as in the measurement of plate voltages in resistance-coupled amplifiers.

For certain other measurements and adjustments, the V.T.V.M. is practically indispensable. A good example of this is in the adjustment of discriminator circuits, used in frequency modulation receivers, and in those sets employing automatic frequency control circuits. Another important function is in the testing of automatic volume control circuits.

The service man should make an effort to become familiar with this instrument, and it is a good idea to attempt construction of a V.T.V.M. even though the final result does not compare with a manufactured job. The experience gained will be invaluable. Various circuits will be found in the RCA tube manual, the Cornell-Dubilier *Capacitor,* and in the Mallory-Yaxley *Mye Technical Manual.*

(b) **Voltage Ranges.** The instrument should have a.c. and d.c. voltage ranges at least as high as 1000 volts, and there is a trend toward a top range of 5000 volts, because of the need for high voltage ranges in testing television receivers.

(c) **Ohmmeter Ranges.** To be of any value in service work, the instrument should be capable of measuring resistances as high as several megohms. Regarding the low ranges, it should be kept in mind that a low-reading scale is extremely important in measuring the resistance of r.f., antenna and oscillator coils and transformer windings, as well as in many other instances. Many instruments use what is known as a "back-up" circuit for the lowest resistance range, while others are so designed that a straight scale may be used, but in any case the meter should be capable of indicating values of one ohm or lower.



B

(d) **Method of Changing Ranges.** The switching from one range to another, from a.c. ranges to d.c. and from volts to ohms or milliamperes, may be accomplished by means of switches, phone-tip jacks or a combination of both. All methods have certain advantages, but from a standpoint of reliability the elimination of switches wherever possible is desirable because of the possibility of trouble developing in the switch.

Before leaving the subject of the volt-ohm-milliammeter, it should be stated that it is possible to carry on service work with homemade equipment, if nothing else can be had. The circuit at "B" shows a simple, low-cost instrument that you may construct yourself, using a 1-milliampere meter as a basis. In order to simplify it as much as possible, as well as to reduce the cost of construction, a.c. ranges and low-reading ohmmeter ranges have been eliminated. In cases where cost is the primary consideration, this instrument will be fairly satisfactory for most purposes.

It can be enclosed in a case no larger than 5 by 7 inches, or perhaps smaller, depending upon the mechanical skill of the builder. The panel may be either bakelite or masonite. In the majority of cases, the cost, including the price of the meter, will be ten dollars or less.

The Signal Generator. To be considered satisfactory and reliable, a signal generator should have the following features:

(a) Complete control of signal output, with no breaks, and little or no signal audible when the control is turned down to zero.

(b) A separate tube for generating the modulation frequency.

(c) A switch provided for cutting off modulation when unmodulated output is required.

(d) A switch, jack, or other means of obtaining audio output.

(e) Modulation at about 400 cycles, with a pure tone, neither harsh nor ragged.

Generators are available with many other desirable features, as for example separate jacks for cathode ray modulation; but generally these may be dispensed with. Most generators have two controls for regulating the output. One, a switch with several contacts, provides control in steps, with a rather marked difference in the volume level between steps. The other control is usually a variable resistance, providing continuous control between steps. Should you decide to buy a generator which has been used, carefully check the attenuation or output control for noise or irregular operation. This is a fault which frequently develops in low-priced generators.

There are still a very few generators in circulation which are self-modulated; that is, the same tube produces both the r.f. carrier and the audio modulation. This is an undesirable feature, for in most cases the signal is ragged, sounding, as one service man puts it, "like an ill-tempered buzz-saw." Avoid generators of this type.

The ability to cut off the modulation when desired is an important feature, especially in locating cases of microphonic noise, as well as in numerous other types of work.

A provision for obtaining a straight audio signal from the generator is a necessity, otherwise the generator is of little value in signal tracing work in audio stages.

The Tube Tester. There are two types of tube testers in general use, the emission type and the mutual conductance type, with the latter the more expensive of the two.

The emission type checks the amount of current flowing through the tube between the cathode and the other elements. The amount of current to be passed in order for a tube to be considered satisfactory is predetermined by testing a large number of tubes of that particular type. This type of tester gives only an approximate idea of the value of a tube and is not considered too dependable.

The mutual conductance checker measures this important tube characteristic either by the grid-shift method, in which the d.c. grid voltage is changed by a measured amount and the corresponding plate current change also measured, or by applying an a.c. voltage to the grid and then reading the a.c. component of the plate current. The mutual conductance checker is considered the best type available for service work, but has the disadvantage of being more expensive than other types.

Whatever type of checker you buy, be sure that it includes a short test and a cathode leakage test, and that it is equipped to test the latest types of tubes available. Revamping a checker to bring it up to date is usually a costly process. A noise test of some kind is also very desirable. Examine the sockets and switches used to see whether they are of a type that will prove to be durable. These parts are subjected to a lot of usage and should not only be the best obtainable, but should be arranged so that they are easily replaceable.

An excellent method of testing tubes in the absence of a regular checker is to feed a modulated signal from the generator into the antenna input of the receiver, with an output meter connected. Adjust the generator output so that the output meter reads about half full scale. Note the reading carefully, then remove the suspected tube and substitute a new one or one known to be in good condition. Allow the tube to warm up, then read the output meter again. If the second reading is materially higher than the first, the tube should be replaced.

Voltage Analysis

Making a voltage analysis of one stage in a receiver involves measuring the voltages present at each of the socket terminals in that stage. These voltages may be measured with either the cathode or the chassis as a reference point, depending upon circumstances. Most service men measure from the chassis because it is more convenient, but in doing this it should be kept in mind that the voltages will be slightly higher than the correct values because the amount of the cathode voltage is added. For example, if you are measuring the plate voltage from the chassis to the tube plate, and the reading is 225 volts, the cathode voltage, which is, let us say, 15 volts, must be subtracted to give the correct voltage difference between cathode and plate, 210 volts.

Before taking any readings, you should have:

(1) Knowledge of how to read your instrument.

(2) Some idea of the magnitude of the voltage to be measured, in order that the correct scale may be selected.

(3) Knowledge regarding the polarity of the points to be checked.

Knowledge regarding the approximate value of the voltage to be measured, in order that the correct voltage range be used, can be acquired in several ways. It may be taken from the manufacturer's service bulletins or the Rider manuals. Lacking either of these aids, the RCA tube manual may be used, but remember that the values given in the tube manual are not necessarily the correct ones for the set under test, but may be used only to give some idea of the values to be expected. The experienced service man relies upon his judgment in this respect, based upon his knowledge of tubes and circuits and his past experience.

You will find that most of the job sheets on trouble location which follow give some indication of the voltages usually applied. As an additional aid, the following generalization of voltages may be referred to.

OUTPUT TUBES	A.C. SETS	A.C.-D.C. SETS
Plate	200–275	70–110
Screen	200–275	70–110
Grid	5– 30	5– 20
Cathode	5– 30	5– 20
TRIODE 1ST A.F.		
Plate	75–200	50– 75
Grid	1– 5	1– 5
Cathode	1– 5	1– 5
R.F.-I.F.		
Plate	100–250	70–110
Screen	50–150	70–110
Grid	1– 3	1– 3
Cathode	1– 3	1– 3

PENTAGRID CONVERTER		
Plate	150–250	70–110
Screen	50–125	70–100
Oscillator anode	100–150	50– 80
Control grid	2– 3	1–1.5
Cathode	2– 3	1–1.5

These are by no means the exact values, and it is not intended that you use them as normal readings for comparison with those you take. The values are given merely as a guide in setting your meter on a sufficiently high range.

The beginner is usually advised to use the highest range on the meter and then to reduce the range until a reading of about half the scale is obtained. This is an absolutely safe procedure, but does require a lot of time. Assuming that you are about to measure voltage from cathode to ground and that this voltage will be about 5, and the top range of your meter is 1000 volts, you will have to make about five changes in range. After you have had a little experience you will probably find that when getting ready to take a voltage reading you will make a mental note that the plate voltage, for example, should be about 200, set your meter on the 250-volt range and make the required test. While this procedure is not as safe as starting with the highest range, the chances of damaging the meter are slight if care and judgment are used. If a meter set on the 10-volt range were to be connected to a source of 200 volts, the meter would, in all probability, be instantly ruined. On the other hand, if you were checking a voltage which you expected to be about 200, with the meter set on a 250-volt range, and the voltage turned out to be considerably higher, say 300 volts, probably no damage would be done if the test prods were quickly removed.

In connection with a discussion of meter ranges, it is well to remember that if your meter has provision for changing ranges by means of a switch, you should always set the switch on the highest voltage range when through using the meter and before putting it away. You will then be protected the next time you use the meter.

You will gather from all of the above that the possibility of damage to the meter while it is set on a voltage range is not too great if good judgment is used. Most damage to meters occurs when the instrument is set either on a resistance range or a milliammeter setting, because in these cases the meter is not protected by a high resistance in series.

As far as the polarity of the various test points is concerned, you need only keep in mind that the plate and screen are always positive compared to the cathode, the cathode is positive compared to the chassis, and the grid is negative compared to the cathode. Normally, there is no d.c. voltage between the grid and ground.

Refer to the job sheet on making a voltage analysis on a.c.-d.c. receivers. Note that many such receivers do not use the chassis as ground. Attempting to make measurements of voltages on the various tube elements by placing the negative test prod on the chassis will, of course, lead to false readings. In taking voltage readings on sets of this type, the negative prod must be placed on the *B* minus terminal rather than on the chassis. This point is generally one side of the power line. A convenient place for measurement may be found at one terminal of the on-off switch.

If you have had no previous experience in reading instruments, you should study carefully the job sheets on reading voltmeters and ohmmeters before attempting to take any readings. The average scale used on a multi-range instrument looks complicated at first, but only because a number of calibrations appear on the same scale. Actually, the operation of reading an instrument is no more complicated or difficult than taking dimensions with an ordinary ruler. Do not allow the multiplicity of scales to confuse you, but decide which is in use at the moment, as indicated by the position of the switch, or the jacks which are being used. Concentrate on that range and forget the others.

After you have become familiar with your instrument and have learned to read the various scales, when you have decided upon the probable value of the voltage to be measured and its polarity, and when the meter has been set to an appropriate range, you are ready to begin taking a voltage analysis.

See that the test prods are well insulated and that the insulation comes well down over the metal prod, to within a short distance of the tip. Poorly insulated prods are dangerous to use, and a long, uninsulated portion at the tip of the prod may cause a short by touching some part of the set while testing, resulting in damage to the set, or the test instrument.

If parts are crowded below the tube sockets, you may find it necessary to move some of them aside slightly, so that the prods may reach the terminals. Place the prods firmly in contact with the terminals so that the meter does not fluctuate, and hold them there long enough to get an accurate reading. In the beginning, it is a good idea to jot down the reading, first, to avoid forgetting it, and second, so that you will have a record for later comparison with the normal value. You may wish to use a voltage analysis tabulation such as that shown in diagram "C."

After you have taken a reading, the next step is to decide whether or not it is normal. In making this decision, remember that voltage, resistance and capacity values are subject to considerable variation in mass-produced radio receivers. The usual allowable tolerance in voltages is

TUBE	CATHODE TO PLATE	CATHODE TO SCREEN	CATHODE TO GROUND	CATHODE TO CONTROL GRID	
78 R.F.	195	92	1.5	1.5	
6A7 MIX-OSC.	165	100	1.0	1.0	CATHODE TO OSC. ANODE 60
78 I.F.	195	92	1.5	1.5	
75 2d DET. 1st A.F.	80				
42 OUTPUT	220	220	17	17	

C

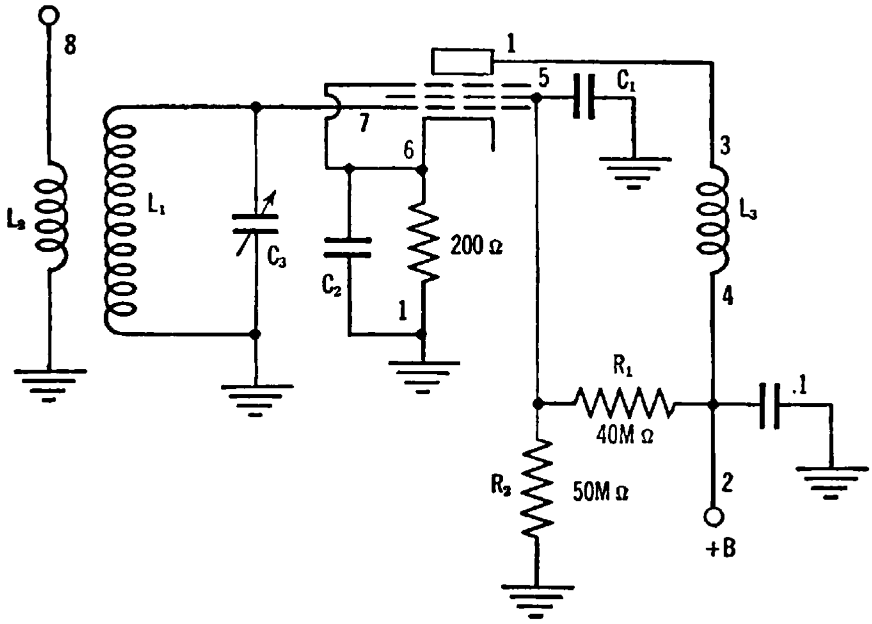
up to ten percent higher or lower than the specified value. If the manufacturer's service information states that the voltage on the plate of an output tube should be 255, then 230 to 280 volts might be considered acceptable. If the voltage as measured was 190 volts, an investigation should be made, even though the set appeared to be operating well.

Point-to-Point Resistance Checking

Before using the ohmmeter for resistance checking in a receiver, practice measuring the values of a number of carbon or other type resistors of known values. Try setting the range switch on various scales in order to become familiar with the idea of multiplying your readings by the factor indicated by the switch. You will find that the markings on the switch or on the jacks associated with the various ranges will be "*R*," "*R* × 10," "*R* × 100," etc. If the meter scale reads 1500 ohms, and you are using a range marked "*R* × 100," it is apparent that the true reading is 1500 times 100, or 150,000 ohms. No difficulty will be encountered if you will keep in mind the factor by which the reading is to be multiplied. Study carefully the job sheet pertaining to the use of the ohmmeter.

When you have become accustomed to using the instrument, you are ready to begin practicing resistance measurements on a receiver. You will find that it is very helpful if the circuit diagram of the set is at hand for reference while testing.

For the safety of your meter, always take the double precaution of turning off the line switch and removing the attachment plug from the outlet before taking any resistance readings. If this is not done, damage to the meter may easily result. On resistance ranges, a comparatively



D

low resistance is in series with the meter, because the battery voltage is generally low. If the ohmmeter should be accidentally connected to a circuit carrying several hundred volts, the current may be many times greater than the full range of the meter, causing burn-out of the movement or other serious damage.

Suppose that you are checking the resistance of the various circuits involved in the r.f. stage shown in diagram "D." Remember that in making such tests, you will have to keep in mind the possible effect of troubles existing in other stages affecting the one under immediate test. For example, if you were testing the r.f. stage shown, upon testing the resistance from plate or screen to ground you might get inaccurate readings due to a shorted screen bypass condenser in another stage. Of course, in actual practice, you would first make a signal substitution test of some type to determine the defective stage, and this would reveal the fact that the other stage (the second mentioned) was not working. But in making tests for practice, you would not have this information, and it is well to keep in mind the possible effect of other stages reacting upon the one you are checking.

1. Measure the resistance from point 1, the plate of the tube to point 2, the common *B* plus terminal. This *B* plus terminal will generally be the termination of the filter circuit, and you will usually find one side of the field coil or the filter choke connected to it. The d.c. resistance of the r.f. coil primary may not be indicated on the circuit diagram, but you know from past experience that it should not be more than a few ohms, say 10. The total resistance of the plate circuit, then, should be 10 ohms from the plate of the tube to the *B* plus terminal. If you should get an infinity, or open circuit reading, there is an open somewhere in the circuit and your next step would be to move the test prod from the plate terminal of the tube to point 3, the top end of the primary, while the other prod remains on the *B* plus terminal. If you now get a normal resistance reading, the open is between point 1 and point 3 and as there is nothing in this circuit but the wire lead, the wire is broken or disconnected at one point.

With the test prods on points 2 and 3 and the meter still showing an infinity or open circuit reading, the trouble then must be between those two points, 2 and 3. Now move one prod to point 4, the bottom end of the primary, still leaving the other one on the *B* plus terminal. Between 2 and 4 there is only a wire connection, so the normal reading should be zero ohms or a short circuit. If you get this reading, the coil winding is open, and this can easily be verified by placing the test prods on 3 and 4, at which points you should get a 10-ohm reading. If your test from points 2 to 4 shows an open circuit, the wire lead between the *B* plus end of the coil and the *B* plus terminal is either open or disconnected.

2. The next step is to check the plate circuit for grounds. Place one of the test prods on the plate terminal of the tube socket and the other on the chassis. If no voltage divider is used between the *B* plus terminal and ground, the normal reading would be practically infinity. But notice that this circuit does employ a divider for supplying correct screen voltages. This divider consists of resistances R_1 and R_2. The total of these two resistances is 90,000 ohms, so that the reading from plate to ground should be not less than this value. If you get a lower reading, it might be an indication of a ground at some point in the circuit. If this ground reading measures 40,000 ohms or so, it is somewhere in the screen circuit, and, therefore, trouble in the plate circuit itself may be ruled out. But if the resistance reading to ground measures a few ohms, or less, look for trouble in the plate circuit. Leaving the test prod in place on the chassis, move the other one to the lower end of the r.f. coil primary. If the resistance reading to ground is now lower than it was before, the trouble is

on the B plus side of the coil; if the reading is no lower, the trouble exists on the plate side of the coil. If you find that the difficulty is on the plate side of the primary, it may be due to grounding of the plate terminal of the socket as a result of excessive solder, or to puncturing of the insulation of the plate lead, with a resulting ground to the chassis.

3. After completing tests on the plate circuit and clearing any trouble you may have found, the screen circuit is to be tested, in the manner just described. The normal reading from the screen terminal, 5, of the tube socket to the B plus terminal is 40,000 ohms, through R_1. An open circuit reading would indicate either that a connection is open or that the resistor itself is open. An incorrect screen reading, from screen to ground, would point to an open resistor R_2. The normal reading here would be about 50,000 ohms. The diagram shows a screen voltage divider employed for several tubes, although common practice in many sets is to use separate dropping resistors for each tube.

If you suspect that the condenser is shorted, disconnect one end of it and recheck the resistance to ground. If you get a normal reading with the condenser disconnected, it is shorted, if not, look for a ground at the socket terminal.

4. Testing the cathode circuit is a much simpler process than checking either the screen or plate circuits. Place one test prod on the cathode terminal, 6, of the tube socket, with the other prod on the chassis. As indicated in the diagram, the reading to be expected under normal conditions is about 200 ohms. An open circuit reading might be caused by an open cathode resistor or a broken connection. A short circuit reading from cathode to ground is generally caused by shorting of the cathode bypass condenser. Verify by disconnecting the condenser as described under 2, above.

5. Test the grid circuit by placing one test prod on the grid terminal, 7, of the tube socket, while the other prod is touching the chassis. If the resistance of the coil secondary is not specified on the circuit diagram, you will have to make a guess as to its probable value. It will be rather low, probably a few ohms or less. An open circuit reading from grid to ground would point to an open coil, or a broken grid lead. This frequently happens when the tube has a top cap with a lead running to it. A short circuit reading from grid to ground may be caused by a shorted variable condenser.

6. Test from the antenna terminal, 8, to the chassis. Again, the normal reading will be a very few ohms, with an open circuit reading resulting from an open primary.

Signal Tracing

There are two methods of signal tracing in general use by service men. The first method is to use one of the instruments which have been developed for that purpose, such as the Chanalyst. A detailed description of the process used is not necessary here, because each of these instruments is supplied with a very elaborate and well-written instruction book, but a brief outline of the method may be in order.

In using the Chanalyst, for example, the radio receiver is tuned to any desired frequency and a modulated signal of that frequency is fed into the set from a signal generator.

Now, if the set is functioning properly, r.f., i.f. and audio signals will appear at various accessible test points in the receiver. The grid and the plate of the r.f. tube, and the grid of the mixer tube will have present a modulated signal at the incoming radio frequency. The grid and the plate of the i.f. tube and the diode plates of the detector will show modulated signal at the intermediate frequency. From the grid of the first audio tube to the speaker, a.f. will be present. Also, if the set is performing properly, these signals will increase in intensity as they progress through the set from the antenna to the last stage. There are, however, a few exceptions where a loss instead of a gain is realized, even under normal conditions.

The Chanalyst is equipped to detect these signals and to determine, roughly, whether a gain or a loss occurs at the various test points. If no signal appears at a given point, the test probe may be applied to other points to determine just where the signal is lost. If a loss occurs where a gain is to be expected, the test probe may likewise be applied to various points to trace the loss to a particular stage or a portion of a stage.

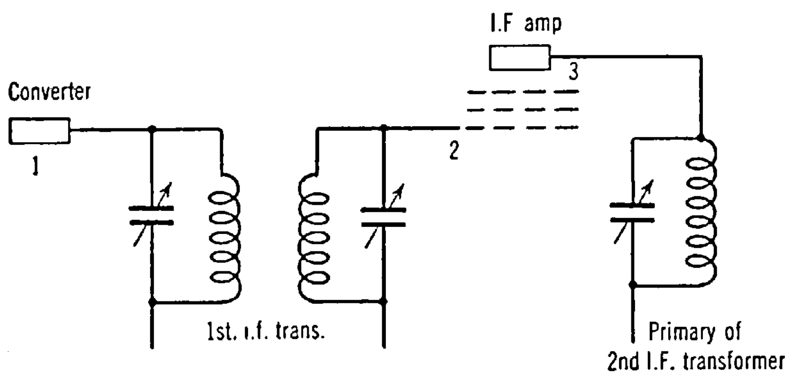
While the value of regular signal tracing equipment cannot be overemphasized, it must be kept in mind that such instruments are costly and are more likely to be acquired after one has become well established in servicing, rather than at the beginning.

But the idea of servicing by tracing the signal has become so vital to modern servicing that many service men have been using a simple, rough substitute for a long time. This method involves the use of a signal generator only.

In this method, the type of signal that normally would be found at a given point in a receiver is fed into that point from the generator and the results observed either by listening or by using an output indicator.

While the process of using a generator for this purpose is described in the job sheets which accompany this chapter, some further amplification of the method might be helpful.

Refer to the circuit at "E." This circuit shows a typical i.f. stage employing a pentode tube such as the 6K7 or 78. Obviously, the signal normally present at the grid of the tube, point 2, is modulated i.f. The generator is adjusted to deliver a modulated signal of the proper frequency, and with the ground side of the output cable connected to the chassis, the r.f. probe or clip is applied to the grid of the tube. If this stage, and those following, are functioning as intended, a signal will be heard at the speaker or will be indicated on the output meter.

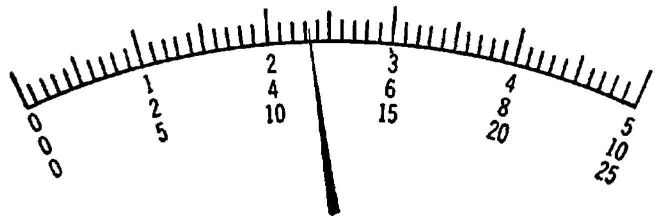


E

If no signal is heard, the probe or clip may be moved to point 3, the plate of the tube. If a signal is now heard, the tube may be defective or the voltages applied to it are incorrect. If no signal is heard with the probe applied to the plate of the tube, the trouble is beyond that point.

If, during the first test, a signal was heard with the probe connected to the grid of the i.f. tube, you may assume that the stage is operating normally, although trouble might still exist in the coupling transformer ahead of the i.f. tube. You can then check this by applying a signal to the plate of the preceding tube, at point 1. No signal, or a greatly reduced signal here, would point to a possibility of trouble in the transformer between the mixer and the i.f. tube.

JOB SHEET NO. 1



AIM: To learn how to read a voltmeter.

THEORY: The sketch above shows the voltmeter scale of a Weston model 772 volt-ohm-milliammeter. The method of reading the scale, however, will apply to any type of meter. Assume that the instrument has the following scales: 5, 50, 250, 500 and 1000 volts.

PROCEDURE: 1. Note which scale is in use by noting setting of range switch. Let us assume that the range switch is set for the 5-volt range.

2. You will see that the scale is divided into five large parts. We shall call these major divisions. They are numbered 1, 2, 3, 4, 5. Each major division is divided into ten smaller parts and we shall call these minor divisions.

3. Each major division is equal to 1 volt, and therefore each minor division is $\frac{1}{10}$ volt, or 0.1 volt.

4. Take your reading and carefully note the position of the needle. In the sketch, the needle is a little beyond the second major division, or 2 volts. However, the reading is more than 2 volts, because the needle is not exactly on the 2 division, but some distance beyond it.

5. Make a note, either mentally or on paper of the reading 2. Now count the number of minor divisions between the 2 mark and the needle, in this case three.

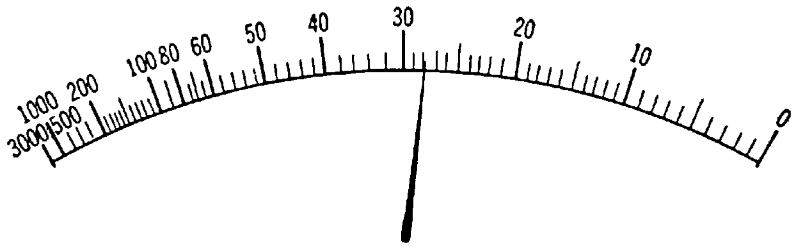
6. We found that each minor division is equal to 0.1 volt, so 0.3 volt must now be added to the 2 volts, giving 2.3.

7. You will see that we still have about one half of a minor division left. $\frac{1}{2}$ of 0.1 equals 0.05, and this is now added to the 2.3 giving a total of 2.35 volts.

8. If the range switch is set for 50 volts, a zero must be added to all figures on the 5 scale. Our reading then will be 23.5 volts.

9. Find the reading on each of the other ranges, 250, 500 and 1000. Be careful first to find the values of the major and minor divisions for each range.

JOB SHEET NO. 2



AIM: To learn how to read an ohmmeter.

THEORY: Study the drawing of the ohmmeter scale above. Notice that the scale is *not* uniform, that is, from zero to 10 on the scale, representing 10 ohms, takes up more of the scale than from 10 to 20, also representing a change of 10 ohms. In other words, as we go from right to left we find that a given number of ohms takes less room on the scale.

PROCEDURE: 1. Before taking a reading, decide whether the value you wish to read is low, medium or high. All good ohmmeters are provided with several ranges. Select the one suitable to your use.

2. Set the range switch or multiplier on the range you wish to use. Ranges are usually marked on the switch as follows: R × 1, R × 10, R × 100, etc.

3. Touch the two test prods together, and adjust the reading to zero ohms, by means of the knob marked Zero Adjuster.

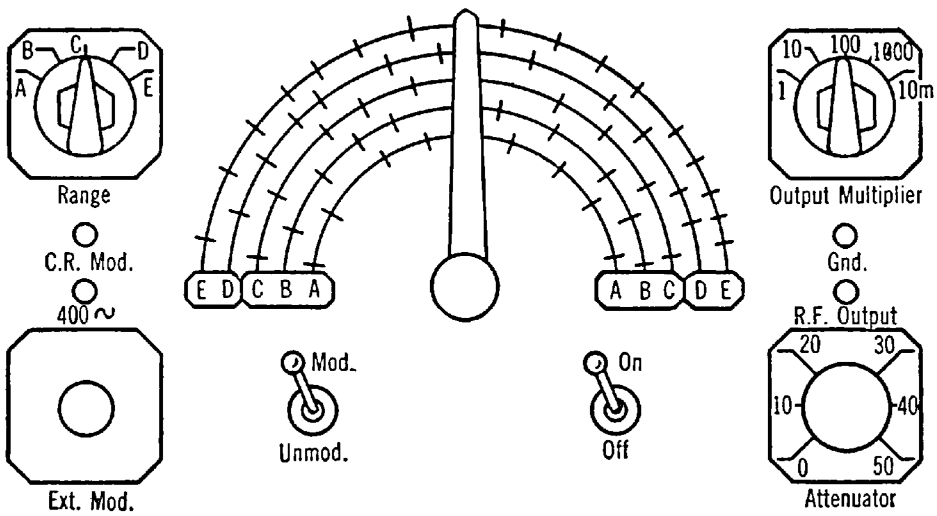
4. Some meters, especially on the lower ranges, are equipped with what is commonly known as a back-up scale. When using a scale of this type, you will note that the instrument will read as soon as the range switch is set on the range desired. The zero adjuster is then operated to bring the needle of the instrument into alignment with the first calibration on the scale. The test prods are not to be brought into contact during this operation.

5. Connect test prods to points where measurement is to be taken. Note position of needle, and read as you did the voltmeter, in the job sheet covering that instrument. Now multiply this reading by the indication on the range switch or multiplier.

6. Example: reading indicated on the sketch above is 28 ohms. The range switch is set on the R × 1000 range. 28 times 1000 equals 28,000 ohms.

7. Whenever possible, try to select a range that will give a reading somewhere in the right half of the scale. As the divisions are much larger, it will be found easier to read them accurately. This is especially true when it is necessary to estimate fractions of a division.

JOB SHEET NO. 3



Courtesy Radio City Products Co., Inc.

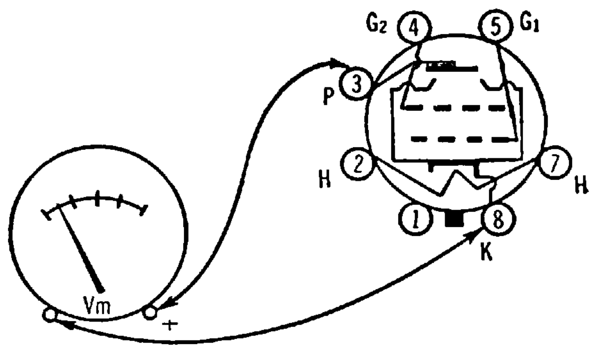
AIM: To learn how to use a signal generator.

THEORY: The generator pictured above is the RCP. When you become familiar with its use, a careful study of the various controls on another generator will probably enable you to operate it in a short time. Any generator is really a small transmitter and is usually equipped to emit three types of signal: radio frequency, audio frequency, and a combination of the two, modulated radio frequency.

PROCEDURE: 1. **Alignment.** Plug generator into outlet. Throw the two toggle switches to the positions marked ON and MOD. Plug output leads into jacks marked GND and R.F. OUTPUT. Find correct aligning frequency as recommended by manufacturer of set. Set main tuning dial to this frequency. Find which frequency range this frequency appears on. Set switch marked RANGE to this range. Connect test clips on output leads to set chassis and correct point in circuit as recommended by manufacturer. When signal is heard, reduce output as low as possible with ATTENUATOR and OUTPUT MULTIPLIER. Note that the output multiplier provides a coarse adjustment, and that the attenuator is used for fine adjustments.

2. **Signal tracing.** For audio stage testing, connect output leads to 400 CYCLE AUDIO and GND jacks. Regulate output by means of output multiplier and attenuator. Tuning dial is not used. For i.f. stages, proceed as for alignment. For r.f. stages or converter stage, select any frequency on the broadcast range of the set. Tune the set and the signal generator to this frequency and proceed with test. For a detailed explanation of alignment and signal tracing refer to the units entitled How to Align a Superheterodyne and How to Do Signal Tracing.

JOB SHEET NO. 4



AIM: To learn how to make a voltage analysis.

THEORY: A vacuum tube, in order to work properly, must be supplied with proper voltages. After we have traced trouble in a radio to one stage, we may find that trouble by measuring the voltages present at the socket terminals in that stage. What are normal voltages? The best way to find out whether the voltages you get are correct is to compare them with the manufacturer's specifications for the set. The voltages are usually included in the service bulletin. If you do not have the bulletin, use the RCA tube manual. Turn to the type of tube used and you will find two or three columns of voltages. These are for different operating conditions, generally one set of voltages for a.c.-d.c. sets and another list of higher voltages for a.c. sets.

PROCEDURE: 1. Before making any voltage measurements, disconnect antenna from receiver and adjust tuning condenser to maximum capacity. This is done so that readings are made with no signals being received. Begin by measuring the plate voltage. Consult the tube manual to get an idea of what voltage to expect. Set the voltmeter to a range higher than this voltage. To be absolutely safe, start out with the highest range on the meter and work down. Place the negative test prod on the cathode terminal of the socket and the positive prod on the plate. If you find that the range you selected is too high, go to the next lower range until you get a reading about half scale. Now read the meter and compare the reading with the recommended value.

2. Transfer the negative prod from cathode to ground. Notice that the reading has increased. This is because the voltage present from cathode to ground has been added to the plate voltage. Both methods of measuring may be used, depending on conditions. However, the tube manual readings and those given in service bulletins are generally based on measuring all voltages from cathode to other terminals.

3. Now look in the tube manual or bulletin and find the screen voltage. Measure from screen terminal of the socket to cathode terminal. As before, start with a high range and work down. Compare your reading with the recommended value. You will generally find that for output tubes the screen voltage is slightly higher than the plate voltage. On other types of pentodes and tetrodes, however, the screen voltage is considerably lower than the plate voltage.

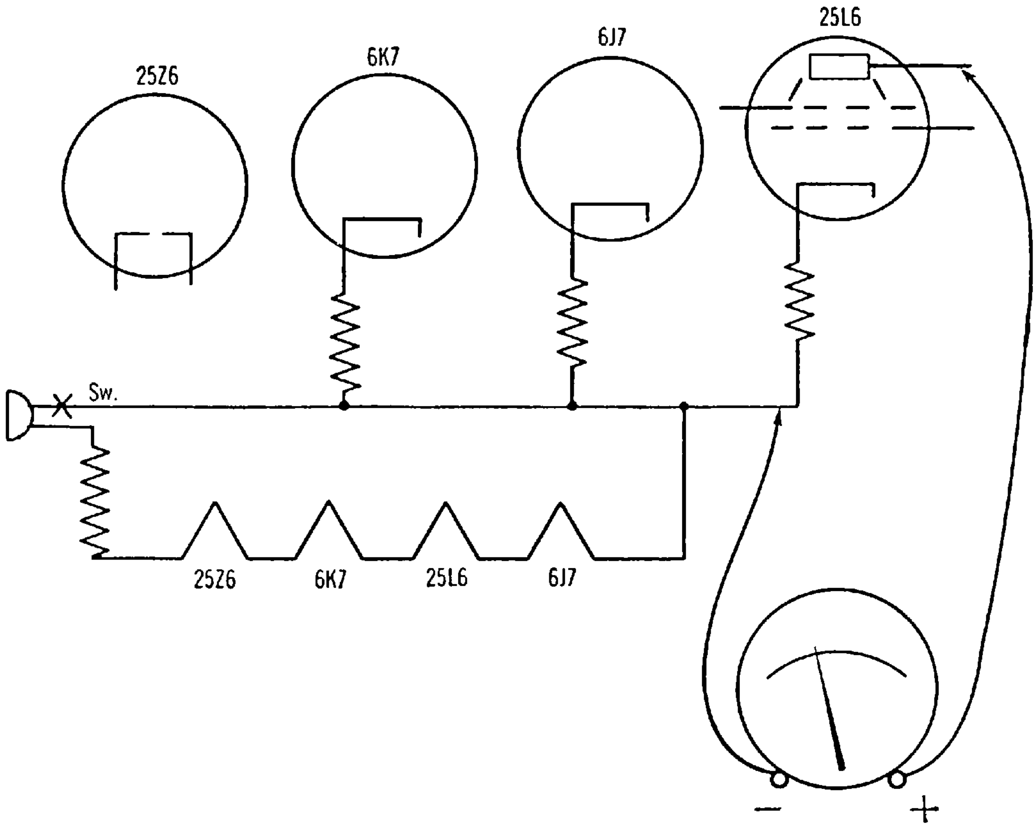
4. Now proceed with the measurement of cathode voltage. Before doing so, determine whether or not cathode biasing is used. If cathode biasing is not used, you will not be able to get a voltage reading from cathode to ground. Trace the circuit of the stage under test from the cathode pin of the socket. If the cathode terminal is directly connected to ground or to *B* minus, the stage does not employ cathode biasing, and measurement of cathode voltage is omitted. If, on the other hand, you find a resistor between the cathode terminal and ground, or *B* minus, the stage uses cathode biasing. In this case, place the positive test prod on the cathode pin and the negative prod on the chassis or *B* minus. Read the meter and compare your reading with the recommended value.

5. With the positive prod still on the cathode terminal, transfer the negative prod to the grid terminal. If you have observed the precautions given under 1, and no signals are being picked up, you will then be measuring the d.c. voltage applied to the grid as a result of the voltage drop across the cathode resistor. With a vacuum tube voltmeter or suitable high-resistance meter, this should be approximately the same as the measurement from cathode to ground. Note, however, that the accuracy of your reading will depend upon the resistance of the meter in use.

6. In those types of tubes having a suppressor grid you will usually find that the suppressor is connected directly to the cathode and it is not necessary to measure the suppressor voltage separately. There are some exceptions to this, though, and if you do not consult the table of correct voltages you may find yourself in error.

7. Ordinarily, the service man does not make a complete voltage analysis of a set. He only checks the voltages in the suspected stage. However, the best way to learn the process, so that you can do it rapidly and accurately, is to practice. You should make a complete analysis on several types of sets, repeating the analysis on each set until you can do it rapidly.

JOB SHEET NO. 5



AIM: To learn how to make a voltage analysis in an a.c.-d.c. receiver using a floating ground, or ground string.

THEORY: In some a.c.-d.c. receivers, you will find that the returns of the various circuits, instead of being connected to the chassis, are connected to a common negative return which is insulated from the chassis. This common negative is referred to as a floating ground or a ground string.

PROCEDURE: 1. Find the common negative terminal of the set. This can generally be done by tracing the negative lead of the first filter condenser. Usually, this lead will eventually return to one side of the line switch, and this point may prove to be a convenient one for measurements. We shall refer to this terminal and all of the wiring connected directly to it as *B* minus.

2. Measure plate voltages by placing the negative test prod on the cathode of a tube and the positive prod on the plate. Now transfer the negative prod to *B* minus and again take a set of readings. Compare the two sets of readings with each other and with the recommended voltages appearing in the manufacturer's service bulletin or in the tube manual.

3. Measure voltages from screen to *B* minus. This is done by allowing

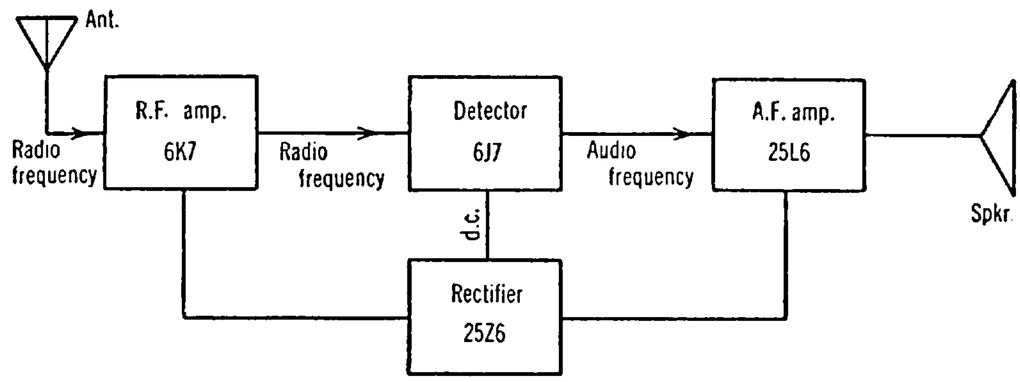
the negative test prod to remain on the *B* minus terminal and transferring the positive prod to the screen. Also measure from screen to cathode. Compare with the recommended voltages.

4. If cathode biasing is used, measure the voltages from the cathode to *B* minus. Touch the positive prod to the cathode and the negative prod to *B* minus. If cathode biasing is not used, omit this measurement.

5. Allow the positive prod to remain on the cathode, while transferring the negative prod to the grid, in order to read grid voltage. Again refer to recommended voltages to determine whether your readings are normal.

6. If a suppressor grid is used, note whether or not it is directly connected to the cathode. If it is, no separate reading of suppressor voltage is necessary. In a few special cases the suppressor will be connected to some other point, and you will have to take a reading from suppressor to cathode.

JOB SHEET NO. 6



AIM: To learn how to use Block Diagrams.

THEORY: Block diagrams are simplified diagrams of radio receivers, and serve several purposes. They help in understanding the action of complicated receivers and they give a clear picture of the path of the signal through the set.

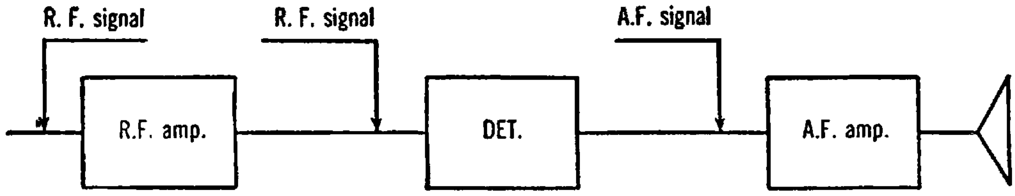
In the sketch above, the squares represent a stage of r.f., a detector stage, an audio stage and a rectifier, or, more correctly, a power supply. Each stage consists of the tube and all of the parts belonging to the stage, such as coils, variable condensers, resistors, bypass condensers, etc.

You will see, then, that instead of a complicated schematic diagram we substitute a simple sketch.

In the receiver pictured above, the signal from the antenna enters the r.f. stage, represented by the first square at the left, and is amplified. We then imagine the signal passing along the horizontal line in the direction of the arrow to the detector. The signal at this point is modulated radio frequency. The signal then enters the detector where it is demodulated. The audio frequency signal then passes in the direction of the arrow to the a.f. amplifier, where it is amplified. The amplified signal then passes to the speaker. The rectifier and power supply develop direct current which is supplied to each of the other stages. In most block diagrams of complete sets, the power supply is generally omitted.

Draw a block diagram of a TRF receiver consisting of two r.f. stages, a detector and two a.f. stages.

JOB SHEET NO. 7



AIM: To learn how to do signal tracing on a simple TRF receiver.

THEORY: Signal tracing is a rapid, accurate method of locating the faulty stage in a receiver which is not operating properly. After the defective stage has been located, we may concentrate on that stage and by means of voltage and resistance tests find the part which is causing the trouble. A very rough method of signal tracing is the well known trick of touching the grids of the various tubes and noting whether a click or hum is heard. In the explanation given below, we shall apply signal tracing to a TRF receiver which is dead, that is, not working at all.

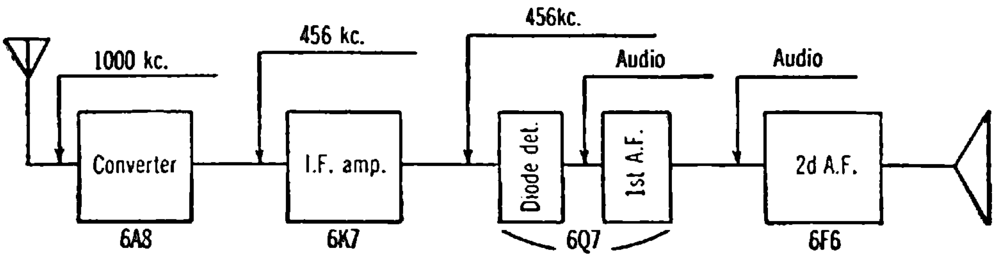
PROCEDURE: Set up a signal generator to give an audio signal. Connect the test clips to the receiver chassis and to the grid of the a.f. stage. If no signal is heard, there are three possibilities: (1) The power supply is not supplying normal voltages. This may quickly be checked with a voltmeter. (2) The speaker is defective. (3) If speaker and power supply are both O.K., the a.f. stage is not working. In such a case, we would test the tube, and if found in good condition, we would proceed to find the defective part by means of voltage and resistance measurements.

Suppose, though, that we were able to get a normal signal through the a.f. stage. This would indicate that the stage is in working order and we then proceed to the next stage, the detector. Tune the receiver to any frequency within its range. Set up the generator to deliver this frequency. Connect the test clips to the chassis and the grid of the detector tube. If no signal is heard immediately, try varying the frequency of the generator slightly. If no signal comes through, it is an indication that the stage is dead, and you must now use other tests to find the trouble.

If a normal signal passes through the detector, test the r.f. stage by proceeding as follows: Allow set to remain tuned to the same frequency. Connect a test clip to antenna terminal of set. If no signal comes through, try applying signal to the grid of the detector tube. If a normal signal is now heard, either the antenna coil primary or the antenna condenser is at fault.

The plate of a tube may be used as a test point as well as the grid. The signal should be stronger at the grid. **Note: A condenser should be connected in series with the test leads at all times.**

JOB SHEET NO. 8



AIM: To learn how to do signal tracing on a superheterodyne.

THEORY: In the block diagram above you will notice that the 6Q7 stage has been divided into two blocks. This has been done because that stage is really two stages in one. The cathode and two diode plates of the tube act as detector, while the cathode, grid and triode plate perform the function of first audio amplifier. When signal tracing in such a stage, we treat the stage as two separate circuits, and feed two different types of signal into each.

PROCEDURE: After the set has warmed up, set up the generator to deliver an audio signal. Feed this signal into the grid of the second audio stage. If no signal is heard, check the speaker and if found O.K., check the power supply. If both are normal the trouble is in the second audio.

If a normal signal comes through the output stage, feed an audio signal into the grid of the first audio. If you do not get a signal at this point, apply the signal to the plate of the first audio. If a signal is now heard, there is trouble in the first audio.

Assume that a signal is heard when the generator is connected to the grid of the first audio. We can be sure that the entire audio amplifier is working. The next test point is the diode plate. A 456-k.c. signal is applied here. No signal indicates trouble in the detector, but if a signal is heard, we may proceed to the i.f. amplifier. With the generator adjusted to 456 k.c., connect the test clip to the grid cap of the 6K7 tube. If you do not hear a signal or if it is weak, try adjusting the trimmers on the second i.f. transformer. Try readjusting the generator frequency slightly if necessary. If you hear no signal, look for trouble in the i.f. stage, but if you find this stage operating satisfactorily, go on to the converter.

Apply a 456-k.c. signal to the grid cap of the 6A8. If you hear a signal, it means that this stage is operating as a mixer, but it may not be performing its second job, that of oscillator. Now set the generator to deliver some frequency in the tuning range of the set. 1000 k.c. is usually satisfactory. Connect the test clips to the antenna terminal and the chassis.

Tune the set to the same frequency as the generator. If a signal is not heard, try readjusting the generator or the set slightly. Also try adjusting the trimmers on the tuning condenser. Be careful not to change these too much, and to restore them to their original setting if the signal is not heard. If all these efforts fail, you probably have trouble in the oscillator.

To verify your diagnosis of oscillator trouble, make the following test. Allow both the generator and set to remain as they are temporarily. Shift the test clip from the antenna to grid No. 2 on the 6A8. Connect an antenna to the set. Tune the set to the frequency of some powerful radio station known to be operating at the time. Throw the switch on the generator to the UNMODULATED position. Now slowly vary the frequency of the generator over a range about 456 k.c. higher than the frequency to which the set is tuned. In other words, if the set is tuned to 1010 k.c., the generator should be tuned to about 1466. Try varying the generator frequency from say 1200 to 1600. If no signal is heard, try connecting the test clip to grid No. 1. If the broadcast station is heard with the test clip in either position, it is fairly certain that the trouble is in the oscillator circuit.

Questions

1. What is the ohms-per-volt rating of a 50-microampere meter when used as a voltmeter?

2. What effect will a comparatively low ohms-per-volt rating have upon voltage readings?

3. What is considered the minimum sensitivity of a voltmeter to be useful in service work?

4. Name one type of trouble in which an unmodulated signal output from a generator might be useful.

5. What is the advantage of a signal generator capable of delivering a straight audio output?

6. What audio frequency is generally used for modulation in signal generators?

7. Why is it desirable to use a separate tube for modulation in a signal generator?

8. When making a voltage analysis, how can you determine whether your readings are normal?

9. What adjustments should be made on a receiver before a voltage analysis is taken?

10. In making a voltage analysis on a.c.-d.c. receivers in which the returns are not connected to the chassis, what is used as a reference point for measurements?

11. What is considered the best type of tube checker for service work?

12. Describe how an emission type tube checker works.

13. Describe a simple method of testing tubes when a tube checker is not available.

14. Name one trouble that might cause a full-scale ohmmeter reading from the plate of a tube to ground.

15. An r.f. stage has a 0.1 mfd. condenser connected from the *B* plus side of the r.f. coil primary to ground. This condenser is shorted. How would this type of trouble be indicated by a point-to-point resistance test?

16. You are making a signal substitution test on a superheterodyne. You get normal results when signals are applied to all stages up to the i.f. amplifier, but no signal on the grid of this tube. In which stage does the trouble lie?

17. A superheterodyne is dead when an attempt is made to operate it in the normal way, but when an 1166-k.c. signal is applied to the oscillator grid of the converter stage, a broadcast station transmitting on a carrier frequency of 710 k.c. may be heard. What is the trouble?

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Signal Tracing

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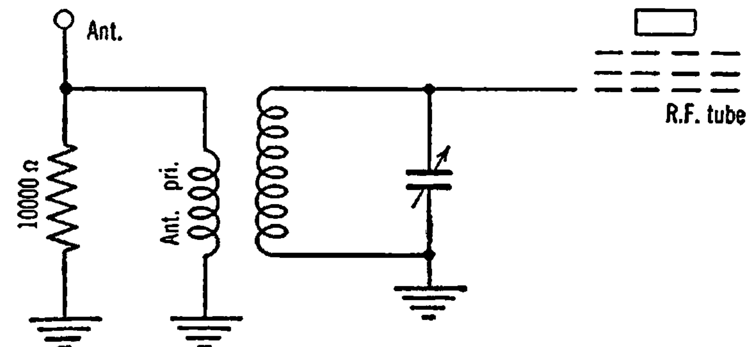
Capacity and Inductance Measurement

Aerovox L–C Checker Instruction Booklet, Aerovox Corp.

2

THE R.F. AMPLIFIER

Since the introduction of the screen grid tube, the r.f. amplifier has probably undergone far less change, in regard to circuit arrangement, than the other stages. Before the screen grid tube came into general use, however, there were many variations in r.f. circuits. One reason for this was the fact that the use of triodes as r.f. amplifiers made necessary some scheme for neutralizing the grid-to-plate capacity of the tube in order to prevent oscillation. A wide variety of neutralizing circuits were used, and although most of these sets are now out of existence, a sample is given at "K" for your guidance in the event that you are called upon to service a set of this vintage.

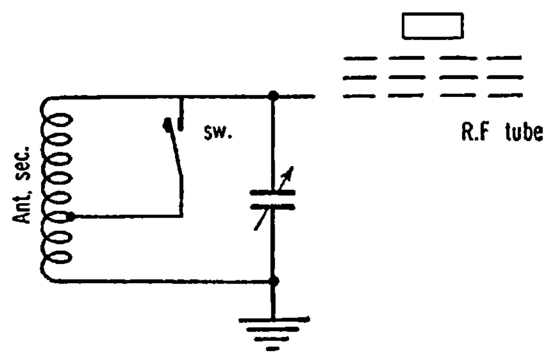


A

In modern superheterodynes, the r.f. stage is generally quite simple, and no particular difficulty will be found in tracing through the circuit and locating trouble. The tube employed in most cases is of the 6K7–78–6D6 group, and in a.c. receivers is operated with from 150 to 250 volts on the plate and from 50 to 125 volts on the screen. In most circuits the lower screen voltage is obtained through the use of a voltage divider. The cathode usually is biased by means of a resistor of several hundred ohms. In a.c.-d.c. sets, the plate voltage will range from 70 to 110, with about the same voltage on the screen.

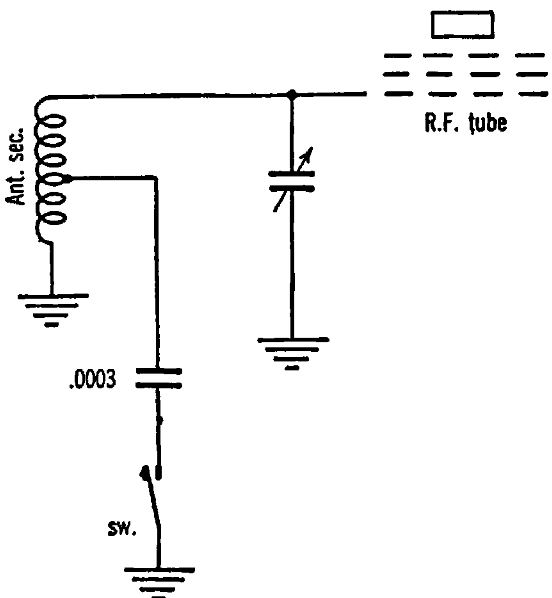
Although, as previously mentioned, the r.f. circuit usually is relatively simple, there are a few modifications that may be puzzling, and they will now be discussed.

You will find a number of sets, built a few years ago, particularly Philco sets, that have a carbon resistor connected from the antenna terminal to ground, directly across the antenna coil primary, as indicated in the diagram at "A." This resistor is usually 10,000 ohms.

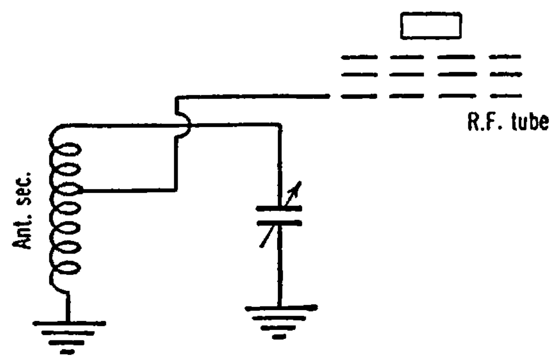


B

Another circuit modification makes provision for receiving some short-wave or police calls. These sets are usually in the low or moderate price brackets, and the circuits are in no way as elaborate as those used in higher priced multi-band receivers. The circuit used involves a tap on the antenna, r.f. and oscillator coils, with a switch to short out some of the secondary turns. Some sets will not have a tap on the oscillator coil



C



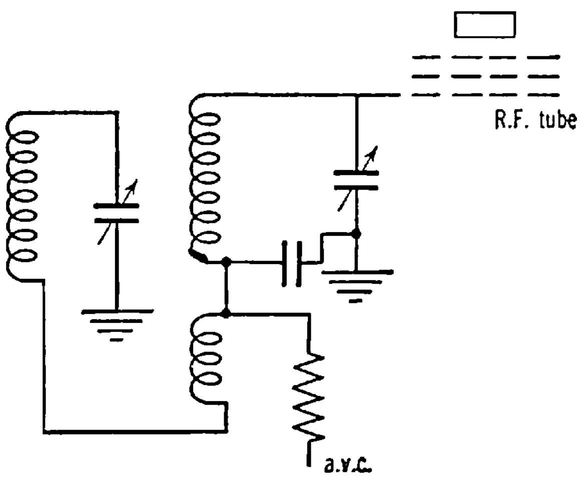
D

and depend upon harmonics of the oscillator frequency for police-call or short-wave reception. The circuit at "B" is a typical example of this idea. The arrangement is not too satisfactory, for trouble is often experienced with broadcast reception while the switch is on the short-wave position.

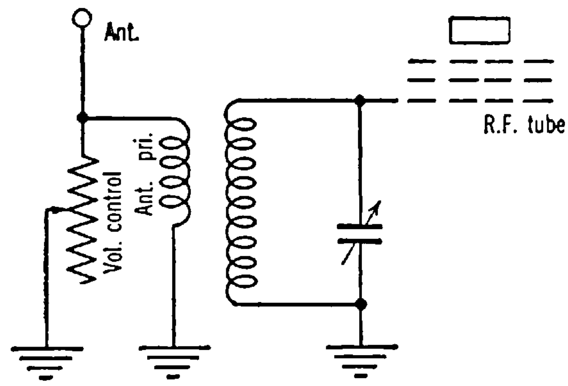
A second version of the tapped-coil circuit for police or short-wave reception is given at "C," in which a small condenser is shunted across part of the coil when the switch is thrown. The condenser is about 0.0003 mfd.

In still another circuit of this type the turns which are shorted out by the switch are located at or near the middle portion of the coil winding.

Some receivers use special circuit arrangements for the purpose of reducing image frequency interference or for improving the selectivity of the set. The latter type of circuit was used mostly in older sets. These two modifications are illustrated at "D" and "E."



E

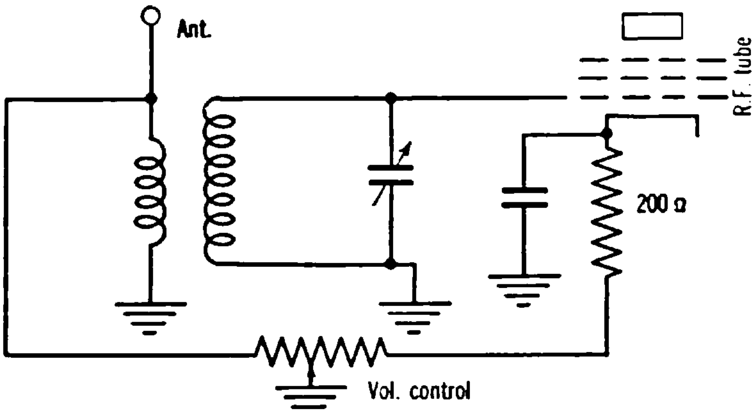


F

In almost all small TRF sets and in many superheterodynes which do not employ a diode detector, the volume control is in the r.f. portion of the set. The two most common methods of obtaining control are by means of controlling the r.f. input to the primary of the antenna coil, and by controlling this input and the r.f. stage bias at the same time.

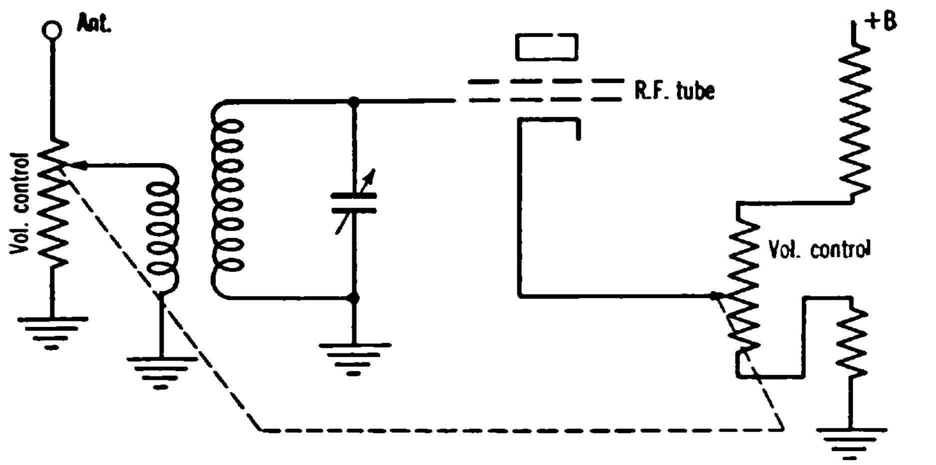
The diagram at "F" shows a method of control in which the signal applied to the r.f. primary is controlled. This circuit, by the way, is not too satisfactory, because it may be found to be impossible to cut down the signals sufficiently on strong stations.

A much better method of volume control, and the type which is used in most of the four-tube a.c.-d.c. TRF sets is seen at "G." Here a single-section volume control is used to vary both the signal input to the antenna primary and the voltage applied to the cathode of the r.f. stage. The control has a resistance of 10,000 to 25,000 ohms in most sets. Note that a carbon resistor of about 200 ohms is connected in series with the cathode to provide minimum bias when the control is adjusted for maximum volume. In testing circuits of this type, it should be kept in mind that the cathode voltage will vary, depending upon the volume control setting. The voltage may drop to a minimum of a volt or two with maximum volume, and rise to perhaps 15 or 20 volts with the control turned all the way down. Slight variations in plate and screen voltages may also be noticed as the control is varied.



G

Another version of the antenna-bias volume control appears at "H." This circuit is used mainly in older superheterodynes, using type 24, 27 and 47 tubes. A dual control is used, one section to control the r.f. input to the antenna coil, the other to control cathode voltage of the r.f. and i.f. tubes. The cathode section of the control is part of a wire-wound bleeder



H

Courtesy Philco

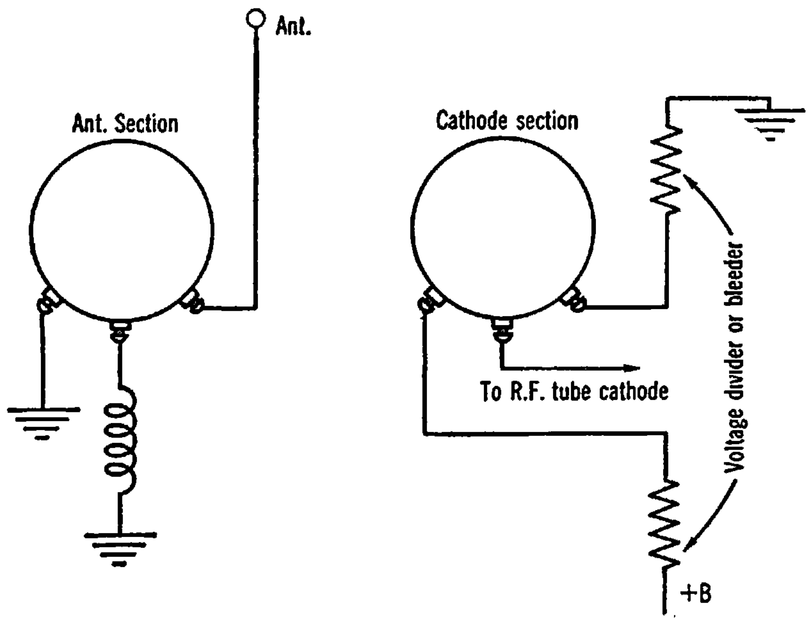
resistor which is connected from the positive side of the *B* supply to ground. As the current through this bleeder, and consequently through the control, is considerable, this section of the control is wire wound.

Troubles Occurring in R.F. Amplifiers

No Signals. May be due to defective r.f. tube; open cathode resistor; open r.f. coil primary; shorted screen bypass condenser.

Weak Signals. Open antenna coil primary; open volume control (if antenna control is used); defective tube; shorted cathode bypass condenser.

Weak Signals; Antenna Trimmer Has No Effect. Open antenna coil secondary.



J

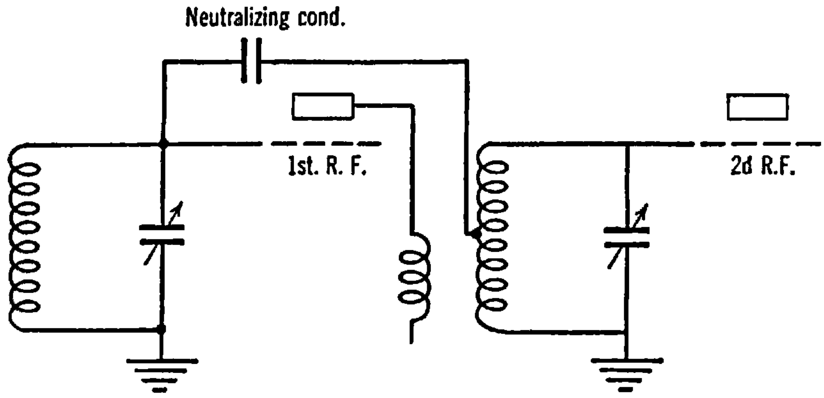
Courtesy Philco

Oscillation. Open screen bypass condenser; wiring not properly dressed, especially grid and plate leads; excessive screen voltage; tube not shielded; tube shield not properly grounded; wiper contacts on variable condenser shaft not making good contact; poor ground connection; stage not correctly neutralized (in cases where triodes are used as r.f. amplifiers).

Under certain conditions it is possible to receive signals with the r.f. stage not working, as the mixer grid lead, or other wiring, will pick up enough signal so that the set will work, but, of course, not with normal volume. The most usual cause of this condition is a burned out r.f. tube. If you find that the signal strength increases greatly when the hand is brought near the mixer grid or the stator terminal of the tuning condenser, it is a good indication of trouble in the r.f. stage.

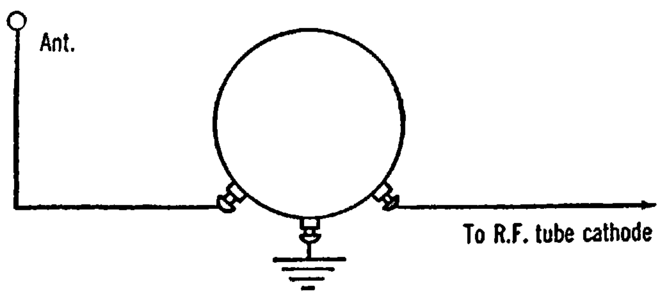
Replacement of antenna and r.f. coils may result in some little difficulty unless the terminal arrangement of the coil is known. Most manufacturers now include sketches of the coils and their terminal lug connections in their service bulletins. If this information is not available, it is advisable to make a drawing of the terminal arrangement before removing the coil, otherwise some tracing of the coil winding may be necessary.

Oscillation in r.f. amplifiers may be due to a number of conditions, but the most likely one is an open screen bypass condenser. In the average case this condenser is about 0.1 mfd. When oscillation develops, the first thing to do is to shunt a 0.1 mfd. condenser temporarily across each



K

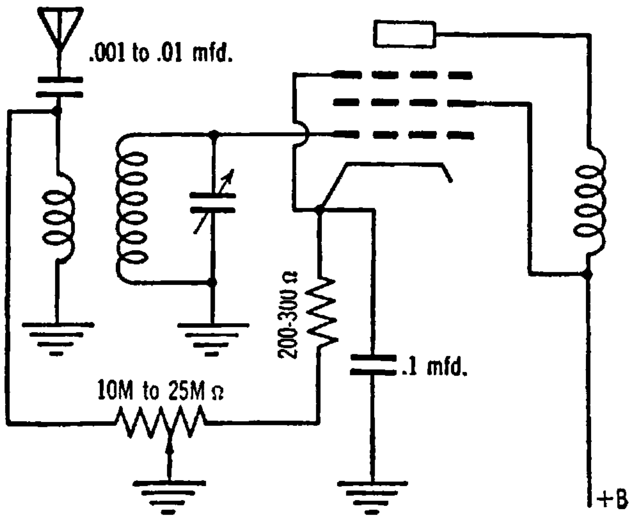
of the screen bypass condensers. This applies to i.f. and converter stages as well as to the r.f. The condenser should be placed directly on the screen terminal of the tube socket.



L

Replacement of volume controls will be simplified if you are careful to observe the connections and, if necessary, make a sketch of them before removing the old control. This is particularly true of two-section controls, where six connections are involved. If you should encounter a set in which the connections have been removed, the sketch at "J" may save you time in replacing the connections. The control is to be held so that the shaft end is toward you, with the terminal connections pointing downward. In the case of single-section antenna-bias controls, with the control held as above, the left terminal goes to antenna, the right to cathode and the center to ground, as shown in sketch "L."

JOB SHEET No. 9



AIM: To learn how to locate trouble in a pentode r.f. stage.

THEORY: The volume control used in this receiver is the antenna- and *C*-bias type. Volume is controlled in two ways. First, the control is in series with the cathode, and varying the control changes the grid voltage on the tube and hence the gain of the tube. Also, the control is across the antenna coil primary, from antenna to ground. When the control is varied the amount of signal applied to the primary is changed.

When all stages following this one have been checked and found to pass a normal signal, the trouble is in the r.f. and procedure in locating it is as follows:

PROCEDURE: 1. Check plate voltage from plate to ground. No voltage here may indicate an open coil. Check the voltage from the *B* plus end of the coil to ground. If normal voltage is present here, turn the set off and make a resistance test on primary of coil.

2. When plate voltage is found to be normal, check voltage from screen to ground. Lack of voltage here might be due to an open lead from screen terminal of socket to *B* plus, or to a shorted bypass condenser, where one is used. This condenser is often omitted in cheap sets. To check for open lead, turn set off and make ohmmeter test from screen terminal of socket to *B* plus. To find a shorted screen bypass condenser, disconnect one end of the condenser, turn set on and again check voltage. If voltage now appears, the condenser is shorted.

3. If both plate and screen voltages are found to be O.K., make voltage test from cathode to ground. In making this test, first measure voltage with volume control turned all the way up, hold test leads in position and

slowly turn control down. Voltage should change smoothly from possibly 1 volt with control at minimum to possibly 10 to 15 volts with the control turned all the way up. There should be no breaks or sudden changes in this voltage increase. Excessively high cathode voltage would indicate that either the control or the cathode resistor is open. A sudden change in cathode voltage while the control is being operated means that the control is open at that point. Should you get no cathode voltage, the cathode bypass condenser is probably shorted. Disconnect the condenser and recheck the voltage.

4. When you have proceeded thus far and all voltages are correct, check the voltage from cathode to grid. If you get no voltage indication, look for an open coil secondary.

5. If you have been unable to get a signal through the stage and all readings have been normal thus far, try feeding a signal directly into the antenna coil primary, rather than to the antenna terminal or lead. A signal at this point but none at the antenna shows that the antenna condenser is open.

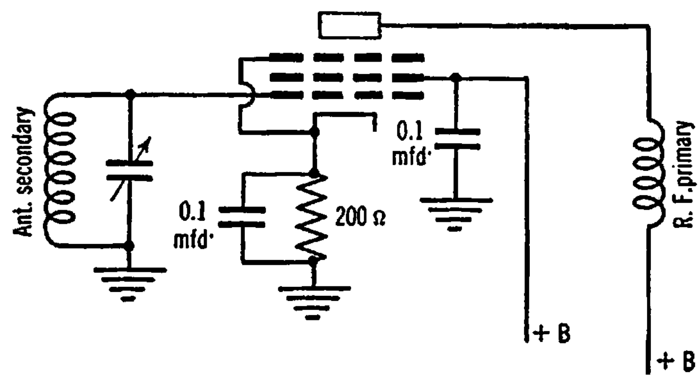
6. If you still have an inoperative stage and everything checks O.K. so far, look for a shorted variable condenser.

Approximate voltage readings for this type of stage are:

Plate	75 to 100	Cathode (control at max.)	1 to 2
Screen	75 to 100	Cathode (control at min.)	10 to 15

Grid same as cathode; depends on setting of control.

JOB SHEET NO. 10



AIM: To learn how to locate trouble in a superheterodyne r.f. stage.

PROCEDURE: 1. Measure plate voltage. If plate voltage is not present, check for voltage at *B* plus end of r.f. coil primary. If voltage appears at this point, test continuity of primary with ohmmeter.

2. If plate voltage is normal, check screen voltage. If none is present, look for open screen supply voltage divider. In this case the divider would be open on the *B* plus side of the screen tap. An open in the grounded side would result in higher than normal voltage. Where the voltage divider is used to supply the screens of several tubes, shorts or grounds in other stages must be taken into account when tracing cause of incorrect screen voltage. In many modern sets it is common practice to use a separate resistor for the screen of each tube.

3. After plate and screen voltages have been checked and found to be normal, measure voltage from cathode to ground. The voltage here normally is very low, so that a low-range meter must be used. If voltage is zero, disconnect one end of cathode bypass condenser and recheck. If voltage is now normal, condenser is shorted. If cathode voltage is much higher than normal, and you are unable to get voltage readings from cathode to plate or screen, but normal readings from ground to plate and screen, the cathode resistor is open.

4. When you have checked plate, screen and cathode circuits, and have either found them all to be normal, or you have cleared all trouble, measure voltage from cathode to control grid. This should give you about the same reading as from cathode to ground. If you do not get a voltage reading, check continuity of antenna coil secondary.

5. If all voltages are normal and stage does not operate, look for shorted tuning condenser, or grounded control grid lead or terminal.

Questions

1. Describe a very simple method, in use in some sets, of adapting the receiver for short-wave or police-call reception.

2. What type of volume control circuit is generally used in small sets of the TRF variety?

3. Name three common causes of a dead r.f. stage.

4. An r.f. stage delivers weak signals and the antenna trimmer has no effect when adjusted. What is probably wrong?

5. Name three usual causes of weak signals in an r.f. stage.

6. What is usually the effect produced by an open screen bypass condenser?

7. What is the simplest method of determining the trouble described in Question 6?

8. What precaution should be observed before removing a defective volume control from a receiver?

9. In an r.f. amplifier, which leads are generally considered critical, and therefore liable to cause oscillation if placed too close together?

10. What is a common method of connecting a neutralizing condenser in a triode r.f. stage?

11. In checking voltages on an r.f. stage, you find that the plate voltage is normal, but that there is no screen voltage. Name several conditions that might cause this trouble.

12. In measuring the cathode voltage on an r.f. stage in which the antenna-bias type of volume control is used, what condition will be observed as the control is adjusted?

13. What is usually the cause of a sudden and violent change in cathode voltage reading as the volume control is adjusted?

14. In working on an r.f. stage, you find that all voltages are normal, but no signals are received. Where would you look for the trouble?

15. What would be the result of a shorted cathode bypass condenser in an r.f. stage, in so far as operation of the receiver is concerned?

16. You are testing an r.f. stage, and your tests seem to indicate that the variable condenser section is shorted. How would you proceed to verify this?

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3

THE MIXER–OSCILLATOR OR CONVERTER

Early superheterodynes used a triode tube as the mixer, or first detector, as it is sometimes referred to, and another triode tube as the oscillator. Various means of injecting the local oscillator signal into the mixer circuit were used.

During the depression years, the trend was toward reduction of the number of tubes used in a receiver, in order to lower the cost. For this reason, a number of circuit arrangements were used in which one tube performed the two functions of mixer and local oscillator. These circuits were developed around tubes of the tetrode and pentode types. A few variations of these circuits will be taken up later.

With the introduction of tubes incorporating two separate sets of elements within the same envelope, still further progress was realized in the utilization of one tube in performing the functions of mixer and oscillator. The 6A7 and 6A8 are examples of this class of tubes.

Tubes in this group are referred to as pentagrid converters. The cathode is common to both the oscillator and mixer sections, the first two grids are used as the control grid and plate, respectively, of the local oscillator, the third and fifth grids are generally tied together and used as a screen, while the fourth grid is the r.f. signal input grid. The oscillator circuit used is the familiar tickler feed-back arrangement.

A later development of the pentagrid converter circuit is now in wide use and employs single-ended tubes of the 6SA7–12SA7 class. The signal input grid in this type of tube is brought out to a base pin instead of to a top cap as in the 6A7–6A8. Although these tubes have the same number of elements as the 6A7–6A8 group, the functions of the various elements and the circuit arrangement are considerably different. The grid nearest the cathode is the oscillator grid; grids 2 and 4 are used as the screen; grid 3 is the r.f. signal input grid and No. 5 is the suppressor.

The oscillator coil used with the single-ended converter is quite simple, having only a single tapped winding. One end of this winding is grounded, the tap is connected to the cathode and the remaining lead is connected to the oscillator grid through a small condenser, usually about 50 mmfd. Note that in this arrangement there is no element which is used solely as the oscillator plate. The advantages of this type of circuit are reduction in cost through elimination of the top cap connector and lead, and shortening of the lead to the signal input grid.

While some form of pentagrid converter has become standard in practically all superheterodyne receivers, a few sets, particularly those having high-frequency bands, have reverted to the use of a separate triode for the oscillator. In such sets, the mixer is generally a 6L7 or similar type and the triode oscillator is a 6C5, or equivalent.

The job sheets included in this chapter cover the testing and trouble location in various circuit arrangements. There is one job sheet devoted to the pentagrid converter circuit using the 6A7 or similar tube, another to single-ended converters of the 6SA7 class, and a third covers circuits using two separate tubes such as the 6L7 and 6C5 combination. Still others refer to the 6J8 and 6K8.

Trouble shooting is somewhat more complicated in circuits using tubes that serve two purposes. This is true not only of pentagrid converters but in the case of detector-audio circuits using tubes similar to the 6Q7, as well. The reason for the difficulty lies in the fact that two entirely separate circuits are involved, but this need not prove to be a stumbling block. Isolation and location of trouble will be considerably easier if you will remember to treat such circuits as two separate stages, and will apply the tests appropriate to each stage in order. First find out, by means of signal tracing or signal substitution, which stage does not function, whether mixer or oscillator. Then concentrate on that stage and find the defect responsible for the faulty operation. It is merely a contrast between the orderly method of trouble isolation to a single stage by means of signal tracing, and the haphazard type of servicing in which all sorts of tests are made without any particular reason for making them. In the first method, the service man considers the pentagrid converter circuit according to the two separate functions performed, decides which function is lacking and proceeds to find the defect. In the latter method he considers the circuit as a vacuum tube with a group of associated parts, without reference to the functions performed by the separate sections of the circuit. Finding the fault in the latter method is, in many cases, largely the result of luck. There are cases, of course, where failure of a part in a converter circuit will affect both the oscillator and the mixer. One example of this is an open cathode resistor.

While on this topic, it is well to note that a puzzling condition sometimes arises in which a signal from the generator apparently passes through the converter when applied to the signal input grid but the set does not receive broadcast signals. This condition will cease to puzzle you if you will stop to analyze what is happening. The signal fed into the converter, you will find, is not at a frequency within the tuning range of the set, but is at or near the i.f. This will indicate that the mixer is operating properly, but that the oscillator is not.

The best method of verifying failure of the oscillator circuit is to substitute a generator signal for the signal normally produced by the oscillator. Tune the receiver to the frequency of a strong local station known to be on the air. Tune the generator to this frequency plus the amount of the i.f. If the local station you select is operating on 1400 k.c. and the i.f. of the set is 455 k.c., the generator is to be tuned to 1855 k.c. Connect an antenna to the receiver and apply the generator test clip to that point in the circuit where the local oscillator signal would normally appear. The generator is to be adjusted to give an unmodulated signal. If no signal is heard immediately, try varying first the generator frequency, slightly, then try tuning the set over a very small range. If the broadcast station is received with something near normal volume, the failure is definitely in the oscillator circuit.

Troubles Occurring in the Mixer

No Signals. May be caused by a defective tube; open first i.f. primary winding; shorted i.f. trimmer across first i.f. primary; shorted screen bypass condenser; open cathode resistor; shorted cathode bypass condenser.

Weak Signals. Improper alignment; incorrect plate, screen or cathode voltages.

Weak Signals: Trimmer Across Mixer Input Circuit Has No Effect. Open coil winding.

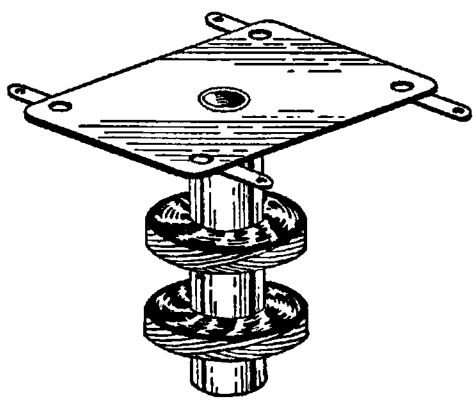
Troubles Occurring in the Oscillator Section of a Pentagrid Converter

Circuit Does Not Oscillate. Open oscillator coil winding; open oscillator grid resistor; open condenser between oscillator grid and oscillator coil; shorted padding condenser; shorted variable condenser; oscillator coil connections may be reversed.

Troubles Occurring in Separate Oscillator

Circuit Does Not Oscillate. Open oscillator coil winding; shorted variable condenser; open oscillator grid resistor.

Some of the older sets using a triode tube as separate oscillator have a series plate resistor, usually about 25,000 to 50,000 ohms. A common trouble is opening of this resistor, resulting in no plate voltage and failure to oscillate. This same type of circuit may employ a coupling condenser between the plate of the oscillator tube and the oscillator coil winding, with a capacity of about 100 mmfd. This condenser may open up, resulting in failure of the circuit to oscillate. Refer to the diagram at "D."



A

The remedies to be applied in order to correct these troubles are in most cases obvious, but a word may be said in regard to oscillator coil troubles.

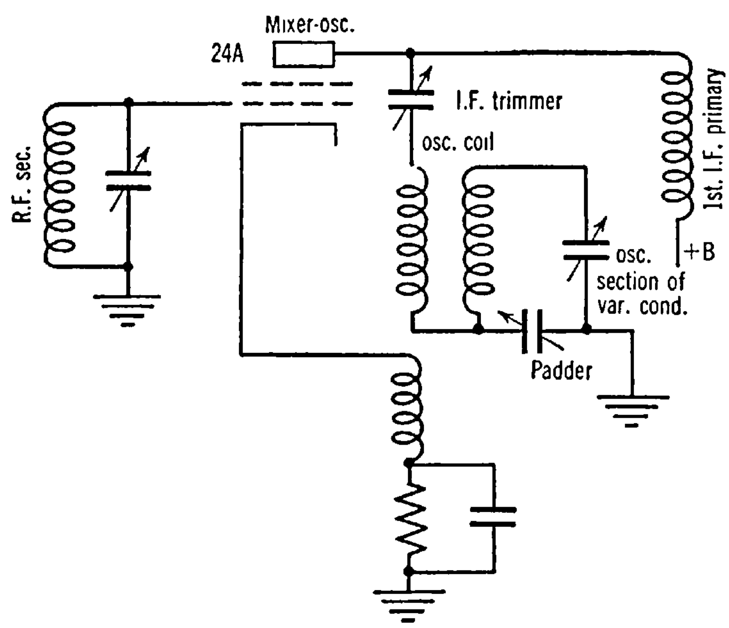
In many sets using a pentagrid converter of the 6A8 or similar type, the coil is similar to that shown in the sketch at "A." This coil consists of two windings on a form about ½ inch in diameter. The ends of the windings are brought out to terminals mounted on a strip on top of the coil. The connection arrangement for these terminals may be indicated by spots of colored paint near each terminal, or by a numbering system. Reversal of connections may result in failure to oscillate, and since it is possible that some one may have worked on the set before you, this possibility should not be overlooked.

An open winding is usually relatively easy to repair in such coils, provided that the break is not too far in from the end of the winding. Peel off the wire until the break is located, then, if only a small amount of wire was removed, reconnect the wire to the proper terminal and resolder. If a considerable number of turns was removed, sufficient wire to make up the number of turns removed may be added.

An open condenser between the oscillator grid and the grid end of the oscillator coil (grid blocking condenser) may be somewhat difficult to locate by any means other than substituting a new condenser. In converters belonging to the 6A7–6A8 group, this condenser is usually about

250 mmfd., while in single-ended converters it is much lower in capacity, about 50 to 100 mmfd.

In some older sets the padding condenser may be of lower capacity than that used in modern sets. A mica condenser will be found connected in parallel with the padder to make up the required total capacity. A trouble which might occur is opening up of this mica condenser, a trouble which is rather difficult to find. The symptoms are weak signals, with the padding condenser having no effect at all when adjustment is attempted. Some of these sets, especially those using the circuit shown in "D," have the padder, the mica condenser just mentioned, and a 50,000-ohm resistor, all in parallel, connected from the tap on the oscillator winding to ground.



B *Courtesy Philco*

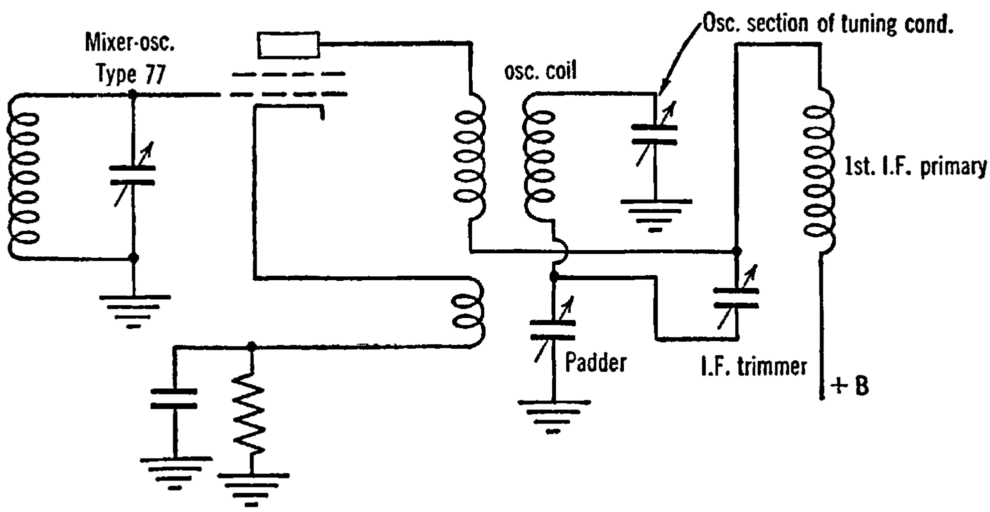
Older Mixer-Oscillator Circuits

Diagram "B" illustrates a mixer-oscillator that was extensively used during the period from 1929 to 1933. Note that while this circuit, and similar ones using a pentode tube, perform the two functions of mixer and oscillator with only one tube, there is not a separate set of tube elements for each function, as in the pentagrid converter.

In the diagram at "B," signals from the oscillator circuit are fed into the cathode of the tube through the use of a cathode winding which is inductively coupled to the other oscillator coil windings.

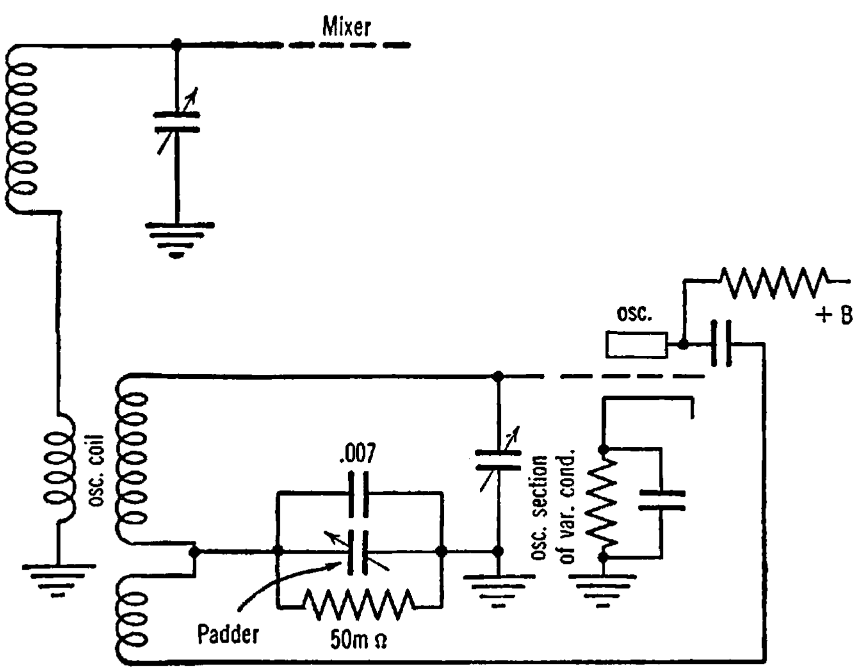
Common troubles that develop in this type of circuit are open cathode winding, open cathode resistor and failure to oscillate due to the tube itself, although the tube may test satisfactorily on a tube tester. It is sometimes necessary to try several tubes in this socket until one is found that will work well.

Another variation of this circuit is shown in diagram "C." If you should encounter a situation in which the tube fails to oscillate, try sub-



C

Courtesy Philco



D

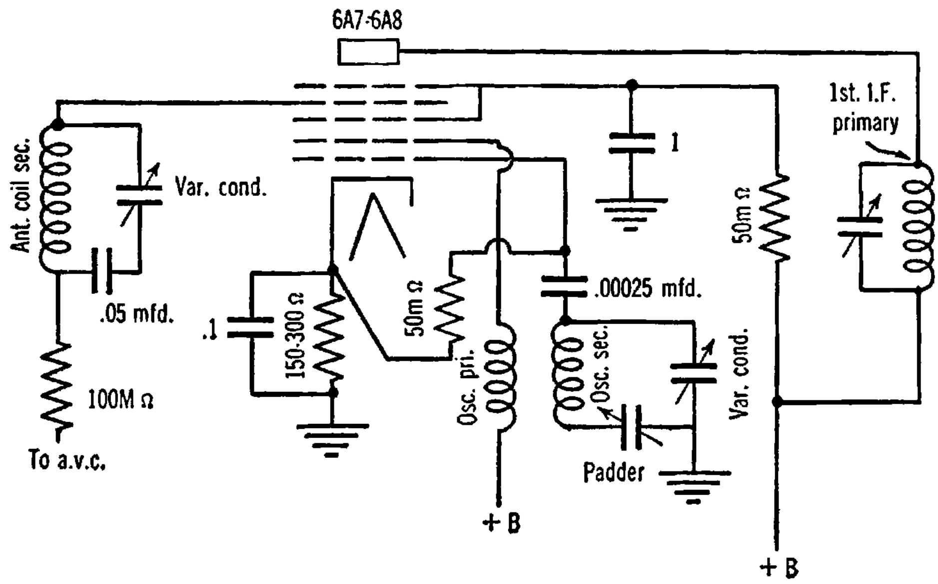
Courtesy Philco

stituting tubes as suggested above. If this does not help, and if no difficulty is evident, try reducing the value of the cathode resistor. This resistor is normally about 15,000 ohms, and under ordinary conditions the circuit should operate well with this value, but after a long period of service, changes in the tube constants, or other variations, may result in the tube working well as a mixer but not as an oscillator. The tube may not oscillate at all or may fail to oscillate at the low frequency end of the tuning range. The resistance value may be lowered to 7000 ohms if necessary.

Another mixer-oscillator circuit similar to those just discussed, but using a pentode tube instead of a tetrode, is illustrated at "C." This circuit is subject to the same difficulties as those using the tetrode.

A great variety of circuits using a triode as a separate oscillator tube have been employed, and it would be quite impossible to take up all of them. A typical example is given at "D." The tube used in this circuit was generally a 27, 56, 37 or 76. Feeding of the local oscillator signal into the mixer circuit is accomplished by means of the coupling coil in series with the mixer grid coil.

JOB SHEET NO. 11



AIM: To learn how to locate trouble in a converter stage.

THEORY: You will recall that in signal tracing the detector-audio stage we tested the audio portion and the detector section as separate circuits. In testing the converter circuit, you will follow the same procedure, because this stage is really two separate circuits—oscillator and mixer.

PROCEDURE:

If Trouble is in Mixer Circuit.

1. We shall assume that by means of signal tracing you have isolated the trouble in the mixer part of the circuit. Measure the voltage from plate to ground. If you do not get a plate voltage reading, look for an open i.f. primary or a broken lead in the plate circuit.

2. If the plate voltage is normal, check the screen voltage. No screen voltage may be due to (a) open screen dropping resistor (50,000), (b) broken screen lead, (c) shorted screen bypass condenser. First, turn the set off and check for continuity in the screen circuit with an ohmmeter. If there are no breaks in the circuit, disconnect one end of the bypass condenser, turn the set on again and recheck for screen voltage. If it is now normal, the bypass condenser is shorted.

3. When both plate and screen voltages are found to be normal, measure cathode voltage. No voltage may be due to a shorted bypass condenser, which can easily be verified by removing one of the condenser leads and rechecking voltage. High voltage might be caused by an open cathode circuit, perhaps an open resistor.

4. Now proceed to check the grid circuit. The best way to do this is to check continuity of the antenna coil secondary, the 100,000-ohm resistor, and back to the point where AVC voltage is supplied. Also check for shorted variable condenser.

If Trouble is in Oscillator Circuit.

If your signal tracing shows that the mixer part of the circuit is functioning and that the trouble appears to be in the oscillator, you should first substitute a signal from the generator for the normal oscillator signal. If the set then works, the trouble is definitely in the oscillator circuit. Then make the following tests:

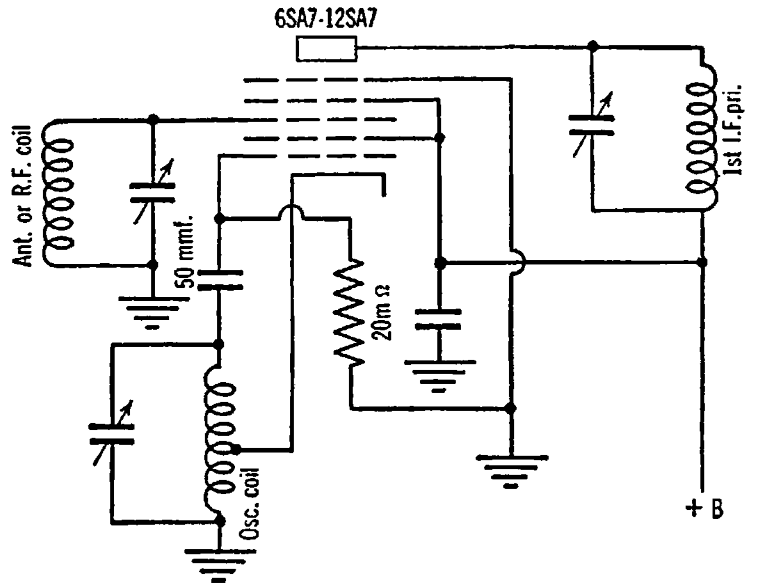
1. Check for voltage on grid No. 2. No voltage at this point may be due to open oscillator coil primary or to a break in the wiring.

2. Check continuity and resistance of the grid No. 1 circuit. This test should include the oscillator coil secondary, the 0.00025-mmf. condenser, the padder, the variable condenser and the 50,000-ohm resistor. The usual troubles here are open coil winding, broken connection or shorted condenser.

Voltage values for this stage are as follows:

	A.C. SETS	A.C.-D.C. SETS
Plate	200 to 250	75 to 100
Screen	75 to 125	40 to 50
Anode grid (No. 2)	100 to 150	75 to 100
Control grid (No. 4)	−1 to −2	−1 to −2

JOB SHEET NO. 12



AIM: To learn how to locate trouble in a single-ended pentagrid converter circuit.

PROCEDURE: Determine whether the mixer circuit is working by applying a modulated i.f. signal to the input grid (No. 3). If this signal comes through, the mixer is probably in operating condition and the oscillator circuit is at fault. If the signal is not heard, look for trouble in the mixer section of the circuit.

1. Check plate voltage. If it is not normal, check continuity of the plate circuit. Trouble may be due to an open i.f. primary winding.

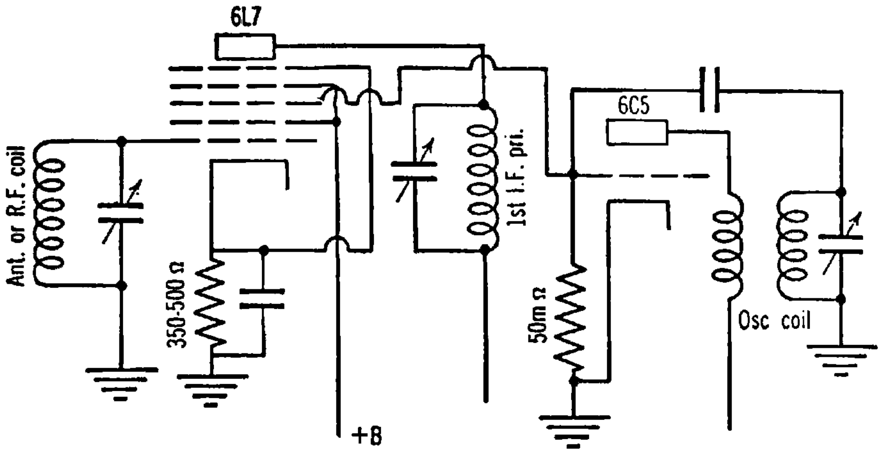
2. If you find plate voltage is normal, measure screen voltage. Lack of screen voltage may be caused by an open circuit or by a shorted screen bypass condenser.

3. If both plate and screen voltages are normal, check cathode circuit. This should be done with an ohmmeter. Note that the oscillator coil winding provides a circuit from cathode to ground. An open coil at this point will result in failure of both oscillator and mixer circuits.

4. If you have found no trouble in cathode, screen or plate circuits, check input grid circuit continuity. An open circuit reading from grid No. 3 to ground indicates an open r.f. or antenna coil secondary, depending upon whether or nor an r.f. stage is used. A short-circuit reading may be due to a shorted variable condenser.

5. If the trouble appears to be in the oscillator circuit, check continuity from cathode to ground and from cathode to stator of the oscillator tuning condenser. Check across oscillator coil winding for possibility of shorted variable condenser. Check oscillator grid resistance value. Substitute new condenser for the oscillator grid blocking condenser.

JOB SHEET NO. 13



AIM: To learn how to locate trouble in an oscillator-mixer circuit using a separate oscillator tube.

PROCEDURE: Determine whether oscillator or mixer circuits are at fault by means of signal tracing. If a modulated i.f. signal applied to input grid of mixer can be heard, mixer is working. Oscillator may be checked by applying correct unmodulated frequency to grid No. 3 of mixer, with set tuned to a station. If station signal is then heard, oscillator is at fault.

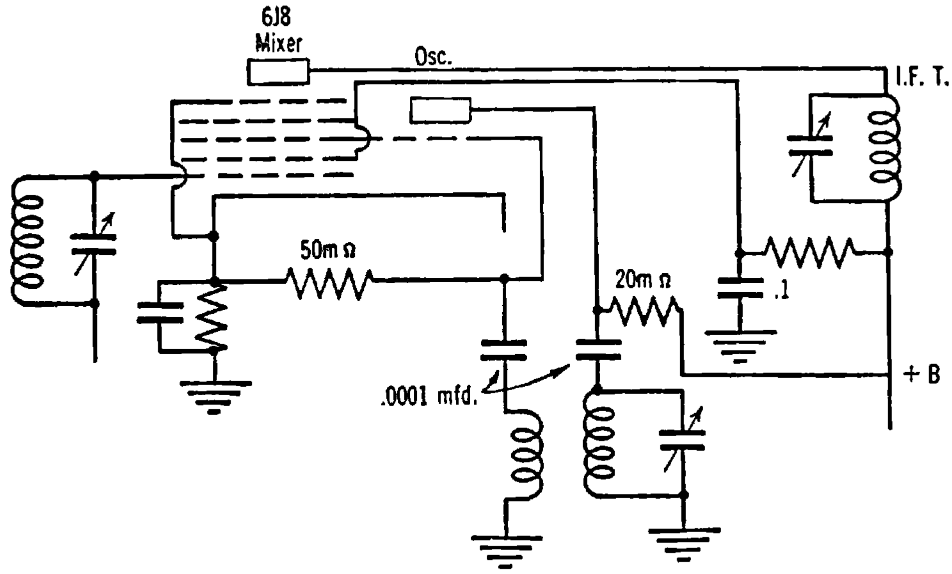
To Check Mixer Circuit.

1. Measure plate voltage. If none is present, check at *B* plus end of first i.f. primary. If voltage is found here, coil is open.
2. If plate voltage is normal, check screen voltage. Lack of screen voltage may be caused by open screen circuit or shorted screen bypass condenser.
3. After checking plate and screen voltages, and finding them normal, measure cathode voltage. No voltage may be due to shorted bypass condenser. Abnormally high voltage may be the result of an open cathode resistor.
4. If all voltages thus far are normal, check voltage from cathode to signal input grid No. 1. Look for open coil secondary or shorted variable condenser.
5. Check continuity from grid No. 3 of the mixer through the oscillator grid resistor to ground.

To Check Oscillator Circuit.

1. Measure plate voltage. If none is found, look for open oscillator plate coil.
2. If plate voltage is normal, check continuity of grid circuit. Look for open grid winding or shorted variable condenser.
3. Substitute new condenser for grid blocking condenser.

JOB SHEET NO. 14



AIM: To learn how to locate trouble in a converter stage using a 6J8 tube.

THEORY: The 6J8 is a triode-heptode converter. The mixer section has five grids and is similar to the 6L7. The oscillator section consists of the cathode, which is common to both sections of the tube, a grid and a plate. Coupling between oscillator and mixer is provided by means of a direct connection inside the tube, between the oscillator grid and the injector grid of the mixer, grid No. 3.

PROCEDURE:

If Neither Oscillator Nor Mixer is Functioning.

1. Test the tube.

2. Check the cathode circuit, looking for open resistor or shorted bypass condenser.

3. Check for voltage at the *B* plus terminal. All plate and screen voltages may be lacking, due to an open in the *B* plus lead.

If Oscillator is Functioning, but Mixer is Not.

1. Measure plate voltage of heptode section. No voltage here may be due to an open i.f. primary winding.

2. Check heptode screen voltage. No screen voltage may be caused by an open screen dropping resistor. Low or no screen voltage may also be due to leaky or shorted screen bypass condenser.

3. If all voltages on heptode elements seem to be normal, check for an open input coil secondary, or a shorted variable condenser.

If Mixer Section is Functioning, but Oscillator is Not.

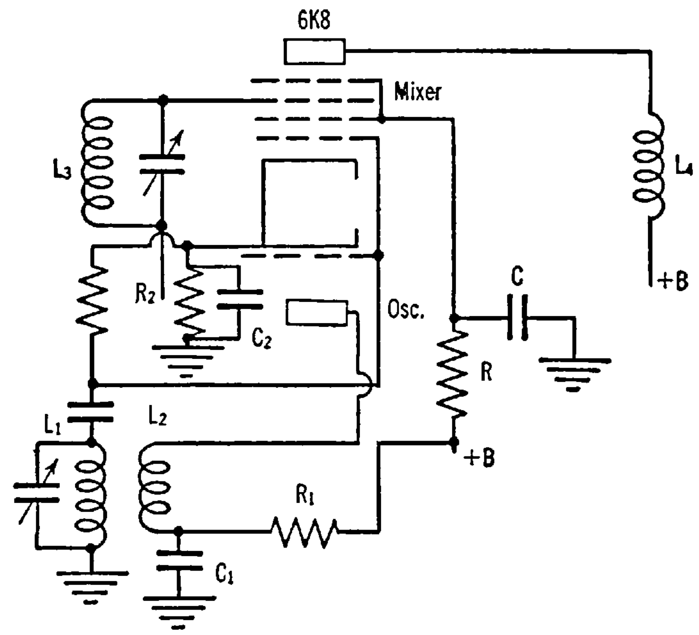
1. Measure oscillator plate voltage. Lack of voltage may be caused by an open oscillator plate resistor.

2. If plate voltage is normal, check windings of oscillator coil for open or short.

3. If voltages are normal, and there appears to be no trouble in the oscillator coil, check the oscillator grid leak.

4. Try substituting new condensers for the 0.0001-mfd. plate and grid condensers.

JOB SHEET NO. 15



AIM: To learn how to locate trouble in a converter stage using a 6K8 tube.

THEORY: The 6K8 tube is a converter consisting of a mixer section using a cathode, four grids and a plate. The oscillator section of the tube uses a separate triode plate, a grid and a cathode which is common with the cathode of the hexode or mixer section. Note that the oscillator grid is connected inside the tube to the No. 1 grid of the mixer. This type of converter gives maximum preformance on both high and low frequencies, and is therefore widely used in broadcast and short-wave receivers, as well as in F.M.–A.M. sets.

PROCEDURE:

Checking Oscillator Circuit.

1. Measure voltage from oscillator plate to cathode. If no voltage appears at this point, check continuity of oscillator plate winding L_2 and resistor R_1. Voltage may be supplied from a divider, and if this is the case, check divider resistor. Check bypass condenser C_1 for short. This may be done by disconnecting one side of condenser and again measuring voltage. If it is normal with condenser disconnected, condenser is shorted.

2. If oscillator plate voltage is normal and you are sure that trouble is in oscillator portion of circuit, check for open oscillator grid coil or shorted oscillator section of variable condenser. Do not neglect possibility of shorted trimmer.

Checking Mixer Section.

1. Measure voltage from plate of hexode to cathode. If there is no voltage at the plate, look for open i.f. primary winding, L_4. If primary is not open, check for open cathode resistor. In this case, of course, both oscillator and mixer will be inoperative. In checking plate voltage of mixer, it is possible that a bypass condenser is connected from bottom end of i.f. primary winding to ground or B minus. If one is used, check it for a short as previously described.

2. If you find that plate voltage is normal, measure screen voltage. No screen voltage may be due to either open screen resistor, R, or shorted bypass condenser C.

3. If plate and screen voltages are normal, check grid circuit of mixer. Input coil L_3 or variable condenser across it may be at fault.

Recommended voltages for this type of converter are as follows:

	A.C. SETS	A.C.-D.C. SETS
Oscillator plate voltage	100	100
Mixer Plate Voltage	250	100
Mixer Screen Voltage	100	100
Mixer Control Grid Voltage	−3	−3

Questions

1. What arrangement of mixer-oscillator circuits was used in early superheterodyne receivers?

2. What advantages are gained by using a single-ended converter tube?

3. In order to simplify trouble locating in the mixer-oscillator stage, how should this stage be considered?

4. If you suspect failure of the oscillator circuit, what is the best method of verifying your conclusions?

5. What type of signal should be used in making the test indicated in Question 4?

6. Name three causes for failure of the oscillator circuit to function.

7. What would probably be the effect of an open coil winding in the mixer input circuit?

8. How would you repair an open oscillator coil winding in an emergency?

9. What effect may reversal of the oscillator coil leads produce?

10. What would be the effect of an open oscillator grid condenser?

11. What is the easiest method of locating the trouble mentioned in Question 10?

12. What trouble sometimes develops in older sets having a mica condenser shunted across the low-frequency padder?

13. Name several causes for lack of voltage at the plate of the converter tube?

14. How would an open screen dropping resistor be indicated by voltage measurement?

15. You are testing a receiver using a separate oscillator tube. Substituting a signal for the oscillator signal proves that the oscillator is not working. All voltages and resistance measurements are normal. What trouble would you look for?

16. What symptom would develop as the result of an open oscillator plate winding in a set using a separate oscillator tube?

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Mye Technical Manual, P. R. Mallory & Co., Inc.; pp. 21–46.

Receiving Tube Manual, RCA. Mfg. Corp.; pp. 32–34.

Hicks, Principles and Practice of Radio Servicing, McGraw-Hill Book Co.; pp. 230–233.

Henney, Radio Engineering Handbook, McGraw-Hill Book Co.; pp. 433–434.

Hoag, Basic Radio, D. Van Nostrand Co., Inc.; pp. 90–93 and 261–262.

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4

THE I.F. AMPLIFIER

The i.f. amplifier may be regarded as an r.f. amplifier with three special characteristics. These characteristics are: (a) the tuned circuits are not variable over a wide range as in an r.f. amplifier, but are intended to operate at one fixed frequency. This frequency is determined when the set is designed, and may not be changed; (b) this operating frequency, in the average receiver, is considerably below the frequencies used in the ordinary broadcast range; and (c) usually both the grid and plate circuits of the amplifier are tuned.

Aside from these special characteristics, an i.f. amplifier is quite similar to an r.f. amplifier and, as such, is subject to the same general types of troubles that appear in r.f. amplifiers. As in r.f. amplifiers, some of the troubles that show up are somewhat more difficult to find than those that occur in audio amplifiers, because of the higher frequencies involved and the consequent probability of losses and unwanted coupling appearing.

Although the job sheet which accompanies this chapter describes and illustrates the trouble-shooting procedure for a stage using a pentode tube, the operations are essentially the same in the event that a tetrode is employed. It is realized that there are still in service a few old sets using triode tubes, but these represent a small minority and are rapidly disappearing.

Since about 1930 most superheterodynes have used tetrodes or pentodes for all stages, with the possible exception of the oscillator. This is fully covered in the chapter dealing with mixers and oscillators.

Aside from the type of tube used, the most important change that has occurred in the i.f. amplifier from the introduction of the superheterodyne to the present time has been the intermediate frequency used. It is well to understand some of the reasons for this change.

One of the factors which led to the development of the superheterodyne, among many others, was the difficulty of preventing the r.f. amplifier stages from oscillating in a TRF receiver. Remember that in those early days, only triode tubes were available, and some method of neutralizing the high inter-electrode capacity of such tubes had to be used. It was recognized that the tendency of a tube to oscillate was greater as the frequency was increased; therefore, lowering the frequency to a point far below the broadcast range seemed to be the logical answer. The result was that the early superheterodynes used an intermediate frequency in the neighborhood of 50 k.c.

During the years that followed, comparatively few superheterodynes were manufactured; in fact, volume production was not attained until about 1930. The sets produced at that time used a higher frequency, about 175 k.c., for it had been found that the lower frequency gave rise to serious interference problems. The higher intermediate frequency was made possible by the introduction of the screen grid tube with its lower grid-to-plate capacity and consequent reduced tendency toward oscillation. Although 175 k.c. was in general use at that time, a few sets used frequencies in the neighborhood of 260 k.c. These frequencies prevailed until 1934 or thereabouts, when the development of multi-band receivers led to the use of the frequencies now employed, from 450 to 480 k.c.

With the number of older sets in service rapidly becoming fewer, it is quite likely that the major part of your work will be concerned with sets using frequencies of 450 to 480 k.c. When working on a newer set, however, do not make the mistake of assuming that any frequency within this range may be used for alignment or testing. Too many service men make this mistake, and align all sets at 456 k.c. because this one happens to be in wider use than others. The result is that the performance of the receiver is not up to the maximum that it is capable of delivering. It must be emphasized that if the intermediate frequency is not stated on a chassis label or at some other place on the set, you should make every effort to get reliable information regarding the frequency in use. This may be obtained from the manufacturer's service bulletins, the Rider Manuals or the Mallory-Yaxley Service Encyclopedia.

Usual I.F. Amplifier Troubles

Weak Signals. May be caused by improper alignment of the amplifier or not using the intermediate frequency for which the set was designed. Also may be due to defective tube, incorrect voltages applied to tube elements, or defective i.f. transformer. Refer to the job sheet for information on checking voltages. See job sheet included in this chapter for testing of i.f. transformers.

I.F. Amplifier Dead. Look for defective tube, possibility of shorted i.f. trimmer, open cathode resistor, shorted screen bypass condenser. For additional information on locating and correcting shorted i.f. trimmer condensers, see the chapter on second detector.

Oscillation. May be due to open screen bypass condenser; verify by temporarily connecting a 0.1 mfd. condenser in parallel with the original one. Can also be the result of an unshielded tube or wiring, especially grid and plate leads, not properly dressed or routed.

Distortion. This condition may be due to impropeı alignment, excessive bias as a result of cathode resistor changing value or to some defect in the AVC system. If this latter condition is suspected, refer to the discussion of AVC troubles included in the chapter on the second detector.

Remedies for the Above Troubles

Improper Alignment. Align the receiver in accordance with the manufacturer's specifications. If you do not have the service bulletin, look up the correct intermediate frequency in the Mallory-Yaxley Manual. Do not assume a frequency, as some service men do, or attempt to find the frequency by connecting a generator to the set and varying the generator frequency until you hear a signal. In either case you may be wrong. In the latter case someone may have adjusted the set to the wrong intermediate frequency. However, if you are stuck, and the set must go out and there is no other way of finding the correct frequency, you might do some guessing, but don't forget that you are taking a chance.

If you do guess, check the set carefully to see that it has normal sensitivity before returning it to the customer. In making such guesses, keep in mind that most sets using 24 or 35 type tubes as r.f. and i.f. amplifiers employ 175 k.c., a few 260 k.c. Most sets using 6.3-volt tubes and having short-wave bands use about 455 k.c. Again, remember that this information is given with a word of warning—avoid guessing.

Incorrect Voltages. Locate the cause of the incorrect voltages as directed on the job sheet.

Defective I.F. Transformer. Replace the transformer. Refer to the information below regarding replacing coil and removing shields where necessary. In an emergency, repair the coil as noted below.

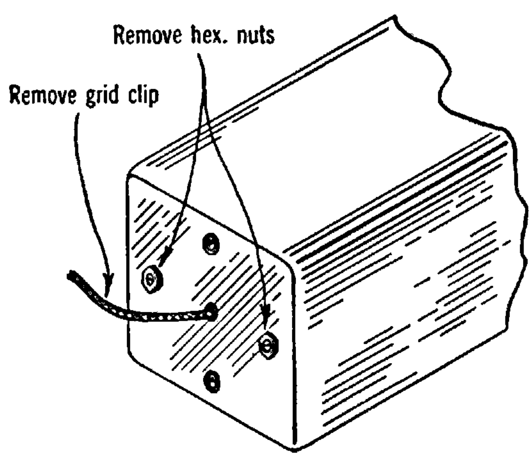
Shorted I.F. Trimmer. Try to clear the trouble by working the trimmer screw back and forth. If necessary, remove coil and replace mica in trimmer.

Open Cathode Resistor. Replace the resistor with one of correct value.

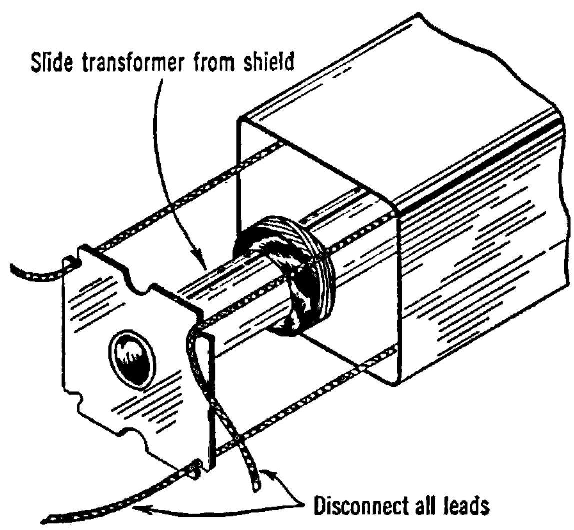
Shorted Screen Bypass Condenser. Replace the condenser with one of correct capacity and working voltage. Do not cut corners by connecting bypass condenser from any convenient point on the *B* plus supply line to the screen. Connect it directly to the screen terminal. Be sure that you use a good quality condenser. If the working voltage of the new condenser is higher than that of the old one, all the better, provided you can fit it in place.

Open Screen Bypass Condenser. See note above.

Wiring Not Properly Dressed or Routed. Try moving leads with a pencil (not metallic), or an aligning tool. When you think you have found the trouble and have moved the lead or leads causing it, recheck to be sure the i.f. amplifier is still properly aligned. Sometimes changing the positions of leads will disturb alignment so that the amplifier will stop oscillating.



A



B

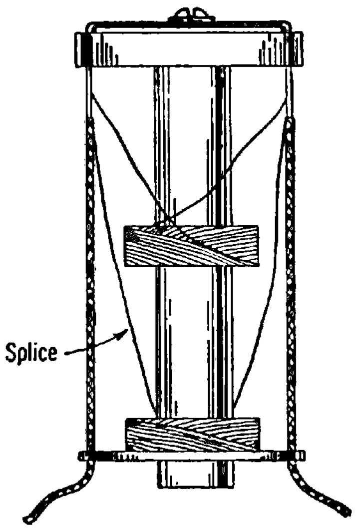
Service Hints on I.F. Transformer Repair and Replacement

All repairs to i.f. transformer coils will entail removing the shield. The drawings at "A" and "B" show clearly how this may be done.

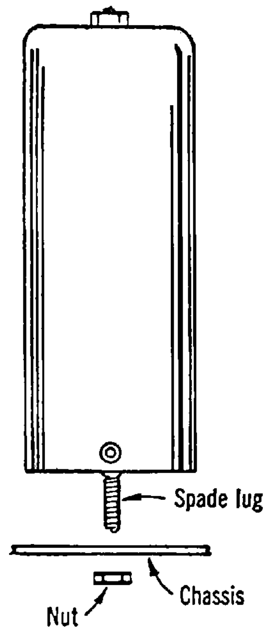
If the coil is open the break may be at the point where the winding is connected to the terminal lug. This can usually be repaired very easily. This type of trouble and the repair required is illustrated in sketch "C."

In making this type of repair, you may find that the broken end of the winding is too short to reach the terminal lug. In this case take a piece of wire from an old coil and splice it to the broken end. If the winding is of stranded wire, be careful to remove the enamel from each of the individual strands. This may be done with a piece of very fine sandpaper, about 6/0. Another way to make repairs when the winding is broken rather short is to remove one turn from the coil, enough so that the wire will now reach to the lug. This will not make any material difference in the performance of the circuit.

If the break is inside the winding and not at the end, one of the following steps will be necessary: (a) start unwinding the coil and trust that the break will not be too far from the outer end; (b) unwind the coil and



C



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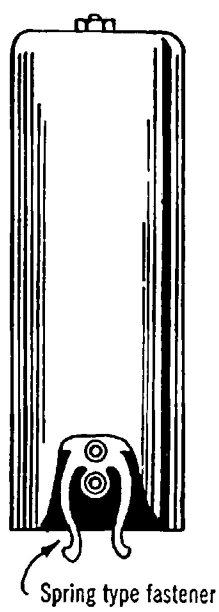


E

Courtesy Philco

rewind completely; (c) replace the coil winding with one taken from a similar transformer, or with a replacement coil made for this purpose; or (d) replace the entire transformer. Rewinding the coil is to be regarded as an emergency procedure only.

If it becomes necessary to replace the transformer, you may or may not have to replace the shield as well. If you purchase a transformer not made by the manufacturer of the set, one that is intended for general replacement purposes, you will usually receive it complete with shield can. Set manufacturer's replacement transformers ordinarily are supplied without the shield; in fact, in some sets the shield is not removable from the chassis. Assuming that you are installing a general replacement transformer, or that the shield can has been damaged, study the drawings at "D" and "E" to familiarize yourself with some of the fastenings used. The common type of shield which is held to the chassis by means of two spade lugs and two hexagon nuts is simple to take off. This shield is illustrated at "D." Some other shields, notably those used in Philco receivers, employ a snap-on type of fastening, and may be most easily removed by using a special type of tool supplied by the manufacturer. This type of fastening is seen at "E."

You will find that some types of transformers appear to be much more complicated in construction than others. One reason for this is that certain manufacturers include resistors and condensers within the shield can. For instance, one model sold by a large mail order house some years ago had the r.f. filter condensers, r.f. filter resistor, diode load resistor and coupling condenser inside the shield. Of course, the practice of including resistors within the shield can is standard in FM receivers. Certain old Majestic models used a combination coil which included an oscillator and i.f. coil in the same shield can.

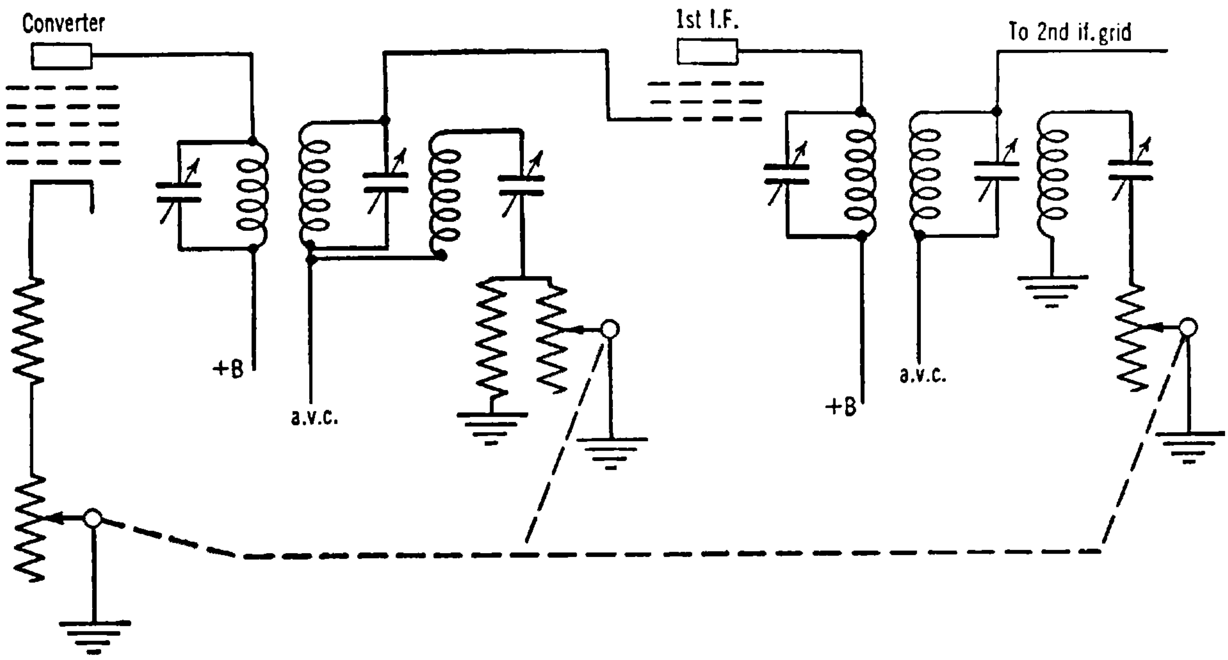
Special I.F. Circuits

Now and then you may find a set which has three i.f. transformers instead of the usual two. Some sets use two i.f. amplifier tubes for additional gain and selectivity, especially in cases where no r.f. amplifier is used. And, of course, most FM receivers use more than two transformers.

In addition to the above, however, there are several other types of sets using three transformers. One such case is a receiver using automatic frequency control. The third transformer is the discriminator transformer. For additional information refer to the section on AFC.

Another type of set using three transformers is the high-fidelity receiver. In the average superheterodyne, the selectivity is far greater than that obtained in the usual TRF circuit. In fact, at times the selectivity may be greater than desirable. You have learned that in receiving broadcast signals the receiver must not only accept a single frequency, but must admit a band of frequencies on either side of the carrier. If the selectivity of the receiver is too great, some of the frequencies may be cut off, and the frequencies eliminated will be the higher ones. You can get somewhat the same effect by deliberately mistuning a set a few kilocycles either side of the carrier frequency. The result will be a serious form of distortion. Much the same thing happens when the selectivity is too high. The higher musical range suffers, the music loses much of its brilliance, and the result is drummy or bassy. This condition is referred to as cutting side bands.

Some years ago, the listening public began to demand better and better fidelity, with the result that many changes in design were made to improve tone. Audio amplifiers and speakers were improved so that the musical range handled was increased. But merely improving the audio system was not enough, because in many cases the loss of higher frequencies occurred in the i.f. amplifier. The logical step was to design an i.f. amplifier with variable selectivity, so that a high degree of selectivity might be used when listening to a weak, distant station with a strong one on an adjacent carrier, but reduced selectivity for use on strong local stations.



F *Courtesy Philco*

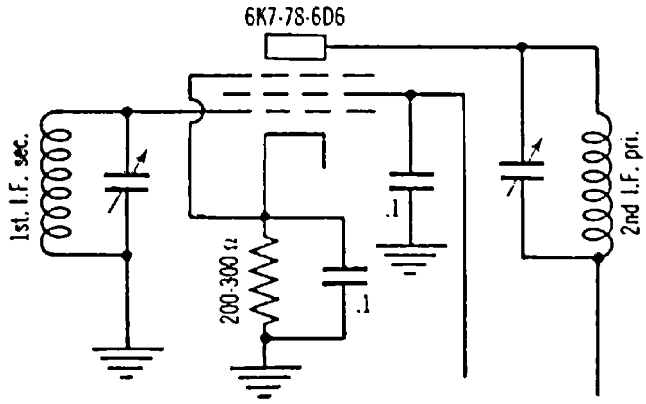
One method of obtaining variable selectivity was the use of i.f. transformers with primaries that could be moved in or out of the secondaries. The primary coils were provided with a cable and pulley arrangement operated by a control knob on the front panel of the set. Such a set used three i.f. transformers, one of which had fixed coupling between the primary and secondary while the other two were variable. With the control in the maximum selectivity position, the primary and secondary coils were moved apart; with the control set for minimum selectivity or high fidelity, the coupling between the two coils was maximum.

Another scheme for attaining the same effect is shown in sketch "F." Here the i.f. transformer has three windings, with a variable resistance connected in parallel with the third winding. With this resistance at minimum value, the selectivity of the transformer is broadened considerably to give high fidelity. Here again, three i.f. transformers were used, with one transformer having fixed or nonadjustable selectivity. The selectivity control consisted of three potentiometers mounted on one shaft so that they could be operated simultaneously. Two of the resistance units were used for controlling the selectivity of the two adjustable i.f. transformers, with the third unit connected as a variable cathode resistance in the converter circuit. This was done to keep the gain of the receiver fairly uniform with changes in selectivity.

The principal troubles that might develop in receivers of this type are poor quality due to improper alignment, failure of the cable control in the variable coupling system, and noise developing in the selectivity-sensitivity control just mentioned.

Alignment of receivers with variable selectivity should be performed with the selectivity control adjusted for maximum selectivity, otherwise the procedure is exactly the same as for other types of sets.

JOB SHEET NO. 16



AIM: To learn how to locate trouble in the i.f. amplifier.

PROCEDURE: 1. Measure voltage from cathode to plate. If there is no voltage at this point, turn set off and check continuity from plate of tube to *B* plus. You may find that the i.f. primary is open.

2. If primary is not open and plate circuit continuity test shows no break in the plate circuit, measure voltage from plate to ground. If voltage is normal on this test, then check cathode voltage. If cathode voltage is abnormally high, turn set off and check continuity of cathode circuit with ohmmeter. You may find that the cathode resistor is open.

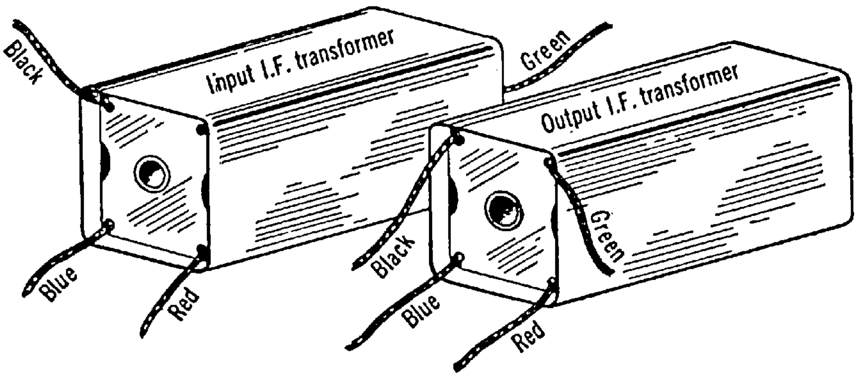
3. If plate voltage was normal on the first test, check screen voltage. If screen voltage is very low, or if there is no voltage at all, look for shorted or leaky screen bypass condenser.

4. If both plate and screen voltages are normal, measure voltage from cathode to ground. If there is no voltage on this test, turn set off and check resistance of cathode circuit. If you get a zero reading from cathode to ground, disconnect one side of the cathode bypass condenser and check continuity again. If the resistance reading is now normal, the bypass condenser is shorted.

5. If all voltages up to this point are normal, check voltage from grid to cathode. No voltage may indicate an open first i.f. secondary.

6. If all voltages are normal and the stage still does not function, look for a shorted trimmer on either the first i.f. secondary or the second i.f. primary. If the set uses AVC, look for trouble in that circuit.

JOB SHEET NO. 17



AIM: To learn how to test i.f. transformers.

THEORY: I.f. transformers are of two types—input and output. The input transformer is connected from the converter tube to the i.f. amplifier tube. The output transformer is connected between the i.f. amplifier tube and the detector tube. When tubes with top grid caps are used, the input transformer may be identified by the fact that one lead is brought out through the top of the shield can instead of through the lower end. The output transformer has all four leads coming out at the lower end.

PROCEDURE: 1. If the transformers have standard color coding, you will find that the leads are colored red, blue, green and black. Red is *B* plus, blue is plate, black is ground or AVC, and green is grid. In other words, inside the shield can are two separate windings, each tuned by a small condenser. These two windings are the primary and the secondary. The ends of the primary are the red and the blue leads, and the ends of the secondary are the black and the green. In some output transformers the diode plate lead (which corresponds to the grid) and the ground lead may be colored differently.

2. With a low-reading ohmmeter, measure the resistance from the red to the blue lead. The normal reading can best be taken from the manufacturer's specifications. If these are not available, you may accept from 7 to 35 ohms as average. If you get a reading of zero ohms, the trimmer condenser is probably shorted. If you get an open-circuit reading, the winding is open.

3. Repeat the above test for the black and green leads. The reading should be about the same. In some transformers, however, there are slight differences between the two windings.

4. Repeat the two tests for the output transformer.

Questions

1. In what two important respects does an i.f. amplifier differ from a tuned r.f. amplifier?

2. What intermediate frequency was commonly used in very early superheterodynes?

3. What intermediate frequency was commonly used in superheterodynes in the period around 1930?

4. What range of intermediate frequencies is used in most superheterodynes today?

5. What trouble may develop as the result of tuning the i.f. transformers to a frequency somewhat higher or lower than the frequency for which they were designed?

6. What defects might be responsible for weak signals in an i.f. amplifier?

7. What symptom might be caused by a shorted i.f. screen bypass condenser?

8. How would the operation of a receiver be affected by an open i.f. screen bypass condenser?

9. Name several causes for distortion arising in the i.f. amplifier.

10. What effect may be produced by excessive selectivity in an i.f. amplifier?

11. What special design features are used to overcome the effects of excessive selectivity in an i.f. amplifier?

12. Describe two methods of obtaining variable selectivity in an i.f. amplifier.

13. In i.f. amplifiers employing variable selectivity, how should the selectivity control be adjusted when aligning the amplifier?

14. Name several troubles that might occur in an amplifier using variable selectivity.

15. Name two types of i.f. transformer in general use.

16. Generally speaking, how may an input i.f. transformer be identified?

17. What is the color code generally used for i.f. transformer leads?

18. An i.f. transformer primary winding shows a resistance reading of less than 1 ohm. What is wrong with the winding?

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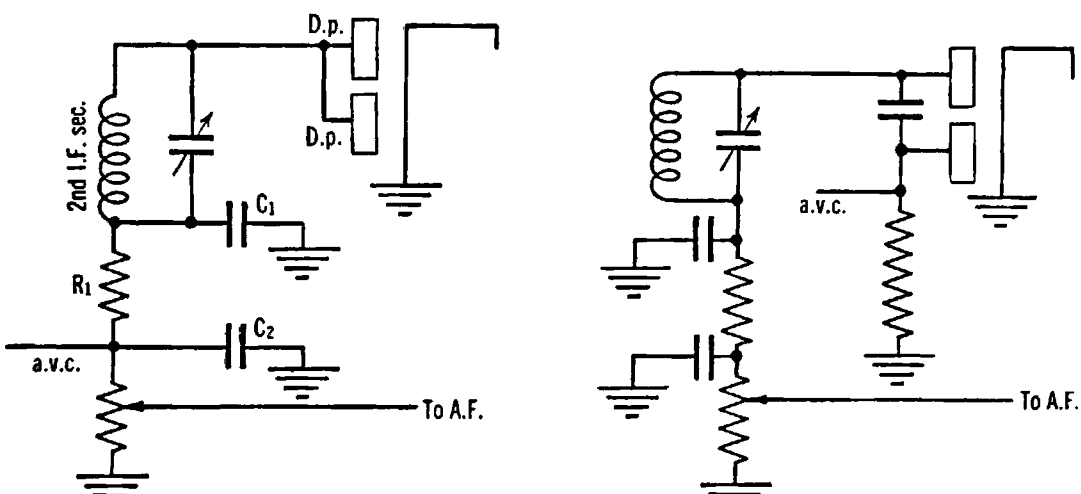
5

THE DETECTOR AND AVC CIRCUITS

The Detector

Two types of detectors are in general use at the present time—the pentode, which is usually found in small receivers of the TRF type, and the diode, used in superheterodynes. Except for the fact that most diode detectors supply AVC voltage, and in many cases the functions of detector, first audio and AVC are combined in one tube, the diode is the simplest type of detector. For convenience, we shall consider these



A B

three functions separately. The basic diode detector circuit is shown above at "A."

The tube may be a 6H6, in which case you will probably find that the two plates are connected together, as are the two cathodes. In circuits using the 6Q7 or similar tubes, you will likewise find that in most cases the two plates are connected together, although there are a few sets in which one diode plate performs the detector function and the other is used to supply AVC voltage. This type of circuit is illustrated at "B".

Considering the diode detector only, and for the time omitting the AVC circuit, let us take up some of the troubles that may develop.

No Signals. This complaint might be due to any one of the following causes: defective tube; open i.f. transformer secondary; shorted i.f. trimmer; open r.f. filter resistor; open volume control, or a shorted r.f. filter condenser. The r.f. filter condenser referred to is one of the two small capacitors connected from the top and bottom ends of the r.f. filter resistor, R_1 in the diagram at "A." The condensers are shown at C_1 and C_2.

At this point it may be well to call your attention to a service procedure which may aid you in diagnosing trouble in detector and AVC circuits. It is often difficult to decide whether trouble exists in the detector, the AVC circuit, or in the r.f. or i.f. stage. This is especially true in certain cases of distortion and overloading. Some receivers use one tube for detection and a separate tube for the AVC function. When this is the case, the AVC tube may be removed and the action of the receiver observed without AVC. Remember, however, that if each stage is equipped with an individual filter circuit, which is generally the case, the possibility of trouble in the filter components has not been eliminated by removing the AVC tube.

If a duo-diode or similar type tube is used as combined detector, AVC rectifier and first audio stage, it will obviously be impossible to follow the procedure outlined above. General practice in such cases is to substitute a fixed voltage for the AVC voltage. This may be supplied by a battery. The main AVC lead may be disconnected at the point marked AVC in the sketch at "B," and the battery inserted at that place. The battery voltage must be applied, of course, so that the grids of the controlled tubes are made negative. The voltage of the battery to be used will depend upon the sensitivity of the receiver and may vary from a minimum of perhaps 4.5 volts in a set having very low sensitivity to perhaps 22.5 volts for one with high sensitivity.

The remedies to be applied in order to clear up the troubles just mentioned are as follows:

Defective Tube. There are certain cases in which a detector tube will test "good" on a tube checker of the emission type, but will not operate in the set. As a matter of fact, this applies to other stages as well as the detector, for the emission-type checker is often unreliable. Try substituting a new tube before going further.

Open I.F. Transformer. General information on testing i.f. transformers will be found in a job sheet covering that topic. This job sheet is included in the chapter on i.f. circuits. Also refer to the material on removal and repair of i.f. transformers in that chapter.

Shorted I.F. Trimmer. Try setting the adjusting screw in various positions. Usually the trimmer will short only when the adjustment is rather tight. Sometimes, running the screw up and down a few times will clear up the trouble. If not, remove the coil from its shield and try to locate the cause of the short. It may be due to defective mica or to one of the plates improperly centered and touching the adjusting screw. You may verify this by removing the screw entirely and observing the positions of the plates. If any are off center, restore them to their normal positions.

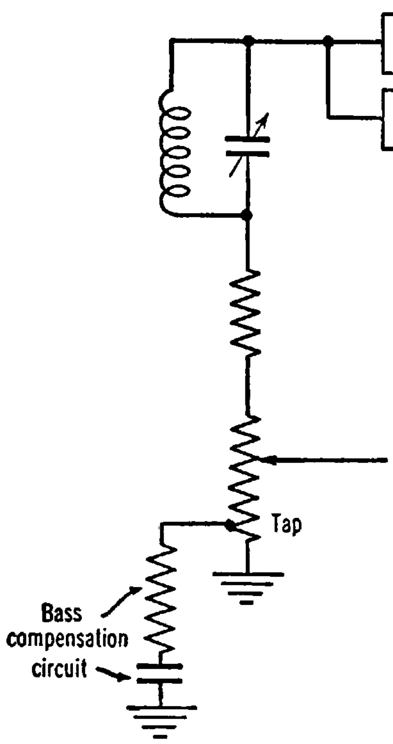
Open R.F. Filter Resistor. This is not a usual trouble. The remedy, of course, is to replace the resistor, generally about 50,000 ohms.

Open Volume Control. Refer to information given under this heading in the section on the audio amplifier. Volume controls have appeared in a wide variety of resistance, taper, physical size, length of shaft, type of mounting, etc. Some controls have an additional connection which is used for bass compensation. This feature is used to compensate for the drop in low-frequency response and the apparent increase in high notes when the volume is reduced. The general idea of this scheme is given in diagram "C." The resistance strip in the control has a tap somewhere in its lower half, usually about one third of the way from the ground end. When the control is adjusted to a point near the lower end, some of the high frequencies are bypassed through the resistor-condenser combination to ground, giving the effect of increased bass. It is well to remember that a defect in the condenser will greatly reduce the volume of the set, and that even if the resistor-condenser combination is in good condition, its removal from the circuit will increase volume considerably.

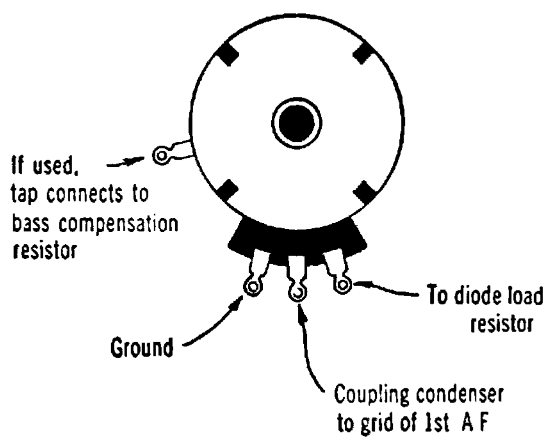
You may experience some confusion when replacing a control, because of the wide variety of types mentioned above. It is suggested that you acquire a copy of the Mallory-Yaxley replacement guide and refer to it whenever replacement is indicated.

Never attempt to remove the nut from a control with pliers. Use a wrench of the proper size, or an adjustable wrench. When disconnecting leads from a control, it is good practice either to make a sketch of the disposition of the wires or to arrange them so that they are in correct positions when the new control is installed. However, since you will probably forget this precaution at some time (experienced service men have been known to forget it repeatedly), the drawing at "D" shows how the average control is wired into a diode circuit.

Shorted R.F. Filter Condenser. Replace the condenser. These are usually mica condensers, and their capacity ranges from 0.0001 to 0.00025 mfd. Their function is to filter the r.f. component from the rectified current. In some circuits, only one condenser is used, from the top end of the diode load resistor to ground. In cases where the customer desires better high-frequency response, it is possible to omit one condenser, or to reduce the values of the condensers. You may experi-



C



D

Courtesy Philco

ment with various values and combinations, to find an arrangement that will keep the circuit from oscillating and yet will not cut off too much of the high-frequency end of the range. Some high-fidelity receivers use only one condenser of 0.0001 mfd. capacity.

Weak Signals. The usual causes are defective tube, i.f. trimmer not properly adjusted, and, possibly, an open secondary, load resistor or volume control. Under some conditions, weak signals will be heard with any one of the three last-mentioned defects. The method of correcting these difficulties is given under "No Signals," above.

I.F. Trimmer Not Properly Adjusted. It is possible for this condition to result in weak signals, or, in fact, no signals at all. However, correct procedure at the time of isolating the trouble to a single stage by means of signal tracing should have eliminated it.

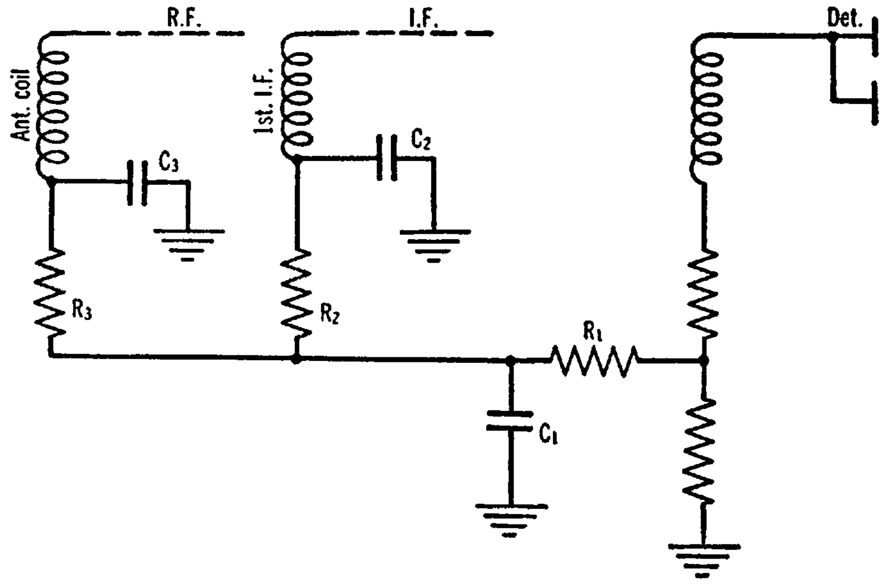
The AVC Circuit

Automatic volume control, referred to as AVC, is a method of automatically bringing all signals, regardless of intensity, to a uniform level. The rectified current delivered by the detector depends upon the strength of signal present in the secondary of the last i.f. transformer. When this signal is strong, the rectified current is large, and as the signal becomes weaker the amount of rectified current decreases. This rectified current passes through the diode load resistor and the volume control (or a resistor substituted for the control in cases where the d.c. is to be kept out of the control). In passing through the control, a voltage is developed across the control's terminals, and the amount of voltage depends upon the intensity of the rectified current and, consequently, upon the signal strength. The direction of current flow is such that the top end of the control is negative compared to ground.

This variable voltage is then applied to one or more tubes (r.f., i.f. or converter, or all three) as a bias. Let us say that the receiver is tuned to a given station. In passing to another, stronger station, without AVC we would encounter a sudden, annoying increase in volume. But with AVC the increase in signal strength results in increased rectified current in the diode circuit with a resulting rise in the negative voltage applied to the grids of the controlled tubes. This increase in bias reduces the gain of the controlled tube or tubes, and so results in a decrease in volume. This should all take place rapidly enough so that no appreciable increase in volume occurs when the new station is tuned in.

You will see that the AVC action, so far, takes place in the diode circuit, and up to this point no additional circuit complications are involved. When using AVC in an actual circuit however, several other things must be considered. First, the rectified current actually consists of several components, a.c. and d.c. The a.c. varies at an audio rate, and if this voltage were to be applied to the grids of the controlled tubes, the gain of the tubes would vary at the same rate as the original audio signal, and that signal would be obliterated. Second, since the AVC voltage is to be applied to several tubes, the resulting common circuits might cause feed-back. Last, it is sometimes desirable to operate one tube with higher or lower AVC voltage than that impressed on the other tube or tubes.

These factors lead to the use of the AVC distribution and filter circuit, commonly called the AVC network. The diagram at "E" illustrates such a circuit, in which two tubes are controlled—the r.f. and the i.f. Nonessential portions of the circuit have been eliminated for the sake of simplicity. You will see that there is no reason for the mystery some service men attach to AVC circuits.



E

The function of R_1 and C_1 is to eliminate the audio component of the rectified voltage. R_2, C_2 and R_3, C_3 act as additional filters and in addition, resistors R_2 and R_3 act as decoupling resistors to prevent interaction between the controlled circuits. Still another function of R_2 and R_3 is that of a voltage divider to distribute the proper amount of voltage to each stage.

Troubles in AVC Circuits

Overloading and Distortion. Generally due to a leaky AVC filter condenser. The best procedure is to substitute a good condenser for the suspected one, while one terminal of the old condenser is disconnected.

Motorboating and Oscillation. Open AVC filter condenser. Try connecting a good condenser across the suspected one, before replacing. Values of these condensers are usually critical.

AVC Slow in Operating. In other words, the volume is not reduced or increased until an appreciable period after tuning in a station. May be caused by AVC filter condenser or resistor having changed value.

The Pentode Detector

This type of detector is found in small sets of the a.c.-d.c. TRF variety, and is also used to some extent in a.c. TRF receivers. The tube employed is a 6J7, 77 or equivalent. The conventional circuit and test procedure is given in the job sheet.

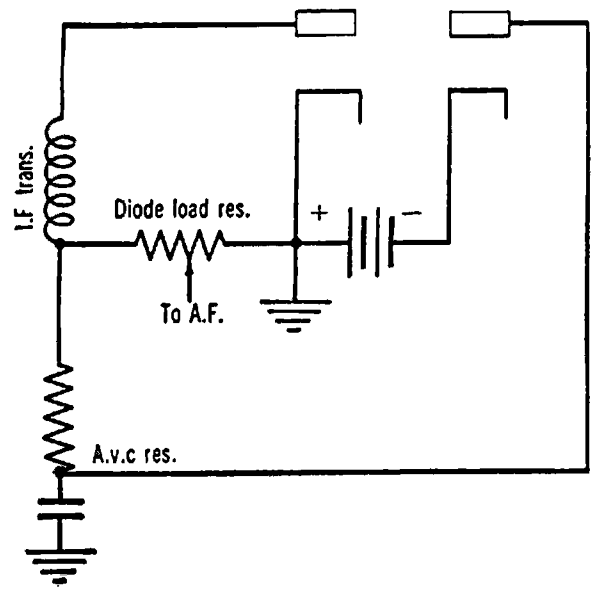
Troubles in the Pentode Detector

No Signals. Look for open cathode resistor, shorted screen bypass condenser, open r.f. coil secondary, shorted tuning condenser, open plate resistor or open screen resistor. None of these defects requires further comment, as they have been fully covered in other sections of this book.

Weak Signals, Distortion. Wrong value of plate, screen or cathode resistor. Shorted cathode bypass condenser.

Delayed AVC

While it is true that AVC does accomplish the desired effect of maintaining nearly constant volume regardless of signal strength, it is also true that it produces one undesirable effect. This is the tendency to reduce the gain of the receiver for weak signals as well as strong ones.



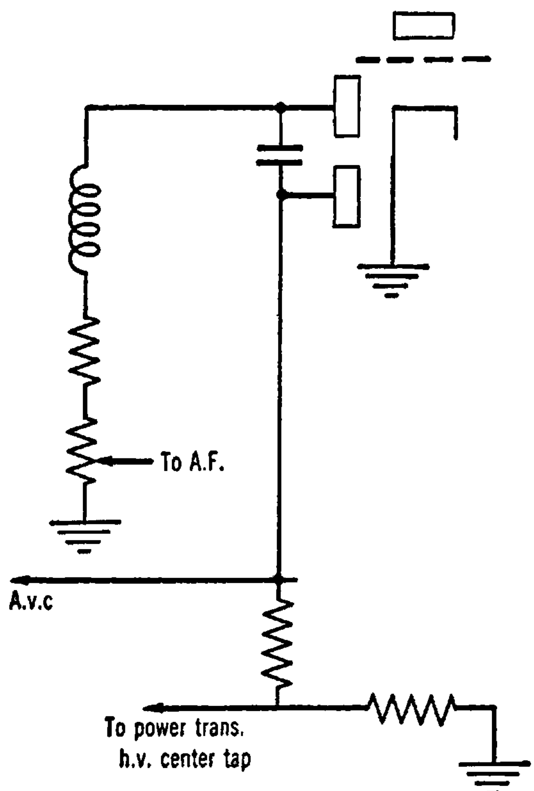
F

Under some conditions, it is more desirable to maintain the sensitivity of the set as high as possible on very weak signals, and in order to accomplish this, the AVC is prevented from functioning until a predetermined value of AVC voltage has been developed, or, in other words, until a signal of predetermined strength has been tuned in.

In the circuit shown at "F," one diode is used as the detector, and is connected in the usual way. The second diode, used as the AVC rectifier, has its cathode at a slight negative potential with respect to its plate.

This negative potential may be supplied by a battery, as indicated in the drawing, but general practice is to obtain it from a tap on a voltage divider, which may be connected between the center tap of the power transformer winding and chassis.

On weak signals, the plate of the AVC diode passes current of a constant value and the AVC resistor is maintained at a constant voltage with respect to ground. When the incoming signal reaches a value greater than that of the negative voltage on the cathode, the plate of the AVC diode becomes negative compared to its cathode, and current no

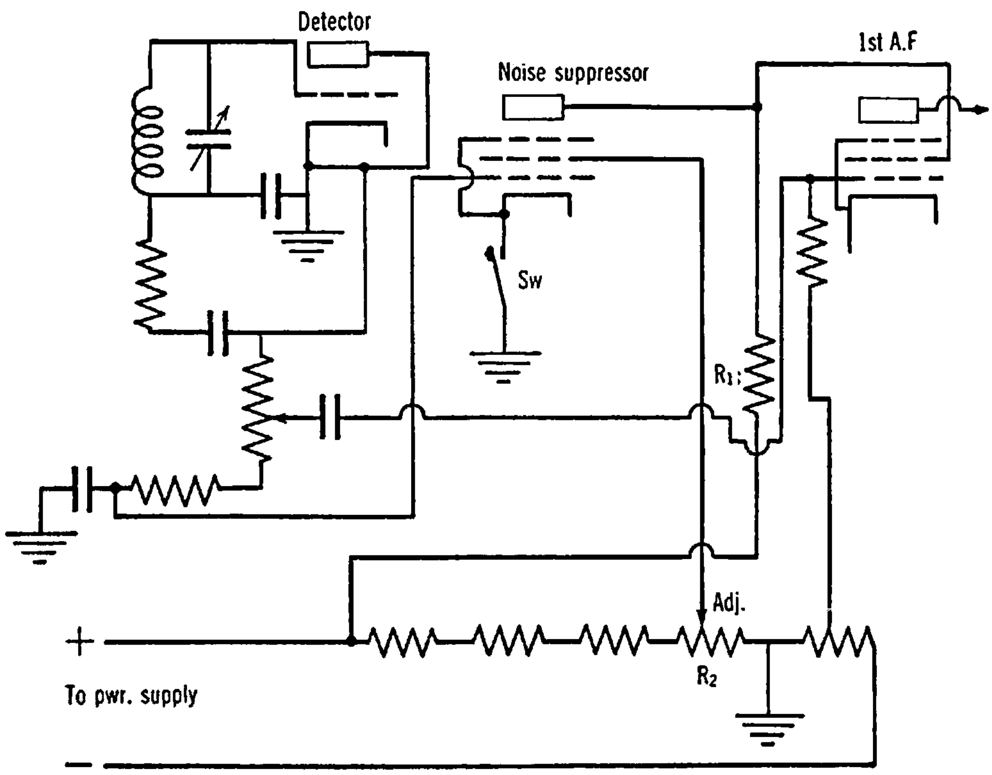


G

longer flows. The current flow in the diode load resistor then controls the voltage applied to the grids of the controlled tubes. In the circuit just described, it will be noted that a double diode tube having two separate cathodes is required. Circuit "G" illustrates a method of getting the same result with a duplex-diode-triode tube, such as the 6Q7 or 6SQ7, having a single cathode.

Noise Suppression Control Circuits

AVC has the additional disadvantage that when no signal is tuned in the r.f. and i.f. tubes are operating at maximum sensitivity and therefore any electrical disturbances present in the vicinity of the set will be heard with maximum volume. The net effect is that when tuning a set using AVC, little or no noise may be heard while a signal is present, but when a point is reached on the dial in between stations, the noise may be terrific. This is obviously undesirable, and in order to overcome it various types of noise suppression circuits have been used. Another name you may hear in connection with such circuits is quiet automatic volume control. You will also hear them referred to as NSC or QAVC.



H

Courtesy Philco

One type of noise suppression circuit is illustrated in circuit diagram "H." The diode detector develops an audio voltage which is taken from the volume control and fed to the grid of the first audio tube. At the same time a portion of this signal is fed to the grid of the noise suppressor tube. With no incoming signal, there is of course no voltage at the grid of the suppressor tube and this tube then draws a high plate current. This plate current flows through resistor R_1, which also supplies the screen of the first audio tube. The high suppressor-tube plate current flowing through R_1 produces such a large voltage drop that no voltage is available for the first audio screen and therefore the first audio tube will not operate. This means then, that with no signals tuned in, the audio amplifier is, in effect, cut off, preventing the reception of noise between stations.

When a signal is tuned in, negative voltage is applied to the grid of the suppressor tube and its plate current is reduced. Reduction of plate current results in a decrease in the voltage drop across resistor R_1 and screen voltage is available for the audio tube, which will now operate normally.

In studying the operation of this circuit, you might compare it to the action of a trap door kept closed by a spring. A small amount of pressure will not open the door, but greater pressure will swing it wide open.

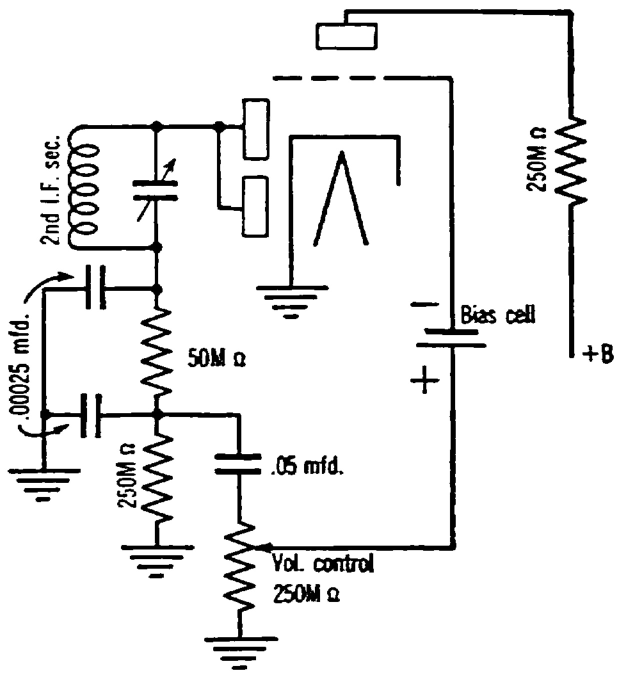
The point at which the suppressor tube will cease operation and thus allow the audio tube to work, is controlled by adjustment of variable resistor R_2. The entire circuit may be taken out of operation by throwing the switch in the cathode of the suppressor tube.

Correct procedure for adjusting the noise suppression circuit must be followed. With the receiver volume control adjusted for moderate volume and the cathode switch open, tune the set to a point between stations, where noise is heard. Close the cathode switch and adjust the variable resistor until the noise disappears. This adjustment will be seen at the rear of the chassis, usually a shaft extending out a half inch or so.

After the adjustment has been completed, tune in a station and note whether reception is clear. If distortion is present, the adjustment has been turned too far. Again tune in between stations and readjust. Continue until no distortion is present. The best way to check is to open and close the cathode switch and note whether there is any difference in reception. There should be no noticeable difference.

A defective suppressor tube will cause serious distortion, regardless of the setting of the variable resistance.

JOB SHEET NO. 18



AIM: To learn how to locate trouble in a diode detector—triode audio stage.

PROCEDURE: To simplify testing in this type of stage, consider the detector as one stage and the audio amplifier as a separate stage. If you find during signal tracing that the audio stage is not operating, proceed as follows:

Testing Audio Stage.

1. Measure plate voltage. If plate voltage is zero, look for an open plate resistor or broken lead from *B* plus to the resistor or from the resistor to the tube socket.

2. Assuming that the plate voltage has been checked and found normal, you are now ready to check the grid circuit. If the stage is biased by means of a bias cell, as shown in the diagram, **do not attempt to measure its voltage with an ordinary voltmeter.** The correct method of measuring the voltage of a bias cell is with a vacuum tube voltmeter. Using an ordinary meter will ruin the cell. If you do not have a vacuum tube voltmeter, substitute a new cell for the old one. If the stage still does not work, check for continuity from the volume control to the bias cell mount, with the cell removed. Also check from the other side of the mount to the grid terminal of the socket. Check for an open volume control. Some sets use cathode biasing instead of a bias cell. In such cases measure the voltage from cathode to ground. If you get no volt-

age, look for a shorted bypass condenser. If voltage is very high, look for an open cathode resistor. If cathode voltage is correct, check grid voltage. If this voltage is not normal, check for open volume control or grounded grid.

Testing the Detector.

When you are satisfied that the audio part of this stage is working and you cannot get a signal through the detector, proceed to test the detector as follows:

1. Test for continuity from the diode plate terminal of the socket to the top end of the 50,000-ohm resistor. If you get a short-circuit reading, the trouble may be due to a shorted i.f. trimmer. An infinity reading across the coil means that it is open.

2. Check the value of the 50,000-ohm resistor with an ohmmeter.

3. Check the value of the 250,000-ohm resistor. **Note**: In some sets you may find that this resistor is the volume control, and that the 250,000-ohm resistor has been omitted. In these cases the coupling condenser will be connected between the volume control and the grid of the triode.

4. With an ohmmeter, check from each end of the 50,000-ohm resistor to ground. You should get a reading of several hundred thousand ohms at each point. If you get a low reading, it is an indication that one of the 0.00025 mmf. condensers is shorted, or that there is a ground at that point.

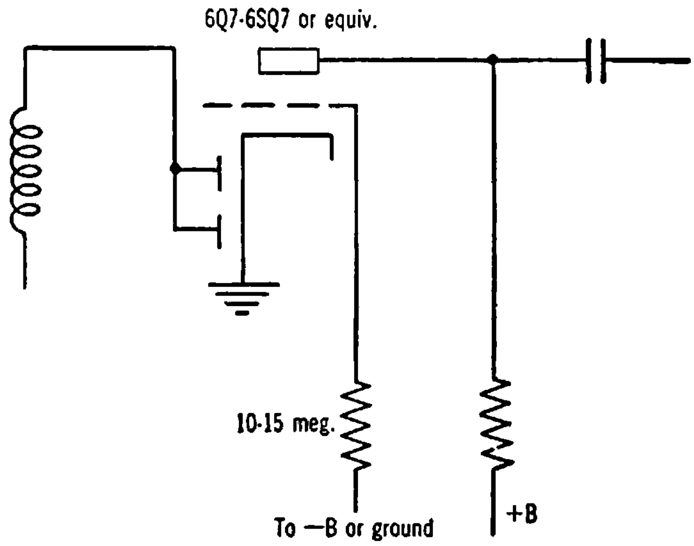
5. Check with an ohmmeter from diode plates to ground. Reading should be several hundred thousand ohms. Low reading indicates a ground.

6. If you still cannot get a signal through the detector, the most likely cause is some trouble in the i.f. transformer, which cannot be detected with an ohmmeter or voltmeter.

Normal voltage readings for the triode portion of the tube are:

Plate	50 to 150
Cathode (when cathode biasing is used)	1 to 3
Grid (when cathode biasing is used)	1 to 3

JOB SHEET NO. 19



AIM: To learn how to locate trouble in a diode detector-first audio stage using a high-value grid resistor.

THEORY: Locating trouble in a stage of the type shown above is similar to the procedure used in checking the stage described in the previous job sheet, using battery bias, except that the cathode is directly grounded and grid voltage will not be measurable by ordinary means. Note that the grid resistor is of a high value (10 to 15 megohms), instead of the usual 1 megohm.

PROCEDURE: 1. Measure plate voltage. No plate voltage may be due to open plate resistor. Low plate voltage may be the result of a leaky or shorted coupling condenser, or loss of bias due to open grid resistor.

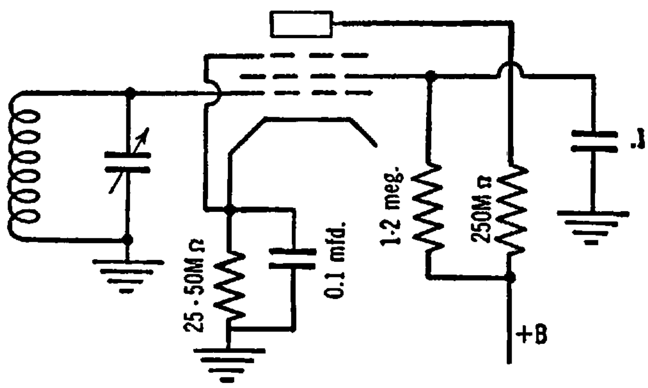
2. Cathode voltage will be zero as cathode is directly grounded.

3. Check continuity of grid circuit with high-reading ohmmeter capable of measuring the high resistance indicated on diagram—up to 15 megohms.

Approximate normal values for this type of circuit are:

Cathode to plate	60 to 150 volts
Cathode to ground	0
Cathode to grid	−1 to −2

JOB SHEET NO. 20



AIM: To learn how to locate trouble in a triple-grid detector—6J7, 77, 6C6, etc.

Assuming that you have found the output stage to be in working condition, since it passes a normal signal from the generator, and that you have also been able to get a signal through the coupling condenser, but that you have tried to get a signal through the detector without success:

PROCEDURE: 1. Measure plate voltage. If none is present, turn set off and check 250,000-ohm plate resistor. An open resistor is a common cause of no plate voltage.

2. If plate voltage seems to be normal, measure screen voltage. No voltage here may be due to two causes, an open screen resistor or a shorted screen bypass condenser. First, turn set off and check the resistor with an ohmmeter. If it is O.K., remove one lead of screen bypass condenser. Turn set on again and recheck screen voltage. Screen voltage should now be normal if the condenser was defective. To verify, replace condenser lead while measuring voltage. Voltage dropping to zero as condenser is connected, definitely indicates a shorted condenser.

3. When plate and screen voltages are found to be normal, measure cathode voltage. No voltage points to a shorted cathode bypass condenser. Check as described above by removing and reconnecting condenser while checking voltage.

4. Excessively high cathode voltage means that the cathode resistor is probably open. A quick way to check this in any circuit using cathode biasing is to first measure plate voltage from plate to ground, then from plate to cathode. High cathode voltage, plus no voltage from plate to cathode is a sure indication of an open cathode resistor.

5. If all voltages thus far are normal, check the grid voltage. Lack of

voltage at this point may be due to an open r.f. coil secondary. Turn the set off and check with a low-reading ohmmeter.

6. If you are unable to get a signal through this stage there are two possibilities left. First, the tuning condenser may be shorted. Of course, mechanical inspection should reveal this, but in some cases it may be difficult to locate. If you have an ohmmeter that will read one ohm or less, just measure the resistance across the combination of coil and condenser. If the condenser is shorted, you will be able to read the difference between the normal resistance of the coil—a few ohms, and the coil with a dead short circuit across it.

The other possibility is some defect in the coil, which will not show up under ordinary resistance test. An instrument such as the Aerovox L–C checker will show this up immediately. Without this type of instrument, the best plan is to substitute another coil and retest the set.

Values indicated in the diagram are average, but may be subject to some variation, due to individual design. One variation of this type of set uses the cathode voltage of the output tube to supply the screen of the detector, eliminating the screen resistor and bypass condenser.

Voltages should be about as follows:

Plate	30 to 60	Screen	15 to 30
Cathode	1 to 5	Grid	1 to 5

Questions

1. Name two types of detectors in general use in superheterodyne receivers.

2. What would be the effect of an open volume control in a diode detector circuit?

3. How would you repair an open i.f. transformer if the break was some distance from the terminal lug of the winding, but was not inside the winding itself?

4. How would you repair the coil if the break was inside the coil and the ends were not visible?

5. What would you do to correct a shorted i.f. trimmer condenser?

6. How does a volume control with a tap for bass compensation work?

7. Which reference manual would be most useful if you had to replace a volume control and did not know the characteristics of the control?

8. What tool would you use to remove a nut from the shaft of a volume control?

9. When replacing a volume control, what would you do to be sure that the leads were replaced on the correct terminals?

10. How does automatic volume control work?

11. What is the purpose of an AVC filter circuit?

12. What defect in an AVC system may cause overloading and distortion?

13. What effect would an open AVC filter condenser have upon the operation of a set?

14. In tuning a receiver you find that the AVC system does not operate immediately, but requires a little time before it takes hold. What might cause this trouble?

15. How would you measure the voltage of a bias cell?

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6

THE AUDIO AMPLIFIER

Audio amplifiers may be divided into two general classes—voltage amplifiers and power amplifiers. The usual arrangement in modern sets is to employ a voltage amplifier followed by one, or perhaps a pair of power amplifiers. The power amplifier is referred to as the output stage. Where two power amplifier tubes are used, it is known as a push-pull stage. The voltage amplifier is referred to as the first audio stage.

We shall start with the output, and consider the troubles that may occur in that stage. Detailed instructions for test procedure are given in the job sheets covering output stages. This procedure describes the method of locating troubles in a beam power output stage, a pentode output stage, a push-pull triode output stage, and a phase invertor.

Troubles Occurring in the Output Stage

No Signals, or Stage Dead. Open output transformer primary (refer to job sheets on speakers); open or shorted coupling condenser; open cathode resistor; defective tube.

In circuits using screen-grid output tubes, you will be able to detect an open output transformer primary readily by the fact that the screen of the tube will glow under this condition. In connection with the cathode resistor, note that in sets employing triode output tubes such as 2A3, 6A3 or 6B4G, you will find that, ordinarily, the bias resistor is connected from the center tap of the heater winding to ground. An open resistor will be indicated by a high voltage from the heater to ground. There are a few sets which use a separate rectifier for bias voltages. In most cases, these sets also have a small fuse in the *B* supply line to the center tap of the output transformer. In the event of failure or removal of the bias rectifier, and the resulting high plate current, the fuse will blow. To prevent removal of the bias rectifier by a layman, the tube is held in its socket by means of a clamp.

Open or Shorted Coupling Condenser. An open condenser will generally result in the stage being inoperative, without other symptoms. A shorted condenser, however, will, in addition, cause the grid voltage to be positive instead of negative. Another indication of this trouble is a voltage reading from grid to ground. For safety, you should always replace a coupling condenser in an a.c. set with one having a voltage rating of 400 to 600 volts. For a.c.-d.c. sets, use a 200- or 400-volt condenser.

Weak Signals. The most common cause is a defective tube. An open grid resistor or a cathode resistor of incorrect value will also result in low gain, although the latter trouble will also give distortion.

Distortion. This is a common trouble in audio amplifiers, and is sometimes difficult to locate. One of the frequent causes is incorrect bias, which in turn may be due to wrong value of cathode resistance, or to a shorted cathode bypass condenser. In a push-pull stage, look for an open half of the input or output transformer. This may readily be verified by removing one of the output tubes and noting any difference in the signal. Then replace the tube and remove the other one. The tube which produces no difference in the operation of the receiver is the inoperative one, and you may suspect that its half of either the input or output transformer is open.

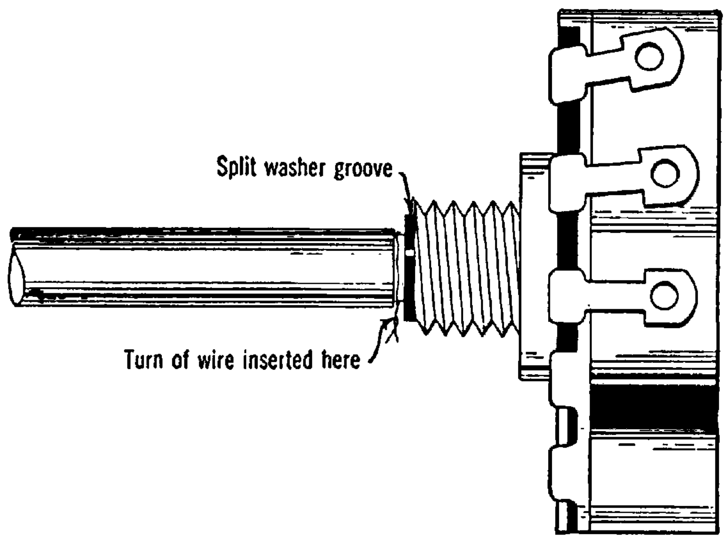
Hum. One of the common causes of hum in an audio amplifier is an open grid. The hum produced by this condition is very loud and characteristic. After you have heard it a few times you will learn to associate it with an open grid. You will find that the defect is an open circuit somewhere between the grid and ground. This open may be in the lead from the grid to the input transformer or grid resistor, an open in the transformer or resistor itself, or an open in the return lead to ground.

The First Audio Stage

Up-to-date receivers may use a high-gain triode such as the 6F5, or the triode section of a double-purpose tube such as a 6Q7 or 6R7 in this position. Less elaborate and cheaper sets may employ a pentode such as 6J7 or equivalent. Job sheets describing and illustrating the test procedure for these circuits will be found in the following pages. In general the troubles which may be found in the first audio stage are the same as those occurring in the output stage, with a few exceptions.

No Signals. Look for the following: open or shorted coupling condenser; open plate resistor; open screen resistor; shorted screen bypass condenser; open cathode resistor; shorted cathode bypass condenser; open grid resistor or volume control.

Where the volume control is used as the grid resistor of the first audio stage, you will often find cases in which the set seems to be dead at certain settings of the control. This is because the rotor of the volume control does not make contact with the resistance material at these points. An added symptom may be noise, as the control is operated. The best remedy, of course, is to replace the control, but there are two methods of



A

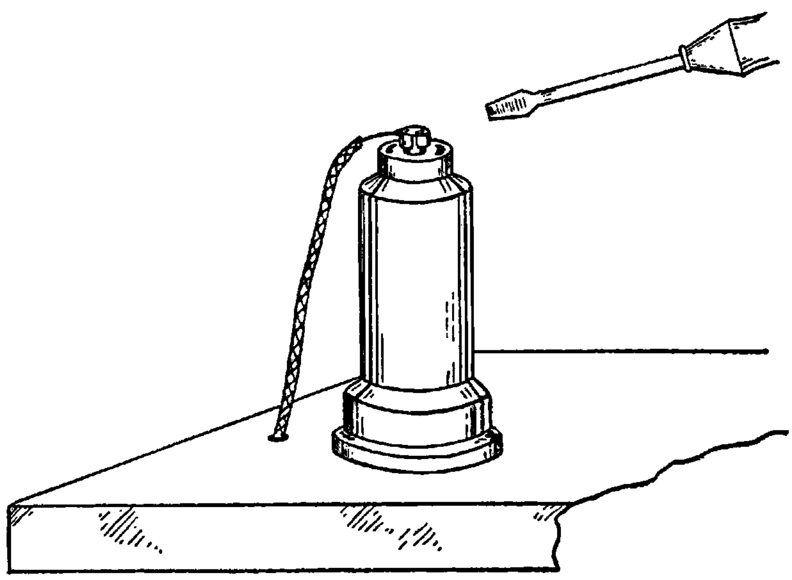
effecting temporary repairs. The first is to clean the resistance strip or track inside the control with carbon tetrachloride. To do this you must bend back the clips which hold the back of the control, or the switch, if the control has one, to the body of the control. If the control is equipped with a switch, be careful to observe its position with reference to the control, and note also the position of the finger which trips the switch. If you do this, you will have no trouble putting the control together again. Clean the resistance strip with a piece of cloth dipped in carbon tetrachloride.

The other method of making temporary repairs to a noisy control is illustrated in the above diagram "A" and involves pulling outward on the control shaft with a pair of slip-joint pliers, and at the same time placing a turn of fine wire in the groove in the shaft which holds the split washer. The wire may be placed either in front of or behind the washer. A suitable type of wire to use is one strand from a piece of line cord.

The ends of this turn of wire are then twisted and cut off about 3/16 in. from the shaft. Remember that these methods afford relief for only a short time, after which the control must be replaced.

Distortion. Distortion in the first audio stage may be caused by the same defects as in the output stage—defective coupling condenser, high or low values of cathode resistor, shorted cathode condenser, etc. In checking cathode resistor values, remember that the bias voltage in output stages is usually much greater than in the first stage, and an error in cathode resistor value is far more serious in the case of the first stage for this reason. Grid voltage values in the output stage range from possibly 15 to 25 for pentodes to 35 to 60 for triodes. In the first stage grid voltages of only 1 or 2 volts may be expected where high-gain triodes are used.

Weak Signals. Generally due to a defective tube; if accompanied by distortion, the possibility of incorrect voltages should not be overlooked.



B

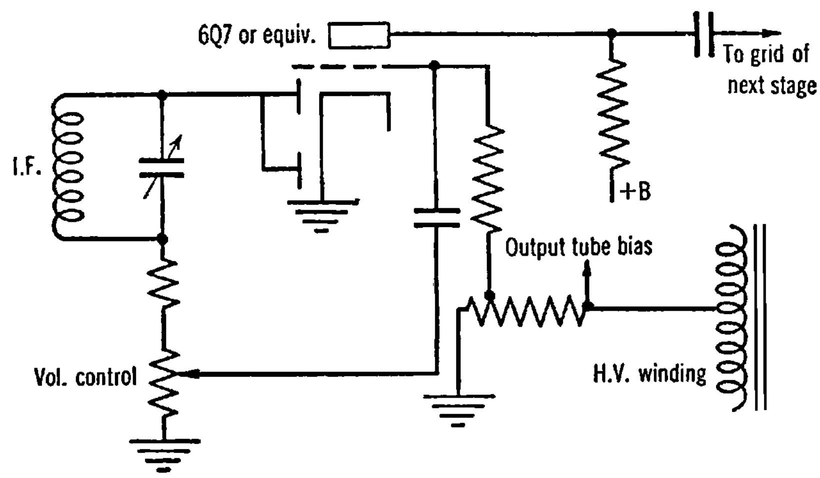
Hum. Anything that will produce hum in the output stage will also cause it in the first audio, and the hum set up in the early stages of a receiver will always be much greater because of the greater amplification following. Refer to the discussion of hum in the output stage for a list of causes. A general treatment of hum will be found in the chapter on miscellaneous troubles.

Excessive hum caused by an open grid circuit is easily detected, for the grid terminal of a tube having an open grid circuit is a very sensitive point. Part of the diagnosis of this kind of trouble may consist of placing a finger or the tip of a small screw driver on or near the grid cap or grid terminal, as illustrated in sketch "B," at which time the hum will become much louder.

First A.F. Circuit Arrangements

Circuit arrangements of first audio stages are very numerous, and while it is impossible to cover the subject thoroughly here, a few of the variations in biasing methods and types of tubes used are presented below. You may find them helpful as a guide.

In "C," the triode section of a 6Q7 or similar tube is used as the first audio stage.



C

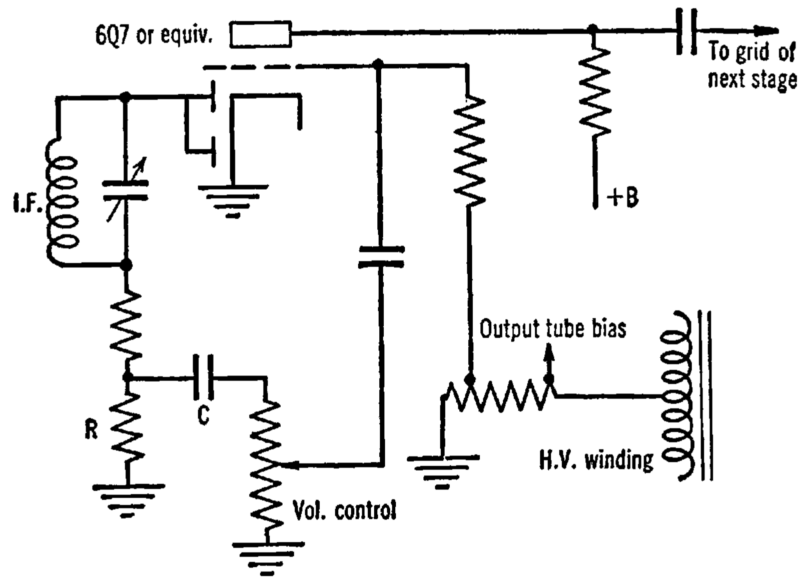
Biasing is effected by means of a resistor or a series of resistors connected between the center tap of the high-voltage winding of the power transformer and ground. The total current passing through the bias resistor will, of course, determine the wattage rating of the resistor. Where high wattage dissipation is not required, ordinary carbon resistors will be used; in other cases the resistor is wire wound. It may be either the flat strip type or a tubular vitreous resistor.

A variation of the method of biasing by means of the resistor in the center tap of the high-voltage winding is the use of the speaker field coil in the same position. This is discussed in the chapter on loud speakers.

The field coil may have several taps for obtaining various bias voltages. The test procedure is exactly the same as in the case where a resistor is used.

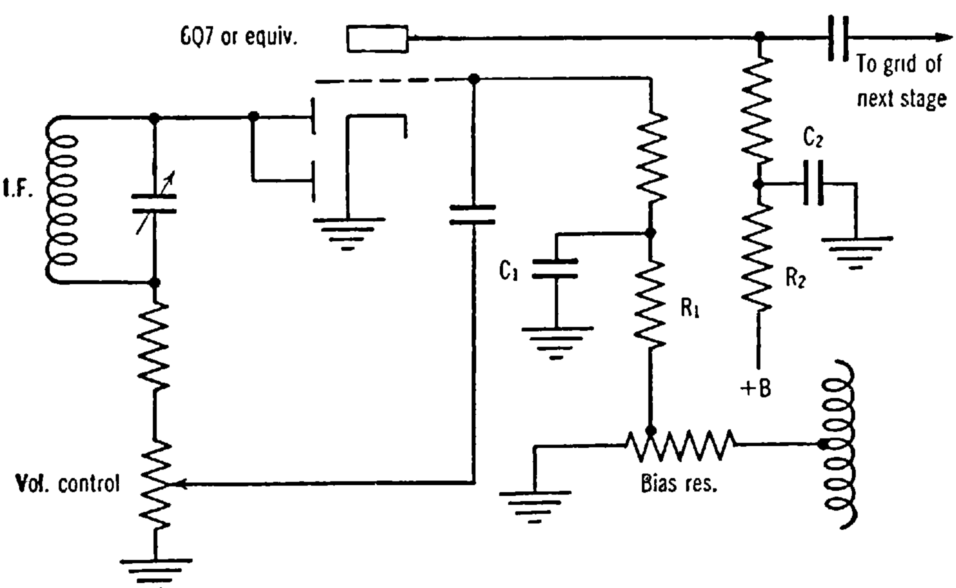
When measuring voltages in this type of circuit, there will be no voltage from cathode to ground, because the cathode is grounded directly. Grid voltage may be measured from grid to ground or from grid to cathode.

"D" shows a modification of the circuit in "C." Here, however, the volume control is not directly connected in the diode return circuit. Instead, resistance R is substituted for the control. The control is coupled into the signal circuit by means of condenser C. The value of R is generally equal to that of the control, and the value of C is the usual coupling



D

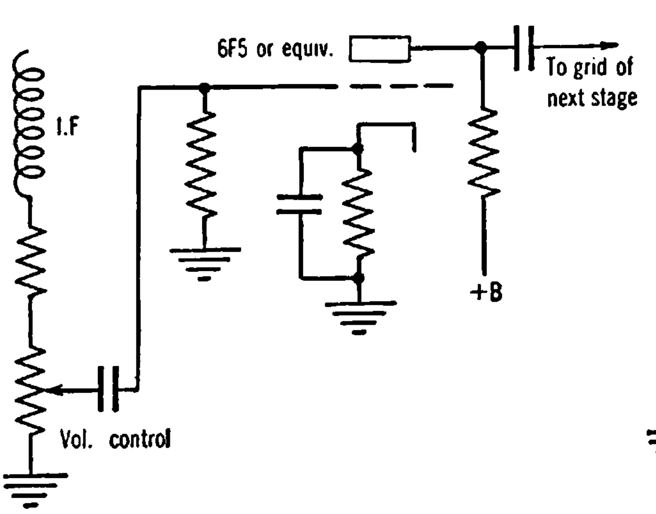
condenser capacity—0.01 to 0.05 mfd. In this arrangement the rectified current is kept out of the control, and it seems to help in reducing the occurrence of noisy controls.



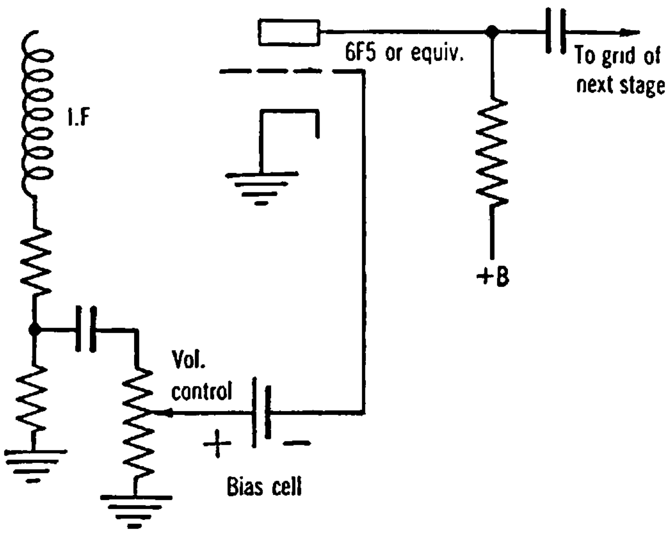
E

The circuit in "E" is identical with "A" except that filters have been added in the grid and plate circuits—R_1, C_1 and R_2, C_2. These are effective in reducing hum, but also add possibilities of trouble due to shorting of condensers C_1 and C_2. Note that the plate voltage will be lower in a stage using this scheme. The values in practice are about as follows: R_1—50,000; C_1—0.09 mfd.; R_2—50,000; C_2—1.0 mfd.

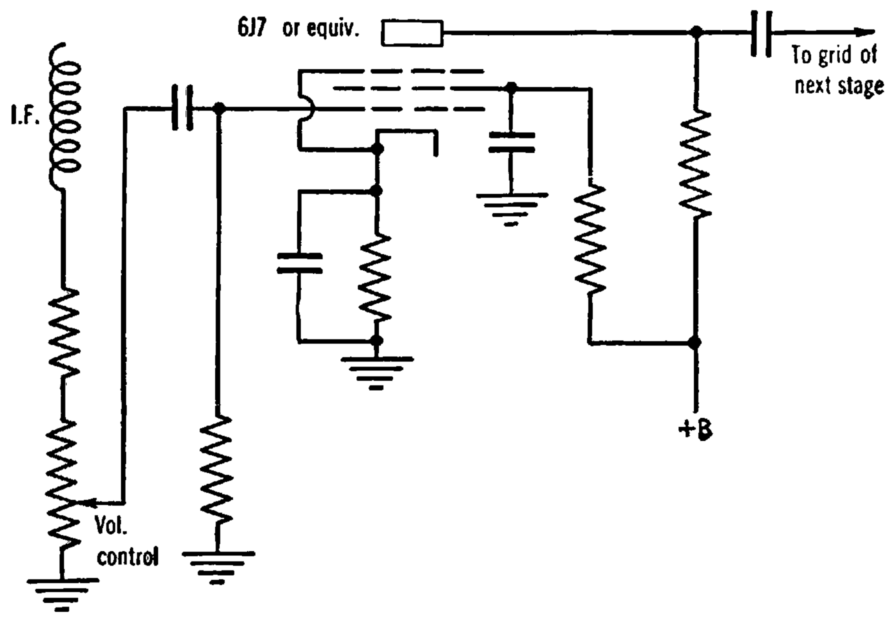
In "F" is seen the most common circuit arrangement where a high-gain triode is used as the first audio. "G" illustrates a similar circuit, except



F



G



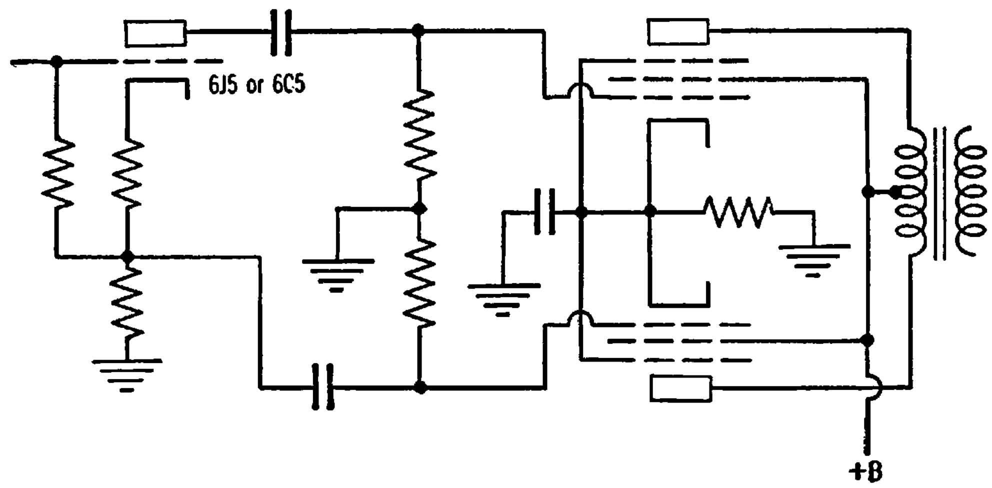
H

that biasing is accomplished by means of the bias cell. Remember that in such circuits the voltage of the bias cell must not be measured with an ordinary voltmeter, and that continuity tests should be made with the cell removed from its mount.

In circuits where a pentode is used as the first audio, the arrangement pictured in "H" is usually employed. In this type of circuit, as employed in a.c.-operated sets, the screen voltage may be higher than the plate voltage. Common values as measured at the socket terminals are about 40 volts on the screen, 20 volts on the plate, and 1 volt on the grid.

Phase Inverter Circuits

The advantages of a push-pull output stage plus the low cost and good frequency response of resistance coupling have led to the development of various types of phase inverter circuits. Since the push-pull input transformer provides grid voltages which are opposite in phase, whenever resistance coupling is to be substituted for the transformer some other means of obtaining this same result must be incorporated in the amplifier. This is done by means of a phase inverter circuit.



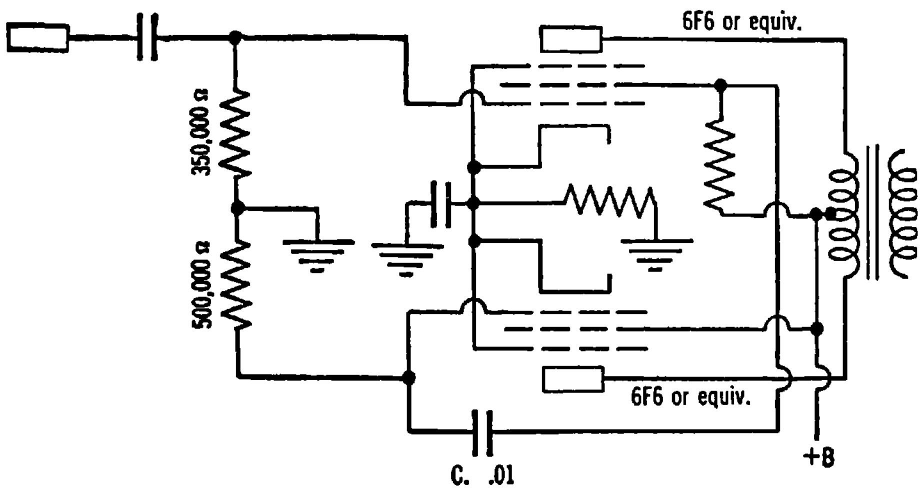
J

There are at least three general types of circuit in use: those employing a single triode tube as phase inverter; those using a twin triode tube; and finally those circuits which do not have a separate inverter tube and in which inversion takes place within the output stage.

Examples of each type of circuit are shown in the diagrams following. "J" illustrates a circuit using a single triode as inverter. The inverter tube may be a 6J5, 6C5 or similar type. In this circuit the pair of output tubes receive their signal voltages from the plate and the cathode of the inverter tube. These two signal voltages are, of course, opposite in phase. This is a fairly common type of circuit.

Diagram "K" shows another type of phase inverter in which a separate inverter tube is not used. Inversion is obtained by coupling one of the output tube grids to the screen of the other output tube through condenser "C." The second tube receives its signal voltage from the plate of the preceding tube. While this arrangement is less expensive than the one described above, its operation is not as satisfactory.

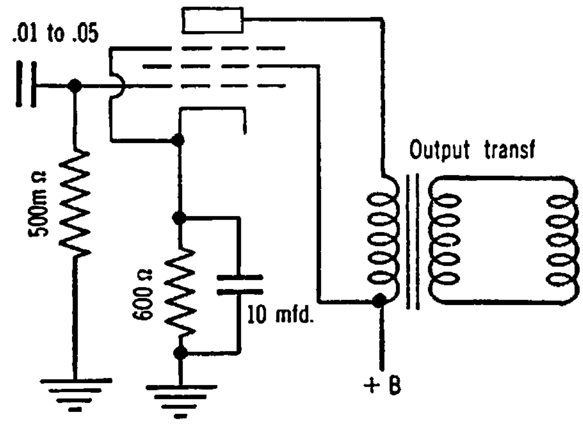
You will observe that in both of the circuits already discussed the signal voltages applied to the grids of the output tubes are not equal in amplitude. This is because one of the voltages has passed through one more stage than has the other. Some provision must be made to compensate for this. The usual arrangement is to use grid resistors of unequal value in the output stage.



K

The necessity of using resistors of unequal value may be avoided by using the arrangement shown in the sketch included in Job Sheet No. 24. Here the inverter tube is a twin or dual triode, such as type 6N7, 6SC7 or equivalent. The plates of the two triode sections of the inverter are coupled to the grids of the output tubes in the ordinary way. One of the triode grids is used as the input and is coupled to the preceding stage. The other triode grid must then be inverted in phase from the first. Note that in the grid circuit of the second output tube there are two resistors. One of these is usually about 0.25 megohm or so, the other about 10,000 to 15,000 ohms As the grid of the second inverter triode is directly connected to the junction point of these two resistors, a portion of the output tube grid voltage is applied to the inverter grid, causing it to be opposite in phase from the grid of the other section of the tube. Instructions for locating trouble in the last type of inverter just described will be found in the following job sheets.

JOB SHEET NO. 21



AIM: To learn how to locate trouble in a pentode output stage.

PROCEDURE: We shall assume that you have definitely isolated the trouble to the output stage, and that you have also checked speaker and power supply and have found them both in good order.

1. Measure plate voltage. If no voltage is present, turn set off and check with ohmmeter for open output transformer primary or break in leads from transformer to tube socket or from transformer to *B* plus.

2. If the plate voltage is normal, measure screen voltage. If no voltage is present, trouble is probably due to break in lead from *B* plus to tube socket. Check with ohmmeter with set off.

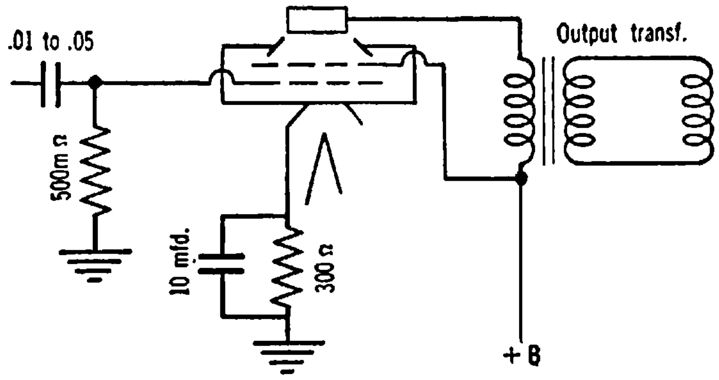
3. After both plate and screen voltages have been found to be normal, check cathode voltage. No voltage usually indicates shorted bypass condenser. Disconnect one side of condenser and check voltage again. Correct voltage with condenser disconnected means that the condenser is shorted. Unusually high voltage probably is due to an open cathode resistor. Check with ohmmeter.

4. When you have found all voltages correct up to this point, check the voltage from cathode to grid. No voltage here may be due to an open grid resistor or a broken lead. If you find that the voltage on the grid is positive instead of negative, look for a shorted or leaky coupling condenser.

Normal voltages for this type of stage are:

	A.C. SETS	A.C.-D.C. SETS
Plate	200 to 250	75 to 100
Screen	200 to 250	75 to 100
Cathode	10 to 25	10 to 20
Grid	10 to 25	10 to 20

JOB SHEET NO. 22



AIM: To learn how to locate trouble in a 25L6 beam power stage.

Let us review what you have accomplished so far. You have found by means of signal tracing that an audio signal fed into the grid of the output tube does not come through the speaker. The speaker has been checked and is known to be in operating condition. There are only two possible causes for this condition: either the trouble is in the output stage, or that stage is not being supplied with proper voltages by the power supply.

PROCEDURE: 1. Adjust the voltmeter for the 250-volt range. Check the voltage from the *B* plus terminal in the power supply to ground. The normal voltage for this type of set is from 75 to 100. If the voltage is correct, the power supplyis operating correctly and therefore the trouble is in the output stage.

2. Measure voltage from plate to ground. It should be slightly lower than the power supply voltage. If no voltage is present at this point, turn the set off and check the primary of the output transformer with an ohmmeter.

3. If the plate voltage was normal, measure voltage from cathode to ground. Since this voltage will be in the neighborhood of 15, the 25-volt range should be used. No voltage at this point probably means that the cathode bypass condenser is shorted. To verify this, disconnect one side of the condenser and again check the voltage. If removing the condenser restores the voltage to normal, the condenser is shorted. You may find that the cathode voltage is several times normal, and such a condition will indicate an open cathode resistor.

4. If the cathode voltage was normal, check the screen voltage, using the 250-volt range. If the voltage is zero, check for a broken wire from screen to *B* plus. In some few cases, a screen bypass condenser may be

used. If so, disconnect one side of the condenser and recheck for voltage. If it is normal after removing the condenser, the condenser is shorted.

5. If you are satisfied that the plate, cathode and screen voltages are normal, check from cathode to grid with a low-range voltmeter. The reading should be nearly the same as from cathode to ground. The polarity of course is, cathode positive and grid negative. No voltage here probably means an open grid resistor. This trouble is not common, but may occur now and then.

6. You may find that the grid voltage is apparently positive instead of negative. In such cases the voltage will also be higher than normal. This is a good indication of a shorted or leaky coupling condenser. To make a positive check of such a condition, remove the condenser from the grid prong of the socket, but do not disconnect the other end. Now recheck the grid voltage. If it has returned to normal value and polarity, hold the test leads in position on grid and cathode and touch the end of the condenser to the grid. If the grid voltage becomes positive again, the condenser is shorted.

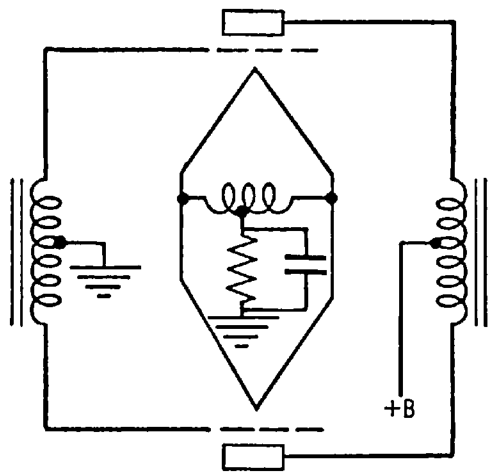
A common trouble is an open or intermittently open coupling condenser. Signals will be heard when generator lead is connected directly to the grid terminal, but not when the lead is connected to the plate side of the coupling condenser. In cases where the signals go on and off, the condenser is intermittently open.

The resistor and condenser values shown in the schematic diagram are average, but may vary somewhat with variations in set design. In some sets you may find an extra lead running from the cathode of the output tube to the screen of the detector tube. This is done to supply screen voltage to the detector and saves one resistor in construction.

Voltages in this type of set should be about as follows:

Plate	75 to 100	Screen	80 to 110
Cathode	15 to 20	Grid	15 to 20

JOB SHEET NO. 23



AIM: To learn how to locate trouble in a push-pull output stage using triode tubes.

THEORY: The bias voltage in this circuit is obtained through the use of a resistor connected from the center tap of the heater winding to ground. The plate current for the output tubes must pass through this resistor, and in so doing develops a voltage across the resistor. Because the plate current is usually high, the resistor is wire-wound, and must be able to dissipate 10 watts or more.

PROCEDURE:

To Locate Hum.

1. With a signal tuned in, try removing one of the tubes and noting whether there is any difference in the signal. If there is, replace the tube and remove the other one. When you find that one tube makes no difference in the signal, that tube is inoperative, and the cause may be a defective tube, or one half of either the input or output transformer is open.

2. If neither of these troubles is found, check back to the heater winding to find out if the bias resistor is connected directly to this winding or to one terminal of a potentiometer across the heater winding. If a potentiometer is used, adjust it for minimum hum, with no signal coming in.

To Locate the Cause of Distortion.

1. Proceed as in locating hum. If you find that one tube makes no change in the signal, check the tube. If tube is O.K., look for open input or output transformer.

To Locate Cause of Dead Stage.

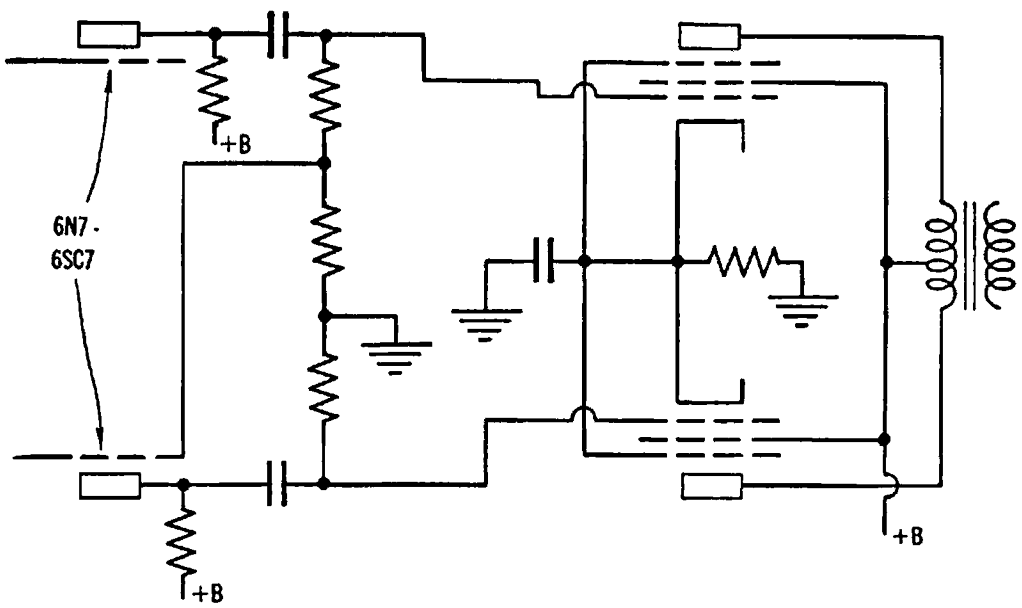
1. Measure voltage from one side of heater (either side) to plate of each tube. If no voltage is present, check from each plate to ground. If voltage is normal at these points, look for open bias resistor.

2. If, when you made the first voltage test, you found voltage at the plate of one tube but not at the other, check continuity of output transformer. You will probably find that one side is open. If neither plate is receiving voltage, check transformer; the center tap or both sides may be open.

3. If plate voltage is normal or nearly normal on both tubes, measure bias voltage. If no voltage is found, check from heater to ground with low-reading ohmmeter. If you get a zero reading, the bypass condenser is probably shorted.

4. If all readings are satisfactory up to this point, measure voltage from heater to grid of each tube. If one tube is receiving no grid voltage look for an open in one side of the input transformer. If neither grid shows voltage, check for ungrounded or open input transformer center tap, or for an open circuit in the secondary.

JOB SHEET NO. 24



AIM: To learn how to locate trouble in a self-balancing phase inverter circuit.

THEORY: Phase inversion is a means of taking advantage of push-pull audio without the use of an input transformer. In a self-balancing inverter, a twin-triode tube is used as the inverter. One grid is used as the input, and the other grid has impressed upon it part of the voltage present on the grid of the upper output tube as shown in the diagram.

PROCEDURE:

If Trouble is in Output Stage.

1. If you are sure that the trouble is in the output stage, as determined by signal tracing or signal substitution, check plate voltages of output tubes. Lack of voltage at either plate may be due to open output primary (half of winding). No voltage on either plate would indicate some trouble in the power supply. Entire output transformer winding might also be open, but this is rather unusual.

2. If plate voltage is normal, it is likely that screen voltage is also normal, since both are obtained from same supply, but it is well to check.

3. After completing check of plate and screen voltages, measure voltage from cathode to ground. No plate and screen voltages may be the result of an open cathode resistor. In this case, the voltage measurement from cathode to ground will show an abnormally high voltage. Low plate and screen voltages might be caused by a shorted cathode bypass condenser. In this event, the cathode voltage will probably be zero.

4. If plate, screen and cathode voltages are normal, measure voltage from cathode to grid on each tube. If voltage is zero, look for open grid resistor. If either grid shows a positive reading, check coupling condenser for short or leakage.

If Trouble is Found to be in Inverter.

1. Check plate voltages of both triodes. No plate voltage on one triode may be caused by open plate resistor. No plate voltage on both triodes indicates trouble in supply. Low plate voltage on either triode may be the result of leaky or shorted coupling condenser.

2. If plate voltages are normal, check cathode voltage. The cathode is common to both triodes. No cathode voltage is generally due to a shorted cathode bypass condenser.

3. After checking cathode voltage, measure grid voltages. If the output stage was functioning normally, the grid circuit of the lower triode is probably all right, but it is just as well to check. No grid voltage on the upper triode might be caused by an open grid resistor. Positive grid voltage would point to a shorted or leaky coupling condenser ahead of this triode.

4. If a. V.T.V.M. or Chanalyst is available, servicing this type of circuit will be made easier. Signal voltages may be measured, and some idea of performance under operating conditions will be had. For example, signal voltages at plate of top triode and grid of top output tube may be measured and compared with those at plate of lower triode and grid of lower output tube. The voltages should be about equal at all of these points if the circuit is functioning properly.

Questions

1. The screen of an output tube becomes red hot and the set is dead. What trouble does this indicate?

2. A set using push-pull triodes in the output stage is totally inoperative. Voltage analysis shows about 250 volts from the heater of the output tubes to ground. What is the most likely trouble?

3. A set is dead, and you find that voltage at the output tube grid is positive with respect to its cathode. What trouble would you look for?

4. A push-pull output transformer has one half of the primary winding open. How may this affect the operation of the receiver?

5. What simple test will detect the trouble described in Question 4?

6. What is a frequent cause for excessive hum in an audio amplifier?

7. What are some of the symptoms that may result from a defective volume control when the control is connected in the grid of an a.f. amplifier?

8. How may a noisy volume control be repaired in an emergency?

9. Would you expect such repair to be permanent?

10. What is generally used for cleaning a volume control?

11. How would the operation of an audio amplifier be affected by a cathode resistor of higher than normal value?

12. What is a simple method of detecting an open grid in an audio amplifier?

13. In checking a push-pull transformer-coupled output stage you find all voltages normal, except that the grid of one tube shows no voltage. How would you diagnose this trouble?

14. In a push-pull stage, the plate voltages are somewhat lower than normal. Grid voltage on both tubes is zero. A resistance measurement shows plate and grid circuits to be normal, but gives a reading of zero ohms from tube filaments to ground. What is wrong?

15. In a first a.f. stage using a pentode tube, you get no voltage from cathode to either plate or screen, nearly normal readings from ground to either plate or screen, and an abnormally high reading from cathode to ground. What is the trouble?

16. What is a likely cause for intermittent operation of an audio stage?

References

Receiving Tube Manual, RCA Mfg. Co., Inc.; pp. 15–24.
Radiotron Designer's Handbook, RCA Mfg. Co., Inc.; pp. 1–81.
RCA-Rider Chanalyst Instruction Manual, RCA Mfg. Co., Inc.; pp. 26–31.
Henney, Principles of Radio, John Wiley & Sons, Inc.; pp. 259–322.
Hoag, Basic Radio, D. Van Nostrand Co., Inc.; pp. 88–89 and 100–102.

7

THE POWER SUPPLY

Your work on power supplies will be on one of two general types—the type used in a.c.-operated sets, where a power transformer is employed; a.c.-d.c. or universal sets, where a power transformer is not used.

The job sheets included in this chapter cover the repair of several varieties of these two types, but it is impossible to present here all of the modifications of these types that have been in use.

The A.C. Power Supply

The function of this device is to provide a.c. heater voltages, d.c. plate and screen voltages, usually a field supply for the speaker, and sometimes bias voltages. While the job sheets show the speaker field used as a choke, there are some cases where the field is connected as a bleeder. This is more fully covered in the chapter on speakers. When the field is connected as a bleeder, a filter choke is substituted for the field.

Troubles Occurring in the Power Supply

(a) No plate or screen voltages.
(b) Low plate and screen voltages.
(c) No heater voltage.
(d) No rectifier heater voltage.
(e) No a.c. or d.c. voltages.
(f) All voltages low.
(g) Low heater voltage.
(h) No bias voltage.
(j) Fuse blows.
(k) Excessive hum.

No Plate or Screen Voltages. May be caused by the following:

Open Field Coil. Replace field coil. (See job sheet on replacing field coil.)

Open Choke. Replace the choke. In so doing, select a replacement that has the correct physical size and at the same time the correct current carrying capacity and inductance. Failure to do so will result in trouble. Insufficient current carrying capacity will cause the choke to overheat and lower inductance will usually cause excessive hum. No particular harm will result from using a choke of higher inductance and current carrying capacity, if it will fit the available space. Most service bulletins give this pertinent information.

Shorted Filter Condenser. The only remedy, of course, is to replace the condenser. If the first filter condenser fails, and the set is allowed to operate long enough, the rectifier tube may be ruined. A shorted condenser overloads the power supply, and this may be reflected in overheating of the power transformer. When replacing the faulty condenser, substitute one that has the correct capacity and a working voltage at least equivalent to that of the old one. Failure to observe the rule in regard to working voltage will result in failure of the new condenser in a short time. Replacing the condenser with one of a lower capacity will cause hum.

In many older sets, the first filter condenser was usually of the wet variety, but the general practice in modern receivers is to use dry condensers for all positions. During the war, the manufacture of wet electrolytic condensers was discontinued because of material shortages. Should you encounter a job on an older set using wet condensers, proper replacement will be facilitated by following the instructions given on page 287 of the *Mye Technical Manual,* published by P. R. Mallory and Co., Indianapolis, Ind. A condensed version of these instructions is given herewith:

1. Determine the surge voltage by connecting a 1-mfd. 600-volt condenser in place of the original filter condenser and by measuring the voltage across this 1-mfd. condenser.

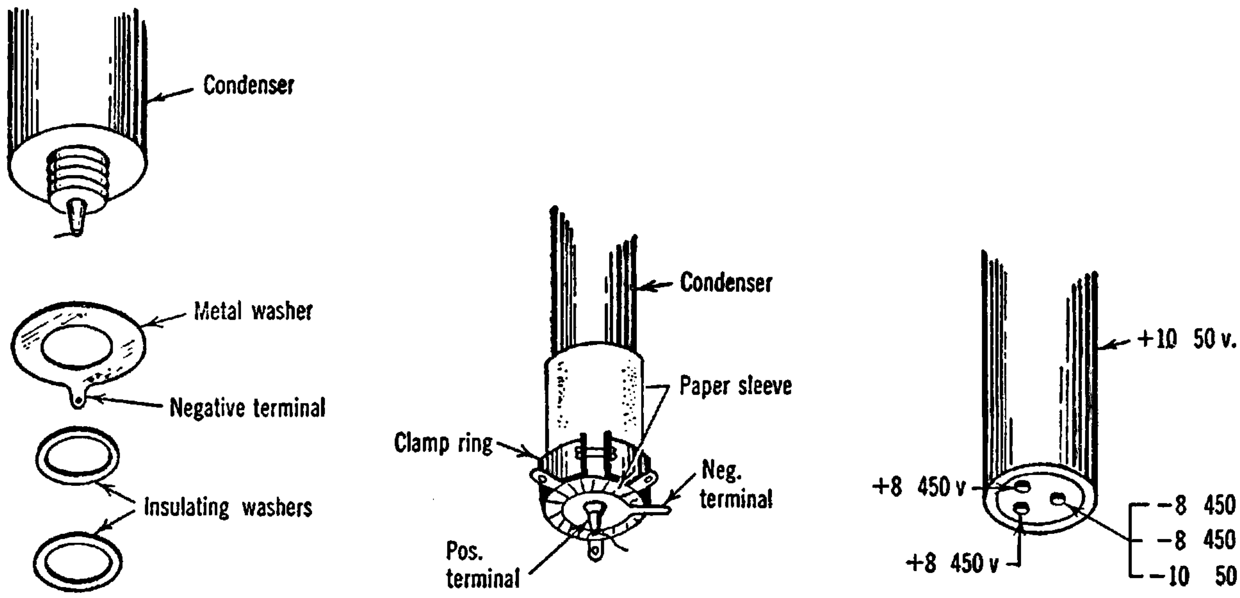
2. If the surge voltage is less than 525, use the dry condenser recommended on page 286, Figs. 70 and 71 of the Manual.

3. If the surge voltage is over 525, connect a bleeder resistor that will draw from 5 to 10 milliamperes, across the output of the power supply, and measure the surge voltage with the bleeder connected. If the surge is now below 525 volts, use the substitute condenser indicated on page 286 of the Manual.

4. If the surge is still over 525 volts, increase the bleeder current (by lowering the value of the resistor) until the surge is below 525 volts, being careful not to exceed the current rating of the rectifier or transformer.

5. If the surge voltage is over 525, another method of handling the problem is to connect two dry condensers in series.

In power supplies equipped to furnish bias voltages from a resistor connected between the center tap of the high voltage winding of the power transformer and ground, the negative terminals of the filter condensers cannot be grounded. When metal can type condensers are used, and the can or container is the negative terminal, the can must be insulated from the chassis. There are several methods of doing this, three being illustrated in the sketches at "A," "B" and "C."



A B C

In "A" a metal washer is placed next to the condenser. This washer has a lug for soldering. Over the metal washer is placed an insulating washer. The assembly of condenser, metal washer and insulating washer is then mounted over the hole in the chassis; another insulating washer is placed over the neck of the condenser and the lock nut is screwed on. The soldering lug which makes contact with the can goes through an insulating grommet to keep it from touching the chassis.

Drawing "B" shows a better arrangement in which a paper sleeve is passed over the condenser. A soldering terminal is slid between the condenser and the sleeve and the whole assembly is fastened to the chassis by means of the clamp.

Still another arrangement is illustrated in "C," in which the insulating washer or sleeve is not necessary. The unit contains two high-voltage sections and a low-voltage section, the low-voltage section being used for bias resistor bypassing. The terminal marked common is the junction point of the negative terminals of the high-voltage condensers and also of the low-voltage section. The can is the positive of the low-voltage condenser.

Low Plate and Screen Voltages. May be caused by defective rectifier, leaky filter condenser or an indirect ground in the receiver.

No Heater Voltage. Usually due to a break in one of the leads from the heater winding to a tube socket.

No Rectifier Heater Voltage. May be traced to cause similar to that given under No Heater Voltage.

No A.C. or D.C. Voltages. The most common causes are: defective line plug; open line cord; defective line switch or open power transformer primary. Check all the other possibilities before deciding that the primary is open.

All Voltages Low. Look for a ground or a short at the heater winding or in the filter circuit.

Low Heater Voltage. Possible cause is one or more of the tubes replaced by a type which draws more heater current. An example: substitution of a 27 for a 56. The 56 takes 1.0 ampere while the 27 takes 1.75 ampere.

No Bias Voltage. Shorted condenser connected across the bias resistor. Usually accompanied by hum.

Fuse Blows. Overload due to a ground in the *B* supply system (generally shorted first filter condenser); heater winding grounded or shorted; condenser connected across primary of transformer is shorted, or shorted turns in the primary.

Excessive Hum. By far the most common cause of hum is an open filter condenser or a condenser of lower capacity than recommended. The former is usually the case when dry electrolytic condensers are used, and the latter when wet condensers are in use. After a wet condenser has been in use for a long time, some "creeping" or evaporation of the liquid will have taken place. This will be characterized by a white deposit around the top of the condenser. When you find a condenser in this condition and the set owner complains of hum, you may be sure that the level of the liquid has dropped to the point where the capacity is seriously reduced, and the condenser must be changed.

The A.C.-D.C. Power Supply

The power supply ordinarily used in universal or a.c.-d.c. receivers is simpler than the one used in straight a.c. sets, because it does not supply heater voltages and in most cases it is of the half-wave type.

Troubles Occurring in the A.C.-D.C. Power Supply

No Plate or Screen Voltages. You will find that the most frequent cause of this condition is a shorted first filter condenser and, in many cases, perhaps a defective rectifier tube as well. The load imposed on the tube is so great that it is ruined if the set is left on very long after the condenser shorts. In all cases where you find a rectifier tube with little or no emission, do not fail to test the condenser carefully before replacing the tube.

A shorted second filter condenser may also be the cause of lack of plate and screen voltages. You will be able to tell very quickly whether the defect is in the first or second condenser by observing whether the field of the speaker is energized. If it is, the trouble is probably in the second condenser, but if not, check the first one.

Always replace filter condensers with new ones of reputable manufacture, proper capacity and sufficiently high voltage rating. In the average set of this type, the condenser capacity is 16 to 20 mfd. per section. The working voltage rating should be at least 150.

Low Plate and Screen Voltages. If you have definitely determined that the trouble is not due to a short or ground in some other part of the set, look for a weak rectifier tube or an open or low-capacity filter condenser. The easiest way to check on this is to temporarily connect a condenser known to be good in parallel with the suspected one. In the usual case the defective condenser will be the first one.

Hum. If you have definitely isolated the hum to the power supply, you will generally find the condition to be caused by an open or low-capacity filter condenser.

Line Ballasts

Sets of the a.c.-d.c. type generally use a resistor in series with the tube heaters to limit the current through the heaters to the desired value. This resistor may take several forms: (a) a line cord with a third wire in the form of a resistance wound over one of the other leads, (b) a wire-wound resistance, (c) a ballast tube with metal envelope, or (d) a ballast tube with a glass envelope. Most of the newer a.c.-d.c. sets equipped with 12-, 35-, 45-, 50- or 70-volt tubes do not have any line resistor or ballast because the total resistance of the tube heaters is sufficient to limit the current to the proper value.

Resistance line cords are made in a wide range of values from 90 to 350 ohms or more. Sets employing the usual combination of a 25-volt output tube, a 25-volt rectifier and 6.3-volt tubes in the other positions require the following values of line ballasts:

4-tube set	180 ohms
5-tube set	160 ohms
6-tube set	140 ohms

A common defect encountered in the use of a line cord is an open resistance. Replacement of the cord with a new one of the correct resistance is advisable, but sometimes a repair may be made if the break is near the set end of the cord. This may be determined by using a pair of test prods with needle points and puncturing the outer insulation of the cord to make contact with the resistance. If you find that the break is near the set, the open piece may be cut off and a wire-wound resistance of value equal to the part cut off connected in series.

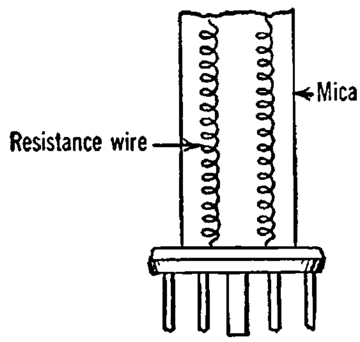
Customers seem to have a habit of shortening the resistance cord with resulting damage to the tubes if they manage to get the resistance reconnected after cutting, or at least rendering the set inoperative if the resistance is left unconnected, which is usually the case.

When installing a new resistance line cord you will find, in most cases, that the resistance lead has a metal tab or a piece of solid tinned wire at the end. In most sets, this lead is connected to the rectifier heater terminal. The black lead, which is connected to the same side of the attachment plug as the resistance, is connected to the rectifier plates, and the red wire runs to the line switch.

Two other types of resistance line cords should be mentioned. These are the tapped cord and the universal cord. The tapped cord has a tap on the resistance lead a short distance from the set end of the cord. An additional lead is brought out to the end of the cord from this tap, making a total of four wires. The purpose of the tap is to provide a drop of sufficient voltage to operate a pilot lamp. When connecting this type of cord, the end of the resistance is connected as usual, and the tap is connected to one terminal of the lamp. The other side of the lamp is wired to the rectifier heater terminal. The second type, the universal cord, has several resistance values incorporated in it and the leads from these are brought out at the end. By connecting these leads in various ways, a number of resistances may be obtained, making one cord adaptable to a variety of sets.

When a ballast tube of the glass-envelope variety burns out it must be replaced. However, if one is not readily available, a line cord, wire-wound resistance, or metal-envelope ballast of the proper resistance may be substituted, with a few wiring changes.

Failure of the metal-envelope ballast is in many cases due to the resistance wire becoming brittle and breaking off. Refer to sketch "D," which shows the internal construction of this type of ballast. You will



D

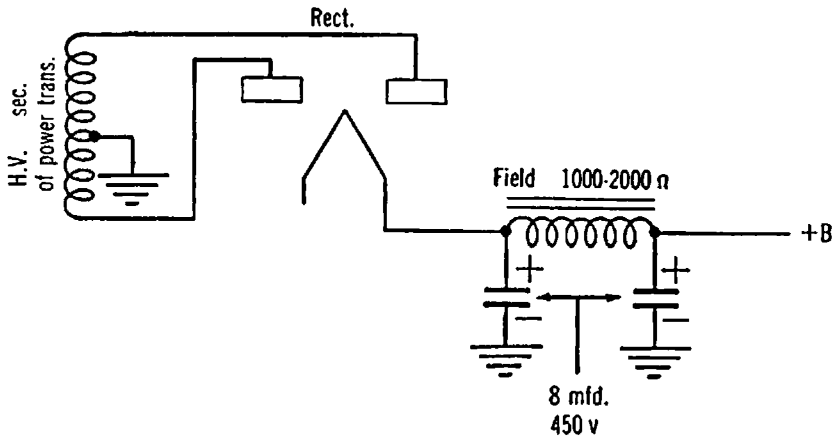
often find that temporary repairs can be effected and the set restored to operation by proceeding as follows:

1. Bend back the metal tabs which hold the metal shell to the base.

2. Carefully remove the shell or envelope and inspect the resistance to locate the break.

3. When the break is found, twist the broken ends together. This must be done very carefully, to avoid breaking the brittle wire in still other places. Try to do the job so that as little as possible of the wire is included in the twist, or you will find that the total resistance of the ballast has been lowered materially. If you are careful, the drop in resistance should be so small that the operation of the set will not be affected, but it is a good idea to check the resistance with an ohmmeter when the job is done. If you have reduced the resistance by more than ten percent, connect a wire-wound resistance of the correct value in series with the ballast, to make up the difference.

JOB SHEET NO. 25



AIM: To learn how to locate trouble in an a.c. power supply without bias supply.

THEORY: The two most common troubles in this type of power supply are no voltage and low voltage.

PROCEDURE:

For No Voltage.

Check voltage from heater of rectifier to ground. If there is no voltage at this point:

1. Disconnect all *B* supply leads from heater of rectifier. When making this test there should be no leads on the terminals except the leads to the heater winding of the transformer. If voltage is then normal, the trouble is in the filter circuit. If voltage does not become normal, measure a.c. voltage from each plate of the rectifier to ground. If the a.c. voltage is not normal, proceed as instructed in job sheet entitled "How to Test a Power Transformer."

2. Should you decide that the trouble is in the filter circuit, reconnect all leads except the positive side of the first filter condenser and measure voltage again. Normal voltage now means that the first filter condenser is shorted.

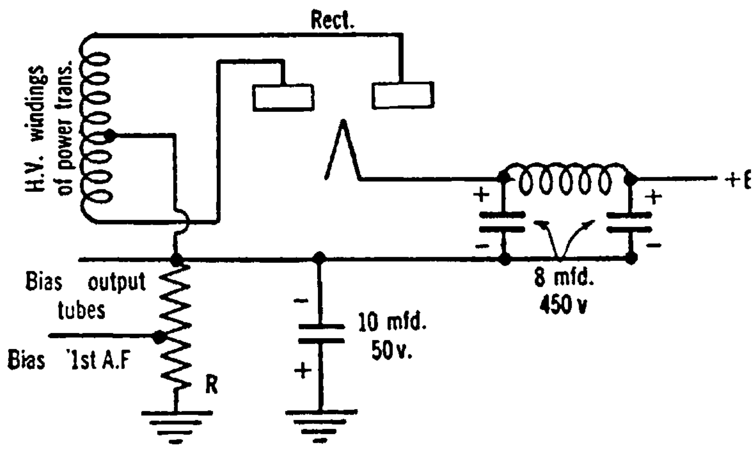
3. If you find that the first filter condenser is not shorted, reconnect the positive lead, and with the set turned off check continuity through the field coil. If the field is not open or grounded, disconnect the positive side of the second filter condenser and check voltage again. If it is normal, the second condenser is defective.

For Low Voltage.

The procedure is the same as for no voltage except for the following:

defective power transformer will be indicated by low a.c. voltage; normal voltage when one of the filter condensers is disconnected shows that the condenser is leaky rather than shorted. Low voltage may also be caused by the rectifier tube having low emission. Normal voltages are: at heater of rectifier about 350, at *B* plus terminal about 250, rectifier plate to ground about 340 a.c.

JOB SHEET NO. 26



AIM: To learn how to locate trouble in an a.c. power supply having provision for fixed biasing.

THEORY: The operation of this power supply is the same as the ordinary a.c. supply, except that the center tap of the power transformer high-voltage winding is not connected directly to ground. Instead, it returns to ground through the wire-wound resistor *R*. This resistor is generally from 100 to 300 ohms. The negative leads of the filter condensers are not grounded, but are connected to the high-voltage center tap. A low-voltage electrolytic condenser is connected from the center tap to ground. Observe the polarities of the condensers.

PROCEDURE:

For No Voltage.

1. Proceed as for the ordinary a.c. power supply, but make all d.c. voltage measurements from the high-voltage center tap instead of from ground.

2. If no trouble is found in the rectifier, the filter circuit or power transformer, check for open resistor *R*.

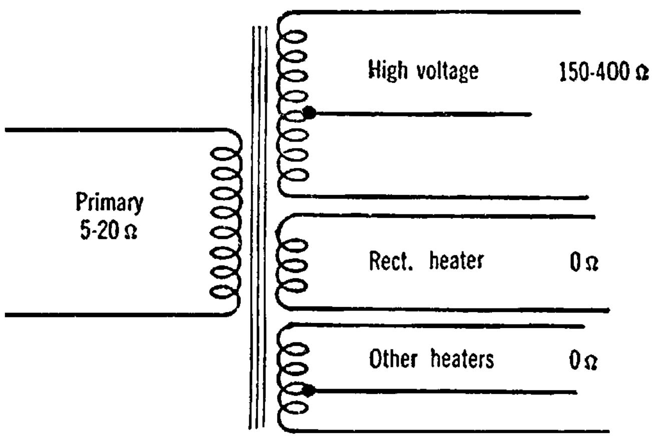
For Low Voltage.

Make all voltage tests outlined in the job sheet on the ordinary a.c. power supply. If you do not locate the trouble, it may be due to lack of bias voltage. Check for shorted filter condenser connected across the bias resistor.

For No Bias Voltage.

Check condenser across the bias resistor.

JOB SHEET NO. 27



AIM: To learn how to identify the windings on an unmarked power transformer.

THEORY: When replacing power transformers, you may get a replacement transformer which does not have its leads or terminals marked or color coded so that the various windings may be identified. Note in the diagram above that the winding having the lowest resistance will be the heater winding. Next in order of resistance is the primary, while the highest will be the high-voltage winding.

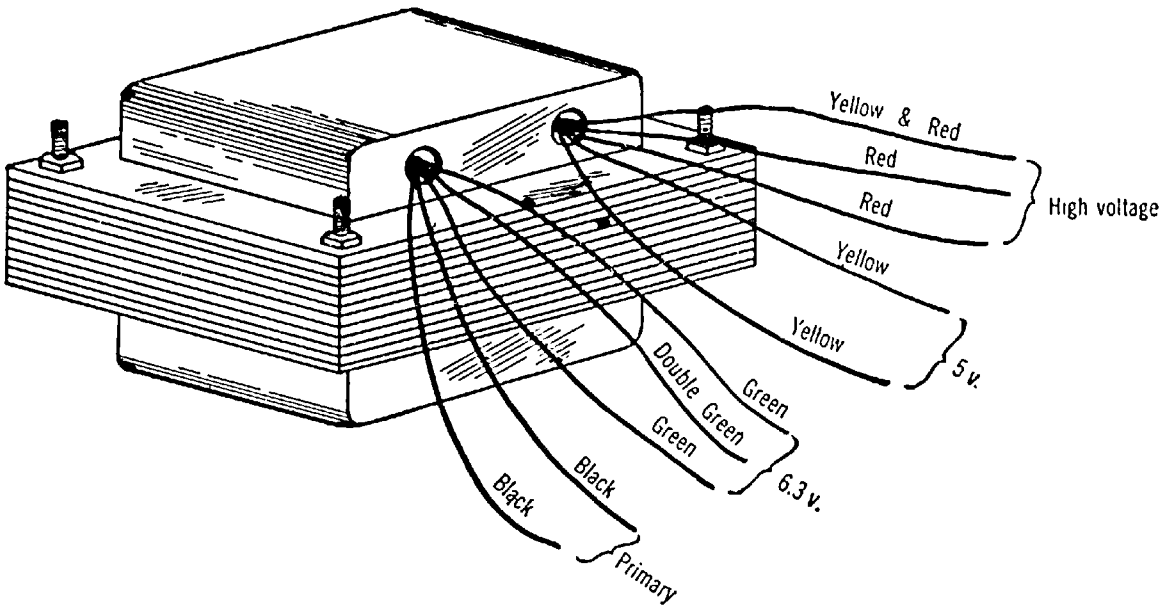
PROCEDURE: If the transformer has soldering terminals instead of wire leads, make a layout or plan showing the positions of these terminals.

1. Set the ohmmeter on the lowest resistance range. Touch one of the test prods to any lead or terminal on the transformer. Now touch each of the other leads or terminals with the other test prod. When you get a continuity reading, twist the leads together or, if the transformer has terminals, show on your plan that the lugs are connected. You may find that in some cases three leads will give a reading. When you have tested continuity from any one lead to all the others, connect the test prod to another lead and repeat the test. Do this until you have tested all the wires or terminals.

2. You will now have several groups of wires or terminals which show continuity. Measure the resistance of each group. The group which shows the highest resistance (about 150 to 400 ohms) is the high-voltage winding. The group having a resistance of 5 to 20 ohms is the primary. The other groups will probably have a very low resistance, almost a short circuit; these are the heater windings.

3. Separate all ends of leads to avoid short circuiting. Connect a line cord to the primary and plug into power line. *Avoid touching high-voltage winding.* With a.c. voltmeter, measure voltage of heater windings to determine which is rectifier heater.

JOB SHEET NO. 28



AIM: To learn how to test a power transformer.

PROCEDURE: 1. Observe whether tubes light to proper brilliancy. If necessary, measure heater voltage. If heater voltage is higher or lower than normal, measure line voltage. If line voltage is normal, check to see whether there may be an overload, due to a ground or some other cause. It may be necessary to disconnect leads and again measure heater voltage. If heater voltage is normal with leads removed, there is a ground somewhere.

2. If tubes do not light at all, and no voltage is found across heater winding, check for open winding or broken lead. An open winding is rather rare, and you will probably find that the trouble is due to an open connecting lead.

3. Using a high-range a.c. meter, measure the voltage across high-voltage secondary and also from center tap to each plate of the rectifier. The voltages across each half of the winding should be equal. A wide difference in the readings, plus excessive heating of the transformer, probably means that there are shorted turns in the winding. No voltage across one half of the winding, plus excessive hum, points to an open winding. No voltage across one half, plus excessive heating, probably means that one of the plate leads is grounded.

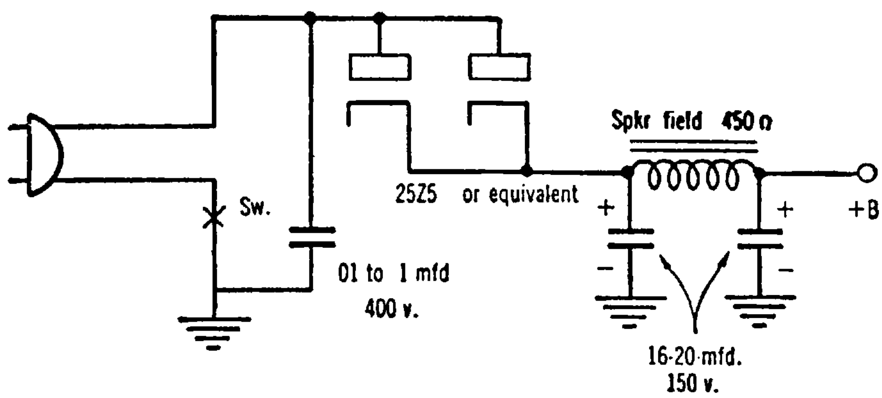
4. Check rectifier heater voltage. If there is no voltage, look for an open winding or broken lead.

5. If there are no voltages at any of the windings, turn the set off and check for an open primary.

6. If all voltages are low and the transformer heats excessively, remove one lead of each winding and recheck voltage with lead disconnected. If removal of a certain lead clears up the trouble there is a ground in that circuit. If you find that the trouble is not cleared up by disconnecting any lead, there are probably shorted turns in the primary.

7. The sketch shows the color coding generally used. There are, however, many variations of this. Philco generally uses the following: Pri., white; 6.3, black; H.V., yellow; H.V.C.T., yellow & green; Rect. heater, blue.

JOB SHEET NO. 29



AIM: To learn how to locate trouble in an a.c.-d.c. power supply.

PROCEDURE: 1. There are in general two types of trouble which occur in a.c.-d.c. power supplies; no voltage at all, and low voltage. Suppose you have used signal tracing and find that no signal comes through the output stage. You then check the plate voltage at that stage and find that it is zero. You then check the voltage at the *B* plus side of the output transformer and find no voltage there either. These symptoms point to trouble in the power supply.

2. Locate the leads which run from the field coil of the speaker to the underside of the chassis. You will find that one of these goes directly to a cathode terminal of the rectifier socket, and the other to a terminal lug where it joins a lead from one of the filter condensers. On this same lug you will probably find other wires which distribute *B* voltage to various parts of the set. Measure the voltage from this point to ground. It should be from 70 to 110. If you find that no voltage is present, disconnect the positive lead of the filter condenser which is connected to this lug. Now check the voltage. If it is normal or nearly normal, the filter condenser is shorted. If removing the condenser lead does not restore the voltage, reconnect the lead.

3. Next trace back through the speaker field to the cathode of the rectifier and you will find there the positive lead of another filter condenser. Disconnect this lead and check the voltage. If you get no voltage at this point, it is likely that the set has been operated with a shorted filter condenser long enough to ruin the rectifier tube. Check the tube. If you find the tube defective, *do not replace it yet.* First measure the resistance from the cathode of the rectifier socket to ground. You should get a fairly high reading. If the reading is anything like a short circuit, you have additional trouble. But usually the reading will

be normal, and you may replace the tube. *Be sure that you do not reconnect the defective filter condenser,* or you will damage the new tube.

4. Turn the set on and check voltage with the new tube in the socket and the shorted condenser disconnected. The voltage will probably be lower than normal, due to the lack of a filter condenser. Connect a condenser known to be good from cathode to ground. The voltage should come up to normal.

5. If you get normal voltage at the cathode of the rectifier tube and find no voltage at the other side of the field coil, turn the set off and measure the resistance of the field coil. You will probably find that it is open.

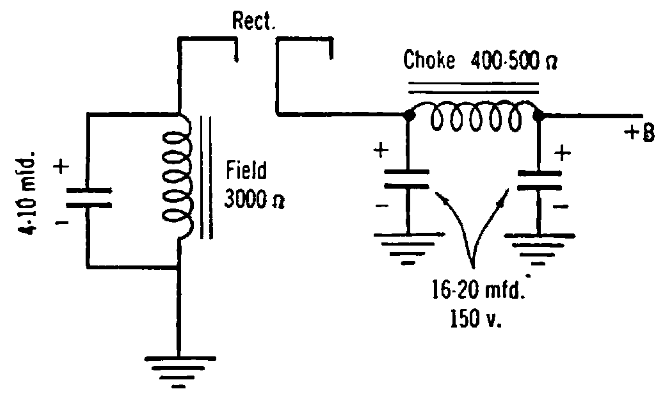
6. You may find that there is no voltage at either end of the field coil; the filter condensers are not open or shorted and the rectifier tube is good. This indicates that the rectifier plates are not being supplied with a.c. Measure with an a.c. voltmeter from plate terminal of the socket to ground. No a.c. voltage here points to an open line cord or defective plug.

7. If the fuse blows as soon as the set is turned on, you will find that the tubular condenser connected from the rectifier plate to ground is shorted.

Normal voltages for this stage are as follows:

Rectifier plate to ground	117 a.c.
Rectifier cathode to ground	75 to 120
B plus terminal to ground	70 to 110

JOB SHEET NO. 30



AIM: To learn how to test a power supply using a separate choke.

THEORY: In this type of power supply the two cathodes of the rectifier are not connected together. One supplies the field current and the other supplies the plate and screen voltages. Three separate filter condenser sections are needed, as shown.

PROCEDURE: 1. Check for voltage at the *B* plus terminal. If none is present, see whether a.c. input voltage, from rectifier plate to ground, is normal.

2. If voltage is low, remove lead from choke to *B* plus terminal and check again. If voltage is now normal, there is a ground in the set, but not in the power supply.

3. If voltage is very low or zero, and you have checked for ground in other parts of the set, disconnect one lead of the second filter condenser. If voltage now rises to normal, the filter condenser is defective.

4. If disconnecting the second condenser does not restore voltage, turn set off and check continuity of choke.

5. If choke is O.K., disconnect one lead of first filter condenser. Recheck voltage. It probably will not be normal. In this case remove rectifier tube and test. If tube is defective it most likely has been ruined by a defective filter condenser. Test and replace the condenser before installing new tube.

6. Test for field supply by checking magnetism at core or by measuring voltage across field. Voltage should be from 60 to 80. If there is no field supply, disconnect one side of condenser across field and recheck voltage. If it still is not normal, the field supply half of the rectifier may be defective. Test tube and replace where required. Test filter condenser for short before reconnecting.

Questions

1. What troubles occurring in an a.c. power supply may cause no plate or screen voltages throughout the receiver?

2. What is the danger of allowing power to remain on a set having a shorted first filter condenser?

3. Why are the metal containers of some filter condensers insulated from ground?

4. Name three methods used to insulate the container of a condenser from the chassis.

5. A receiver is found to have no voltages at any of the tube sockets. Further test shows that the power transformer is not delivering a.c. to the rectifier plates. Name several possible causes of trouble.

6. Heater, cathode, grid screen and plate voltages in a receiver are all low. What may be wrong?

7. How would you diagnose the following complaint: no bias voltages; excessive hum?

8. What is a common cause of excessive hum?

9. What causes a white deposit to collect around the top of a wet electrolytic condenser? What would you do to correct this condition?

10. In an a.c.-d.c. receiver there are no plate, screen, cathode or grid voltages. What is a likely cause of this trouble?

11. What may happen if an a.c.-d.c. receiver is operated for a considerable period with a shorted filter condenser?

12. An a.c. receiver shows no voltages except at heater terminals. Testing pole piece of speaker with a screwdriver shows that the field coil is energized. What is probably wrong?

13. What would be the approximate d.c. voltage from the cathode of a 25Z5 to ground or *B* minus, if the rectifier is used in the ordinary half-wave circuit, and assuming that the receiver is normal?

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8

THE LOUD SPEAKER

Common troubles that occur in the speaker are: no signals or dead set; weak signals; distortion; rattle and hum.

Let us consider these in order and attempt to discover the various causes of each type of trouble.

No Signals or Dead Set. When due to a defect in the speaker, this may be due to any one of the following causes: open field coil; open output transformer; open voice coil or grounded field coil. The method of locating these defects is described in the job sheet "How to Test a Speaker." With the exception of a grounded field coil, the remedy, of course, is to replace the defective part. This will be discussed later.

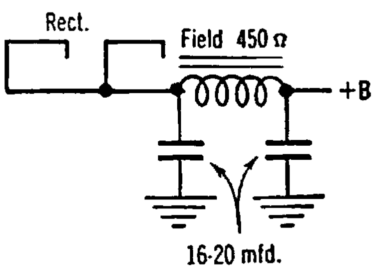
Weak Signals. The most common cause of this trouble is an open field coil. That any signal can be heard at all under this condition is due to the fact that the core holds some residual magnetism, which provides a very weak field.

Distortion. This may be caused by shorted turns in the output transformer or an improper impedance match between the transformer and the speaker or the transformer and the output tube. The latter trouble occurs only when the original transformer has been replaced.

Rattle. There are a number of things that will cause a rattle. In locating this kind of trouble, you can use a variable-frequency audio oscillator to good advantage. Connect the oscillator to the grid of the first audio tube and vary its frequency while listening for the rattle. When the rattle is at its loudest, keep the oscillator at that frequency and look for the cause of the rattle. Among frequent causes are: torn cone; cone loose at the supporting ring; winding on voice coil loose; voice coil loosened from cone; spider loose or broken; centering screws loose; voice coil not properly centered.

Hum. This rarely occurs where the original speaker is in use and has not been repaired or tampered with. One cause is a field coil of improper resistance. Some speakers use what is called a hum-bucking coil. You will find this at the front end of the field coil; it is usually a few turns of magnet wire, is connected in series with the voice coil and the output transformer secondary. Any ripple present in the field coil also appears in the hum-bucking coil and is therefore introduced into the voice coil. The hum-bucking coil, however, is connected so that the hum voltage introduced opposes any hum already there. Accidental reversal of the leads to this coil will increase the hum level greatly. In complaints of this kind, try reversing the leads to the hum-bucking coil and note any change in the amount of hum.

Let us now consider the procedure to be followed in correcting the troubles listed above.



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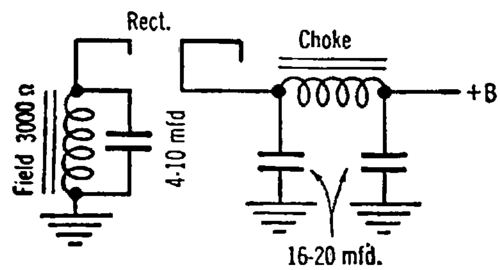
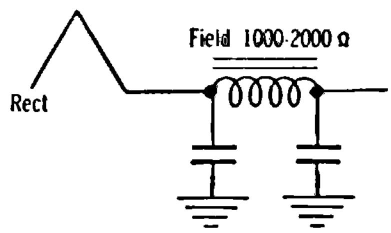


B

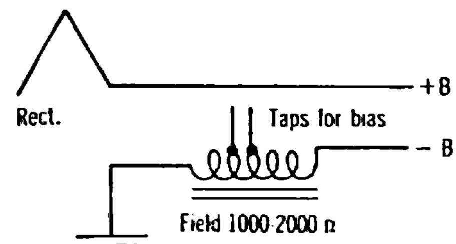
Open Field Coil. Replace the coil. To make proper replacement, a field coil having the correct resistance must be used. Of course, the coil must also have the correct diameter, length and opening to accommodate the core. Generally, the field coil used in a.c.-d.c. sets has a resistance of 450 ohms and that used in a.c. sets is 1000 to 2000 ohms. However, there are exceptions to this rule, as there are to all others. The two sketches below illustrate the method of connection and the field resistance of speakers used in a.c.-d.c. receivers.

Diagram "A" shows the usual method of employing the field as a filter choke. Its resistance is about 450 ohms. In "B" the field current is supplied by one cathode of the rectifier, while the other cathode supplies plate and screen voltages. The field in this case is generally 3000 ohms. The following drawings show some of the methods of obtaining field supply in a.c.-operated sets.

In "C" we have the usual circuit in which the field, from 1000 to 2000 ohms, is used as a filter choke. A variation of this is seen in "D." Here the field is again used as a choke, but is connected in the negative side of the power supply. In addition, taps are provided on the field coil to supply bias voltage. Diagram "E" illustrates a method of using the field, together with a wire-wound resistor, usually about 5000 ohms, as a bleeder across the power supply. In this type circuit the plate and screen voltages for the output tubes is taken from the choke and all other voltages are taken off after the field coil. "F" shows a modification of this idea, in which the field has high enough resistance to eliminate the wire-wound resistance.

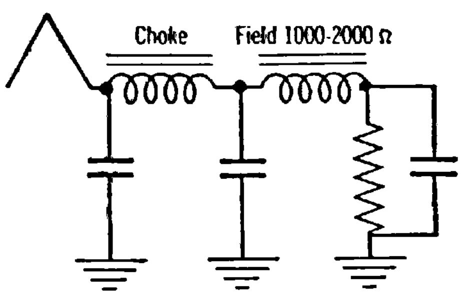


C

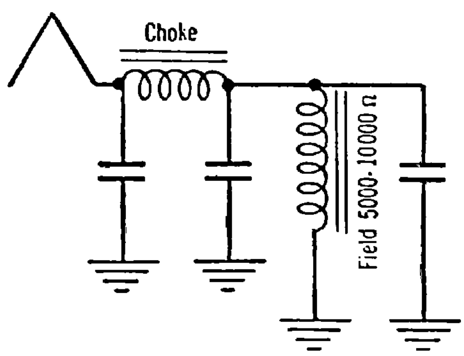


D

Where the manufacturer's service bulletin is not available, a study of these diagrams will usually aid in determining which of the methods is used, and will enable you to substitute a field of correct or nearly correct value. In certain types of speakers you will find that it is quite impossible to remove the field coil. This is because the pole piece is welded to



E

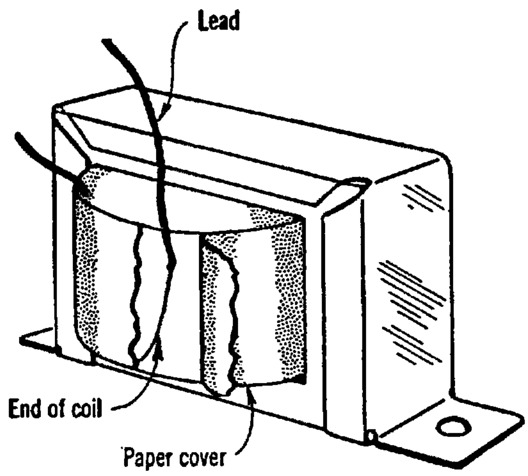


F

the yoke. Repair in such cases generally means replacing the entire speaker. In most cases the field coil can be removed by either removing the core or separating the pole piece from the yoke. The method of replacing field coils is described in the job sheet "How to Replace a Field Coil."

There is at least one make of receiver in which the field coil cannot be removed from the yoke, but the assembly of yoke, coil and pole piece is replaceable. The pole piece is secured to the cone frame by means of four drive screws. To replace this type of assembly, first remove the cone. and then, with a punch, drive out the four drive screws. Fasten the new assembly in place by driving the screws through the holes in the cone frame and into the pole piece with a hammer.

Grounded Field Coil. This occasionally happens and is due to the field coil lead or winding touching the frame or yoke. It may be cleared up without replacing the field coil in cases where the ground is at one of the connecting leads or is at a part of the coil near the outer end. If you can locate the ground, use paper insulation to keep the wire away from the frame.



G

Open Output Transformer. This ordinarily means replacement of the transformer, but if due to the lead breaking off the outer end of the winding, a repair may be made. Cut open the paper covering as shown in sketch "G"; find the end of the winding and resolder the lead to it. Fold the paper back in place and glue or cement a piece of paper over the cut. When it becomes necessary to replace a transformer, be careful to use one which matches the impedance of both the output tube and the speaker voice coil. If you know the model number and make of the set it is best to use the manufacturer's replacement part. If this cannot be obtained, the parts dealer can usually supply an equivalent. There are also available universal replacement transformers, which have a number of taps to adapt them to use with various tube and voice coil impedances.

Shorted Turns in Transformer Primary. The information given under "Open Output Transformer" applies to this type of trouble, except that the transformer must be replaced in all cases.

Open Voice Coil. The only way to make repairs in case of an open voice coil is to replace the voice coil and cone assembly. To do this intelligently you must have either (1) make and model number of set or

(2) diameter of cone, diameter of voice coil, type of suspension. It is a good idea when buying a replacement cone to take with you the old one for comparison. The method of replacing and centering cones is described and illustrated in the three job sheets which follow.

Incorrect Transformer Match. This type of trouble should be suspected only after all other possibilities have been exhausted, and then only in cases where the speaker appears to have undergone previous repairs. You should have a good universal transformer on hand to substitute in suspected cases.

Torn Cone. The best course to follow is to replace the cone, but temporary repairs can be made by spreading a small amount of speaker cement over the edges of the break.

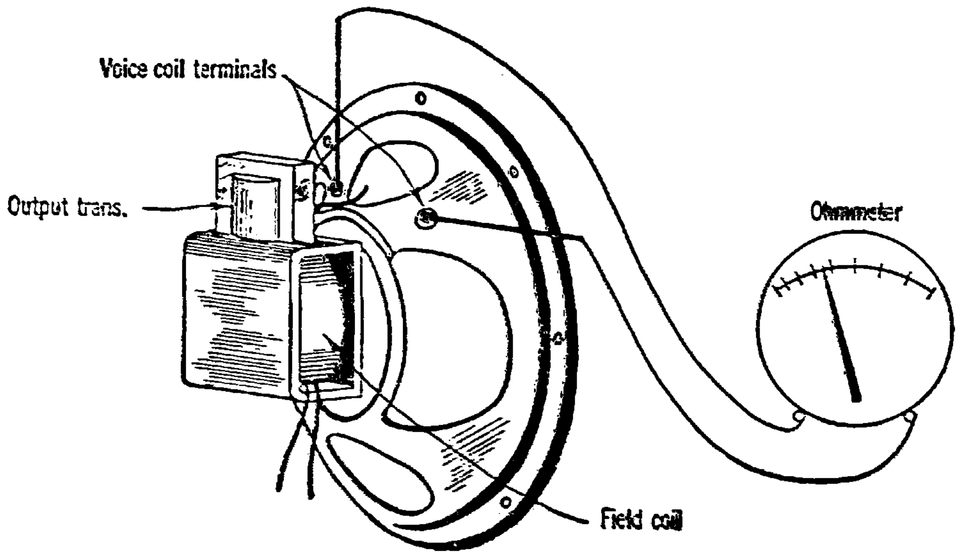
Loose Turns on Voice Coil. This may sometimes be corrected by cementing the loose turn or turns down to the paper winding tube. This is a rather delicate operation, and great care must be used to get the turns back into proper position and to avoid any pressure on the tube which might throw it out of round.

Voice Coil Loosened from Cone. The information relative to loose turns on voice coil may be applied here.

Loose or Broken Spider. Replace the cone assembly.

Voice Coil not Centered, Centering Screws Loose. Recenter the cone as described in the job sheets.

JOB SHEET NO. 31



AIM: To learn how to test a speaker.

THEORY: The most common troubles in a speaker are open field coil, open voice coil, and open output transformer primary. Sometimes the field coil becomes grounded to the frame of the speaker. It is rare to find that the output transformer secondary is open. In addition to these, there are mechanical troubles such as torn cone, cone not centered, etc. However, these are mechanical and cannot be revealed by electrical tests.

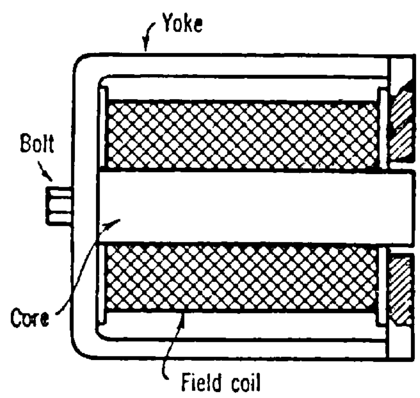
PROCEDURE: 1. To test for open field coil, use ohmmeter across winding. Most speakers used on a.c.-d.c. sets have field resistance of either 3000 or 450 ohms. If set is in operation, continuity of field can be checked by noting whether core is magnetized when set is turned on. In measuring resistance of field, note that the usual a.c. set uses a 1000-ohm field. Some sets use a field with one or more taps. Be sure to check resistance of all taps.

2. A grounded field can be detected by placing one test prod on the frame of the speaker and the other prod on one of the field leads.

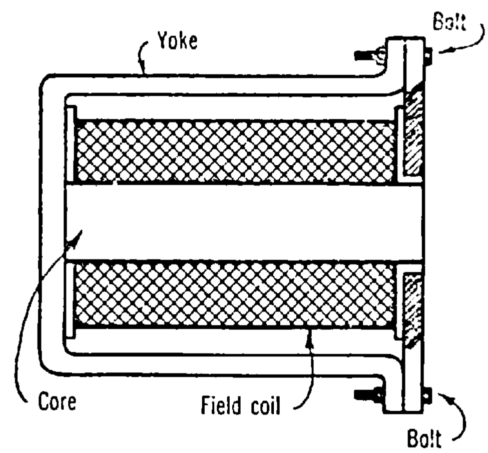
3. Open output transformer may be located by measuring resistance of the primary. If the speaker is used in a set with push-pull output stage, the primary will be tapped. Measure resistance from center tap to each of the outer ends. Shorted turns in the primary will show up as a difference in the resistance of the two halves of the winding.

4. Open voice coil. Disconnect one end of transformer secondary from voice coil terminal as shown in the sketch. If this is not done the two are in parallel. Measure resistance of voice coil and transformer separately.

JOB SHEET NO. 32



A



B

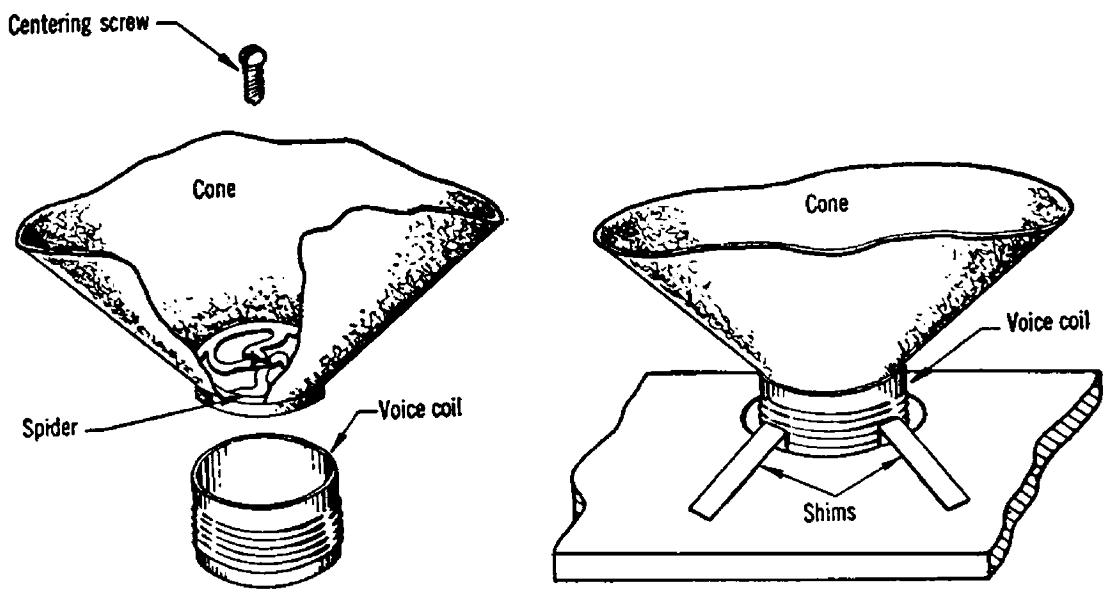
AIM: To learn how to replace a field coil.

THEORY: The sketches show two types of field assembly in general use. In "A" the pole piece, or front of the yoke, is welded to the yoke and cannot be removed. In "B" the pole piece is fastened to the yoke with three or four bolts.

PROCEDURE: **Type "A."** Disconnect field coil leads from terminals. Also disconnect hum-bucking coil, if used. Remove voice coil centering screw. Remove cone frame with cone intact from pole piece. Cone frame will usually be fastened to pole piece with several screws. Loosen and remove bolt at rear end of field assembly. It may be necessary to hold field assembly in a vise while doing this. Use an adjustable or other type of open-end wrench on the bolt. Push the core out through the opening in the pole piece. Remove the field coil. Install new coil and reassemble speaker. Avoid striking end of voice coil against core when replacing cone and frame.

Type "B." Disconnect field coil and hum-bucking coil leads. Remove centering screw. Remove screws which hold pole piece to yoke. Remove yoke. Slide out field coil. Install new coil and reassemble speaker.

JOB SHEET NO. 33



A B

AIM: To learn how to replace and center a speaker cone of the inside-spider type.

THEORY: Figure "A" shows the construction of this type of cone. The support, or spider, is located inside the cone, and is made of fiber, paper or similar material. It is cut out as shown to give it flexibility. The spider is supported and retained in a central position by means of the centering screw. This screw passes through an oversize hole in the spider to permit shifting the spider for adjustment.

PROCEDURE: **To remove old cone:** 1. Remove centering screw. Unsolder voice coil connections. Cut outer edge of cone away from support ring. Remove cone from speaker.

2. With pocket knife scrape away remains of paper and hardened cement from support ring.

3. Draw a piece of friction tape around field coil core to remove dirt or filings from gap.

To replace cone: 1. Spread a thin film of Duco cement, airplane cement or ambroid on support ring.

2. Drop cone into position. Be sure that voice coil leads are in proper position toward terminals. If cone is punched at edge for speaker mounting screws, make sure that holes in cone match up with holes in support ring.

3. Replace centering screw loosely. Allow cement to dry.

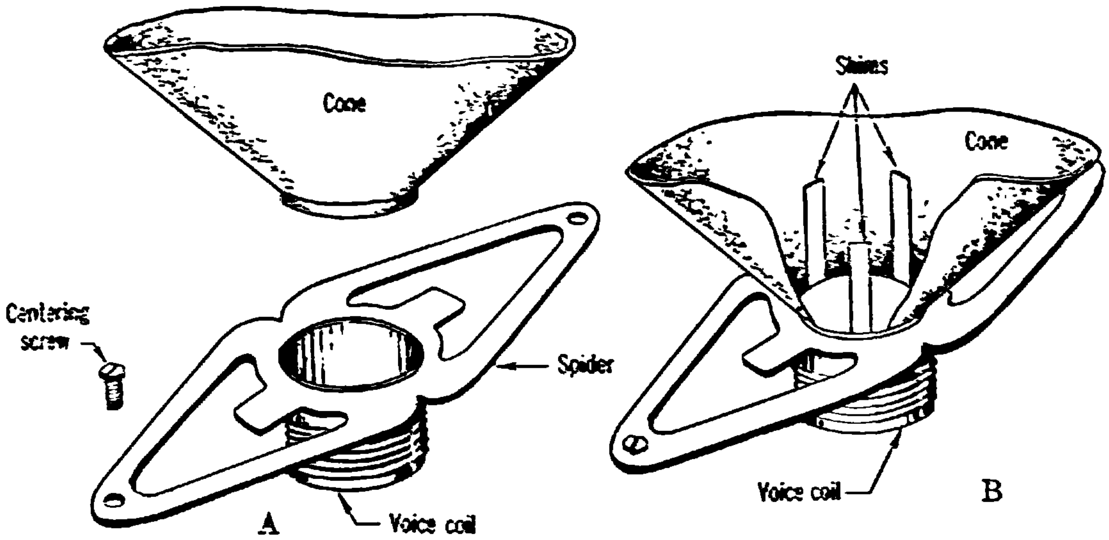
4. With centering screw loose, insert three paper or celluloid shims between voice coil and yoke as shown. Shims should be equally spaced. Shims must be bent as indicated to clear base of cone. Proper thickness of shim can be determined by trial.

5. With shims in place tighten centering screw. Do not tighten so that spider is bent or distorted.

6. Remove shims and test adjustment of cone by moving voice coil in and out slightly. If not correctly centered, loosen centering screw and repeat adjustment.

7. Solder voice coil leads to terminals.

JOB SHEET NO. 34



AIM: To learn how to replace and adjust a speaker cone of the outside-spider type.

THEORY: The parts and assembly of this type of cone are shown in "A." The spider is made usually of fiber; occasionally, in old type speakers, of metal. The spider is supported at its ends by two studs mounted on the front yoke of the speaker. The spider is held in place by two screws which pass through oversize holes in the ends of the spider. The holes are made larger than the screws to permit centering.

PROCEDURE: **To remove old cone:** 1. Unsolder voice coil leads from terminals.

2. Remove centering screws.

3. Cut cone away from support ring. Remove cone.

4. Scrape remnants of cone and cement from support ring.

5. Clean out gap with a piece of friction tape to remove filings or dirt.

To replace cone: 1. Spread a thin layer of speaker cement on support ring. See that cement is evenly spread.

2. Drop new cone into position. Voice coil connections should be turned to correct position, facing terminals. Smooth cone into position on ring. Allow cement to harden.

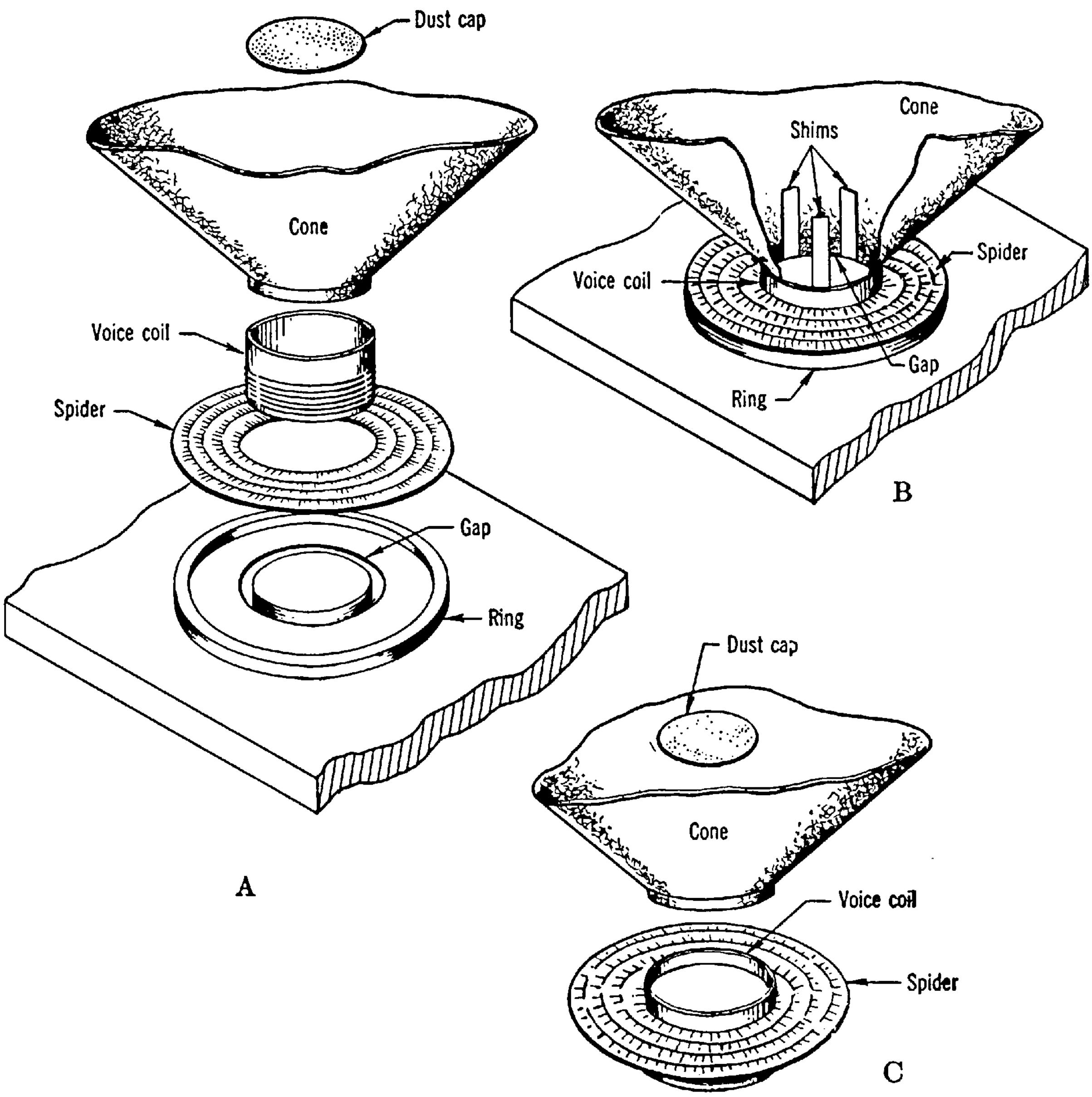
3. Replace centering screws loosely. Insert three shims equally spaced inside of voice coil, between voice coil and core. Refer to sketch "B." Correct thickness of shims can be found by trial.

4. With shims in place, tighten centering screws. It may be found difficult to reach these screws with an ordinary screwdriver. The use of an offset screwdriver or end wrench may be necessary. Be careful not to tighten screws so much that spider is bent.

5. Remove shims and test for correct centering of voice coil by pushing cone in and out slightly. If centering is not correct, replace shims and repeat the adjustment.

6. Solder voice coil leads to terminals.

JOB SHEET NO. 35



AIM: To learn how to replace and center a speaker cone of the enclosed-gap type.

THEORY: This type of speaker cone is so called because the gap in which the voice coil moves is completely enclosed to keep out dirt and metal particles. Refer to sketch "A." The gap is surrounded by a raised ring which supports the spider and to which the spider is cemented. The inside of the spider is cemented to the top end of the voice coil, to which point the lower end of the cone is also attached. The spider used with this type of speaker is made usually of cloth, sometimes paper. It has raised concentric rings pressed into it to give it greater flexibility. With the cone in place, a thin disc of felt or paper is cemented over the voice coil opening, and this seals the gap.

PROCEDURE: Replacement cones for this type of speaker are supplied in two ways, (1) the cone completely assembled, except for dust cap, (2) a kit consisting of three pieces, the cone, the voice coil and spider assembly and the dust cap. This kit is shown at "C." If the cone you are to install is in one piece, proceed as follows:

1. Unsolder voice coil leads.

2. Cut cone away from support ring.

3. Cut spider away from spider support ring.

4. Clean out gap with friction tape or the point of a magnetized knife.

5. Scrape paper and old cement from cone support ring. Clean pieces of old spider from spider support ring.

6. Spread a thin film of speaker cement on both cone support ring and spider support ring. See that cement is even.

7. Drop cone into place. Insert three shims of proper thickness between voice coil and core. Smooth down spider and edge of cone on support rings. Allow cement to harden.

8. Remove shims. Cement dust cap in place. Solder voice coil leads.

If your cone is received as shown in sketch "C," follow this method:

1. Remove old cone as outlined above under 1, 2, 3 and 4.

2. Spread cement lightly on spider support ring. Drop spider and voice coil assembly in place.

3. Insert three shims between voice coil and core. See sketch "B." Smooth down spider in place on ring. Allow cement to harden.

4. Remove shims.

5. Spread cement on cone support ring. Place a light coating of cement on lower end of cone. Drop cone into place. Smooth down edge of cone on ring and see that lower end of cone contacts voice coil all around. Allow cement to harden.

6. Cement dust cap in place.

7. Solder voice coil leads in place.

Questions

1. Name several common troubles that may develop in speakers.
2. Why is it possible to hear very weak signals with an open field coil?

3. What are some of the causes of rattle in a speaker?

4. How would you determine the proper connections for a hum-bucking coil?

5. In a set using the field coil as a filter choke, connected in the positive side of the supply, what would happen if the field coil became grounded?

6. Assuming that the *B* supply is operating normally, what test may be used as a rapid check for open field coil?

7. In checking the secondary winding of an output transformer, why must one side of the voice coil be disconnected?

8. What is the usual remedy for an open voice coil?

9. If you find it necessary to replace a voice coil and cone assembly, and you do not know the make and model of the receiver, what information is required to obtain a proper replacement?

10. How would you check for a suspected mismatch between output transformer and output tubes?

11. How would you correct a loose voice coil winding?

12. In the usual a.c.-d.c. receiver using the field coil as a filter choke, what is generally the field coil resistance?

13. Referring to Question 12, what might be the result of using a field coil with a resistance much higher than normal?

14. What advantage is gained by using the field coil as a choke connected in the negative side of the supply?

15. What is a good method to use in cleaning filings or dirt out of the voice coil gap?

16. What tool is used to adjust spacing between the voice coil and the core?

17. How are shims placed when adjusting an outside-spider type of cone?

18. How are shims used when adjusting an inside-spider cone?

19. What material should be used for holding the edge of a cone to the supporting ring?

20. What precaution must be taken when tightening the centering screw on an inside-spider cone?

21. What parts are generally included in a cone kit for a speaker of the enclosed-gap type?

References

Mye Technical Manual, P. R. Mallory & Co., Inc.; pp. 8–15.

Henney, Radio Engineering Handbook, McGraw-Hill Book Co.; pp. 899–915.

Hicks, Principles and Practice of Radio Servicing, McGraw-Hill Book Co.; pp. 200–211.

9

ALIGNMENT

The average superheterodyne designed for broadcast reception only is equipped with a minimum of six resonant circuits. In order for the receiver to operate at maximum sensitivity, these circuits must be tuned or adjusted to specific frequencies. In the case of the intermediate frequency amplifier, the circuits are permanently tuned to a frequency somewhere between 450 and 470 kilocycles, in most modern receivers. Sets built at the time when short-wave reception first came into vogue in home receivers used an intermediate frequency of about 260 k.c. (this frequency is also quite common in automobile receivers), while those manufactured before the advent of short-wave radio were designed for an i.f. in the vicinity of 175 k.c. Whatever the particular frequency used, an i.f. transformer is built to give maximum response at the frequency for which it was designed. Any deviation from this frequency results in reduced sensitivity, and, in some cases, distortion.

Considering the resonant circuits used in the r.f., oscillator and mixer circuits, we find that it is necessary to provide trimmer condensers here in order that compensation may be made for small differences in coil inductance, tuning condenser capacity and length of connecting leads. Usual practice is to adjust these trimmers at 1400 k.c., although sometimes the set manufacturer recommends another frequency for the adjustment. Some service bulletins prescribe adjusting the oscillator trimmer at 1500 k.c. and the other two at 1400 k.c.

In addition to the necessity for adjusting above mentioned trimmers at the high-frequency end of the range, some means must be provided for taking care of the difference in tuning which exists between the oscillator and the other two circuits at the low-frequency end of the range. This may be done in either of two ways—the use of a specially shaped rotor in the oscillator section of the variable condenser, or the introduction into the circuit of a low-frequency padder.

You will see from the foregoing that even without the further complications of short-wave bands, a superheterodyne without an r.f. stage ahead of the mixer will have six or seven adjustments, and if an r.f. stage is used, one more trimmer is added. For each frequency range added to the set another trimmer, perhaps two, must be provided. Consider all of these factors whenever you hear a service man state that a superheterodyne may be aligned by ear, that is to say, without using a signal generator. It is true that in cases where a set is very badly out of alignment, alignment may be made by "touching up" the various adjustments while listening to a broadcast station. But this does not mean that a receiver so adjusted is operating at peak sensitivity, for you have no accurate knowledge of the frequency to which the i.f. transformers are adjusted. This correct setting may be obtained only through the use of a signal generator. Furthermore, while a fairly accurate adjustment of the high-frequency trimmers may be made while listening to a station whose frequency is known, correct setting of the low-frequency padder under these conditions is extremely difficult. One reason for this is the variation in intensity of the station signal. To sum up, it is agreed by almost everyone in the trade that a signal generator is an absolute necessity in aligning a superheterodyne. To go a step further, it is recommended that you make a complete alignment of each receiver you service in order to assure the customer the maximum in performance.

Output Indicators

Most service men make all alignment adjustments while listening to the signal, but this is not good practice, because the ear is notably unreliable when judging small differences in sound intensity. For this reason it is much better to use an output meter as a visual indicator. The use of the output meter is described in the job sheet at the end of this chapter.

Many sets are equipped with some form of tuning indicator. In such cases alignment is simplified. The tuning indicator, whether plate milliammeter type, shadowmeter or electron ray tube, may be used as an indicator of resonance. In making all adjustments, look for minimum width of shadow if electron ray or shadowmeter is used, or maximum swing of pointer if a milliammeter is used.

Another excellent method of determining resonance is to connect a vacuum-tube voltmeter across the AVC resistor. This will generally be from the bottom end of the r.f. filter resistor in the diode return circuit to ground. Make all adjustments for maximum reading on the V.T.V.M.

Aligning TRF Receivers

Since adjustment of high-frequency trimmers only is involved in this type of set, alignment may be made by using a broadcast signal, as mentioned above. But a generator will prove to be of great value because its signal is of constant amplitude and because its intensity may be controlled.

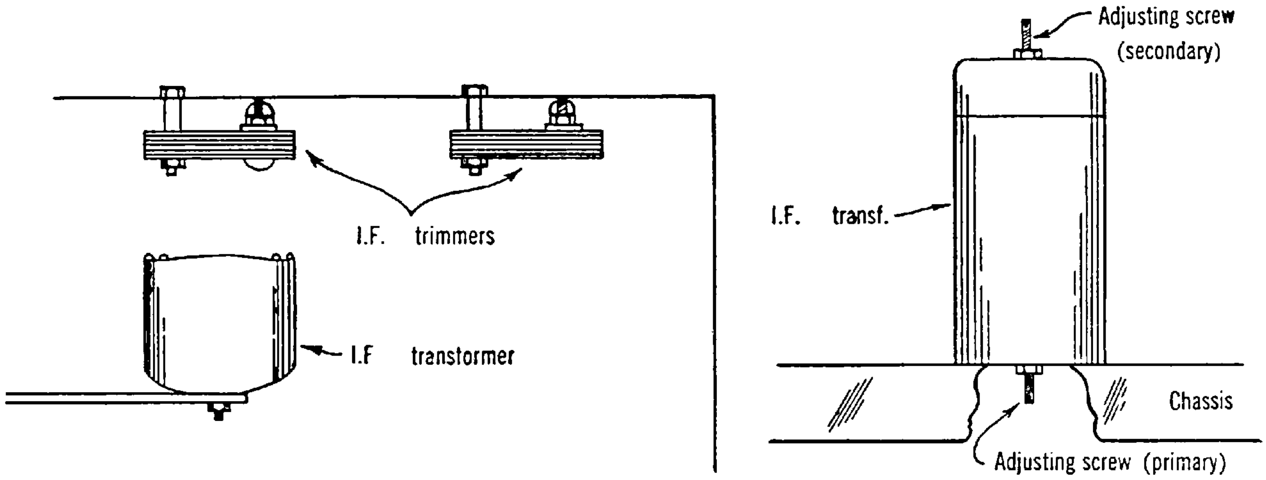
Alignment of TRF sets is generally done at 1400 k.c., although there may be reasons for making the adjustments at some other frequency. For example, the sensitivity of the receiver may be found to drop off at the low-frequency end of the range, and alignment at a lower frequency, say 1200 or even 1000 k.c., may help to offset this difficulty. Bear in mind, however, that when making adjustments at a lower frequency the effect of the trimmers will be much less than at a higher frequency.

The alignment of a typical a.c.-d.c. TRF receiver is fully described and illustrated in the job sheets which accompany this chapter. Sets using two r.f. stages or more will have one additional trimmer for each stage added, but the adjustment of the additional trimmers is exactly the same as that required for the other two. You will find that in all cases the antenna circuit trimmer has a tendency to be broad, that is, turning the screw over a considerable range will have comparatively little effect. This is quite normal. A much more accurate setting of this trimmer may be obtained by using an output meter in conjunction with the signal generator.

Aligning Superheterodynes

I.F. Amplifier. Job sheets describing the complete alignment of a superheterodyne have been included in this chapter, but a number of points may require further amplification.

If the i.f. amplifier appears to be in approximate alignment, the signal generator output lead may be connected to the signal input grid of the converter tube and the i.f. trimmers adjusted in any order. However, there may be situations in which, possibly due to someone tampering with the adjustments, it may be impossible to get a signal through the amplifier. The best procedure then is to connect the output lead to the control grid of the i.f. amplifier tube and proceed to adjust the trimmers on the second i.f. transformer. If the adjustments are very far off, you may find it necessary to work your way up or down in frequency until the correct setting is reached. The frequency to which the transformer has been incorrectly set may be found by varying the generator frequency until a signal is heard and then reading this frequency on the generator tuning scale. Suppose you find that, although the correct frequency is 456 k.c., the transformer appears to be tuned to 470 k.c. and no signal can be heard when the generator is tuned to the correct frequency of 456 k.c. Under this condition, you may lower the generator frequency until the signal is just audible. Let us assume that this new frequency is 465 k.c. Proceed to adjust the i.f. trimmers for maximum output at this frequency. Again lower the generator frequency until the signal is just audible. This frequency may be 460 k.c. Now adjust the trimmers for maximum response at 460 k.c. Repeat this process until you have reached the correct frequency of 456 k.c. When alignment of the second transformer has been completed, transfer the output lead to the grid of



A *Courtesy Philco* B *Courtesy RCA*

the converter tube and adjust the first transformer. If the second transformer has been correctly adjusted, you will probably find that a signal, although weak, will pass through the amplifier at 456 k.c. and that you will not have to repeat the process described above. Of course you may adopt the alternative method of tuning the generator to 456 k.c. and adjusting all the trimmers in turn until a signal is heard, but this is an operation that often requires considerable patience, and the other method seems easier. After completing the adjustment of the first i.f. transformer, go back to the second transformer and recheck your adjustment.

In aligning any receiver, be careful to set the receiver volume control for maximum volume and to control the signal input to the receiver by means of the attenuator on the generator.

Most receivers have the i.f. trimmers located at the top of the transformer shield can, but there are some exceptions worth mentioning. A few older sets use trimmers which are entirely separated from the transformer, Crosley and Philco being among these. The trimmers are usually located along the back edge of the chassis and are reached through a hole in the chassis. This arrangement is illustrated in "A." You may find that the hole through which the trimmer is adjusted is covered by a small metal plate held to the chassis by means of a single drive screw. This plate is to discourage tampering on the part of the set owner.

At least one manufacturer, RCA, uses a transformer with one trimmer located at the top of the shield can and the other at the bottom. It is necessary to turn the chassis over to adjust the lower trimmer. Service men have been known to omit adjustment of this second trimmer, assuming that the transformer was of the single-tuned variety, that is, having one winding untuned. The location of trimmers in this type of transformer is shown at "B."

High-Frequency Adjustments: RF, Antenna and Oscillator Circuits. Most service men make these adjustments at 1400 k.c. as a matter of course, but there are set manufacturers who specify that they be made at other frequencies, notably at 1500 k.c. Wherever possible, obtain a copy of the manufacturer's service bulletin pertaining to the set at hand and follow the instructions given.

A few service bulletins call for alignment at a specified frequency, generally 1600 or 1700 k.c. with the tuning condenser set at minimum capacity. In order to obtain this minimum capacity setting accurately a piece of paper or a celluloid shim is placed between the free end of the rotor plates and the edges of the stator plates while the tuning dial is turned as far as it will go toward the high-frequency end of the range.

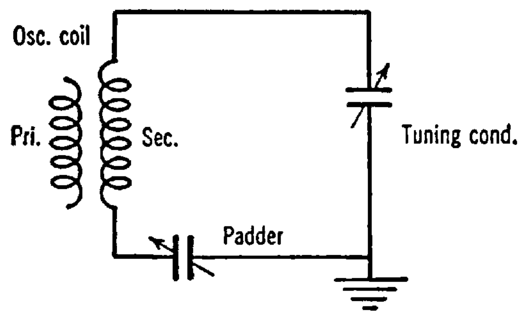
In adjusting the high-frequency trimmers, bear in mind that three things must be done: (1) the generator must be tuned to the frequency specified, (2) the receiver must be tuned to that same frequency, and (3) the trimmers must be adjusted for maximum signal. If the generator is not accurately adjusted or if the receiver is incorrectly tuned, you may succeed in aligning for maximum sensitivity, but you may find that the receiver does not tune to the frequency indicated on the dial.

This brings us to the matter of those receivers in which the tuning scale is a part of the cabinet rather than of the set. Such dials usually consist of a glass or celluloid strip on which the calibrations appear. In cases where the receiver is a small table model, no problem is involved, but it is unusual for the service man to remove a large floor cabinet to his shop. Some manufacturers, RCA particularly, have overcome the difficulty by printing a full-size reproduction of the tuning scale in the service bulletin covering the particular set. Lacking this device, it might be a good idea to mark the positions of the dial pointer at the 1400- and 600-k.c. settings in a convenient place on the set, such as the dial frame back of the pointer, before removing the set from the customer's home. When working on small sets in which the dial scale is part of the cabinet, you will have to place the set in the cabinet, tune it to the desired frequency, then remove it from the cabinet and proceed with the alignment.

In the course of adjusting the high-frequency trimmers, you will find that the oscillator is critical; in other words, a slight adjustment either way may cause the signal to disappear entirely. Incidentally, this trimmer is largely responsible for adjusting the frequency at the high-frequency end of the range, and, because the other trimmers tune relatively broadly, this fact may be used to work your way up or down in frequency in cases where the signal being received does not check with the dial calibration. The other circuits will probably be broad enough to admit a signal, even though not accurately tuned to it, especially where no r.f. stage is used. If you find, for example, that the dial scale reads 1250 k.c. but the station being received is known to be operating on 1400 k.c. you will know that in order to bring the pointer to its correct setting of 1400 k.c. the circuit capacity must be reduced (tuning condenser must be turned toward high-frequency end of the range). To permit this reduction of tuning condenser capacity, capacity must be added by turning the trimmer in (increasing capacity). Tune the generator to the same frequency as the set, then detune until a signal is just audible, and readjust the oscillator trimmer. Proceed as described under "I.F. Alignment," following up each change in oscillator trimmer capacity with a change in generator frequency until you find that the dial reads 1400 k.c. when the generator is tuned to 1400 k.c.

Low-Frequency Padder. As mentioned before, the low-frequency padder is provided to compensate for differences in tuning between the oscillator and other circuits at the low-frequency end of the dial. The padder is connected in series with the oscillator coil secondary and the oscillator tuning condenser, as shown in "C."

The adjustment of this padder is made at about 600 k.c. and involves a procedure referred to as rocking the tuning condenser. When performed by an experienced operator, the motion of the tuning condenser becomes fairly rapid, hence the term rocking. Actually, an adjustment of the padder is made in either direction, and then the tuning condenser is readjusted. If this readjustment produces an increase in signal, the padder adjustment is continued in the same direction. If not, the padder screw is turned in the opposite direction. This is continued until a point is found where further movement of either padder or tuning condenser will result in reduced signal. When you first try this operation, you will probably find that the adjustment is somewhat difficult, but after a little experience you will be able to make the two motions simultaneously and quite rapidly.



C

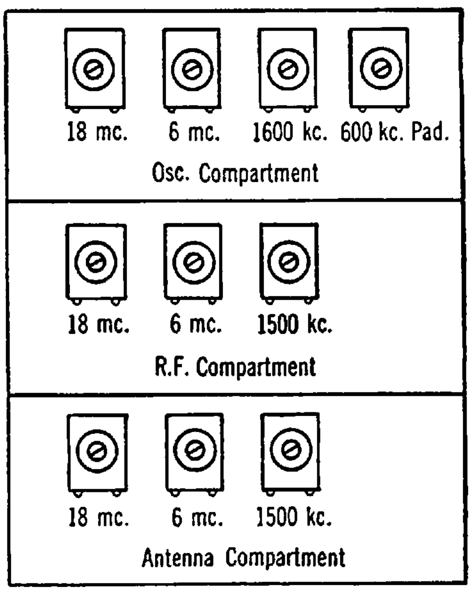
Multi-Band Receivers

The alignment of a receiver having one or more short-wave bands is no more difficult, when proper instructions are at hand, than one having only a broadcast band. Without knowledge of trimmer location and a description of the correct aligning procedure, however, the job can be something that service men would rather, and sometimes do, avoid. Of course, situations will arise where service bulletins are not available and the job must be done; it is to cover these cases that the following hints are given.

Perhaps the chief difficulty is in ascertaining the functions of each of the trimmers. In a set designed only for the 500- to 1600-k.c. band, the trimmers are almost always located on top of the tuning condenser. Many modern multi-band sets are constructed so that the antenna, r.f. and oscillator components are arranged in separate shielded compartments, and the associated trimmers are located in an accessible place in each compartment. In receivers using this type of construction, no particular trouble should be encountered in determining which trimmer tunes a circuit, except in cases where low-frequency padders are used on the short-wave bands, and even then you will be able to distinguish between a high-frequency trimmer and a low-frequency padder, because the padder will have a greater number of plates. A sketch of a set of the type discussed above is shown in "D."

Sometimes you will find that all trimmers and padders are located on a panel or strip at the rear of the set, as in "E," and are reached through holes in the rear of the chassis. The easiest way to identify the various adjustments is to trace the wiring from the trimmer or padder to the coil, noting the type of winding on the coil. The coil having the greatest number of turns on its secondary is the broadcast-band coil (or long-wave band, if one is used), the next in order of number of turns is the one belonging to the lowest frequency short-wave band, and so on.

Another method of locating the various adjustments is to set the receiver wave band switch on the lowest frequency band, set the generator to the desired frequency, tune the set to that frequency and try the adjustments one at a time until the correct one is found. This procedure is none too satisfactory, first because it is possible for one adjust-



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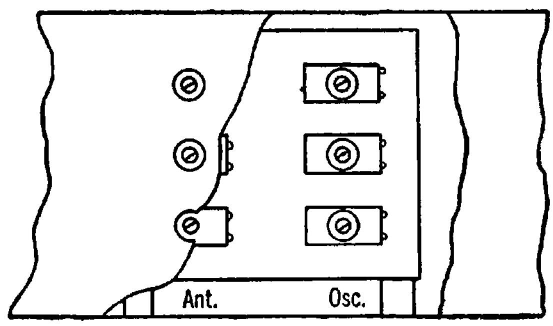


E

ment to affect the others, and second because you must use some method of noting those adjustments which have been made to prevent throwing an adjustment off.

The second difficulty met in aligning an all-wave set is determining the correct aligning frequency for each band. While it is not absolutely correct procedure, this may be overcome by making all high-frequency adjustments at a point about ten percent of the total band from the high-frequency end, and all padding adjustments about ten percent of the total range from the low-frequency end of the range.

Before leaving the subject of alignment, it seems appropriate to mention that sometimes difficulties which arise in getting a set to track, or to tune in stations at the correct dial readings, often are not alignment troubles at all, but are due to the fact that the tuning indicator or pointer is not properly set. You will generally find a mark on the dial scale, beyond the last frequency calibration, to which the pointer is to be set when the tuning condenser is fully closed. Incorrect setting of the indicator will throw the calibration off over the entire tuning range.

Troubles Encountered in Alignment

I.F. Amplifier. Signals weak, i.f. trimmer makes no difference regardless of setting. May be due to open coil or shorted trimmer.

Signals nearly normal, i.f. trimmer makes no difference, screw may be turned continuously without tightening.

Thread on trimmer screw, or on bushing into which it fits, is stripped.

Antenna, R.F. and Oscillator Trimmers. Antenna or r.f. trimmer increases intensity of signal when tightened, but no definite peak can be reached.

Oscillator trimmer adjustment too tight. Reduce capacity of oscillator trimmer, and realign.

Antenna or r.f. trimmer increases intensity of signal when loosened, but no definite peak can be reached.

Oscillator trimmer adjustment too loose. Increase capacity of oscillator trimmer and realign.

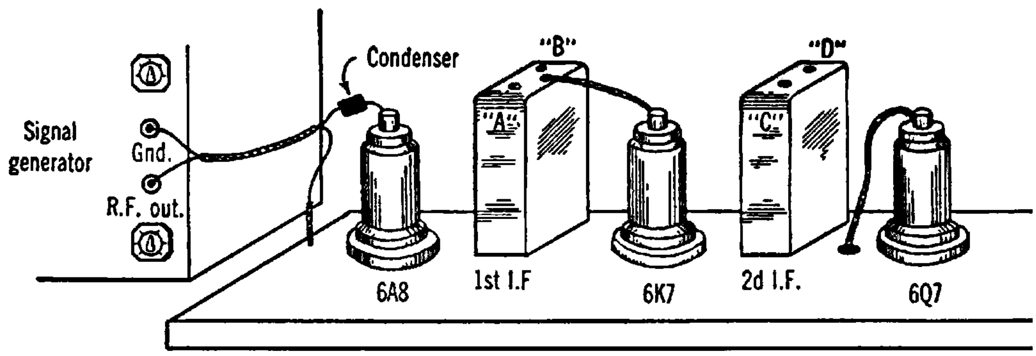
Signals very weak, trimmer makes no difference in intensity of signal. Probably caused by open coil secondary.

Low-Frequency Padder. Stations do not track, signals weak.

Shorted low-frequency padder.

Another cause for this arises in sets where the low-frequency padder is smaller than usual and a fixed condenser in parallel with the padder is used to make up the required capacity. If this fixed condenser is open, the padder will be ineffective.

JOB SHEET NO. 36



AIM: To learn how to align the i.f. amplifier.

THEORY: The i.f. amplifier usually consists of two i.f. transformers, each transformer having two windings. Connected across each winding is a small adjustable condenser. The coil winding and the condenser form a resonant circuit which must be tuned to a specified frequency before the set can be placed in operation.

PROCEDURE: 1. Find the correct intermediate frequency from the manufacturer's service bulletin, Rider manuals or the Mallory-Yaxley encyclopedia. Set up the signal generator to deliver this frequency.

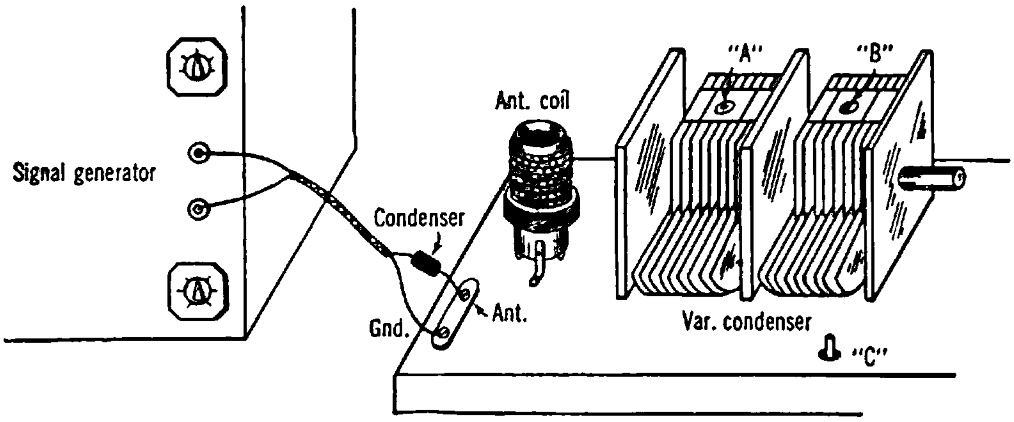
2. Plug the generator output leads into the jacks marked GND and R.F. OUTPUT. Connect the shielded or inner wire of the cable to the control grid of the converter. On types 6A8, 6A7, etc., this is the top cap. On single-ended tubes, 6SA7, 12SA7, etc., it is generally pin No. 8. Connect the outside wire, or shield, to the chassis. You should have a 0.00025-mfd. condenser in series with the shielded lead.

3. If you hear a signal, adjust the "Output Multiplier" and "Attenuator" until it is just loud enough to be heard. You will be able to make a much more accurate adjustment with low output.

4. Using an insulated screwdriver, turn the screws marked "A," "B," "C," and "D" until maximum output is reached. In other words, start with "A," let us say. Tighten the screw slowly. If you find that this reduces the volume, turn it the other way until you get the loudest response. As the volume increases, reduce the output at the generator to keep the signal as low as you can hear it. Repeat the adjustment with "B," "C," and "D."

5. When all adjustments have been made, go back to "A" and repeat the operation with all four screws to be sure all have been made accurately.

JOB SHEET NO. 37



AIM: To learn how to align the antenna and oscillator circuits.

THEORY: The antenna and oscillator circuits are tuned by means of a variable condenser. This variable condenser is fitted with small auxiliary condensers called trimmers. These are used to compensate for any differences in the two circuits due to wiring, differences in coils, etc. In addition, another small condenser called a padder is connected in series with the oscillator variable. This padder enables the circuits to track or "keep in step" at the low-frequency end of the range.

PROCEDURE: 1. Set up the generator to deliver 1400 k.c. Plug the output cable into the GND and R.F. OUTPUT jacks on the generator. Connect a small condenser to the antenna terminal of the receiver. Connect the ground side (shield) of the output cable to the ground terminal of the set, if set has a ground terminal. If set does not have ground terminal, connect the shield to chassis. Connect the "hot" side of the cable to the other end of the condenser which has been connected to the set antenna.

2. Tune the receiver to 1400 k.c. Turn volume control all the way up. If you do not hear a signal, try varying the frequency of the generator slightly.

3. Adjust output of generator to a very low level to insure accurate alignment.

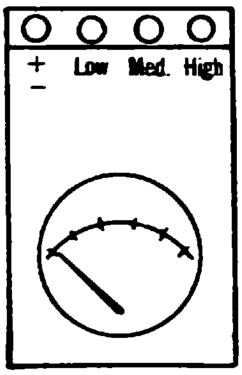
4. Adjust trimmers "A" and "B" to give loudest response. You will find one of the trimmers very sensitive or critical. This is the oscillator trimmer. If you had to throw the frequency of the generator off to hear a signal, you can bring it back by adjusting the oscillator trimmer a little at a time, at the same time increasing or decreasing the generator frequency slightly until you reach a point where the generator and the set are both tuned to 1400 k.c. and you are getting maximum response.

5. Tune both set and generator to 600 k.c. Find the padder. It may protrude through a hole in the chassis as shown, or may be under the chassis. In some sets it is accessible through a hole at the rear of the chassis. Screw in the padder slightly. If signal becomes weaker, retune variable to try to make signal louder. If you can, turn the padder some more in the same direction. When you reach a point where turning the padder causes the volume to drop and it cannot be increased by retuning, you are then at the proper adjustment. If, when you first tightened the padder screw, you found that the signal became weaker, and retuning the variable condenser did not restore the signal to its former volume, you are then adjusting the padder in the wrong direction. In that case, loosen the padder screw, and try retuning.

6. After you have obtained the best possible adjustment of the padder, return to the trimmers. Retune the generator and set to 1400 k.c. and recheck these adjustments. Often adjusting the padder will throw the 1400-k.c. adjustments off slightly.

Some receivers are not equipped with a padder condenser. In such cases you will find that the two sections of the tuning condenser are different in shape. The oscillator section is the smaller one.

JOB SHEET NO. 38



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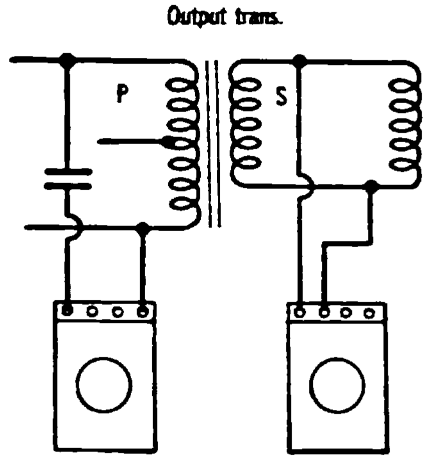

B

AIM: To learn how to use an output meter.

THEORY: Up to this time you have aligned sets by ear. That is, when making adjustments, you have listened for changes in signal strength. However, the ear is not reliable as an instrument. An output meter is therefore used to read the variations in signal visually.

PROCEDURE: 1. If a regular output meter is not available, you may use an a.c. voltmeter.

2. In figure "B" above, you will see that there are two methods of using an output meter. One is to connect the meter across the speaker voice coil as shown at the right side of the diagram. The second method is to connect the meter across the primary of the output transformer. This connection is shown at the left side of figure "B." *Note that when connecting the meter this way, a condenser must be connected in series with the meter to block direct current which is present in the primary circuit.*

Either of the two methods of connection may be used. If you connect the meter across the voice coil, you will have to use a lower range than when it is connected across the primary. This is because the primary voltage is higher than the voice-coil voltage.

3. Set up the signal generator for alignment of either the i.f. or r.f. and oscillator circuits. Connect the meter as shown at the left of "B." Start with the meter set on its highest range. If you find that the meter needle goes off scale, reduce the generator output until the needle reads about half scale. Proceed with the alignment. As you make adjustments and the signal increases, reduce the output of the generator to keep the reading about half scale.

4. Repeat the above with the meter connected as shown at the right side of "B."

Questions

1. What are the effects of improper adjustment of i.f. trimmer condensers?
2. What frequency is generally used for adjusting the h.f. trimmers in antenna, r.f. and oscillator circuits, on a single-band set?
3. What two circuit arrangements are in common use to provide for tracking at the l.f. end of the range?
4. What frequency is ordinarily used in aligning a TRF receiver? Give a reason for using a frequency other than that ordinarily used.
5. What procedure would you follow if you found that you could not get a signal through the i.f. amplifier when fed into the grid of the mixer?
6. What would you do if you could not get a signal through an i.f. amplifier on its normal operating frequency but could hear one at a frequency far removed from the normal?
7. How should the receiver volume control be adjusted when aligning a superheterodyne?
8. In adjusting the h.f. trimmers, you find that the dial calibration is incorrect. How would you correct this condition?
9. What frequency is usually used for adjusting the l.f. padder?
10. Describe the process of adjusting the l.f. padder.
11. In cases where trimmer condensers are not located on top of the tuning condenser, how would you distinguish between the various adjustments?
12. How would you distinguish trimmers used for the broadcast band from those used for a high-frequency band?
13. In the absence of correct aligning instructions, at what frequencies would you adjust the h.f. trimmers and the padder?
14. In aligning an i.f. amplifier, you find that the signal strength is low after all adjustments are made. The primary trimmer on the first transformer does not change the signal strength. What are two possible troubles?
15. You are aligning the antenna and oscillator stages of a set. You discover that varying the low-frequency padder makes no difference in signal strength; signals are weaker than normal, and stations do not come in at correct dial settings. What is probably wrong?
16. In connecting an output meter across the primary of an output transformer, why must a condenser be used in series with the meter?

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10

MISCELLANEOUS TROUBLES

Intermittent Operation. It would be quite impossible to list all the causes of this condition. The customer's complaint usually states that the set "fades," "dies out" or suddenly "goes dead."

The trouble may be centered in any stage, and may be due to almost any component in the set.

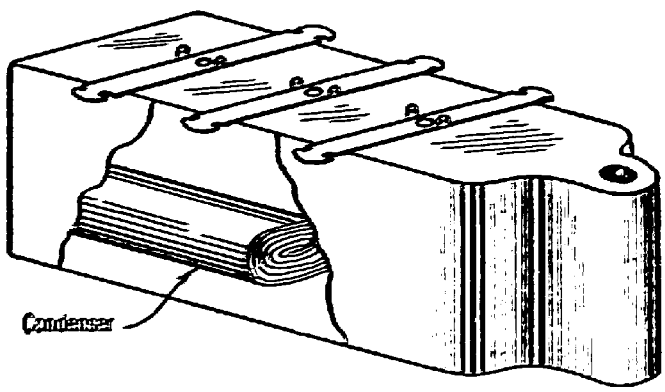
There are two distinct types of intermittent operation. In one case, the receiver goes dead suddenly, and normal operation is restored just as suddenly. The other type of intermittent operation produces a gradual decrease in volume, with either a sudden or a gradual restoration of normal operation. One of the most mystifying phases of the condition is that often the turning on of an electric light or electrical appliance will restore the set to normal. This is because the switching on of the lamp or appliance produces a voltage surge which is sufficient to clear up the condition temporarily. About the same thing happens when an attempt is made to take voltage readings, the application of the test prods again producing a voltage surge.

The most common cause of intermittent operation is a loose connection, and unless the loose connection is fairly obvious, the only way to locate it is to probe through the set using a non-metallic pencil or an aligning tool, tapping and wiggling parts and connections. You will probably find that as you proceed with the examination of the receiver and approach the immediate area of the trouble, the noise will become louder. This examination should be performed with the set in normal operation and the volume control turned on full. In fact, the volume control may be used in aiding you to find the noise. If the receiver is a superheterodyne using a diode detector, or any other type of set using a volume control in the audio circuit, turning the control to minimum volume, and tapping the parts and connections will indicate whether the trouble is in the audio end of the set. If the noise persists with the control set at minimum, the chances are that the trouble is in the audio amplifier. If the audio end seems to be clear of trouble, turn the control on full and proceed to check the rest of the set. Whether a signal is to be tuned in while making the check, depends upon conditions. These conditions will be determined by the action of the set; sometimes the noise is more evident with a signal coming in, in other cases it is not.

Shorted or intermittently shorted elements in a tube can produce noise and intermittent conditions which are almost identical with those due to a loose connection. The customer may tell you that noise is set up when someone walks on the floor in the vicinity of the set. Sometimes tapping on each of the tubes will disclose the noisy one, but more often such tapping will set up the noise regardless of which tube is struck. The best plan is to hold each tube while tapping it. Your hand will thus act as a sort of vibration damper and will prevent the vibration from being transmitted to other tubes or parts of the set. An excellent device to use for tapping the tubes is one of the round rubber bumpers used to support the chassis in the cabinet. These bumpers often have a hole in the center into which a short length of ⅜-in. dowel or an aligning tool may be inserted. This device is used as a small hammer.

Coupling condensers are a frequent source of intermittent trouble. Many service men, when confronted with a fading or intermittent complaint, replace any and all coupling condensers in the set as a matter of course. This is a safe procedure to follow, but very often perfectly good condensers are changed. A coupling condenser should be replaced only after all other possibilities have been explored, and even then a new condenser may be temporarily shunted across the suspected one. The number of cases of faulty coupling and bypass condensers assumed the proportions of an epidemic during the period extending from about 1928 to 1934. Since the service man could not be sure, after replacing the defective condenser, that another one would not fail in a short time, he usually replaced all of them. Many of these sets are still in service, and, it must be remarked, giving excellent service after many years. You will soon learn to recognize these sets and will probably adopt the practice of changing all condensers as a safety measure.

While on this topic, it might be well to mention the rather unusual type of paper condenser used by Philco for many years. The condenser itself is conventional, but it is enclosed in a molded case as shown in sketch "A." The condenser leads pass through small holes in the terminal lugs, which are mounted on top of the case, and are then soldered to the lugs. When these condensers develop intermittent trouble it is due to a poor connection between the lead and the tinfoil inside the condenser. An improved type of condenser was soon brought out to overcome the trouble. This new type of condenser uses a stranded lead rather than a solid wire. The strands are fanned out at the point where they connect to the foil, with the result that the chances of an open are minimized. When you are called upon to eliminate intermittent operation in a Philco set over eight years in service, look for solid wire leads on these condensers. If the condenser has a solid connecting lead, it is of the old type and should be replaced. Among the receivers which might develop such trouble are the following model numbers—70, 71, 90, 91 and 112.



A

Courtesy Philco

The type of condenser mentioned above has caused some confusion among service men, because it is not marked with the capacity as in the case of a conventional tubular condenser. Instead, a manufacturer's part number is used. This part number consists of four figures and a letter for example, 3903–M. The figures indicate the capacity, while the letter refers only to the terminal lug arrangement. In a still later condenser, four figures and several letters were used, as 3903–SU or 3903–DG. In the latter arrangement, the meaning of the letters is as follows: S, single condenser; D, double or twin condenser; G, grounded, meaning that one terminal is arranged so that mounting the condenser on the chassis will ground that terminal; U, ungrounded. These letters also occur in combinations as, for example, SU, meaning single unit, ungrounded; or DG, twin unit with common connection grounded. For your guidance, some of the common values with a Philco part number are given on page 148.

MFR'S. NO.	CAP. (MFD.)	MFR'S NO.	CAP. (MFD.)
3615	0.05	4989	0.09
3793	0.015	7625	0.006
3903	0.01	7296	0.002
6287	0.15	8035	0.0001

Another suspect in the list of parts which may cause fading or intermittent complaints is the old style carbon resistor with metal ends.

Still another cause may be found in r.f., antenna or oscillator coils. The trouble here is generally due to a poor connection between the end of the coil winding and the coil terminal lug, the result of either corrosion or failure to properly remove the enamel insulation before soldering. Detection of this type of trouble is often difficult, so that if you have exhausted all other possibilities, you might try resoldering all coil terminals with a fair-sized iron, being careful to see that the joint between coil end and terminal is thoroughly sweated in.

A peculiar type of intermittent often shows up in a.c.-d.c. sets, and is produced by an intermittent connection at one of the heater terminals inside of a tube. The result is a sort of thermostatic effect causing the tube heaters to blink on and off. The 50L6 is a common offender.

The more common causes of intermittent operation have been covered, but it is realized that the list is far from complete; many other possibilities exist. In most cases a method of signal tracing may be used in an attempt to isolate the trouble to a single stage. This means, of course, that the signal generator must be connected to one stage at a time and the generator allowed to run until the defect shows up or until the stage is found to be clear of trouble. This requires time, but it will at least limit the possible causes to parts associated with a single stage.

Hum. While hum is not usually as difficult to locate as fading, it often involves a job that takes considerable time.

You will naturally begin with the power supply, for most cases of hum arise here, filter condensers being the chief offenders. But you will occasionally find cases where no trouble exists in the power supply, although the set has an abnormally high hum level. Your next step should be to look for an open ground in the heater circuit. Some sets have one side of the heater winding grounded, while others use either a heater-winding center tap or a potentiometer across the heater winding, the center terminal of which is grounded. Incorrect adjustment of this hum potentiometer will result in high hum. An open ground either at the center tap or at one side of the heater circuit can result in hum.

An open bypass condenser often will produce excessive hum, particularly a cathode bypass condenser. If this is in the r.f., mixer or i.f. circuits, the effect will be a tunable hum, meaning that the hum is present only when a signal is tuned in.

There is a possibility that the hum-bucking coil, if one is in use, may have been reversed during a previous repair, or that the speaker may have been replaced with one having a field of incorrect resistance. Incidentally, the mere fact that an open field coil has been replaced with one of correct resistance does not indicate that the field also has the proper inductance. Speakers with field coils of equal size, may have widely different inductances with consequent difference in filtering effect. The physical size of the field may be taken into account in this matter.

As noted in the section on the audio amplifier, an open grid circuit is a frequent source of hum.

The signal tracing method is to be used to isolate hum in cases where the trouble is found to be outside the power supply. Try grounding the grid of each tube in order, with a screwdriver or other metal implement, observing whether any difference in hum level is produced by the grounding; for example, if you find that the hum disappears when the grid of the output stage is grounded, that stage has an open grid circuit, or the hum is being introduced into the circuit through a preceding stage. Grounding the grid of the preceding stage will then either confirm or eliminate the possibility of an open grid in the output stage. If the hum drops when the grid of the preceding stage is grounded, the output stage does not have an open grid circuit. Remember that hum may be picked up by any stage, but that hum introduced into the earlier stages of a set is likely to give more trouble because of the higher amplification.

Oscillation. Oscillation may be produced when voltage (signal voltage) is fed back from the plate circuit of a tube to the grid circuit of the same tube or of another tube. Interaction may also take place between the plate circuits of two tubes. This feedback may arise through capacity coupling, inductive coupling, or direct coupling (where the two circuits have some part of the circuit in common).

Let us take up some of the more common causes of oscillation and see how they fit into the three categories.

Open Bypass Condenser. All tetrodes, pentodes or pentagrid converters employ some type of bypass condenser from the screen to ground. This condenser forms a path for signal currents from screen to ground and keeps the screen at ground potential as far as r.f. is concerned. When this condenser becomes open the screen no longer acts as a shield between plate and grid; the plate-to-grid capacity increases and feedback may take place through this inter-electrode capacity.

Screen bypass condensers should be connected directly to the screen terminal of the tube socket, and not at some common point on the voltage divider or *B* supply terminal. When oscillation occurs, try connecting a condenser of at least 0.1 mfd. capacity from the screen terminal of each tube socket to ground.

Oscillation Caused by Filter Condenser. Occasionally the second filter condenser in the power supply will produce oscillation, although the condenser will exhibit no other signs of a defect, insofar as hum or reduced voltage output are concerned. This is because the condenser does not pass radio frequencies but will still function effectively at audio frequencies.

In cases of this kind, try bypassing the filter condenser with a paper condenser of at least 0.1 mfd. capacity. If this clears up the trouble, the filter condenser need not be replaced.

In the trouble described above, oscillation occurs because the filter condenser is depended upon as a bypass to keep r.f. present in the plate circuit of one tube from entering the plate circuit of another tube through the direct coupling resulting from their common circuit.

Tube Shield Missing or Not Properly Grounded. The feedback in this case results from the coupling between the unshielded elements of the tube and some other part of the circuit, another tube, a coil or some portion of the wiring. One-piece tube shields generally are provided with a tube-shield base into which the shield fits tightly. The contact at this point should be positive. Two-piece Goat shields usually have a contact spring at the base of the shield and a wire ring which holds the two parts of the shield together. A broken contact spring or missing ring may cause oscillation.

Type 75 tubes and 6Q7, 6R7, 6K5 and other types of high- or medium-gain triodes with glass envelopes, when used as first audio amplifier, are usually shielded. A missing shield here may cause hum or audio oscillation. The lead running to the grid cap of this type of tube may be shielded, and this shield should be inspected for a poor or missing ground. In some sets the grid lead is intended to be run up to the grid cap inside the tube shield instead of shielding the lead separately. If this lead is run outside the shield instead, hum pickup or audio oscillation may be caused.

Some tube shields in older sets have a cap which fits tightly over the top of the shield and shields the entire tube. These caps must be in place and must fit tightly.

In some circuits the top caps of metal tubes used as r.f. amplifier and converter are intended to be shielded. A small metal cap is used which fits over the shoulder of the tube. If you encounter a stubborn case of oscillation, try placing caps over these tubes.

Poor or Indirect Ground. This condition sometimes causes oscillation which may prove difficult to find, because r.f. may pass through the chassis and be distributed to some part of the circuit remote from the immediate cause of the trouble. When you feel that you have tried about everything and seem to be unable to overcome oscillation, try running all the r.f. and i.f. grounds to one common point, thus avoiding the use of the chassis as a conductor.

Wiring Not Properly Routed. In many high-gain circuits the proper location of wiring, especially the grid and plate leads, is an engineering problem. The positions of various wires is not only carefully planned but is in the first model of a set subject to considerable experimentation in routing, in order to eliminate coupling. After the correct positions have been determined, the proper routing of wires is observed in the production of all sets of that model.

You will see, then, that any considerable movement of critical leads may result in a form of oscillation which may be difficult to clear up. Which leads or parts may prove to be critical will depend upon the particular set under consideration. In general, grid and plate wiring should be separated as much as possible, and plate leads should be run close to the chassis. Some set manufacturers give in their service bulletins information regarding the routing or dressing of certain parts and wires.

If you have tried most of the usual remedies for oscillation, you might experiment with the positions of various wires, moving them about with a pencil.

Wiper Contacts on Variable Condenser Have Insufficient Tension or are Dirty or Corroded. These contacts, usually made of phospher bronze or other similar, springy metal, fit over the rotor shaft of the variable condenser. They are intended to provide good contact between the shaft and the condenser frame, for the contact between shaft and frame at the bearings is poor. Contact between one or more of these springs and the shaft may be poor due to dirt, grease, corrosion or relaxation of the spring tension, leaving the rotor plates virtually ungrounded. We then have two (or more) circuits carrying r.f., neither of which is grounded, with direct coupling between the two circuits through the rotor shaft—an almost ideal condition for producing oscillation. Remove all the wiper contacts, clean them of dirt and grease with benzine or carbon tetrachloride and polish the contact surfaces with fine emery cloth. Bend the springs to restore lost tension, and replace them.

Noisy Reception. Many cases of noisy reception are due to causes entirely outside the set and are the product of electrical interference in the vicinity. Other noise complaints may be traced to loose or broken connections in the antenna system and, in fact, have been known to be caused by two neighboring antennas touching. To determine whether the cause lies in the set, remove the antenna and connect a jumper wire from the antenna terminal to the chassis. Make this jumper as short as possible.

Now turn the volume control all the way up and run over the entire tuning range, noting whether any serious disturbance is present. Some sets may have sufficient pickup through grid leads, etc. to permit some signal and consequently noise to be heard even with the antenna grounded. However, even under this condition you will be able to determine if a marked reduction in noise has been effected. If so, the noise is caused by some condition outside the receiver. If it proves to be due to a defective antenna system, it is usually best to install a new antenna, especially if it has been in use for some time.

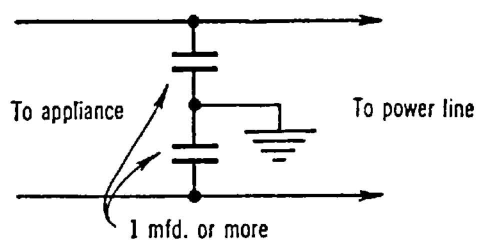
If the noise is caused by electrical disturbances outside the set, two procedures are possible. The first is to locate the cause of the disturbance and install a filter to clear it up. Locating the source of interference is sometimes a difficult job. Portable receivers with directional loop antennas have been used with some success. The make or break of any electrical circuit in which a spark results can set up serious disturbances that will be radiated over a considerable area. Not only may they be radiated by the point of spark production, but also by the power lines throughout a building.

A filter employing capacity only is shown at "B." The condensers should be at least 1.0 mfd. and should have a voltage rating at least twice the power-line voltage. The filter is to be connected across the line as close to the source of noise as possible.

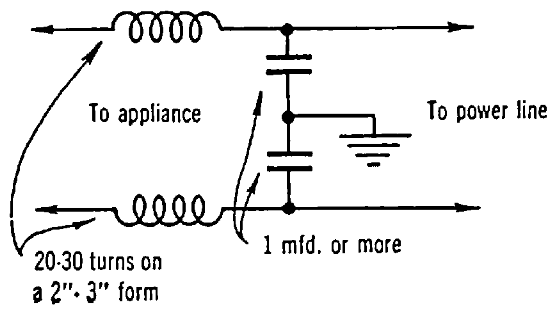
Another type of filter, using chokes as well as condensers, is illustrated at "C." This filter generally gives better results, but it should be borne in mind that the wire used in winding the chokes should be ample to carry the current consumed by the device you wish to filter. The chokes should be two or three inches in diameter and should have twenty or thirty turns of wire.

If you are unable to locate the source of the interference and to apply a filter, the only way left to reduce the noise is to install some type of noise-reducing antenna. The most commonly-used types employ a shielded or twisted-pair lead-in, which may or may not be coupled to the antenna and the set through coupling transformers. The idea is to produce a lead-in which is incapable of picking up either noise or signals.

Here we come to a point which is often misunderstood by laymen and service men alike. While the lead-in cannot pick up noise and may be run through a noisy area, in order to realize the benefit of this type of antenna system the antenna proper must be installed in a noise-free location or the whole purpose is defeated. Some experimenation may be necessary to find the most desirable location and direction of the antenna. Remember too, that the signal pickup with a noise-reducing antenna of



B



C

given size is usually less than with a conventional antenna of equal size because the lead-in, in the case of the noise-reducing aerial, does not act as part of the antenna system.

Should you come to the conclusion that the noise is caused by some defect in the receiver, try to isolate it to one definite part of the set. In sets using an audio volume control, this is simplified, because the control may be turned all the way down, at the same time noting whether the noise disappears. If it does, the trouble is ahead of the audio amplifier; if it does not, the audio system may be suspected.

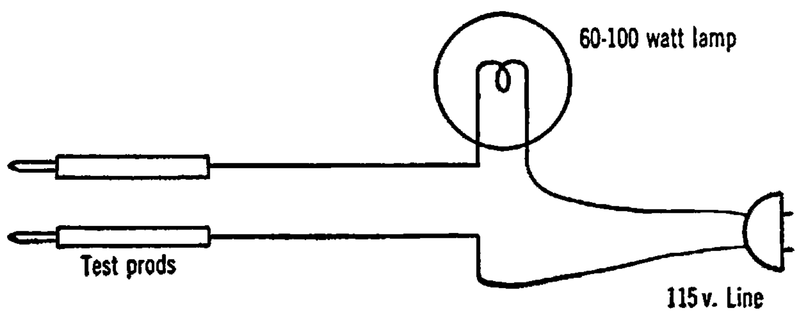
Some of the causes of noisy reception are loose connections, tubes with elements that touch and the partial or intermittent failure of audio transformers, condensers, resistors and coils.

Noise Caused by a Variable Condenser. Several conditions may arise in a variable condenser which can result in noise. One such condition is the failure of rotor shaft wiping contacts to make proper contact with the shaft, as already mentioned.

A shorted or partially shorted condenser may also result in a noise complaint, brought about either by the plates being bent and actually touching or by metallic particles between the plates. Repairing a condenser with bent plates is usually not very successful and is not to be encouraged.

The reason for this is that the various sections of the condenser must have the same capacity, not only when the condenser is entirely closed, but also at each point in the condenser's range. You will understand that this is almost impossible to accomplish without special equipment for measuring the capacity at at least five points within the range of the condenser.

Metal particles between the plates can result in a scratching noise that is sometimes mistaken for a condition in which the plates touch. It can be easily cleared up with the aid of the device shown in the drawing at "D." Disconnect one side of the coil from the condenser and touch the test prods to the rotor and stator terminals of the condenser. Now



D

rotate the condenser back and forth through its full travel. You will see some harmless fireworks as sparks jump between the plates. Continue rotating the condenser until no more sparks are seen. The condenser will then be found to be cleared of shorts. Needless to say, this will not work on a condenser which is solidly shorted because of bent plates.

Noise Caused by Antenna Connections. If a Fahnestock clip or binding post is used as an antenna connection, you might find that it is not tightly riveted or eyeleted to the terminal lug. This may be detected by wiggling the connection and noting whether any noise is produced. If so, the riveting may be tightened by placing a metal block or heavy hammer on one side of the rivet and tapping the other side with a hammer, or with a hammer and a flat end punch.

Some sets have leads brought out through the chassis for antenna and ground connection. A break in the antenna wire, or a bare spot rubbing against the chassis at the point where the lead passes through, may cause extremely noisy reception.

In some older receivers, audio transformers have been known to cause noise. Sometimes the noise can be detected by tapping the part, but in other cases it may be necessary to substitute a known good part for the defective one. This substitution transformer need not be the exact equivalent of the original one, but merely the same general type so that the set may work and an observation made as to whether the trouble has been overcome. The correct replacement transformer may then be bought and installed.

In the discussion on intermittent operation, attention was directed to the method of tapping and moving various parts in an effort to locate the source of the trouble. This may be applied to noise complaints with good results.

Questions

1. What effects are produced by the two general types of intermittent troubles?

2. What is the most common cause of intermittent operation?

3. What is a good procedure to follow in locating a loose connection in a set under test?

4. A customer complains of noise whenever someone walks across the floor near the radio. Name two possible causes for this complaint.

5. Describe a simple method of locating noisy tubes.

6. If you suspected that a defective coupling condenser was the cause of intermittent operation, how would you verify this?

7. What is the significance of the part number in Philco bakelite case condensers? The letter following the part number?

8. What type of trouble may be caused by the old-style metal end carbon resistors?

9. What is the most common cause of excessive hum in a receiver?

10. What is meant by "tunable" hum?

11. Name a common cause of tunable hum.

12. What may be the result of an open screen bypass condenser?

13. What precaution should be observed when installing a screen bypass condenser?

14. What condition might arise as a result of dirty wiper contacts or contacts that make poor connection at the rotor of a variable condenser?

15. In the case of a complaint of noisy reception, how would you definitely establish whether or not the noise existed in the set itself?

16. What two procedures may be followed in cases of noisy reception, where the noise is due to interference outside the receiver?

17. Explain how you would clear a short caused by metal particles between the plates of a variable condenser.

References

Intermittent Operation

RCA-Rider Chanalyst Instruction Manual, RCA Mfg. Co., Inc.; p. 41.

Hicks, Principles and Practice of Radio Servicing, McGraw-Hill Book Co.; pp. 283–285.

Hum

Radiotron Designer's Handbook, RCA Mfg. Co., Inc.; pp. 199–202.

RCA-Rider Chanalyst Instruction Manual, RCA Mfg. Co., Inc.; p. 29.

Electrical Interference

Mye Technical Manual, P. R. Mallory & Co., Inc.; pp. 310–324.

Eliminating Electrical Interference, Philco Radio & Television Corp.

11

MISCELLANEOUS TROUBLES (Cont'd)

Repairing and Adjusting Dial Mechanisms

Probably no other type of repair, except perhaps the location of intermittent troubles, can cause the service man so much effort and bring him so little compensation, as repairs to dial mechanisms, particularly in older sets, and especially when the replacement of a cord or cable drive is involved.

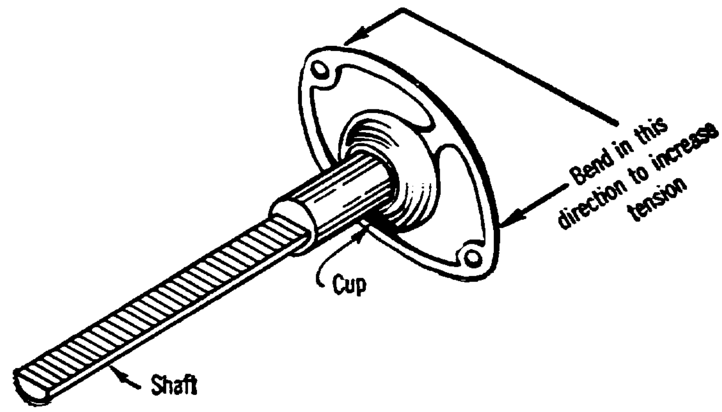
The customer knows only that "the little string around the dial is broken and the dial doesn't turn." He often does not realize the amount of time required to replace the "little string" and, since it appears to him to be only a minor job, may be unwilling to pay for the labor expended. There seems to be room for some consumer education in this regard.

There have been numberless types of dial mechanisms used, so that classification is almost impossible; but three general types have been in wider use than others. The first is the planetary type in which a central shaft bearing the control knob has a cluster of steel balls around its inner end. These balls make frictional contact with the inner surface of a tube or hollow shaft which is fitted over the central shaft. Turning the control shaft causes these balls to revolve, and the rotation of the balls turns the outer hollow shaft, but at slower speed than the control shaft, thus accomplishing a reduction drive or "vernier" control. The hollow shaft is geared, or directly connected to the tuning condenser shaft.

Failure of this type of drive is usually due to wearing of the inner shaft, and the result is slipping of the drive. Replacement of the drive assembly is the only permanent cure, although the type illustrated at "A" may sometimes be kept in service for a while by bending the ears on the cup-shaped ball retainer, as shown in the drawing, to increase the friction between the balls and the drive shaft. Another type of planetary drive is shown at "B." No adjustment is possible with this type.

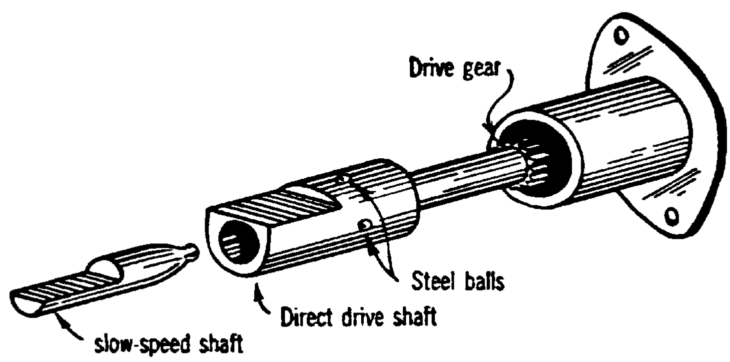
A second type of dial mechanism is one using a woven fabric belt.

This belt may be used to operate the dial scale pointer, the tuning condenser, or both. As a result of constant wear and tension, these belts will frequently stretch or break, causing the mechanism to slip or perhaps



A

Courtesy Philco



B

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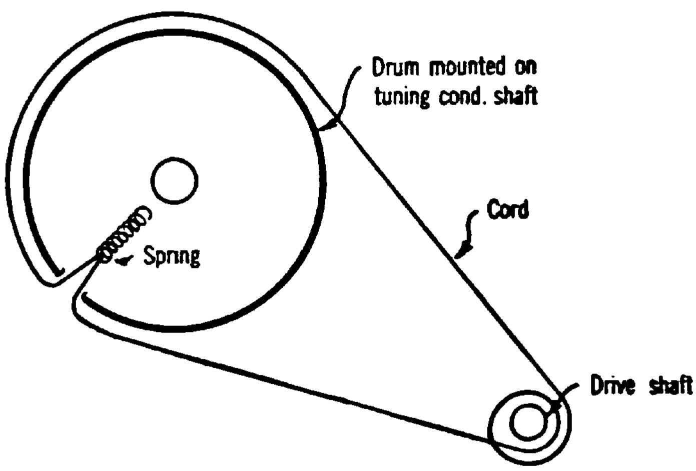
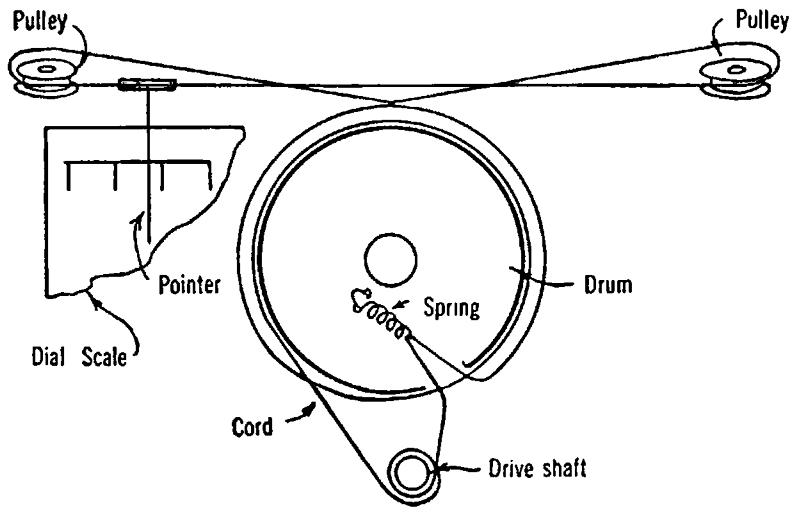


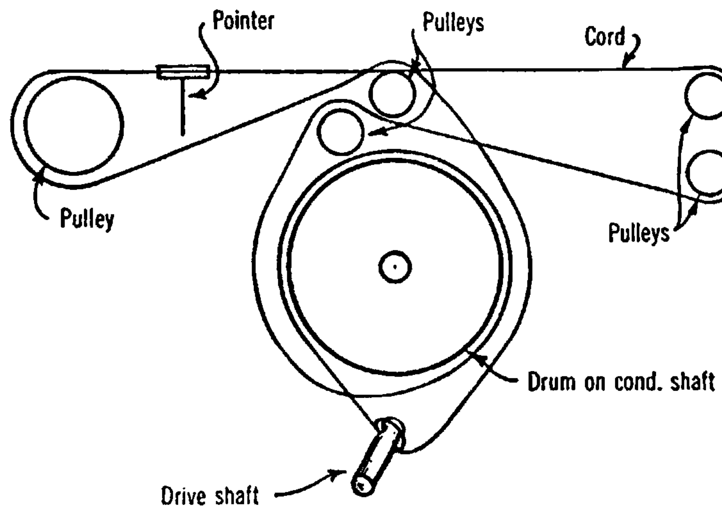
C

rendering it completely inoperative. Several parts manufacturers make a complete line of replacement belts for all makes and models of receivers, and even issue a helpful circular or catalog which lists the set make and model, the size belt required and the part number. It is a good plan to replace belts showing excessive wear even though the customer has not complained of any difficulty with the dial action.

The replacement of parts in either of the dial mechanisms already discussed is not particularly difficult. The type of dial which employs a cord or cable for operating the mechanism, however, is another matter. Replacement of the cord or cable can be a job requiring patience and con-



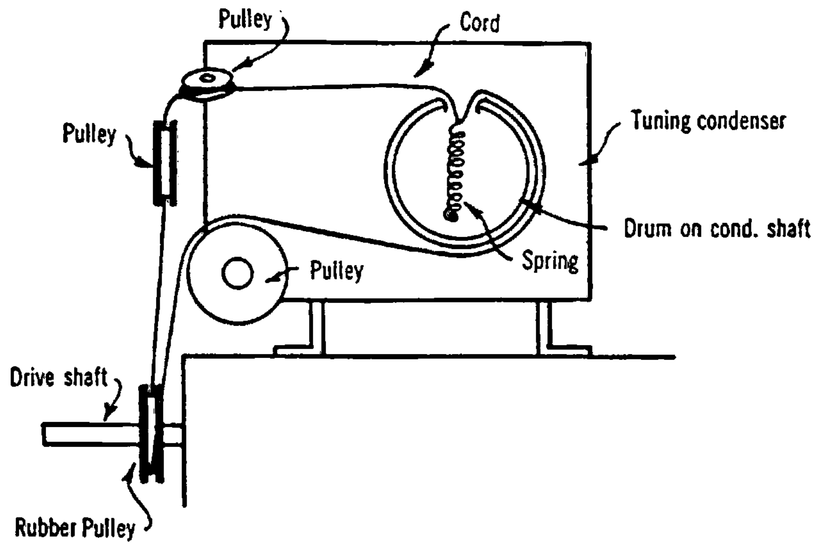
D



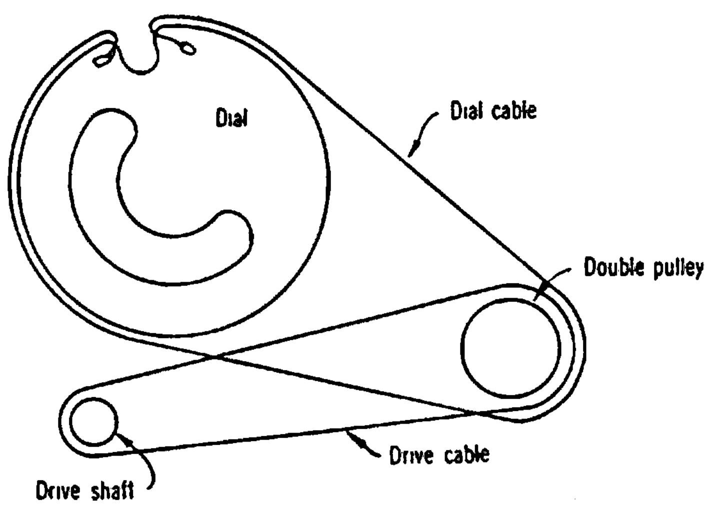
E

siderable time. The drawings at "C," "D," "E," "F," and "G" illustrate a few of the common types of cable drives, and are presented, not as illustrations of all the types in use, but merely as samples for your guidance. In studying these sketches, remember that the cord is not shown in its normal position in contact with the various pulleys and drums but is kept away from them in order that you may more easily trace the path of the cord. The chief difficulty arises in replacing a broken cord, and running it around the pulleys in the correct manner.

Unless you have had previous experience with the particular make and model of set being serviced, or unless you have available a service bulletin which describes the correct method, you may have to make a number of trials before getting the right arrangement. One stumbling block may be determining how many times a cord passes around or over a particular drum or pulley. Of course, if you find that after you have carried the



F



cord around the various points it appears to be too short, you have made too many turns around one or more of the pulleys. If you have cord left over, it was intended that the cable should pass several times around one of the drums.

If the cord is not worn or broken, and the complaint is slipping of the dial, the remedy is often simple. You will notice that all the cord drives illustrated use a spring to maintain tension on the cord. Sometimes this spring stretches and the tension will relax enough to permit the cord to slip. This may be corrected by shortening the spring or installing a new one. It you are careful, this may usually be done without removing the cord and going to the trouble of replacing it. When the spring is removed, the cord may usually be anchored at some convenient point to keep it from coming off the drum and pulleys. If you find that the cord must be removed, or if you encounter one badly worn and replacement seems advisable, make some sort of sketch showing the path of the cord before removing it.

An alternative method of correcting slipping of the cord is to apply belt dressing to it. Hold the stick of belt dressing against the cord at all accessible places and work the control knob back and forth through its entire travel several times. Unless the spring is very weak or the cord has stretched a great deal, this treatment is very effective.

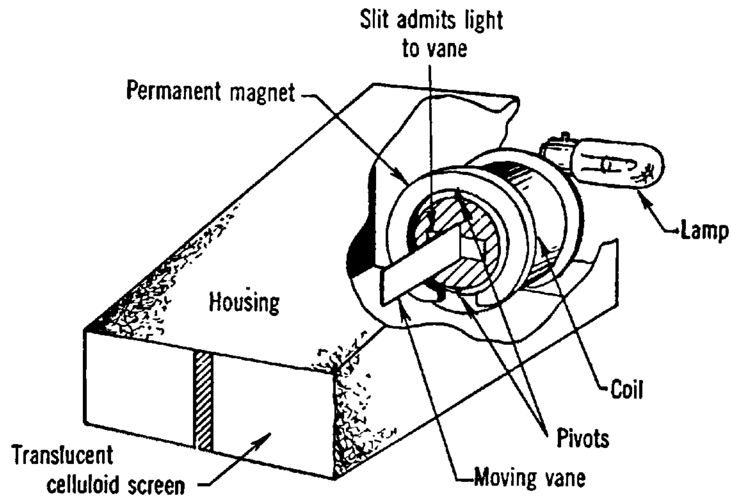
Tuning Indicators

The three most widely used types of tuning indicators are the milliammeter, the shadowmeter and the electron-ray indicator.

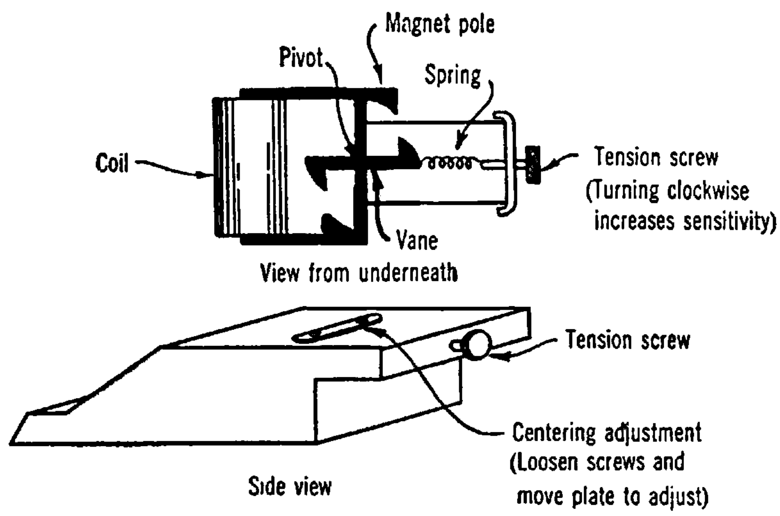
The first two depend for their operation upon the decrease in plate current in an AVC-controlled tube when a signal is tuned in. This decrease in plate current results from the increase in grid voltage due to AVC action. These indicators are connected in series with the plates of the r.f. or i.f. tubes, or both. The milliammeter type is a conventional meter of proper range (about 5 to 15 milliamperes). It is often mounted in an inverted position, with the needle pivot at the top, and of course the scale calibrations are likewise inverted.

The operational principle of the shadowmeter type of indicator is as follows: a light iron vane is pivoted so that it may swing horizontally inside a coil which carries the plate current of the controlled tube or tubes. Behind the vane is a pilot lamp, the light from which enters the shadowmeter case through an opening at its rear. The pilot lamp is usually shielded so that the light is concentrated on the desired area. The light passing through the meter casts a shadow of the vane on a small translucent celluloid screen at the front end of the device. The entire indicator is mounted over the tuning dial of the receiver and is visible through an opening which is provided. In a later version of the instrument, the celluloid screen is dispensed with and the front of the shadowmeter is clamped against the dial glass, which has a translucent area for viewing the shadow.

When the set is first turned on the shadow of the vane thrown upon the screen is a narrow line, because the vane is at rest. As the set warms up and the tubes begin to draw plate current, the vane swings and the shadow widens. If no signal is tuned in, the shadow remains wide, but when a signal is received the AVC action reduces the plate current of the controlled tubes and the width of the shadow decreases. The shadow width depends upon the sensitivity of the set and the strength of the incoming signal. The sketch at "H" is a cut-away view of the shadowmeter. An



H



J

improved type of shadowmeter has adjustments for regulating the shadow width and for centering the image on the screen. This type is illustrated at "J."

The electron-ray indicator is widely used and its operation is fully described in the RCA tube manual. For this reason, a lengthy discussion of its operation seems unnecessary. Briefly, electrons from a cathode are caused to strike a target which is coated with a fluorescent material which glows under the impact of the electrons, similar to the action in a cathode-ray oscilloscope. In traveling to the target, the electrons must pass a small metal vane and no electrons strike the target in the area of this vane, causing the shadow of the vane to be thrown upon the target. Variations in voltage produced by AVC action are applied to the control electrode and thus the width of the shadow depends upon the strength of the signal.

Troubles Occurring in Tuning Indicators

Set Dead, no R.F. or I.F. Plate Voltage. (Set uses shadowmeter or plate milliammeter indicator.) Tuning meter or shadowmeter is open. Some sets have a resistor, of about 1000 ohms, shunted across the meter. If this is used, the set will operate with the meter open. A set may be restored to temporary operation without the meter by either connecting a resistor across the indicator or by shorting it out.

Set Operates Fairly Well, but Indicator Does Not Swing Sufficiently. May be due to a defective tube, insufficient antenna length, a break in the antenna or set out of alignment.

Shadow Does Not Appear on Screen. Screen is Dark. Shadowmeter pilot lamp may be burned out; lamp shield may be turned so that light does not enter the indicator; lamp bracket may be bent so that light does not reach the meter.

Shadow Not in Center of Screen. If the meter is of the type which has a centering adjustment, loosen the two screws which hold the small metal plate on top of the device and shift the plate until shadow is centered. If no adjustment is provided, try bending the lamp bracket until shadow is centered.

Shadow in Electron-Ray Indicator Not Properly Positioned. Rotate tube and tube socket in mounting clamp. Some sets have a clamping screw which must be loosened before this can be done.

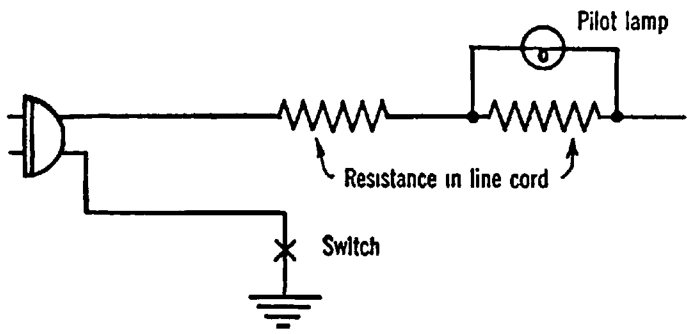
Electron-Ray Tube Operates Well, but Fluorescence is Dimmer. Tube is defective. Replace.

Pilot Lamps and Circuits

In a.c.-operated sets the pilot lamp, or lamps, are connected in parallel with the tube heaters, but in a.c.-d.c. sets a number of arrangements are in use.

Perhaps the simplest is that in which the pilot lamp is connected in series with the heaters; but this method has disadvantages. When the set is first turned on, the lamp will flare up brightly and gradually dim as the tubes warm up. Furthermore, lamps seem to burn out rapidly in this type of circuit. To avoid these difficulties, several manufacturers used a 115-volt lamp connected across the line:

A better circuit is that shown in "K," in which the lamp is connected across a portion of the resistance line cord or the ballast resistance. A later and still better arrangement is possible when a rectifier with a tapped heater, such as the 35Z5, is used. That portion of the heater connected between base pins 2 and 3 requires about 7 volts, and the rest of the heater 28 volts. The pilot lamp is connected in parallel with the 7-volt section. This eliminates much of the flaring up when the set is turned on and reduces the possibility of burn-out. Another advantage is that the set is not rendered inoperative when the lamp burns out, as is the case with the



K

straight series circuit. A rather common complaint, however, develops in sets using the 35Z5. This is failure of the 7-volt section of the heater. In such cases the receiver may be restored to operation, even when a 35Z5 is not readily available, by connecting a 40- to 45-ohm wire-wound resistor from pin 2 to pin 3 on the rectifier tube socket. This resistor should be capable of passing at least 0.15 ampere without overheating.

When replacing pilot lamps, be careful to observe the color of the glass bead at the base of the lamp filament. The color of the bead indicates the current requirement of the lamp. Installing a lamp which requires more current than the original one will result in the lamp burning dimly, while using one with lower current consumption than intended will cause the lamp to burn out more rapidly. In some cases the normal operation of the set might also be affected.

Loop Antennas

Antennas of this type are highly directional, as can easily be demonstrated by moving a small set into different positions and noting the effect on the received signal. Customers should be advised of this condition, for often a considerable improvement in the reception of a weak signal will be noted when the set is turned to a different position.

Some large floor sets have provision for rotating the loop from the outside of the cabinet. One example of this is a Stromberg-Carlson receiver which uses a cable drive and a system of pulleys operated from a control knob on the front panel. Other sets make provision for adjusting the loop for best reception by reaching inside the cabinet and turning it.

When working on sets which are equipped with a loop, look for a loop trimmer condenser, often mounted on the loop frame. This condenser must be adjusted for maximum signal strength, and some manufacturers specify that it be adjusted after the set is installed in the cabinet. The general procedure in making such adjustments is to locate your signal generator near enough to the loop so that radiated signals will be picked up. If not enough energy is picked up in this way, some wire may be made up into a loop about a foot square and having four or five turns. The ends of this loop are then connected to the r.f. and ground terminals of the generator, and the loop placed close to the loop in the receiver. The trimmer is then adjusted in the same manner as an antenna trimmer.

Cabinets

It has become common practice for the service man to make minor repairs to cabinets, such as cleaning, polishing, covering up scratches, etc. Many service men also repair broken cabinets if the damage is not too extensive. Just how far you may wish to enter this type of work will depend upon your inclinations and your abilities in that direction.

Cleaning. Over a long period of time, any cabinet will collect a film of dust, dirt, and under some conditions, grease. The most effective means of cleaning this accumulation from a cabinet, without danger to the cabinet or finish, is to use a damp rag with a little soap. When cleaning a wood cabinet, do not use too much water and be careful to dry the cabinet immediately. No harm to the finish will result if it is not allowed to remain damp for a considerable period. Benzine may also be used for cleaning, but it is rather risky because of the fire hazard and the possibility of damaging the cabinet if the cleaning agent is not used carefully.

Polishing. In the opinion of most professional cabinet finishers, the best treatment for wood cabinets, and for all furniture, is crude oil with the addition of about 20 per cent benzine. This mixture will be made up in small quantities by your local paint dealer, and is best applied by soaking a piece of felt in it and rubbing the wood with the oil-soaked felt. Wherever possible, rub in the direction of the grain. Apply all of the mixture that the wood will readily absorb, and do not remove the excess for a day or so. This preparation keeps the finish flexible and prevents cracking or "checking." If you do not care to use the method described, the next best polishing agent is wax, preferably a solid wax.

Returning a set which has been repaired so that it operates perfectly, and which is encased in a clean, polished cabinet, will help to convince your customer that you take pride in a thorough job, which will certainly pay dividends in the form of future recommendations.

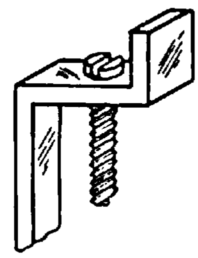
Repairing Broken Cabinets. Wood cabinets which have split or loosened at the joints should be repaired by gluing. Never attempt to use nails or brads to hold broken edges or surfaces together. This may suffice in carpentry, but this type of fastening is never used in cabinet work, at least not in a place where the nails or brads might be visible. Any good glue may be used. Casein glue is about the best, but prepared liquid glue may be somewhat easier to use. The important thing to remember is that satisfactory gluing cannot be done without applying pressure and keeping the glue job under pressure for several hours, preferably over night. This pressure may be obtained through the use of clamps, or in an emergency by winding string or rope around the work or by placing a weight on it. Plastic cabinets are generally very difficult to repair, and this type of job should be avoided, unless the damage is limited to a minor crack which may be held together with speaker cement or by means of a metal strap over the break, fastened to the cabinet with small screws. This latter can only be used where the break is not visible. In most cases, replacement of the cabinet is advisable.

Push-Button Tuning Adjustments

Push button systems may be divided into two general classifications, mechanical and electrical.

Mechanical Push-Button Tuning. In most mechanical systems, when a station button is depressed an eccentric cam is actuated, which causes the tuning condenser to rotate until the desired station has been tuned in. This type of automatic tuning rarely gives trouble, and the only occasion for adjustment is when wearing of the cam or lever produces a change in the condenser setting or when it is desired to change the stations. No special equipment is required for resetting the buttons and the operation is fairly simple.

There are two types of mechanical systems in general use. In one type the manual tuning control is located on the front panel of the set and in the other it is on the side of the cabinet. To reset buttons on a set using the first type, first tune in the desired station by means of the manual control, then remove the plastic button from the lever. Under the button you will find an adjustment screw, as shown in illustration "L." Hold the manual tuning knob to keep the tuning condenser from shifting, and loosen this screw. Now, depress the station lever as far as possible, at the same time making sure that the tuning condenser does not turn. Tighten the screw, and the adjustment is completed, except for checking the adjustment. This is done by tuning in the station manually and then depressing the station button. If there is no further movement of the tuning condenser when the button is pressed, the adjustment is satisfactory.



L

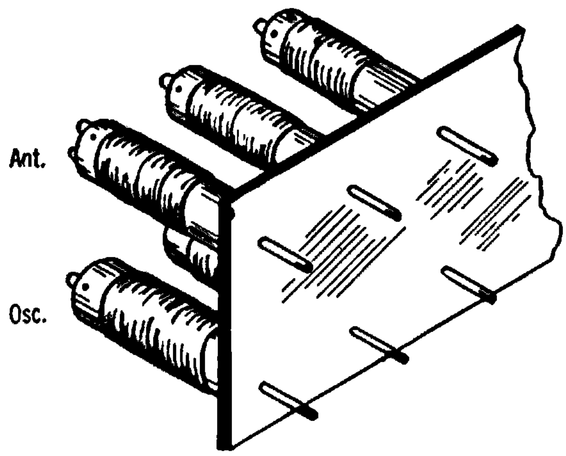
If the set to be adjusted has a knob at the side or end of the cabinet, you will also find a large screw at the center of the tuning control knob. Loosening this screw will allow all of the tuning cams to slip on their shaft. To readjust buttons, loosen this screw and tune in the first station desired by means of the manual control knob. Hold the control knob tightly in position and depress the first button. Tune in the next station manually, hold the knob and press the second button as far as it will go. Repeat this for all of the buttons. When all have been adjusted, hold the control knob and retighten the screw. Recheck the settings by tuning each station manually, depressing the correct button and observing whether any movement of the dial occurs. If not, the adjustment is properly made. If only one or two stations are found to be incorrectly set, it is a simple matter to loosen the screw, tune correctly to the desired station and then tighten the screw. No other adjustments will be disturbed if you are careful not to press any buttons other than the one under adjustment.

This type of mechanical tuning is as trouble-free as the one previously described, but remember that any adjustments made can be only as accurate as the manual tuning; in other words, if the station is not properly tuned in by the manual control, the button adjustment will necessarily be inaccurate.

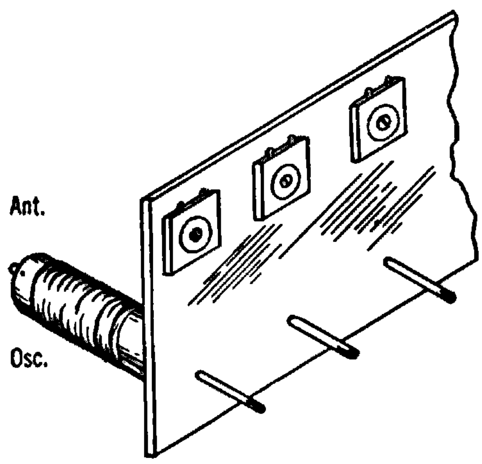
Electrical Push-Button Tuning. With the exception of those sets which use a motor to turn the tuning condenser, all electric push-button systems are of the tuned substitution type. This means that when a button is pressed, some type of pre-adjusted tuning device is cut into the circuit. This may take the form of a trimmer condenser which is switched into the circuit in parallel with the antenna or oscillator coil at the same time that the variable condenser is disconnected. Another method disconnects both the coil and the variable condenser and substitutes a coil which is tuned by means of a movable iron slug in its center.

Push-button circuits are generally used only in sets having no r.f. stage ahead of the converter; if an r.f. stage is used, arrangements are made to cut it out of the circuit when automatic tuning is in use. Each push button therefore makes two substitutions in one operation—one for the oscillator circuit, another for the antenna circuit.

Tuned substitution circuits may be further classified as follows: (1) trimmers used for both antenna and oscillator circuits, (2) variable



M



N

inductance coils used for both circuits, (3) trimmer condensers used for the antenna circuits and variable inductance coils for the oscillator circuits. Illustrations of these are shown at "M" and "N."

Regardless of the type of substitution, the method of adjustment is the same. Many service men prefer to make the adjustments without using a signal generator, by first tuning in the desired station with the manual control, then operating the button and finally turning the adjustments until the signal is brought in. This takes considerable time and some experience.

A much easier and faster method is to use a generator tuned to the frequency of the desired station. First, make sure that the receiver operates normally on the manual control. Then operate the first button. Tune the generator to the frequency of the station wanted and connect the generator to the antenna and ground of the set. If an outside antenna is used with the set, it should be disconnected for this operation. The signal emitted by the generator should be modulated. By trying both of the adjustments associated with the button in operation, you will find that one of these adjustments is more critical than the other. This is the oscillator adjustment and should be set first. Some broadcast signals will probably be heard even though the antenna has been disconnected, but these are to be ignored, and the trimmer or coil adjusted as accurately as possible to the generator signal. After the oscillator adjustment is completed, set the antenna trimmer or coil to give maximum response.

When the two adjustments for the first station have been completed, tune in the second station desired, by manual means, and then press the second button. Tune the generator to the frequency of the second station and proceed with the adjustments for the second button. Repeat for all buttons.

On most sets one tuned circuit will not cover the entire broadcast band, but only a portion of it. You will usually find a label somewhere on the set—on the rear of the chassis, underneath the cabinet or inside the cabinet—that will specify the range of each button.

When all buttons have been set, press the button for manual control and tune in the first station which has been set up on the buttons. Tune as carefully as you can, then press the button which has been adjusted for that station. When the change is made from manual to push button operation there should be no noticeable drop in volume; in fact, in some cases there will be an increase in signal strength. If the volume does drop, the adjustment has been improperly made and should be repeated.

You will very likely find many customers who do not use the push buttons—usually because they have not been accurately adjusted, have changed adjustment over a period of years, or were not reset after the change in station frequency allocations some years ago. Some customers may tell you not to bother about setting the push buttons, but it is suggested that you give this matter attention even though the customer does not request it. Get a list of his favorite stations, and after completing repairs on the set, adjust the buttons to those stations. When you deliver the set, call attention to the improved operation of this feature of the set. Make no extra charge for adjusting the push buttons, for after all it took you only a few extra moments. You will be repaid with the customer's confidence, for this is one of those little things that make the set owner feel that he is receiving special attention.

Push-Button Troubles

One or More Buttons Fail to Operate. If this is a mechanical defect, that is, if the button cannot be pushed in, do not force it. The switch is probably stuck, and the repair will depend upon circumstances. It may mean merely freeing the stuck segment, or possibly replacement of the switch. If the switch moves freely but no station is heard when button is operated, the trouble may be due to the adjustments being so far off that no signal is picked up, a segment of the switch not making contact, broken contact, a broken connection, or, if variable inductance coils are used, a coil may be open.

Buttons Go Out of Adjustment After a Short Period. Probably due to loose adjusting screws which change position under vibration. May also be caused by drifting as a result of inductance or capacity changes produced by variations in temperature or humidity. If the former is the case, and trimmer condensers are used for adjustment, remove the trimmer screw entirely and bend the plates back to put more tension under the screw head. If coils are used, a dab of speaker cement will hold the screw in place after the adjustment is made.

Noise, Fading; Set Goes Dead on Push-Button Operation. It is sometimes difficult to determine whether the complaint arises from a defect in the switching system or from some other part of the set not associated with push-button tuning. Try holding down the manual button and tuning in various stations. If no noise, fading or cutting off is encountered after a reasonable time, it may be safely assumed that the trouble is in the switching system.

If you then find that pushing a station button gives rise to a scratching or grating noise, your diagnosis will be verified. In almost every case the trouble may be traced to faulty contact at the various switch fingers or contacts. Some cases may be cleared up by working carbon tetrachloride into the contacts. The fluid may be applied with a medicine dropper and the button then worked back and forth a number of times. This will clean out dirt or grease that may be present.

However, many cases may not respond to this treatment, either because the contacts have corroded or because they have lost their original tension or springiness. The switch must then be taken apart and the trouble corrected. Be careful to note the positions of the various segments before doing so. If the contacts are corroded, they may be cleaned with very fine emery cloth or crocus cloth. The crocus cloth is preferable. If the contact fingers do not touch or if they do not make solid contact, they should be bent to restore their original tension.

Phonograph Record Players

The Pickup. Almost all present-day phonographs use a crystal pickup. These pickups vary widely in frequency response and voltage output. When replacement becomes necessary, the correct type of crystal cartridge must be installed if the results are expected to be the same as those obtained with the original cartridge.

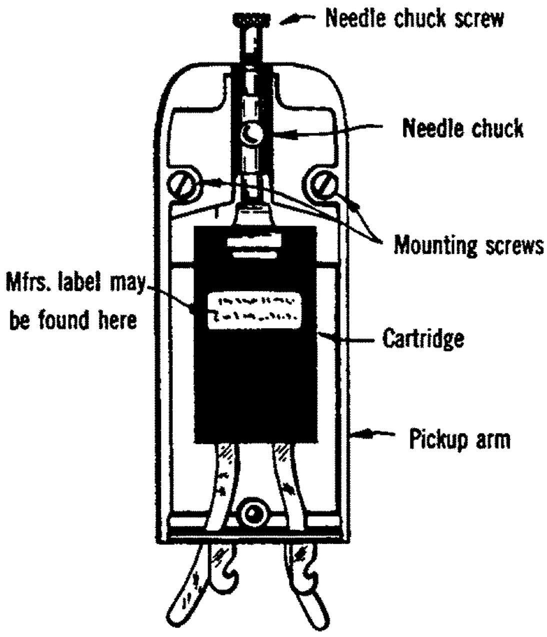
The most common trouble experienced with a crystal pickup is severe distortion accompanied by greatly reduced output. This does not mean that this difficulty occurs frequently, but merely more often than do others. The average crystal cartridge will last for several years if not subjected to severe shocks or temperature extremes. When a complaint of this kind appears, it is well to first look for causes outside the pickup, causes such as defective tubes, incorrect bias, etc. If all the usual tests have been made without revealing the cause of the distortion, you may suspect that the crystal has become defective. Incidentally, if the phonograph amplifier is also equipped for radio reception, you should check the quality on radio music. If no distortion is present, the trouble is probably in the pickup. The only remedy is to replace the cartridge. If a steel needle is used, do not neglect the possibility of a worn needle creating the distortion.

While on the subject of needles, it might be well to point out that in so far as the needle or stylus is concerned, crystal cartridges fall into three classes—(1) those having a thumb screw for tightening the needle in the needle chuck (either a steel needle or one of the semi-permanent types); (2) those having a needle chuck screw with slotted or recessed head, which type of screw must be loosened with a screw driver or an Allen wrench. (This type of cartridge usually comes equipped with some type of semipermanent needle); (3) those in which a jewel stylus is used, generally sapphire, which can not be removed. In almost all cases when the stylus wears out, after 5000 plays or more, the entire cartridge must be replaced.

The drawing at "P" illustrates a popular type of pickup, the method of mounting the crystal being shown. If replacement of the crystal is necessary, first look at the underside of the crystal at the point indicated by the arrow in the drawing, and you will very likely find a label on the cartridge giving the name of the manufacturer and the type number. Be sure that when you purchase a replacement the type number is the same.

To remove the old crystal, first unsolder the two leads which are soldered to the terminal lugs. (A very small proportion of the cartridges in use employ screw-type terminals.) If the pickup has a thumb screw for holding the needle, this projects through a hole in the end of the pickup arm, and must be removed before the cartridge can be taken out. Then remove the two cartridge mounting screws indicated in the drawing. The cartridge will now drop out of the arm. Do not lose the needle screw because in some cases a new one is not supplied with the replacement cartridge.

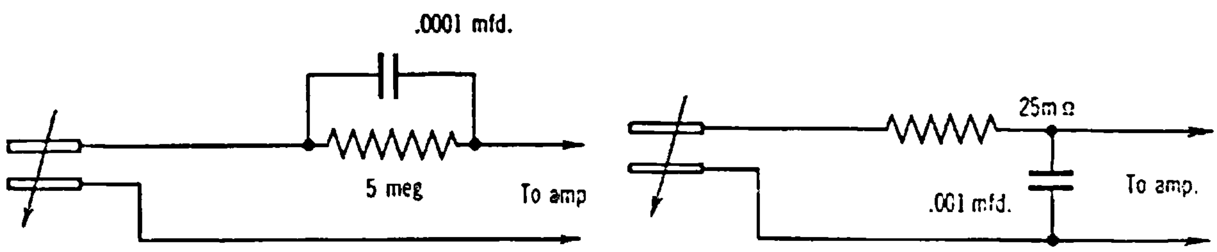
To install the new cartridge, hold it in place in the arm so that the mounting holes in the cartridge are centered over the holes in the pickup arm. Insert the mounting screws and tighten them snugly, but do not



P

exert too much pressure when tightening, or the cartridge may be damaged. When reconnecting the leads, notice that one of the soldering terminals on the cartridge has a little strap which makes contact with the metallic case of the cartridge and also with the pickup arm, unless the arm is plastic. The shield, or braided outer covering of the cable is to be connected to this terminal, and the inner wire to the other terminal. A word of caution is necessary regarding soldering. This is one spot where you may disregard all you have learned about applying plenty of heat to a soldered joint. *The application of too much heat to the terminals can easily ruin a new crystal cartridge.* Twist the end of the wire around the terminal and then apply just enough heat and just enough solder to make an electrical connection. This connection is not subjected to any mechanical strain and sweating-in is not necessary.

You will probably have many customers request advice regarding the best type of needle to use. In giving such advice, remember that initial cost, number of plays possible, amount of record wear and the listener's preference regarding frequency response, must all be taken into account. For good response, low cost and some relief from the bother of changing needles, the ten- to twelve-play steel needles made for use in automatic record changers and sold under various trade names are probably best. However, they have several disadvantages. First, they have good frequency response, so that all of the high frequencies are reproduced, including surface noise, if any is present. Second, most people are inclined to forget to change the needle after a number of plays, with resulting damage to tone quality and possibly to records also. The semi-permanent needle should be recommended in such cases. Most needles of this type tend to attenuate the high frequencies, in fact, their adver-



R T

tising stresses the reduction of scratch. Furthermore, they are available in types that will play from 1000 to 5000 records without replacement. The sapphire is probably the best of this type.

The customers' tastes regarding frequency response vary widely and you may be called upon to make some corrections in this respect. It is a simple matter to introduce a correction circuit between the amplifier and the pickup to do this. The circuit shown at "T" will cut off some of the higher frequencies and give the effect of increased bass. That shown at "R" will produce the opposite effect. Although many phonographs and radio-phonograph combinations have some type of correction circuit included, they may be changed to suit the taste of the individual listener.

The Motor. The most commonly used types of motors are the worm-drive, rim-drive and the synchronous motor.

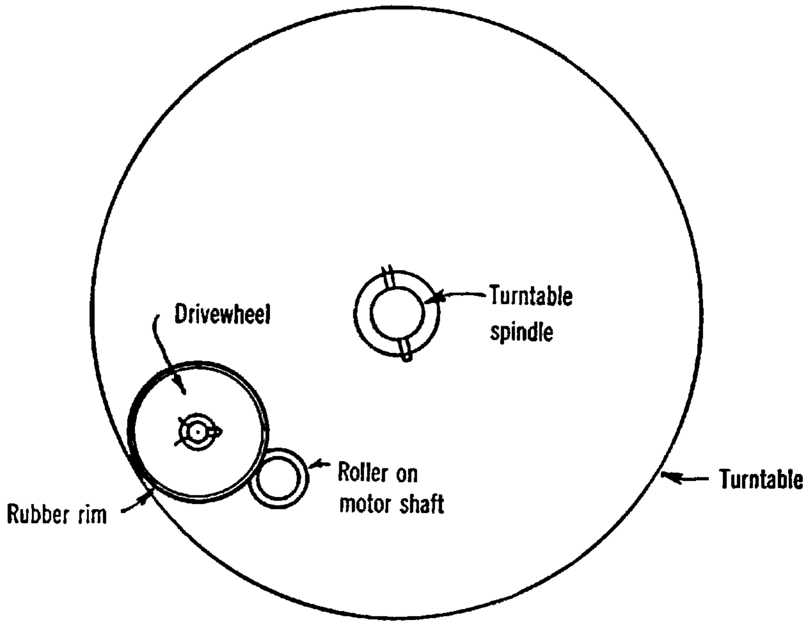
The worm-drive motor has several distinct advantages and is usually regarded as the most desirable type. These advantages include more constant speed and provision for speed regulation. In this type of motor the armature is mounted horizontally and the armature shaft carries a worm which engages with a gear on the turntable shaft or spindle. Also mounted on the armature shaft is a governor consisting of a pair of weights, which are arranged so that they may move in or out from the armature shaft. Fastened to these weights is a metal disc which is free to slide along the armature shaft. The weights are connected to the disc by means of a lever system. If the speed of the motor tends to increase, the weights, due to centrifugal force, fly out and away from the shaft, causing the disc to slide along the shaft until it bears against a piece of felt or leather. This felt or leather brake applies friction to the disc, causing the motor to slow down slightly. This slowing down, of course, causes the governor weights to move in toward the shaft again. In addition, the felt or leather brake is arranged so that it may be moved by means of a speed-control lever, thus providing a means of adjusting the motor speed.

The few troubles that occur in this type of motor are caused by failure of the governor, the brake or through lack of lubrication. Sometimes one of the levers which hold the governor weights will break. In such cases the entire governor assembly should be replaced. If it is impossible to secure a new governor, some kind of patch-up job may be attempted, until a new unit can be had from the manufacturer. Remember, though, that the action of these levers must be such that the weights are free to move in or out and the brake disc free to slide on the shaft. Lack of speed control may be found to be due to wearing of the felt or leather. Some motors have provision for moving the friction material to compensate for wear. In other cases it must be replaced. A marked reduction in the speed of the motor, or failure to revolve at all, can be the result of gummed-up grease on the worm or gear or lack of lubrication of the turntable spindle. Clean the gears with kerosene, gasoline or benzine and then apply petroleum jelly. Use light oil on the spindle. Heavy grease on the gears will cause excessive drag and slow the motor, especially at low temperatures.

The rim-drive motor is probably in more extensive use than any other type, because of its low cost and simplicity of construction. The armature is mounted vertically and carries a metal roller which rides against a wheel having a rubber rim. This rubber bears against the inside of the turntable and drives it by friction. The general idea is illustrated in sketch "S."

Many of the lower-priced rim-drive motors are lightly constructed and frequently develop trouble. Wearing of the rubber rim will result in the motor running at incorrect speed. Not much wear is necessary to produce a noticeable speed change, particularly when symphonic records are played. There is no satisfactory method of correcting this trouble, and as it is usually difficult to get a new wheel, in most cases the entire motor must be replaced. Some service men have tried to compensate for the wear by putting several coats of rubber cement on the edge of the wheel, but this is not too successful, nor is it a permanent cure. Another trouble is the appearance of flat spots on the rubber surface, with a resulting change in speed when the flat spot strikes the inside of the turntable. This is often the cause of a rumble which shows up in phonographs using this type of motor.

If not too serious, this can be overcome by lightly sandpapering the rubber. Of course, this will reduce the diameter of the wheel and cause



S

a change in speed, but when compared to the rumble it is usually the lesser of two evils.

The rubber wheel rotates in a bearing on the motor bed plate, and has a spring to keep it in contact with the turntable. No lubrication at the drive wheel bearing may cause the wheel to stick and result in slowing of the turntable. This same complaint may be brought about by failure of the spring to keep the wheel against the turntable. This spring may easily be bent to restore its former tension. In lubricating the drive wheel bearing, be careful not to get any of the oil on the rubber surface. Light machine oil should be used.

The entire motor assembly may be supported in rubber cushions and the motor mounting screws may pass through rubber grommets. This rubber may harden with age and the vibration of the motor may be communicated to the motor board and in turn to the pickup. This will show up as a low-pitched rumble, audible over the music. Very often the rumble can be heard to synchronize with the pulsation of the motor, giving a clue to the nature of the trouble. New rubber mounting washers and grommets can probably be made out of rubber tubing, old rubber chassis mountings or the grommets used to keep line cords from cutting on the edge of a chassis.

A peculiar trouble referred to as "wowing" often turns up in motors of this type, and occasionally in other motors also. A "wow" is produced when the pitch of a note rises and falls instead of remaining steady. It is most noticeable on a sustained note, and generally when the note is of a medium to high frequency. It may easily be confused with the same sort of trouble which is inherent in some records and is a result of speed variations in the recording apparatus when the record was made. Therefore, when you receive a complaint of this type, be sure to play several records in which long-sustained notes appear, before you decide that the complaint actually arises from a fault in the record player. If the wow is in the phonograph, it is generally produced by some condition that applies friction or drag at some point during only a part of a revolution; that is to say, the mechanism revolves at normal speed during most of a revolution, but at one point in its revolution is slowed down by something. One place where this frequently happens is at the turntable bearing, as a result of lack of oil or a defective bearing. It is most likely to show up in automatic record changers, on account of the length of the spindle.

All of the foregoing will indicate the importance of checking the speed of the motor. In reproducing all ordinary popular and classical records, the motor is intended to turn at a speed of approximately 78 revolutions per minute. Long-playing records and transcriptions are generally recorded at 33⅓ revolutions. You can check the speed of a turntable by placing a piece of paper under the record and counting the revolutions with watch in hand, but this is not entirely satisfactory. A stroboscope disc should be used, and should be viewed under a neon lamp, shading the disc so that light from other sources does not strike it. The check should be made with a record on the turntable and the pickup in playing position.

The third type of motor to be considered is the synchronous type. This was used in a number of very low-priced record players sold a few years ago. The stationary portion of this motor consists of a disc which has a toothed or milled edge. Mounted on this disc are the two stator coils. The turntable carries a toothed ring and a spindle. The spindle revolves in a bearing which is mounted on the stator, and the ring is arranged so that it may revolve very close to the toothed edge of the stator. This type of motor functions very well, but it has one outstanding disadvantage in that it must be revolved by hand until operating speed is attained, when it will turn of its own accord. There are only two troubles that commonly appear in this type. The first is an open in one of the coils, which cannot be corrected except by rewinding the coil or replacing the motor. The other trouble is a tendency to wow, which is a result of lack of lubrication, which causes sticking of the spindle. To cure it, remove the turntable and spindle by lifting the turntable. Polish the spindle with very fine emery cloth or better yet, crocus cloth. The best way to do this is to hold the turntable in a vise, wrap one turn of a strip of abrasive cloth around the spindle and work the cloth back and forth to polish with a circular motion. Polishing the spindle lengthwise may result in getting it slightly out of round.

Record Changers. Each make and model of automatic record changer presents an individual problem, because their construction differs greatly. To devote much space to the troubles which appear is not within the scope of this book. There are several excellent books entirely devoted to the subject. However, a few brief suggestions may be helpful.

One of the most popular changers is the so-called "drop" type, in which the record to be played drops into playing position from a stack of records supported above the turntable. The record to be played is removed from the stack, in most cases, by separator knives which are operated by the motor through gear action. A tendency to damage records may show up in changers of this type, resulting in a cracked record, especially if the record was produced during the war, when they seemed to be particularly fragile, perhaps on account of the use of reclaimed shellac. Laminated records are not so likely to break, but in any event the result might be a chip taken from the edge.

If the changer has non-adjustable separator knives, polish the edges and surfaces of the knives with crocus cloth. Do not use emery cloth or sandpaper for this purpose, and never under any circumstances try to overcome the trouble by bending the knives. See that the two parts of the separator assembly are free to move slightly in a lateral direction. If necessary, apply a very small quantity of vaseline at the point where the two halves are hinged. Do not allow any vaseline to get on the surfaces of the knives, where it might come in contact with a record.

Some changers use a screw adjustment to set the blades, and to provide for records of different thicknesses. Improper adjustment at these points may result in "grabbing" and damage to records. For changers of this type it is always best to get a copy of the manufacturer's service bulletin pertaining to that particular model and to follow carefully the instructions given for making the adjustments.

In cases of seizing or grabbing of records by the knives, the record may not break, and the mechanism will stall. If this should happen while you are servicing a changer, turn off the motor switch at once, or the motor may be damaged. If the stall cannot be cleared readily by revolving the turntable by hand, pull back slightly against the knife which has jammed, at the same time pushing the edge of the record downward.

Another frequent trouble is failure of the changer to drop both edges of the record. When this happens, one edge remains on the separator while the other rests on the pickup or on the record below. This, of course, will cause a slow-down of the record being played. This trouble is caused by one of the knives seizing the record. If the blade assembly is nonadjustable, polish it as described above; if adjustable, check the adjustment. The one which failed to drop the record is the one requiring attention.

Failure of the pickup to land in correct position on the smooth area at the edge of a record is generally easy to correct. If you will examine the mechanism immediately under the pickup, you will find a lever which moves the pickup during a record change. There will be at this point some type of adjustment which limits the motion of the pickup after the change is completed and the needle is about to land on the record. Generally there will be a screw which can be loosened, after which the pickup arm will be found free to turn. Rotate the turntable by hand until a change has been all but completed and the pickup is just ready to drop. Then hold the lever assembly which moves the pickup arm, and move the arm until it is in correct position to land about 1/8 of an inch outside the first groove on the record. Then retighten the screw.

Many very old records do not have a spiral run-in groove at the start of the record, and for this reason cannot be played on the changer unless it is equipped with a "booster" spring. This spring comes into action after the pickup has landed and moves the arm in until the first groove is reached. The spring generally takes the form of a flat piece of spring metal or a stiff wire. It may be bent to give correct action. If you receive this type of complaint and the changer has no booster spring, there is nothing to be done but to explain the circumstances to the customer.

Certain types of changers are designed to repeat the last record until turned off, while others stop after playing the last record. In the latter type, the mechanism sometimes fails to stop as intended and keeps repeating the last record. This is generally due to a failure of the automatic switch to turn off the motor. This switch is actuated by the pickup resting on the switch button. This button may be stuck, resulting in continuous operation. There are various causes for the button sticking, and the remedy will be determined by the cause.

Most record changers are designed to be mounted on support springs, usually one at each corner of the mechanism. Sometimes two springs are used at each corner, one under the changer bed plate and another under the mounting bolt head or nut. These springs must be in place so that the changer floats. If one or more springs are omitted and a corner or edge of the bed plate comes into solid contact with a part of the cabinet, the vibrations of the speaker will be transmitted to the pickup, resulting in a microphonic rumble or howl. In addition to the spring support, some changers have provision for leveling the mechanism by adjusting screws at the corners. If you receive a complaint of faulty operation of a changer and leveling screws are used, check the position of the changer to make sure it is level before looking for other trouble.

Questions

1. What is a common cause of failure in a planetary type dial drive mechanism?

2. What are the usual troubles encountered with woven-fabric dial belts?

3. What difficulty often arises when replacing a cord-type dial drive?

4. Name two methods often employed to correct the slipping of a dial cord.

5. Describe the operation principle of the plate-milliammeter type tuning indicator.

6. A superheterodyne using a shadowmeter is inoperative due to an open shadowmeter coil. How would you restore the set to operation if a new shadowmeter could not be obtained?

7. What are some of the causes of insufficient indication or swing on a tuning meter?

8. What effect may be noticed in an electron-ray type indicator after it has been in use for a long period?

9. A universal receiver using a 35Z5 tube as rectifier is dead due to an open heater of the 35Z5 between pins 2 and 3. If a new tube could not be obtained, how would you restore the set to operation?

10. How would you determine the correct type of pilot lamp when replacement becomes necessary?

11. The automatic tuning push buttons in a receiver operate, but the correct stations do not come in. This has occurred several times within a short period. What might be wrong?

12. A set fades when the automatic push buttons are used, but operates normally when used on manual tuning. How would you correct the trouble?

13. When replacing the crystal cartridge in a pickup, what precaution should be taken when soldering the leads to the new cartridge?

14. What would probably be the result of flat spots on the rubber drive wheel of a rim-drive phonograph motor?

15. How would you correct a tendency of a record changer to chip the edges of records? The separator knives are not adjustable.

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12

AUTOMOBILE RADIO

When automobile radio sets are considered from the standpoint of tube types used, circuits, operating principles, and so on, they will be found to be quite similar to comparative types of home radios.

There are, however, a few major differences, and it is well to review these before discussing auto radio service problems. These differences are:

1. The auto radio must operate from an antenna of very limited size.
2. It must derive all heater, plate, screen and bias voltages from a 6.3-volt d.c. source. (There are a few exceptions to this, as a small number of cars have used a 12.6-volt battery.)
3. The receiver must be very compact and unusually rugged.
4. Due to space requirements in the average passenger car, the set is often located in an out-of-the-way place.

Now let us consider briefly the effects of these requirements upon the design of auto radios.

Compactness, Ruggedness, Location. These three points may be considered together, since their implications, as far as the service man's work is concerned, are inter-related. The average car set is almost always very compact in arrangement, enclosed in an all-metal container (for reasons of shielding as well as protection), and mounted in various hard-to-get-at places in the car.

The net result of these requirements is that car sets are apt to be a bit more difficult to service than home sets, not because they are more complicated, but because considerable time may be required in getting at the set so that the actual process of trouble shooting may begin.

Most car receivers operated from a remote control unit, employ flexible shafts to operate the controls, and are mounted on the fire wall or partition between the engine and the driving compartment. The set is often installed just below the instrument panel and above the brake and clutch pedals, as illustrated at "D." This may be varied by mounting the set inside the engine compartment (not a good idea, by the way). In either case, the set may be removed for servicing by disconnecting the tuning and volume control cables (tone control lead also, if used), loosening or removing several mounting bolts (usually three), disconnecting battery and antenna cables and then removing set from the car. Early models use several studs which pass through the fire wall and are threaded into the receiver case. Later models have several clips or brackets riveted or welded to the case. These brackets have a slot cut in them so that removal is much simpler. The mounting studs are loosened several turns and the set lifted from the mountings. In some special installations, such as in taxicabs, it is usual to mount the set in the trunk or luggage compartment, with long flexible shafts extending from the receiver to the arm rest alongside the passenger seat, or to a location on the back of the driver's seat.

Those sets which have no remote control unit and have a conventional dial, often with automatic push button tuning, will usually be hung from the under side of the instrument panel or mounted in back of a special cutout in the panel. In the latter case; the cutout is usually fitted with a grille provided by the motor car manufacturer. Removal of this type of set is usually simpler than those using a remote control unit.

There are various methods of mounting remote control units, or control heads as they are sometimes referred to. Older model sets used a control unit clamped to the steering column. If removal becomes necessary, removing a screw which secures a clamp band to the column is all that is required. Another method of mounting control units used with older sets was to hang the control from the instrument panel by means of one or two machine screws.

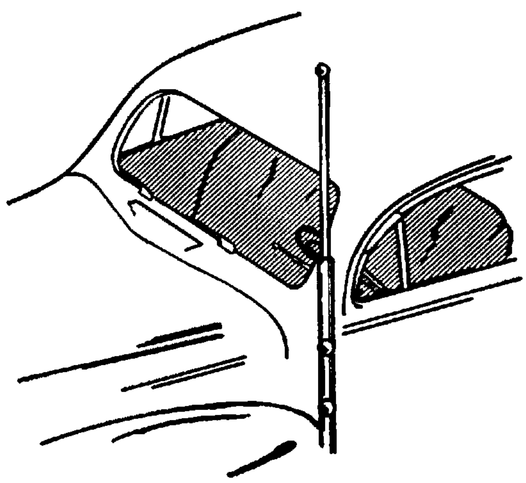
While on the subject of remote control units, it may be well to mention that many sets were furnished with a standard control which could be adapted to most any car. In order to improve the appearance of the installation, some manufacturers, particularly Crowe, made a line of control units that harmonized with the instrument panel and interior appointments of the particular car. For example, a certain model of Philco receiver was furnished with a standard control unit, but if intended for installation in a 1937 Buick, this standard unit did not particularly harmonize with the fittings of the car. If the purchaser of the set so desired, he could purchase, at slight extra cost, a Crowe unit that produced a much more pleasing effect when installed on the instrument panel. Most car manufacturers provided a convenient place for installing the control unit either on the instrument panel or in the glove compartment.

All of the factors just mentioned will have an important bearing on car radio servicing. They will affect the time consumed on the job, especially until you learn all the tricks of removing and reinstalling equipment in a minimum of time. On the average, the amount of time consumed per job will probably be considerably higher than in home radio work.

You will do well to study the instructions issued by manufacturers relative to the installation of receivers, even though you do not have a job at hand on that particular make or model. You will discover many procedures that may prove to be time savers on future jobs. A few of these procedures are discussed under "Service Hints."

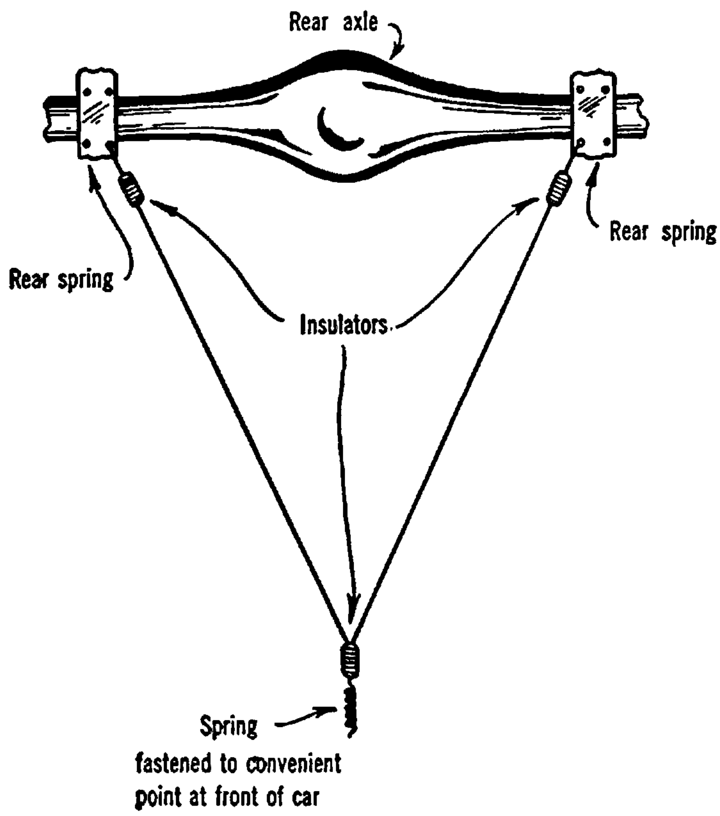
Antennas

A number of different types of antennas have been used in the past, or are at present in use. The service man should become familiar with all of these types. Here is a list of common types of aerials:

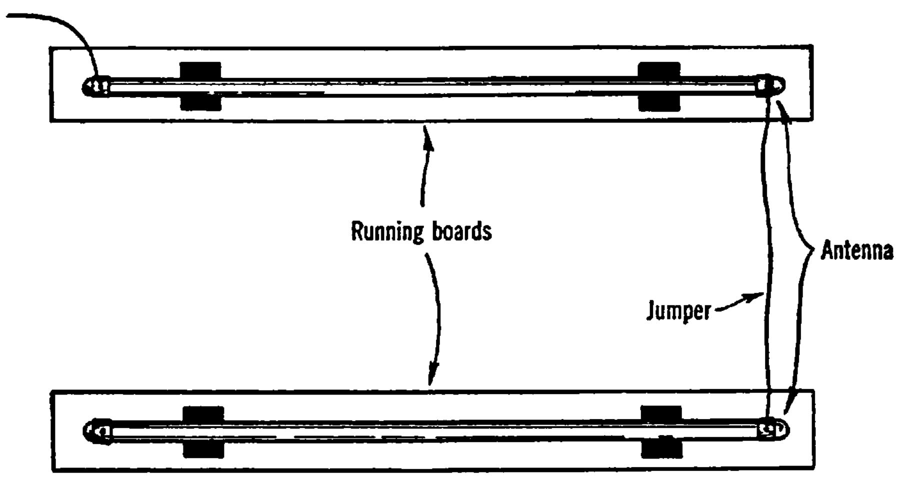


A

1. **Vertical Rod or "Whip" Antenna.** This may be of solid or tubular construction and of varying length. Some types are made in one piece, while others are sectional, permitting them to be raised or lowered when necessary. Preferred mounting arrangements are: on the cowl, on the dividing strip between the two sections of the windshield, or clamped to the rear bumper. Some manufacturers have designed aerials which may be raised or lowered by operating a control inside the car. Among these are the ones used with custom Philco auto radios supplied with new Studebaker, Chrysler, Ford and other cars. Sketch "A" shows a cowl antenna.



B



C

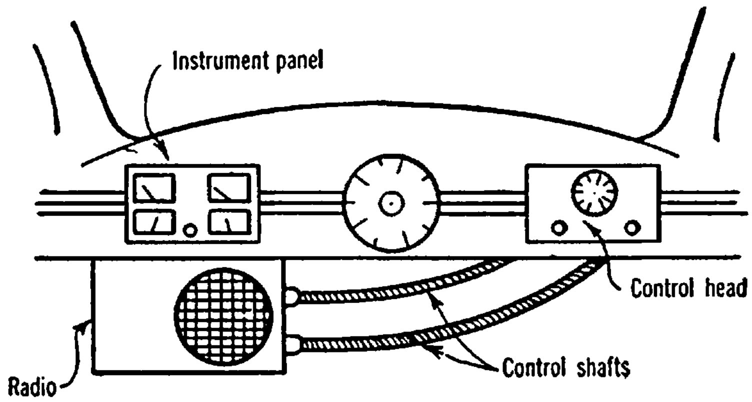
2. **Undercar Antennas.** The earliest undercar antenna consisted of a V-shaped cable stretched under the car between the rear axle and the front end of the car. Although now obsolete, one is still seen now and then. This type of aerial is kept taut by means of a coil spring. See sketch "B."

A later development consisted of a length of rod or tubing under one or both running boards. When units were used under both running boards, they were interconnected by means of a piece of flexible cable, as shown in illustration "C."

The undercar antenna had several disadvantages, among them being poor pickup as compared to the whip antenna, and the possibility of damage caused by running over brush, tall grass or other obstructions. They were also subject to rust or corrosion as a result of exposure to mud and water.

3. **Cartop Antennas.** These ordinarily took the form of a length of rod or tubing, generally plated to resist corrosion, placed on the roof of the car, and held in place by means of either suction cups or more permanent screw fastenings.

4. **Built-in Roof Antennas.** This type, like the undercar antenna, is now generally obsolete, but is mentioned here for two reasons. First, during the war years cars were at a premium, and many old relics were



D

given a new lease on life. It is possible that you may be called upon to service a set using this type of antenna. Second, it is interesting to review the various methods used to provide auto sets with an antenna, each step representing an improvement in the performance of the average set.

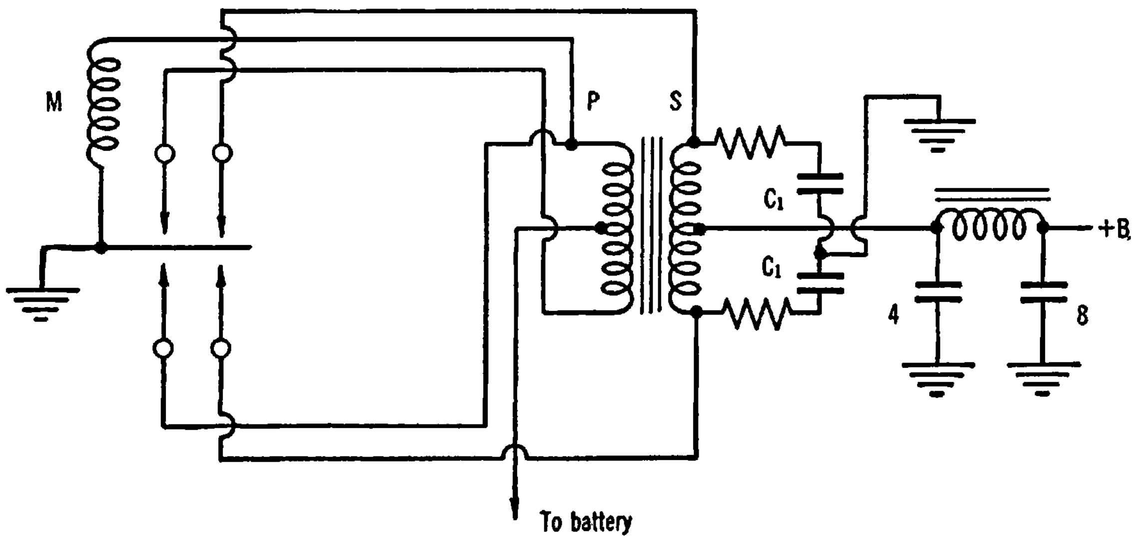
Before the introduction of cars using metal roofs, or the so-called turret top, many automobiles were made with a section of screen wire built into the top between the fabric roof and the upholstery. This made a fair antenna. If the car was not provided with such screen wire, it was common practice to tear down the upholstery and install either screen wire or a length of insulated wire. Incidentally, you will probably find that the built-in roof antenna compares favorably with the performance of other types.

5. **Trunk-lid Antenna.** At least one make of car used this unique arrangement. The lid of the trunk or luggage compartment is insulated from the body of the car and used as an antenna. This involves insulating the hinges as well as the edge of the lid. Performance, however, is not as good as with other types.

Power Supply

Here we find the most important difference between car sets and home receivers. In the average car, the only source of electrical energy is the storage battery. From this d.c. source we must get power for the tube heaters, supply for screens, plates and bias, and current for the field coil, unless a PM speaker is used.

Heater supply is solved by merely connecting the tubes in parallel across the battery. Incidentally, it is no accident that most tubes are designed to operate from a 6.3-volt source, the voltage of a three-cell storage battery when charged. The earliest 6.3-volt tubes, the types 36,



E

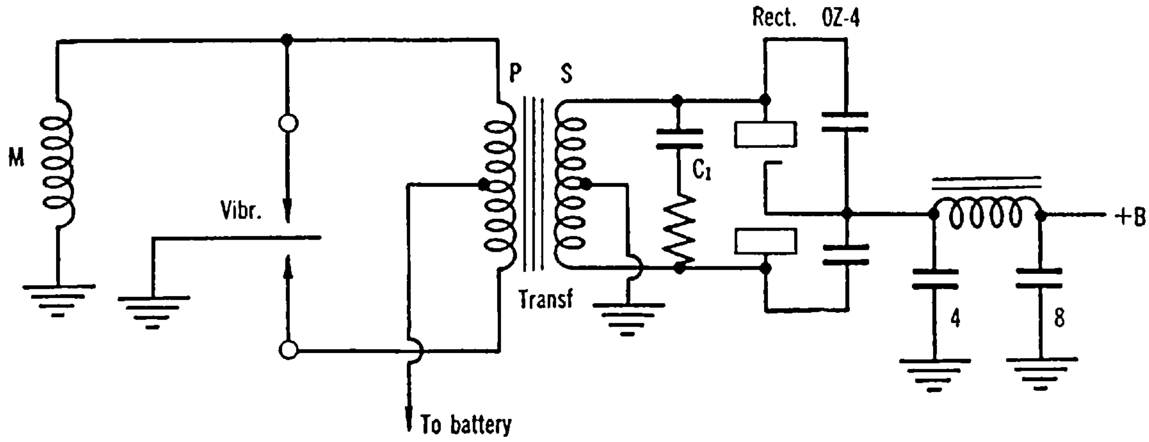
37, 38 and 39 were intended to be used in car sets. Some manufacturers of home receivers found that they got superior performance using these tubes, and adopted them for home radio use. For a number of years some manufacturers adhered to the old practice of using 2.5-volt tubes while others used the 6.3-volt types.

In order to obtain d.c. supply for the plates, screens and bias, the battery voltage must be changed to a.c., stepped up to the desired voltage, usually about 200 to 250, rectified and then filtered. All this is accomplished by means of the vibrator power supply.

Auto radio power supplies may be classified as follows:

1. **Synchronous, Self-rectifying.** In this type of supply, shown in diagram "E," the vibrator has two pairs of contacts. One pair is used for interrupting the primary voltage supplied by the storage battery, while the other pair "commutates" the secondary voltage. Thus the vibrator acts as an interrupter and rectifier at the same time.

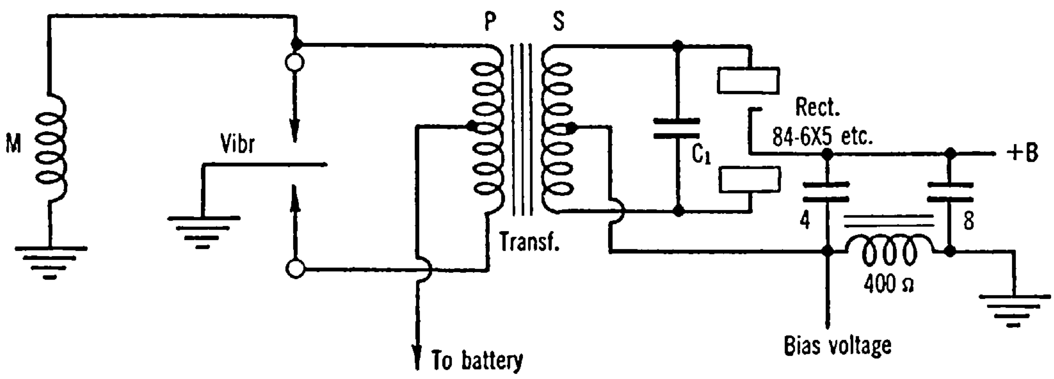
The construction of this vibrator is somewhat more complicated, and its initial adjustment more critical than other types to be described. This is so because the primary and secondary contacts must make and break in correct synchronism. Therefore, sets using this vibrator are likely to require more service than others.



F

2. **Cold-cathode Rectifier, Non-synchronous Vibrator.** This type is illustrated in diagram "F." The rectifier generally used is the type OZ–4. The operation is similar to the supply described in the paragraph below.

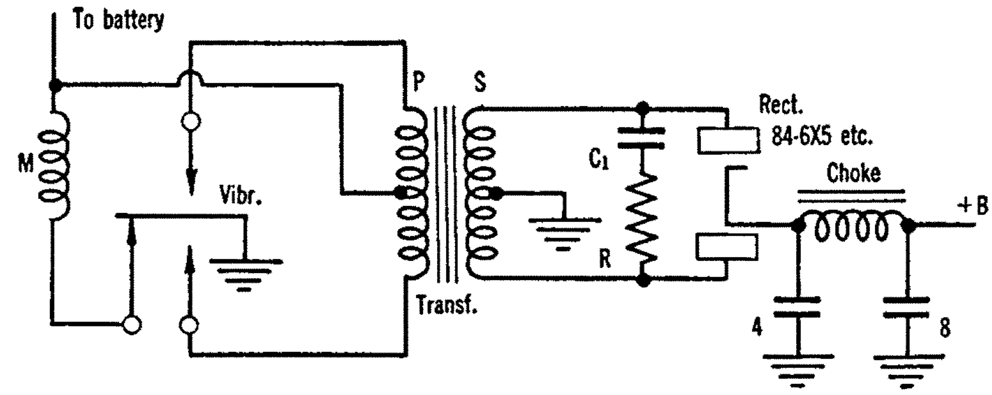
3. **Hot-cathode Rectifier, Non-synchronous Vibrator.** Several versions of this type of power supply are illustrated at "G," "H" and "J."



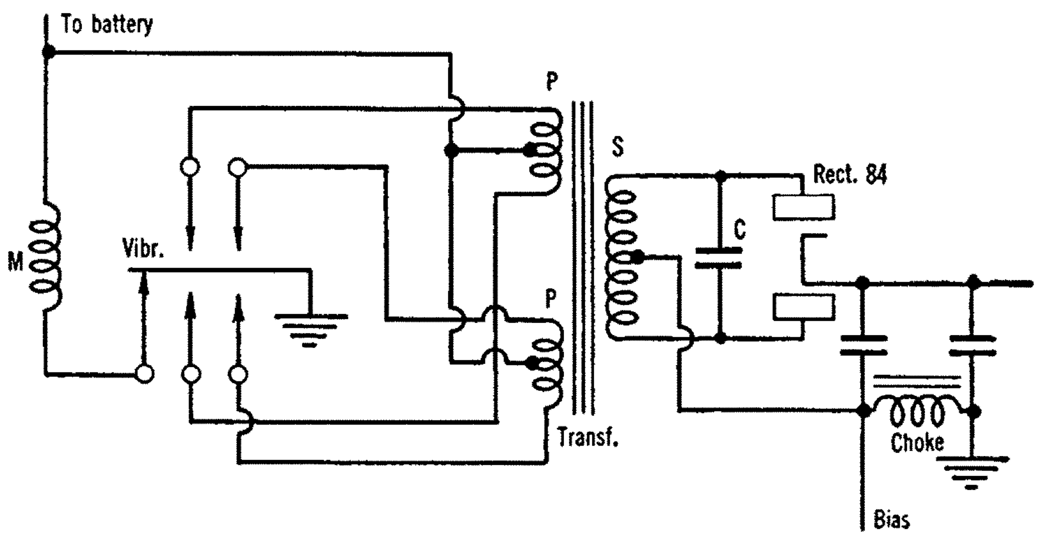
G

In diagram "G," note that when the set is turned on, battery current flows through half of the power transformer primary and the magnet coil *M*, to ground. This energizes the magnet coil, and pulls the reed out of its normal position. The contact shown on the upper side of the reed in the sketch then closes, short-circuiting the magnet coil and de-energizing it. The reed then releases, but instead of returning to normal position, it travels past this position so that the lower contact is closed, allowing battery current to flow through the lower half of the transformer primary. At the same time, opening of the upper contact causes current to flow again through the magnet coil, repeating the cycle.

The flow of direct current through alternate halves of the transformer primary produces a.c. in the secondary, which is then rectified. The rectifier tube is usually an 84, 6X5 or a similar type having a cathode and



H



J

designed for operation on 6.3 volts. Ordinary types used in home receivers, as 80, 5Y3, 5Y4, etc., cannot be used, for two reasons. First, they are designed for 5-volt operation; and second, they use a filament type cathode. As most car sets have one heater terminal of each tube grounded, this would mean that the heater of the rectifier, which is also *B* plus, would be grounded.

The filter circuit shown in "G" is somewhat unusual in that filtering is accomplished by means of a choke (400 ohms) in the negative side of the supply. The voltage drop across this choke is used as bias for the output tube.

The rest of the filter circuit consists of the two electrolytic condensers.

The first has a capacity of 4 mfd., the second 8 mfd. These capacities are smaller than those generally used in home sets, for the reason that the frequency handled is considerably higher. Instead of the 60-cycle supply common in home receivers, the vibrator produces a frequency which ranges as high as 135 cycles per second. The voltage ratings of the filter condensers are usually lower than in most a.c.-operated home sets because car radio power supplies generally deliver a voltage not much over 250.

Particular attention should be given condenser C_1 in "G." This is the timing or buffer condenser and plays a most important part in the correct performance of the vibrator. Omission of this condenser, or use of one having incorrect capacity may result in rapid failure of the vibrator. Some power supplies may have a primary buffer in addition to the one shown in the sketch. All vibrator power supplies use some type of buffer condenser. Should replacement become necessary, be sure to use the capacity specified by the manufacturer of the set. Finally, be certain that the replacement condenser is of excellent quality and that the voltage rating is high enough. It is common practice to use a condenser having a rating as high as 1600 volts for this purpose.

Compare the diagram shown at "H" with the one just described. Here the battery current passes through a normally closed vibrator contact (note that an additional contact is required), and through magnet coil *M*. The coil is energized, pulling the vibrator reed from its normal position. This causes battery current to flow through one half of the transformer primary. At the same time, the circuit to the magnet coil is broken, causing it to lose its magnetism and to release the reed. The reed travels past the rest position and closes the other contact, allowing current to pass through the other half of the transformer winding. The supply illustrated employs filtering in the positive side of the *B* supply. Note the 32,000-ohm resistor in series with the buffer condenser. This is used in some makes of receivers.

The two circuits just discussed illustrate examples of the two general types of vibrators—circuit "G" using a shunt coil and "H" a series coil.

Circuit "J" shows a variation of a series coil vibrator in which a total of five contacts are used. One contact is used to open the circuit to the driving coil, one pair supplies battery current to the two halves of one transformer primary and the last two contacts make and break the circuit to the two halves of a second primary. This circuit also uses filtering in the negative side of the supply, the drop produced across the filter choke serving as bias for the output tube.

Common Auto Radio Troubles

Fuse Blows. May be caused by: defective vibrator; defective rectifier tube; shorted filter condenser; grounded *B* plus; shorted bypass condenser; shorted buffer condenser.

Repeated Vibrator Failure. Generally caused by an overload. Excessive drain may be the result of: defective rectifier tube; defective power transformer; defective buffer condenser; short in *B* supply.

Set Dead. If due to power supply trouble, look for: defective vibrator; defective rectifier tube; short in *B* supply; defective buffer condenser; defective power transformer.

If tubes do not light and speaker field is not energized, look for defective on-off switch, or, in the case of sets having the switch mounted on the remote control unit, disconnected switch lead.

If the trouble appears to be in some part of set other than power supply, localize it to an individual stage as described in Chapter I. When the defective stage has been isolated, proceed to locate the trouble as described in the section relative to the particular type of stage.

If the set is dead and the vibrator does not appear to be working, as indicated by the lack of vibration when hand is placed on the case of set or on the vibrator, the trouble is likely to be either a defective vibrator or no battery supply to the vibrator.

Some sets are mounted in such a way that the tubes and vibrator are in an inverted position. Under these conditions the vibrator may have a tendency, due to its weight, and to road shock, to drop out of its socket.

A number of manufacturers have eliminated this possibility by using a clamping arrangement to hold the vibrator tightly in its socket.

If such is the case, and trouble is encountered, the clamp may have loosened and may easily be retightened. If no provision is made for clamping the vibrator, try bending the socket contact springs to provide additional tension.

Certain sets may be affected by the polarity of the car battery; that is to say, with the positive side of the battery grounded, the set will function, but will not operate with the negative side grounded. This is especially true of sets employing a synchronous vibrator. When this occurs, it is merely necessary to remove the vibrator from its socket, rotate it 180 degrees and replace in socket.

Weak Signals. May be caused by: defective vibrator; defective rectifier tube; defective power transformer; open speaker field; defective tube in stage other than power supply; improper alignment.

Weak Signals; Noisy Reception. Generally due to poor or defective antenna, or to a break or defective connection between antenna and lead in.

Whip antennas of the jointed variety have a tendency to rust or corrode at the joints, reducing the effectiveness of the antenna.

Some types of under-car antennas are dual, that is, an antenna is provided under each running board. The two sections of the antenna are connected by means of a jumper. A loose connection at the points where the jumper is connected, or a break in the jumper, will naturally reduce the pickup. This rather common complaint is usually the result of running over obstructions.

Loose connections or corrosion are fairly common occurrences, especially in types of antennas that are exposed to weather, such as the under-car, spare wheel type, etc.

Speaker Rattle. (May be accompanied by weak signals.) Look for an accumulation of metal particles or dust in speaker gap. Most car radio speakers are protected from dust by cloth covering over the grille and, in some cases, around the rear of the speaker. This trouble has been reduced by the use of enclosed-gap speakers. When replacing this type of cone, be sure to include the dust cap.

Stations are not Received at Correct Dial Settings. May be the result of incorrect alignment. If the set is equipped with a remote-control unit, the trouble may be caused by incorrect relationship between the settings of the dial and the tuning condenser.

Tuning Dial Shifts Position After Control Knob is Released. This may arise as a result of too many bends in the flexible shaft, or the shaft being bent too sharply.

Tuning Control or Volume Control on Remote Unit Operates Stiffly. Same cause as for shifting of dial, mentioned above.

Intermittent Operation. This is likely to show up when traveling over rough roads. Among the common causes are: loose connection at antenna lead-in, or elsewhere in the receiver; shorted tube elements; defective vibrator. Often the set will go dead while the car is not in motion, and jarring the set will restore operation. Many complaints of this type may be traced to a defective vibrator.

Remedies for the Troubles Listed Above

Defective Vibrator. Replace the unit. It is practically impossible to repair a vibrator in the service shop. In isolated cases, service men have had unusually good luck and have succeeded in repairing a vibrator by filing or polishing the contacts or by bending the springs. The safest procedure, however, to reduce possibility of a repeat call, is to install a new vibrator. Furthermore, the defective vibrator may, in some cases, still be within the manufacturer's guarantee, and any attempt to open, or otherwise tamper with it will void the guarantee.

Defective Rectifier Tube. Replace the tube.

Defective Filter Condenser. Replace with a new unit of equivalent capacity and voltage rating. In sets having filtering in the negative side of the supply, the condenser generally has a common positive connection. If the correct replacement cannot be obtained, the defective section only may be replaced.

Repeated Vibrator Failure. Clear up the cause of the overload, then replace the old unit with a new vibrator of the correct type.

Defective Power Transformer. Install new transformer.

Defective On-Off Switch. If the switch is a part of the volume control assembly, the entire control will usually have to be replaced, unless the switch is of the detachable type.

In many sets using a remote control unit the switch is a part of the control unit rather than the set. The switch unit is easily replaced in those cases. Some sets have separate terminals or jacks for connecting switch leads from control unit. If one lead is disconnected, the set will be inoperative.

Improper Alignment. Realign in accordance with manufacturer's specifications.

Whip Antenna Corroded at Joints. Replace with a new antenna. It is, in most cases, impossible to make a satisfactory repair, nor does it pay to do so.

Undercar Antenna Connecting Jumper Broken. Replace with a new lead. It is advisable to use a piece of stranded, well-insulated wire for this purpose. If the jumper is not broken but is disconnected or loose, clean the ends of the wire and terminal units and then reconnect the wire, tightening the nuts well.

Stations Off Calibration Due to Incorrect Setting of Tuning Condenser or Remote Control Dial. Loosen the knurled nut or clamp at the point where the cable enters the receiver housing. Remove the end of the cable from the condenser drive. Adjust the condenser to its maximum capacity; set the tuning dial to its lowest frequency; reinsert the end of the cable and tighten the knurled nut or clamp. Recheck to see if calibrations are now correct.

Bends in Flexible Shaft. (Resulting in stiff operation of controls, or in movement of the controls after the knobs are released.) See that shafts are run as directly as possible from the tuning unit to the set.

Do not make any unnecessary bends or twists in the shaft. When a bend is necessary, make its radius as great as possible. If you find that the cables are much longer than required, shorter shafts may be obtained, or the original ones cut to proper length. Do not try to cut them yourself without the special equipment needed, as you will probably be unable to replace the end fittings. A number of large service stations specialize in this type of work. When installing or reinstalling a set, do not wind or twist the shafts around the steering column, the speedometer shaft, the choke rod or other parts, to get rid of slack. If the loop is likely to get in the driver's way, it may be clamped, taped or tied to a convenient point, at the same time avoiding sharp bending of the shaft.

Interference in Auto Radios

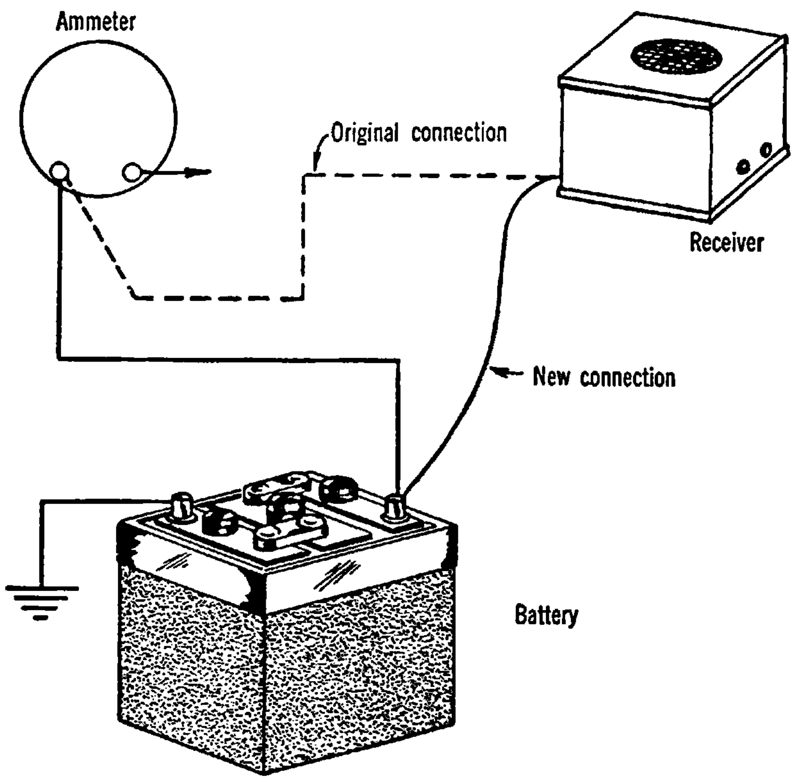
The possible causes of interference are so numerous that it is impossible to list even a fair proportion of them, but a few of the more common ones will be taken up.

By far the most common cause of noise or interference is the ignition system. The trouble points here are the ignition coil, plugs and distributor. The next points to be suspected are the generator, the starting motor and other auxiliary equipment.

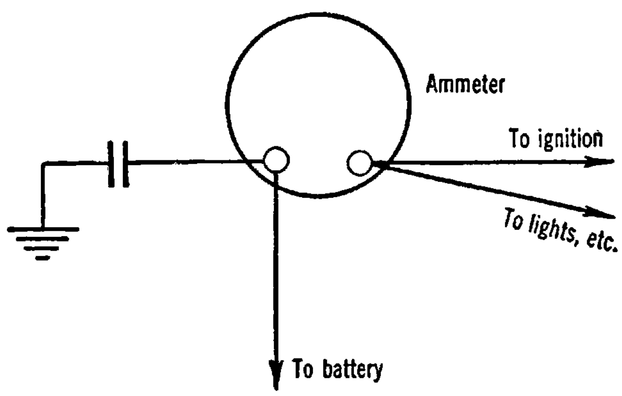
In tracing interference, perform the following steps in the order indicated:

1. Be sure that the sensitivity of the set is normal. Check condition of tubes and alignment of receiver.
2. See that the set is operating with a normal antenna in good condition. Check for breaks in the antenna lead-in, corrosion of connections, etc. Any condition which reduces the pickup will tend to increase noise.
3. If the antenna is provided with a shielded lead-in, make sure that the shield is well grounded to the car frame or to a point which makes good contact with the frame.
4. If the receiver battery cable is connected to the ammeter, the ignition switch or any point other than the battery terminal, remove it and reconnect it directly to the battery terminal as shown in "K." Do not forget that all connections made to the battery should be covered with grease to reduce corrosion from acid.

5. Try connecting a condenser from the battery terminal of the ammeter to a good ground. Use the standard shielded condenser available for this purpose, connected as in "L."
6. If the interference is traced to the car generator, filtering may be applied at this point. Generator interference may be recognized



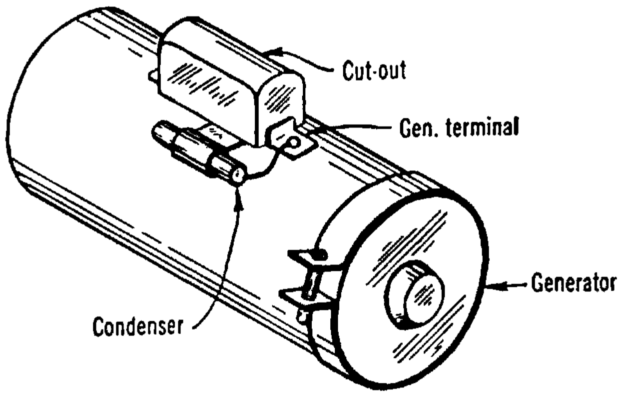
K



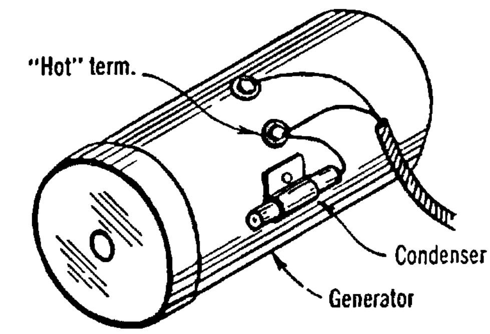
L

as a rather high-pitched whine, as distinguished from the ticking sound produced by the ignition system. The standard remedy for generator interference is to connect a condenser from the hot side of the generator to ground. In older cars, the generator has a cutout mounted on the top of the casing. By tracing the wiring, you will find that one terminal of the generator is connected to one terminal of the cut-out. The condenser is to be connected at this point. See illustration at "M."

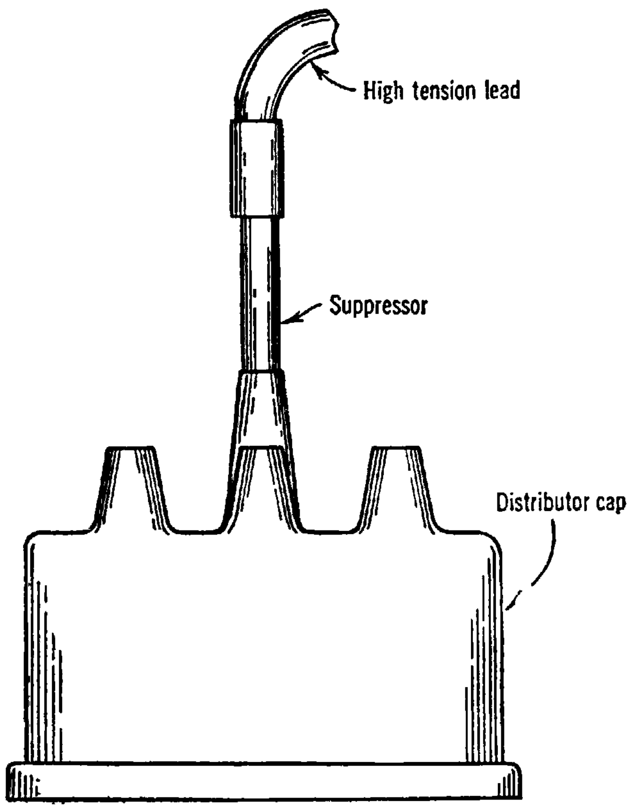
Later model cars use a voltage regulator for controlling charging of the battery. If this is the case, the condenser may be connected directly to the hot generator terminal, as in "N."



M



N

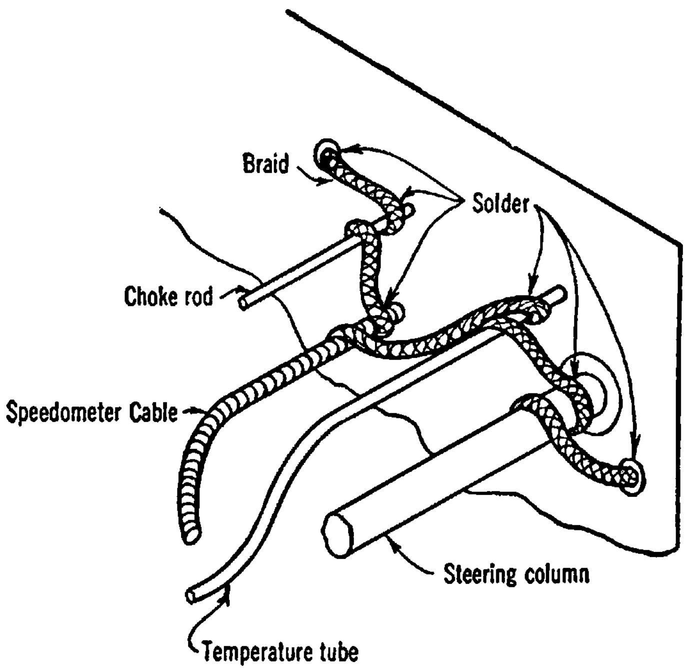


P

7. Try an interference suppressor connected between the center (rotor) terminal of the distributor and the lead from the high tension side of the ignition coil. It is not necessary to cut the lead to install the suppressor. Just remove the lead from the terminal or socket, plug the suppressor into the distributor and connect the high tension lead to the top end of the suppressor, as indicated in "P."

8. In certain cars the ignition coil was so installed that part of the coil protruded through the bulkhead or fire wall into the passenger compartment. This caused considerable interference in sets using a built-in or roof-insert aerial. The only remedy is to install the coil inside the engine compartment.
9. To prevent engine ignition interference from being carried outside the engine compartment, it is good practice to ground all metal rods, tubing, etc., which pass through the bulkhead. It is true that these parts are connected to the frame of the car, but this does not prevent them from acting as conductors of r.f. energy.

   The best procedure to follow is to wrap a length of woven metallic braid around each of the parts to be grounded, first carefully cleaning the part. Solder the braid to the various parts, then



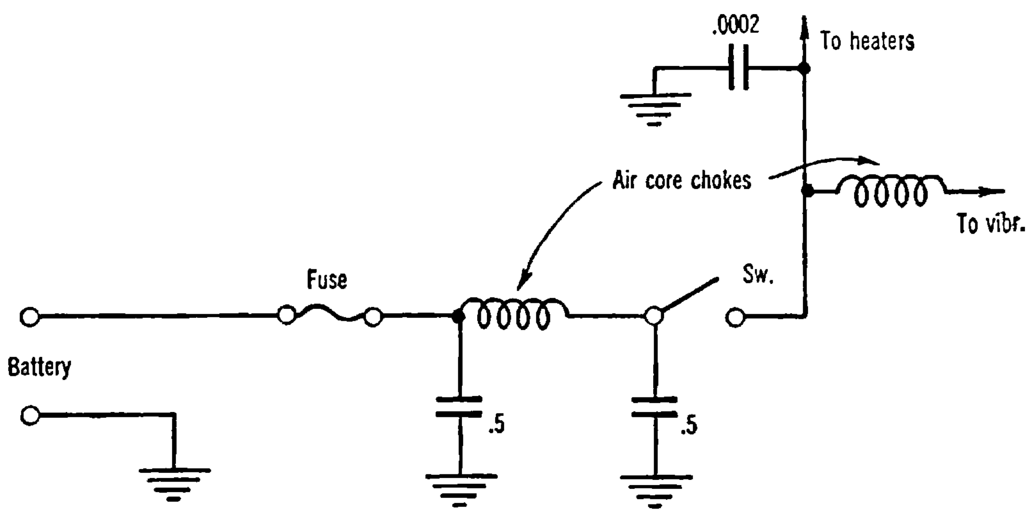
Q

   ground each end of the braid to the bulkhead. One piece of braid should be used to interconnect all parts. The parts to be grounded include the steering column, the speedometer cable, the temperature tube, the choke rod, etc. The grounding should be done on the engine side of the bulkhead and all grounds are to have as little resistance as is possible. See sketch "Q."
10. The installation of spark plug suppressors may be necessary in certain cases. It has been demonstrated that these will not impair the performance of an engine, provided that the engine is in satisfactory running condition before the suppressors are installed.

11. There have been extreme cases in which shielding of all high-tension ignition leads was required, but this is not recommended.
12. Almost all car receivers have condensers and chokes connected in the battery supply lead, as seen in "R." Inspect these to be sure none have been removed during a previous service job and to see that they are in good condition.

"Hash." Hash is a form of interference that may persist when the antenna is disconnected from the set and the antenna terminal grounded. Ordinary engine ignition interference or generator noise will usually disappear when this is done. The following suggestions may be helpful in eliminating hash:

1. See that the vibrator is firmly seated in the socket.



R

2. As noted under ordinary ignition interference, inspect chokes and condensers connected in the *A*-supply lead of the receiver.
3. All screws used to fasten the cover of the set to housing, and chassis to housing, must be in place and drawn up tightly.
4. Try another vibrator.
5. In extreme cases try bonding various components to ground with a metallic braid well soldered to the parts. Likely points to try are: vibrator case; case or core of choke; core of output transformer; metallic case of filter condenser.

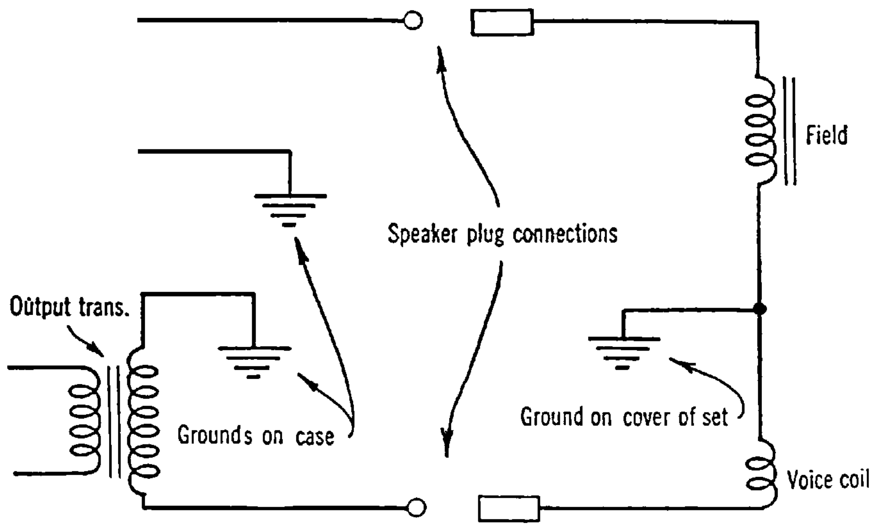
Wheel or Tire Static. This shows up generally on very dry days and is caused by friction of tires on the road. The static cannot be conducted to the frame of the car as there is not a good connection between wheel and axle, because of the bearing grease.

The remedy is to install a static collector, usually in the form of a helical spring installed under the hub cap and providing a path for the static from hub cap to axle. These devices may be obtained from auto supply stores, auto radio distributors and auto radio service stations.

Static Produced by the Whip Antenna. Certain types of whip antennas terminate in a point. This produces a form of static which may be overcome by fitting the top of the antenna with a small plastic or metal ball.

Service Hints

Removal of Set From Car. You may find it necessary to open the bottom of the receiver for testing or adjusting, and do not want to go to



S

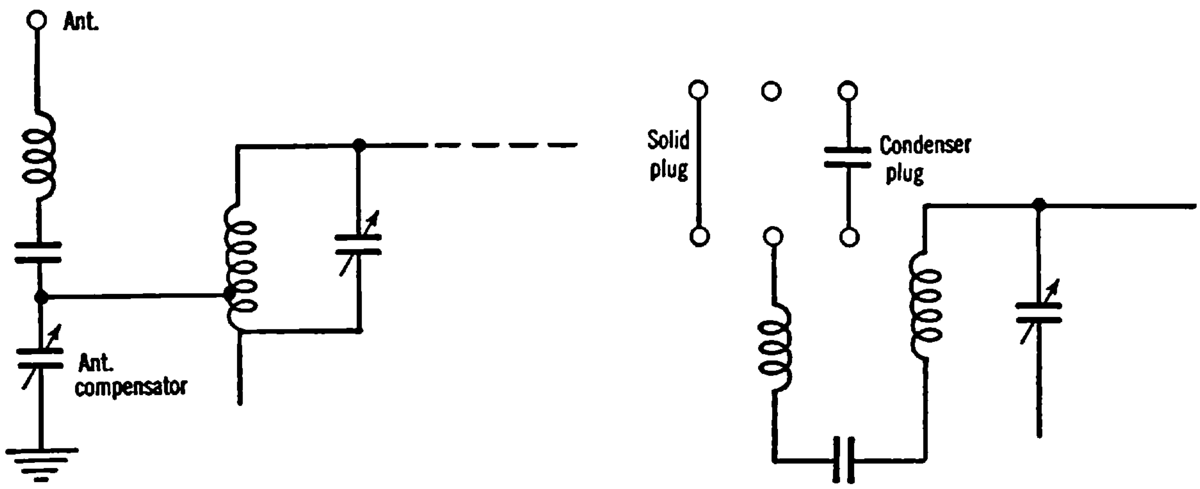
the trouble of disconnecting the control shafts. Do not forget that when the set is removed from its mounting it is no longer grounded to the frame of the car and therefore the battery return circuit is open. To provide for a return, carry a length of heavy wire with a clip at either end. Clip one end to the case of the receiver, the other to a convenient grounded point on the car.

Removal of Cover of Set. Many receivers have the speaker installed in the cover. Very often the return for the voice coil or field, or perhaps both, is through the cover. Removal of the cover then, opens up one or both windings. The reason is illustrated in sketch "S." A return circuit should be provided as described in the paragraph above.

Alignment. If the receiver has been aligned on the bench, you may find that sensitivity is somewhat low after reinstalling in car. If this happens, look for an antenna compensator, often connected as shown in "T." The general procedure for adjusting this compensator is to tune in a station at the high-frequency end of the range and to adjust the compensator for maximum volume with the regular car antenna connected.

Some sets have provision for antennas of varying capacity. Certain Philco models were equipped with a metal plug and a small condenser the exact size of the plug.

Before inserting the antenna lead into the antenna receptacle on the set, either the solid plug or the condenser plug is inserted. The solid

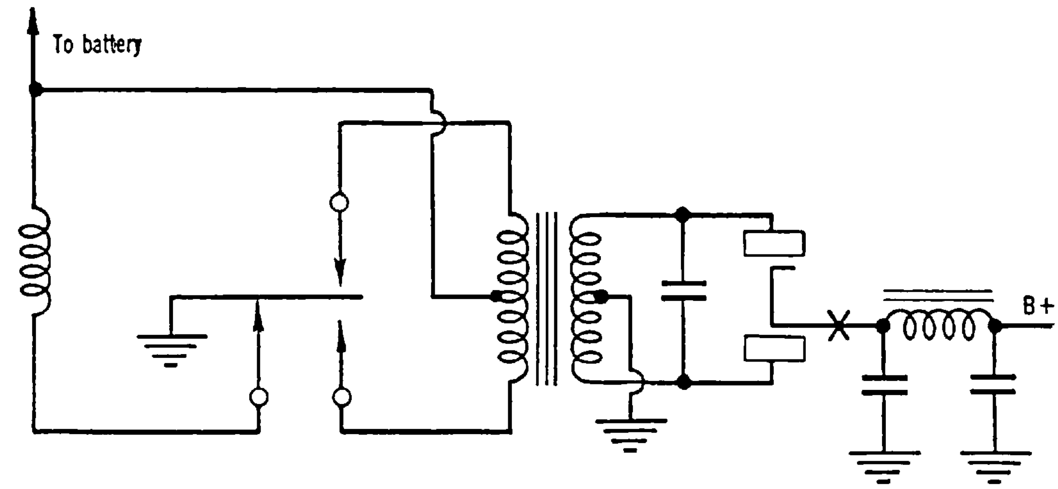


T V

Courtesy Philco

plug is used for low-capacity antennas, such as an under-car or a spare-wheel antenna, and the condenser plug is used when operating on a relatively high-capacity antenna such as trunk-lid or a built-in-top antenna. The circuit for this arrangement is shown at "V."

JOB SHEET NO. 39



AIM: To learn how to locate trouble in an auto radio power supply.

PROCEDURE:

If Fuse Blows When Switch is Turned On.

1. Remove vibrator and replace with a new one.

2. If fuse still blows, replace rectifier tube.

3. If there is still evidence of excessive battery drain (this may be checked by connecting an ammeter in series with the battery), check a.c. voltage from plate terminals of rectifier socket to ground. If voltage is low or if there is no voltage at these points, trouble is most likely due to shorted buffer condenser or defective power transformer. If the a.c. voltage is about normal, look for trouble on the d.c. side of the power supply.

If Fuse Does Not Blow But D.C. Output Voltage is Zero or Very Low.

1. Disconnect main *B* plus supply lead and first filter condenser at point marked "X." Now recheck d.c. voltage at cathode of tube. Normal voltage now shows that trouble is due to ground on d.c. side of supply, shorted filter condenser or shorted bypass condenser, etc.

2. If d.c. voltage is still zero or very low, with load removed from rectifier, replace the rectifier tube.

3. If new tube does not clear up the trouble, you have isolated it to the a.c. portion of the unit. Now proceed as follows:

4. Measure a.c. voltage at rectifier plates. If no voltage appears, disconnect one lead of buffer condenser. Normal voltage with buffer dis-

connected shows that the condenser is shorted. If a.c. voltage is zero or low with buffer disconnected. look for trouble in transformer.

5. If you get a normal reading on one plate of tube but low or no voltage on the other, look for short or open in one half of the transformer secondary. Verify with ohmmeter.

6. Very low or zero voltage at both plates of the tube points to trouble in the transformer, probably in its primary.

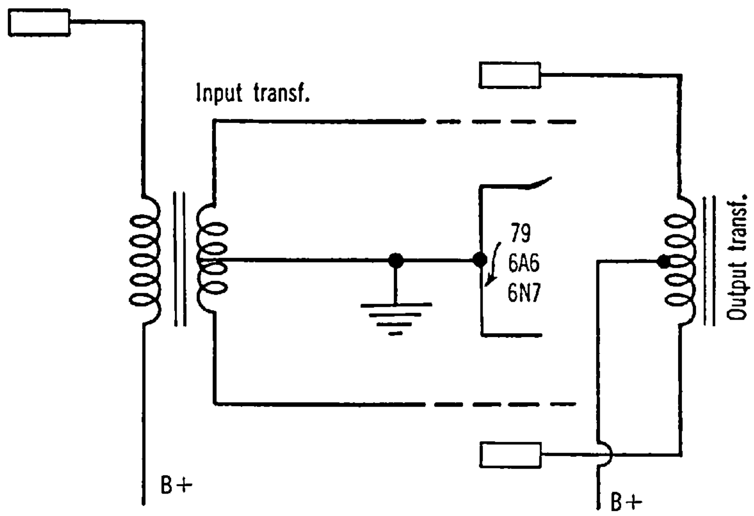
Excessive Hum.

1. Check condition of filter condensers by temporarily connecting a known good one across each in turn.

2. If substituting new condensers does not clear up the hum, check for excessive current drain on the supply. May be caused by short or ground, shorted bypass condenser, etc.

3. If the supply is not being overloaded and filter condensers are in good condition, look for possible short or open in one half of the transformer secondary, or defect in one side of the rectifier. This type of trouble is usually accompanied by lower than normal d.c. voltages.

JOB SHEET NO. 40



AIM: To learn how to locate trouble in a class *B* auto radio output stage.

THEORY: This type of output stage is used in some car receivers in order to obtain increased power output. The circuit uses a dual triode tube and is similar to the usual push-pull stage except that: (a) the stage operates with zero grid bias, (b) with no signal the plate current will be nearly zero and, (c) the input transformer is step-down ratio.

PROCEDURE:

If Stage is Dead.

1. Check voltage from the cathode to the plate of each triode. No voltage on either plate means that trouble is in power supply or that the entire winding of the output transformer primary is open.

2. Check continuity from each triode grid to cathode. An open input transformer secondary, while not usual, will cause dead stage.

3. If you find that plate voltages on triodes are normal and input transformer secondary is not open, check voltage at plate of preceding stage. No voltage here might result from an open input transformer primary.

Distortion.

1. Check for possibility of defect in one triode section.
2. Test primary of output transformer for open circuit.
3. Test secondary of input transformer for open circuit.

Excessive Hum.

1. Make same tests as for distortion, above.

Questions

1. Name several types of auto radio antennas in common use.

2. What are the three general types of auto radio power supplies?

3. Why is the manufacture and adjustment of the synchronous vibrator much more critical than that of the non-synchronous types?

4. What is the usual tube type used in auto receivers when a cold-cathode rectifier is desired?

5. Give two reasons why the type 80 tube could not be used as a rectifier in car receivers.

6. Why may the capacities of filter condensers in car sets be lower than in home receivers?

7. Explain the difference between series and shunt magnet coil vibrators.

8. The fuse of a car set blows as soon as the switch is turned on. What would be your first step in locating the trouble?

9. Describe some of the symptoms you would expect to find in a set having a shorted buffer condenser.

10. In working on an auto radio, the service man has omitted the buffer condenser. What is likely to be the result?

11. Describe how you would proceed to clear up interference caused by the car generator.

12. Name one objection to the use of an under-car antenna.

13. Why should the battery supply lead to a car radio be connected directly to the battery terminal, rather than to the ammeter?

14. What provision is generally made, within the receiver itself, to reduce the possibility of interference?

15. While working on a receiver, you find that removal of the cover causes the set to go dead. What is the cause of this condition, and how would you correct it?

16. How would you overcome tire static?

17. Name several tube types usually used as class *B* twin triodes in the output stage of a car radio.

18. In what respects does a class *B* output stage differ from the usual push-pull stage?

References

Mye Technical Manual, P. R. Mallory & Co., Inc.; pp. 64–92.
Philco, RCA, Motorola, Delco Service Bulletins.

13

BATTERY-A.C.-D.C PORTABLE RECEIVERS AND SUBSTITUTION OF PARTS AND TUBES

During the past five years or so the demand for receivers of the portable variety has been great, and it seems safe to say that the future demand may be even greater.

Service on portables, therefore, is likely to constitute a fair proportion of your work, and you should become thoroughly familiar with the circuit arrangements, the various features and the troubles that commonly occur in this type of set.

There are many existing portable sets which were designed for operation on batteries only, but as the circuits of these sets are comparatively simple, it does not seem necessary to devote any space to a discussion of them. A far more desirable and more flexible arrangement, and, incidentally, the one that has enjoyed the greatest popularity, is one which permits operation as desired, from batteries, a.c. line or d.c. line.

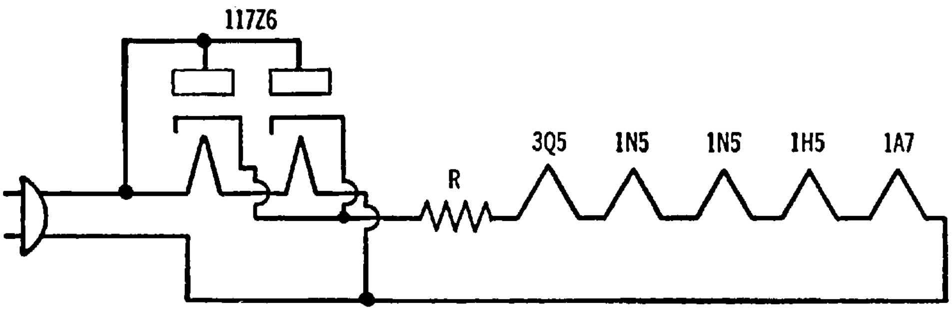
Generally speaking, such sets use a series filament arrangement, with provision for shifting filament supply from an "A" battery to some form of a.c.-d.c. supply, and plate and screen supply from a "B" battery to a supply from the same line source.

The most commonly used type of a.c.-d.c. operation employs the filaments in series, as mentioned above, supplying them with current obtained from a half-wave rectifier. Other arrangements are possible, as, for example, using the filaments in series as a bias resistor for an output tube.

A number of different types of rectifiers are in general use, among them being the 35Z5, 35Z3, 45Z3, 117Z6, and 117L7, the latter a combination rectifier and beam power output tube. You may encounter an occasional set using a 25Z6 or 70L7, and you will find a few sets using one output tube for battery operation and another for a.c.-d.c. operation. In such cases the output tube used on batteries will probably be a 3Q5 or a 1A5, with a 50L6, or the tetrode section of a 117L7 or 70L7 used for line operation.

All of the above indicates that a more or less complicated switching arrangement must be used to change the filament circuit from battery to rectifier, the *B* supply from *B* batteries to rectifier, and perhaps one output tube to another. The switching circuits are not too complicated but they do represent a departure from what the average service man has become accustomed to. However, to a progressive service man, this means only a challenge which may be overcome with a little perseverance. In working on a set using an unfamiliar circuit, never try to trace the circuit and keep in mind the portion you have traced. Have a pencil and paper at hand, and as you trace through a small portion of the circuit, draw a sketch of it. You may have to redraw your diagram several times, but eventually you will have a completed circuit.

There are a few additional features that must be taken into account when working on three-way portables. These are: (a) filter circuits



A

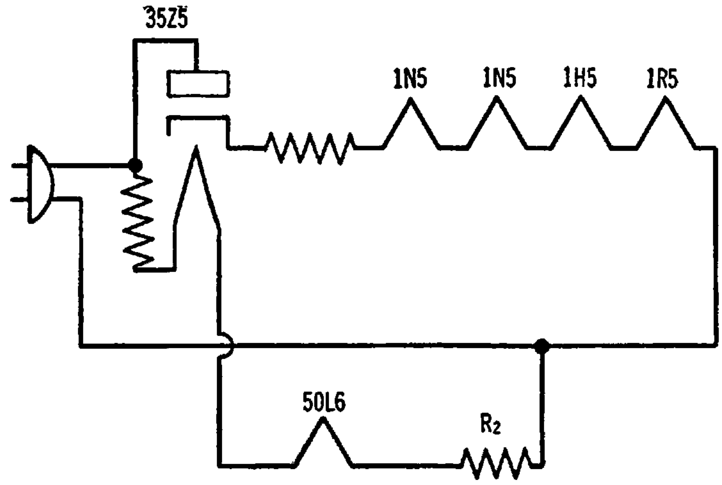
that may appear to be unconventional are used in many sets, (b) a variety of loop antenna circuits are used, in many cases with provisions for attaching an outside antenna, (c) some sets use a vibrator power supply, (d) still others use a small storage battery with means for recharging it.

Having noted the major points of departure from usual practice, let us consider the circuits involved in portable sets.

Filament Supply Circuits

Series Filament Circuits. Two examples of series filament operation from a rectifier are shown in diagrams "A" and "B." In "A" all the filaments, including that of the 3Q5 output tube, are in series and are supplied with current by the 117Z6 rectifier tube, with a resistance, *R*, in series to limit the current to the recommended value. The heater of the 117Z6 is, of course, connected directly across the line.

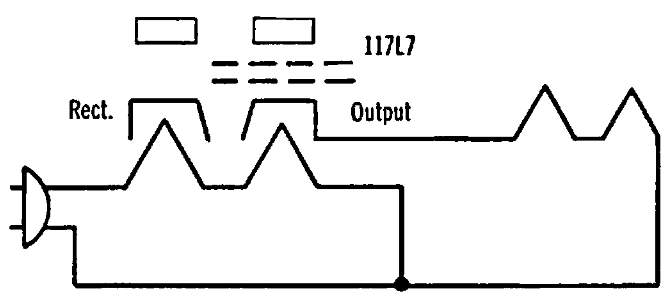
Diagram "B" shows the filament circuit of a set which uses two output tubes, a 50L6 for line operation and a 3Q5 on batteries. All filaments, except that of the 3Q5, are in series, and are supplied with d.c. by the



B

35Z5 rectifier. The 3Q5 is supplied with filament power only when the set is operated on batteries. The heaters of the 35Z5 and 50L6 are in series and are connected across the power line with resistors R_1 and R_2 in series. The first circuit shown is in much more common use than the second.

Another method of supplying filament current is shown in "C," in which a 117L7, combination rectifier and beam power output tube is

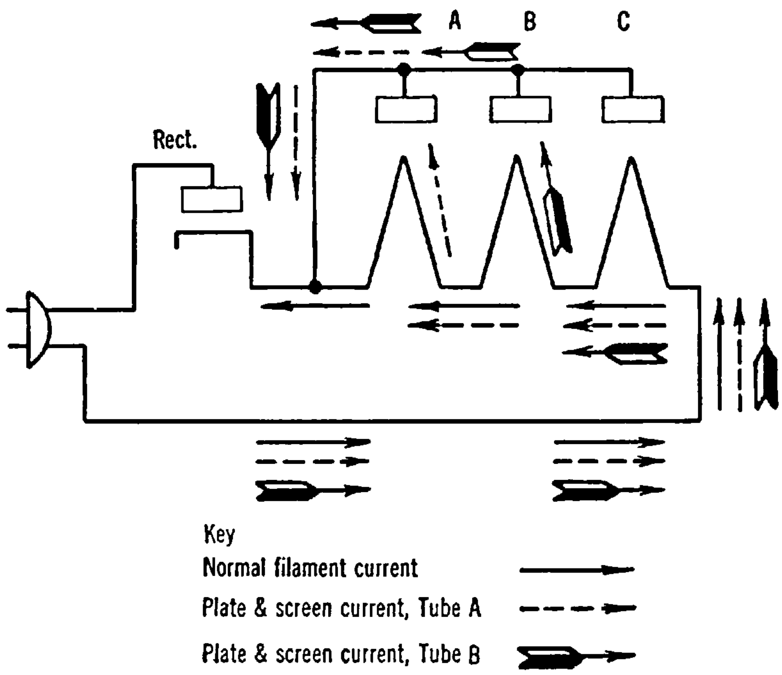


C

used. The filaments of all tubes except that of the 117L7 are connected in series with the cathode of the beam power section of that tube and form part of the bias resistor. Only two tube filaments are shown so connected, since the third, another output tube, is used only when the set is operated on batteries.

In operating tube filaments from the output of a rectifier, a serious difficulty may arise, in that the total filament current in the series circuit at some points may be higher than the recommended current, unless special precautions are taken. The reason for this condition may be seen by studying diagram "D." The plates of the three tubes are shown tied together, although actually each tube plate circuit has its own resistor, coil or transformer winding. Filament and plate currents are indicated by various types of arrows.

Let us assume a normal filament current of 50 milliamperes. This current, indicated by the single arrow, will flow through the filaments of all the tubes, from the line back to the cathode of the rectifier. However, in addition to the filament current, plate and screen currents, also supplied by the rectifier, must flow through the filaments of some of the



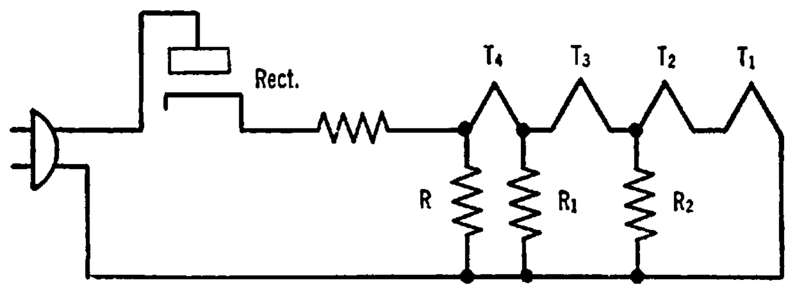
D

tubes in order to return to the rectifier. Suppose that the combined plate and screen current of tube *A*, an output tube, is 10 milliamperes, indicated by dotted arrow. To reach the plate of tube *A*, this current must pass through the filaments of tubes *B* and *C*. Furthermore, the plate and screen of tube *B* draw current which may amount to 3 milliamperes, indicated by double arrow, and this must pass through the filament of *C* in order to reach tube *B*.

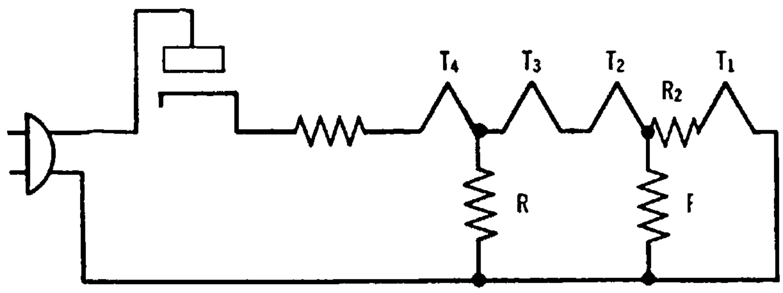
Thus you will see that the filament current through *C* may be as high as 63 milliamperes, an overload of 26 per cent, while that passing through *B* may be as high as 60 milliamperes, a 20 per cent overload.

This condition will result in rapid failure of some of the tubes in the string, unless some means is used to keep the current near the normal value. This is usually done by shunting the filaments of some of the tubes.

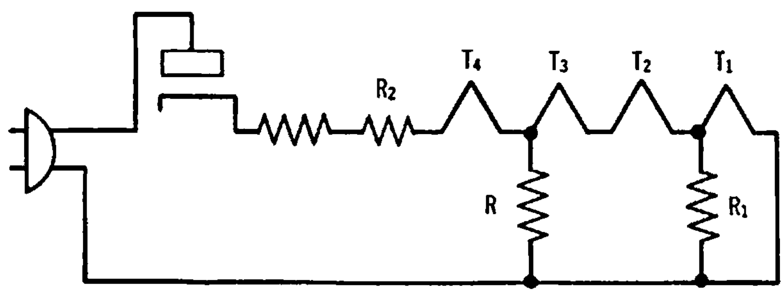
Shunted Filament Circuits. Diagrams "E," "F" and "G" show various types of shunted series filament circuits. In "E," resistor R_2 shunts tubes T^1 and T^2. The value of R_2 is calculated so that only the recommended filament current passes through the filaments of T^1 and T^2, while the plate and screen currents, or at least their portion of the total current, passes through the resistor. At the same time T^3 is shunted by



E



F



G

resistor R_1, and T^4 by resistor R. Another reason for using resistor R is to prevent the voltage from rising to an abnormal value in case of burn-out of one of the tubes.

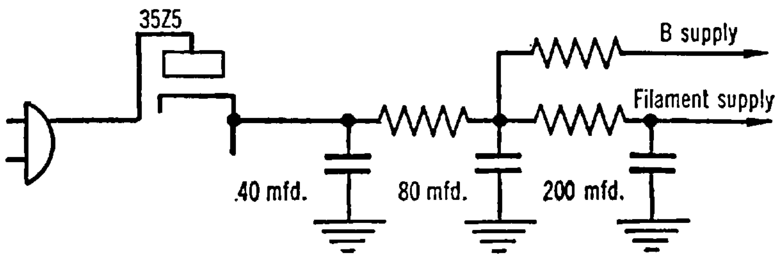
Diagram "F" is slightly different, in that T^1 is shunted by resistor R_1, and tubes T^2 and T^3 by R. No shunt resistor is used across T^4.

Circuit "G" is quite similar to "F," except that series resistor R_2 is placed at the other end of the filament string, next to the rectifier, instead of between T^1 and T^2. Of course a wide variety of these circuits is to be found, and those shown here will not apply to all sets, but they are sufficiently representative, so that you will be able to trace most filament circuits without difficulty.

Plate Supply Circuits

Perhaps the most notable feature of portable receiver power supplies is the fact that in most cases a filter choke is not used and, because a permanent-magnet speaker is almost universally used, the speaker field does not appear in the filter circuit. Instead, both the *A*- and the *B*-supply circuits use a resistor-capacity filter. Another point worth mentioning is that the filter condensers are of a much higher value than those used in a.c. or a.c.-d.c. sets.

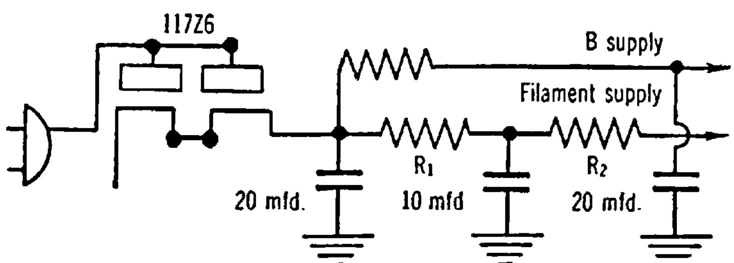
Look at circuit "P," which is fairly typical. The *A* supply consists of condenser *C*, 30 mfd., resistor *R*, condenser C_1, 100 mfd. and, on the other



H

side of the 3Q5 filament, a third condenser, C_2, 100 mfd. The *B* supply includes the first condenser, *C*, which is common to both the *A* and *B* supplies, resistor R_1, and condenser C_3, 20 mfd. Note that high-capacity condensers are used in the *A* supply. The last condenser in the *A* supply circuit is ordinarily of low working voltage, possibly 10 volts.

A variation of this circuit appears at "H." Here, however, filter resistor *R* is used for both *A* and *B* supply circuits, while another, R_1, is used for the *A* supply alone. Note the capacities of the filter condensers used—40, 80 and 20 mfd.

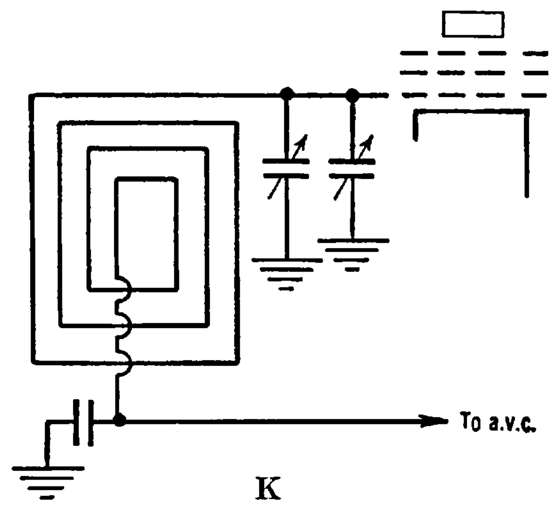


J

A third circuit is shown in sketch "J." The *A* supply includes the first condenser, *C*, 20 mfd., filter resistor R_1, 1000 ohms and the second condenser, C_1, 10 mfd. Resistor R_2 limits the filament current to the proper value. Condenser *C* is used for filtering both *A* and *B* supplies, and this condenser, together with filter resistor R and condenser C_2, completes the B-supply filter circuit. The rectifier used is a 117Z6.

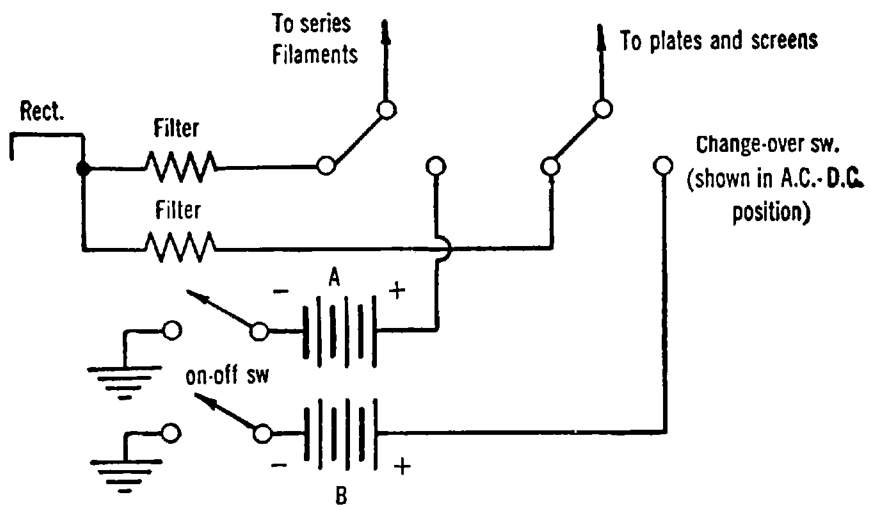
Switching Circuits

The change-over switch, in most portables, takes care of changing the filament, plate and screen circuits from A and B batteries to rectifier



K

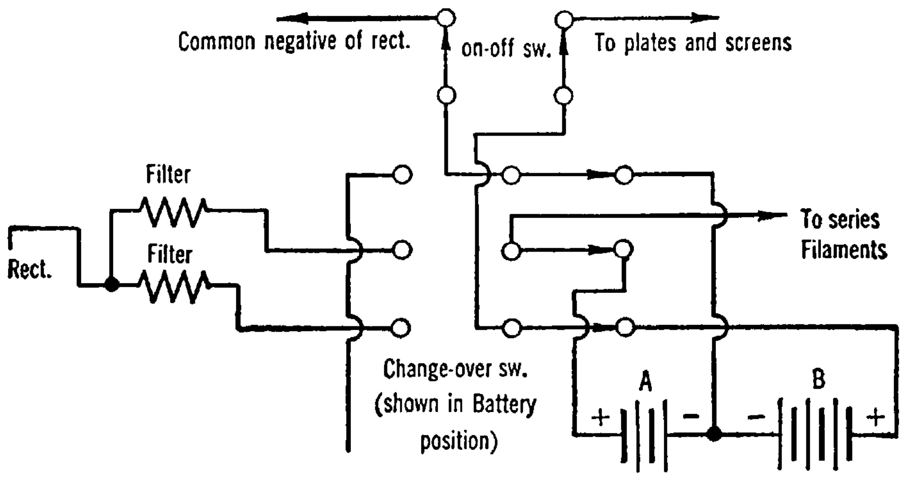
supply. This change-over switch is used in addition to the usual on-off switch, which, by the way, is generally a two-pole switch, one pole used for A supply, the other for breaking the B supply.



L

A typical change-over and on-off switch is shown at "L," in which a double-pole single-throw switch is used to turn the set on and off, and a double-pole double-throw switch for changing from batteries to a.c.-d.c. power supply.

Some other switching circuits are considerably more complicated than the one just described. "M" illustrates one arrangement using a double-pole single-throw switch to turn the receiver on and off, and a three-pole double-throw switch for change-over from batteries to line supply. The

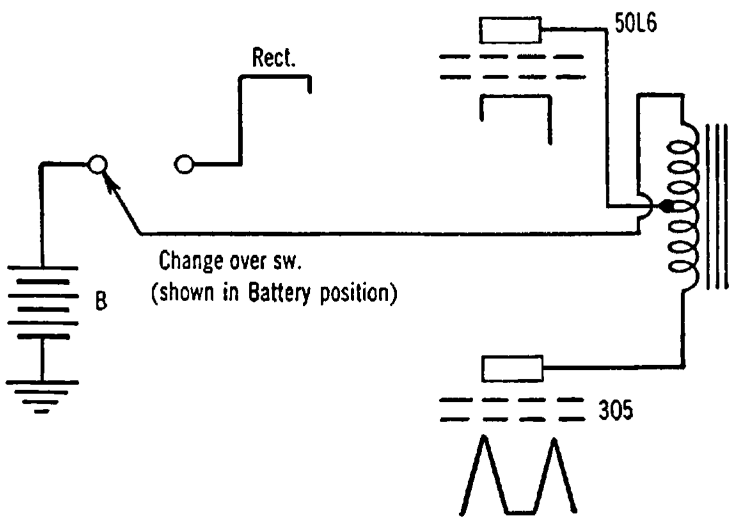


M

Courtesy Philco

extra switch blade in this circuit is used to break the common negative line.

As stated above, certain sets are designed to use one output tube for battery operation and another for line operation. This type of circuit is seen at "N," which illustrates the method of changing output tubes. The rest of the circuit, involving the change in filament and *B* supply

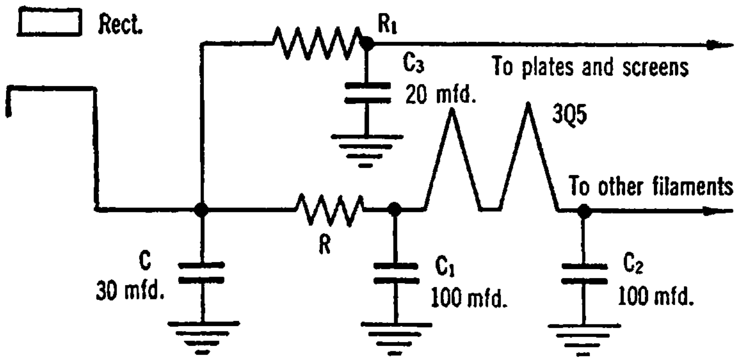


N

has been omitted for the sake of clarity. Note that an output transformer with a tapped primary winding is used, the entire winding for the 3Q5 tube, and one half of it for the 50L6. Only a single-pole double-throw switch is then required to change tubes.

If the receiver is equipped with more than one tuning range, it will have, in addition to the on-off and change-over switches, the usual wave-change switch, which is generally about the same as that used in the ordinary a.c. or a.c.-d.c. home receiver.

Certain portable models which were designed for operation on several frequency ranges use a separate loop antenna for each range. In this



P

case a switch mounted on the same shaft as the regular wave-change switch is provided to change from one loop to the other.

Vibrator Power Supply

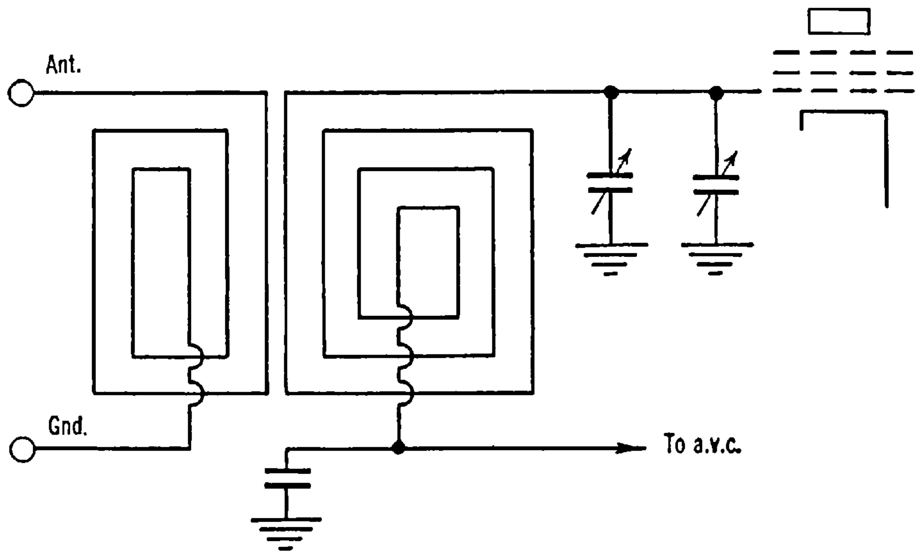
A few receivers have been designed to use a vibrator power supply not yet discussed here—in some cases for supplying *B* voltages only and in conjunction with a storage battery, in other sets to supply both *A* and *B* voltages.

An interesting example of the latter type is one in which a small storage battery is used to supply the filaments of 1.4-volt tubes connected in parallel. When operated from an a.c. line, the battery furnishes the filament voltage and the *B* supply is drawn from a vibrator power supply operated from the same battery. At the same time the battery is recharged from the line through the medium of a step down transformer and copper-oxide rectifier.

On battery operation, the battery still supplies filament voltage directly and *B* supply is drawn from the vibrator, but the battery is not being recharged. The battery may be recharged from the line or from an external battery when the set is out of operation.

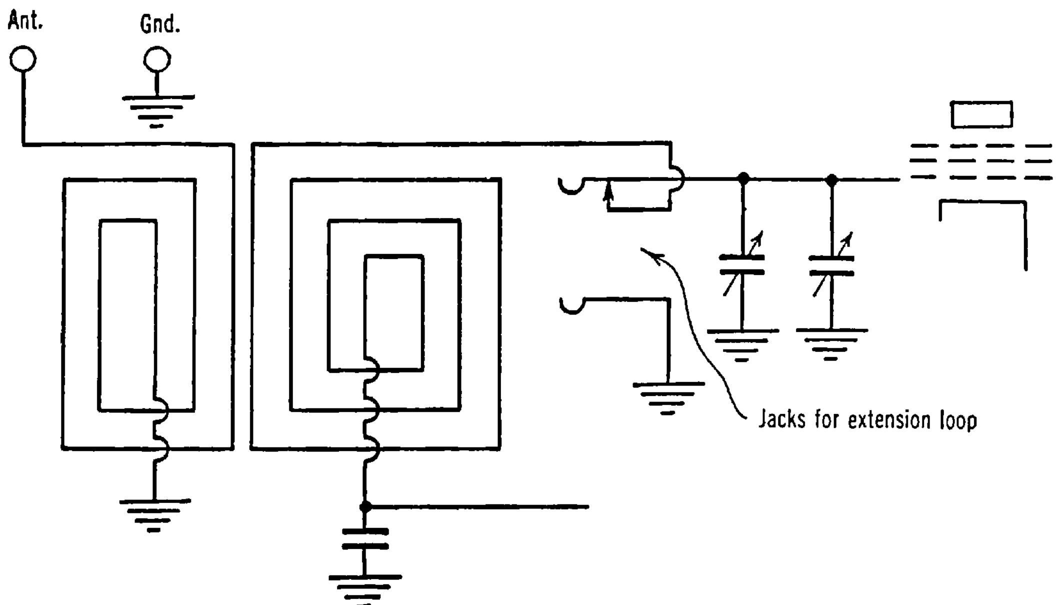
Loop Antenna Circuits

Little space need be devoted to a discussion of the various types of loop antennas used in portable sets, for in most cases they are similar to those used in other compact receivers. Sketch "K" shows the most usual form, consisting of a single-winding loop with no provision for connecting an external antenna. This loop is connected in exactly the same manner as the secondary of an antenna coil. The antenna trimmer may be mounted either on the loop or on the variable condenser. Diagram "Q"



Q

shows the usual arrangement of a loop having a primary winding, with the ends of the primary brought out to terminals for connecting an external antenna and ground.



R

As stated before, some receivers include provision for connecting an extension loop when operating the set under poor receiving conditions. An example of this type of antenna circuit is shown in sketch "R." When the extension loop is plugged into the pin jacks, the built-in loop is disconnected. Extension loops are generally provided with some means of fastening to a window or other smooth, vertical surface, usually by means of rubber suction cups.

Locating Trouble in Three-Way Portables

Before listing the common troubles, it is well to mention the precautions to be taken when servicing sets of this type.

As portables are unusually compact, parts are placed very close together, and extreme care must be taken when making measurements.

Tube filaments, in most cases, are designed for 50-milliampere operation, and may easily burn out due to a short circuit that causes even a slight overload. Great care must be used to prevent the test prods from making contact with any points other than the terminals at which measurements are taken. It is a good idea to use prods having rubber tubing insulation, and to pull the rubber well down on the prod so that only a small portion of the tip is exposed. This will greatly lessen the danger of shorts.

Battery-operated tubes, with a few exceptions, produce very little light due to heating of the filaments. It is therefore often difficult to determine whether the tubes are functioning, which fact has led many service men into difficulty. When working on a.c. or a.c.-d.c. receivers, it is common practice to omit the measurement of heater voltages; but do not commit this error when working with battery-type tubes. Many cases will develop in which all other voltages are normal and the failure of the set to function will appear to be a mystery until it is found that there are no filament voltages. A typical case comes to mind in which a short circuit developed across the filament terminals of one tube, rendering the set dead, yet all the voltages usually measured were normal.

You will undoubtedly find cases in which tube failures occur repeatedly. These, of course, are almost invariably due to excessive filament current. If you encounter such trouble, and find that the set uses a shunted filament circuit, look for an open shunt resistor, or a series dropping resistor which has changed value. The most satisfactory method of checking filament current is to connect a milliammeter in series with the particular filament involved, but this will mean opening up the filament circuit. An alternative method is to use a high-resistance voltmeter to measure the voltage directly across the filament terminals of the socket.

Common Troubles in Three-Way Portables

Tubes Burn Out Repeatedly. As mentioned above, this is generally due to excessive filament current, although it is possible to have a run of failures and yet to find the current normal. If the set has filament shunts, check each shunt for an open. Check series resistors for value. Sometimes a series resistor will change value only when hot.

If the set does not use filament shunts, not much can be done unless you care to work out a series of shunts. Usually a resistor of 800 to 1000 ohms will help bring the current down to near normal value. A cut-and-try procedure may be used to find the correct value of shunts.

Another way in which repeated burn-out of tubes may develop is through charging of one of the *A*-filter condensers at a higher-than-normal voltage. If one tube burns out and the set has no provision for preventing a rise in *A* voltage which results from removing the load from the *A* supply, the filter condenser may charge to a higher-than-normal value. When the new tube is installed, the condenser may discharge through the filaments, burning out one or more. To prevent this, remove all tubes and discharge condensers, then replace the tubes.

Set Operates on Line, But Not on Batteries. *A* or *B* battery, or both, may be dead. If the set uses a separate output tube for battery operation the tube may be defective. May also be caused by broken battery lead or corroded plug.

Set Operates on Batteries But Not on Line. Usually due to a defective rectifier tube. If a separate output tube is used for line operation, check this tube. Open filter resistor or shorted filter condenser may also cause this condition.

Set Does Not Work, Due to Oscillator Trouble. Generally due to defective oscillator tube, but may also be due to trouble in oscillator coil.

Excessive Hum While Operating on Line. Usually due to an open filter condenser, or one having reduced capacity.

Audio Howl. The two most common causes are dead or weak batteries, or an open filter condenser, usually the last electrolytic in the *A* supply.

Distortion. Among the common causes are defective filter condenser and defective output or rectifier tube.

Filament Series Resistor Burned Out or Overheated. Due to excessive current flow. May be the result of shorted filter condenser or a ground at one point in the circuit.

No Signals or Weak Signals, Sometimes Accompanied by Oscillation. May be caused by an open loop.

Service Hints in Repairing Portables

Defective Filament Series or Shunt Resistor. These resistors generally are of the flat strip variety or flexible wire-wound types. Be sure that the replacement resistor has ample wattage, or repeated burnout or overheating may result. In installing flat strip, metal case resistors which are riveted to the chassis, look for grounds between metal case and the terminal lugs.

Dead Batteries. When it becomes impossible to secure proper replacement battery packs, substitute packs may often be made up from standard *A* and *B* batteries. If dead batteries are allowed to remain in the battery compartment for very long periods, corrosion of the zinc case may take place. This results in the active material in the cells coming through the case and in extreme cases may cause the batteries to "freeze" in the battery compartment. Under such conditions it may be necessary to cut open the battery pack and remove cells individually to make replacement. Some sets have clips or brackets for holding the batteries in place. These should never be omitted.

When replacing batteries, the connecting harness and plugs should be inspected for broken wires, frayed insulation on leads, broken or corroded plug pins. Sets using two separate *B* units generally have the jumper connecting the two batteries included in the harness.

Defective Rectifier Tube. In many cases this is the result of a shorted filter condenser. Always check the condensers before installing a new tube.

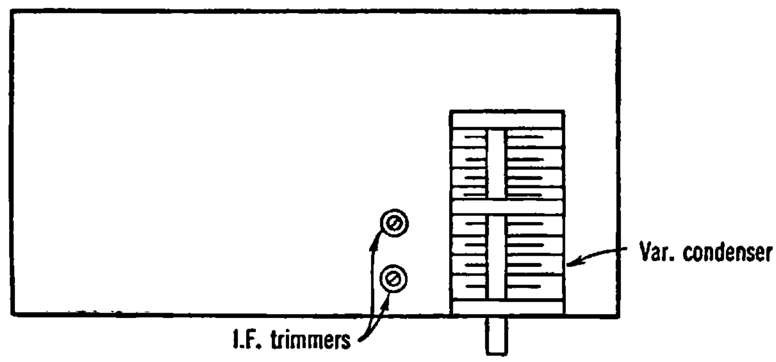
Shorted Filter Condenser. This condition may result in charring of the filter resistor. If this occurs, it is advisable to replace the resistor as well as the condenser, for the resistor may have changed value due to excessive heating. If the resistor is of the flexible wire-wound type, the charring may have been carried to the extent that the resistance winding is exposed, in which case replacement must be made.

If the filter condenser in the *A* supply is of the low-voltage high-capacity type, failure may occur as a result of burn-out of one of the tubes. This will happen when no provision is made to limit the voltage rise under such conditions.

Defective Oscillator Tube. Some mixer-oscillator tubes, especially the 1A7 and 1R5, will test satisfactorily on a checker, but will not oscillate. If signal tracing or signal substitution indicates that the trouble is in the oscillator stage, substitute a new tube before going further.

Open Loop. This condition generally occurs as a result of repeated flexing of the loop leads as the back of the cabinet is opened and closed. If a test loop is kept on the bench, the trouble can be verified rapidly. Even though the test loop does not have the correct inductance for the receiver under test, the receiver will still perform, although perhaps not perfectly. Another reason for keeping a spare loop on hand is that some sets, when removed from the cabinet, cannot conveniently be connected to the loop mounted on the back of the set, due to short connecting leads.

For some reason, a few service men have difficulty in removing portable sets from cabinets. The principal reason seems to be a disinclination to use the proper tool. A large number of sets are mounted in their cabinets on a small supporting shelf, located over the battery compartment. The chassis is retained in the cabinet by means of four self-threading, or



S

standard machine screws passing through this shelf. Very often the heads of these screws are not slotted. The only tool that will remove the screws easily is a socket wrench, usually a No. 4 (¼-inch) with a handle short enough to fit inside the battery compartment. Trying to use long-nosed pliers or slip-joint pliers means loss of time, damage to the screw heads and perhaps damage to your temper as well.

In another section of this book, mention was made of the sales value of little touches which may be added to the job by a thorough service man, including the cleaning and polishing of cabinets. This applies to portable cabinets as well. Many portable cabinets are leather covered, and the original appearance of these may be restored by an application of saddle soap, which is obtainable from shoe stores in jars or cans costing about twenty-five cents. Remove the set and batteries from the cabinet before treating. The soap is applied by wetting a small piece of sponge, wringing it almost dry, then rubbing it on the cake of saddle soap. Rub a small area of the cabinet at a time, rinsing the sponge frequently and taking a fresh application of soap. When the entire cabinet is completed, rub dry. When the leather is thoroughly dry (after an hour or two) apply leather dressing or good quality shoe polish. Polish with cloth or brush. *Caution: be sure that the cabinet is real leather. This treatment may damage imitations.*

Cabinets finished in the style of airplane luggage may be cleaned with a damp cloth and a little soap. Use sparingly and dry immediately. Worn cabinets of this type will be improved by a coat of good quality white shellac, applied very thinly. The usual consistency of shellac is four or five pound cut, which is too heavy. Thin it with about 25 per cent alcohol before using.

Aligning Portables

The alignment of portable sets is generally the same as that of other home receivers, with one or two exceptions. The loop antenna trimmer is, in many cases, mounted on the back of the cabinet. Adjustment of this trimmer is generally made at 1400 k.c. When using an external antenna, this adjustment may change slightly. For this reason it is a good idea to readjust the antenna trimmer on a high-frequency station after the external antenna is connected.

Many sets have one of the i.f. transformers mounted under the chassis, with the adjustments accessible from the top, through holes in the chassis. In some cases the trimmers are located near the tuning condenser, as indicated in drawing "S." Very often the i.f. trimmers are so located that the tuning condenser must be closed in order for the trimmers to be accessible.

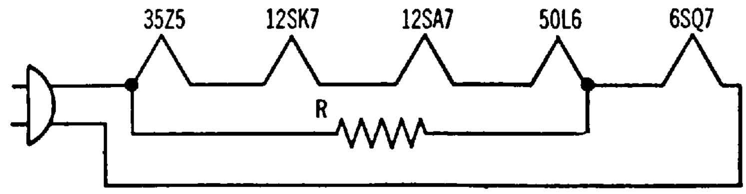
SUBSTITUTION OF PARTS AND TUBES

Radio parts, tubes and batteries were scarce and in some cases nonexistant during the war, and at the time of this writing it seems likely that the shortages will continue for a considerable period.

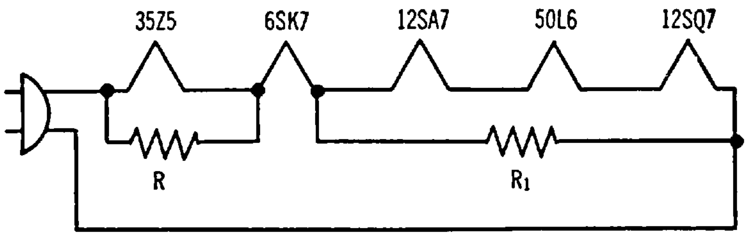
The scarcity of materials has developed a great deal of resourcefulness and ingenuity on the part of service men in devising substitute parts and circuit changes in order to keep sets operating.

A discussion of this topic seems appropriate for several reasons—(a) there is a possibility that you may have occasion to make similar substitutions under adverse conditions, (b) you may be called upon to repair sets in which certain changes were made to permit the use of parts or tubes which were not part of the original design, and (c) many sets so altered did not afford maximum performance and you may be required to restore them to their original condition. Although a number of diagrams of common alteration or conversion jobs will be given to aid you in understanding the nature of the changes made, this type of work is a perfect example of the importance to the service man of service bulletins, manufacturer's wiring diagrams and other servicing information.

Tube Substitution. One of the most severe shortages has been in tubes used in a.c.-d.c. receivers, particularly in the 12-volt series, the loktal types, and types 50L6, 35Z5 and 25Z6. Many sets have been restored to operation by substituting a type 12K7 for a 12SK7 for example, a 12Q7 for a 12SQ7, and a 12A8 for a 12SA7. In the first two cases, only rearrangement of the socket connections was necessary,



T



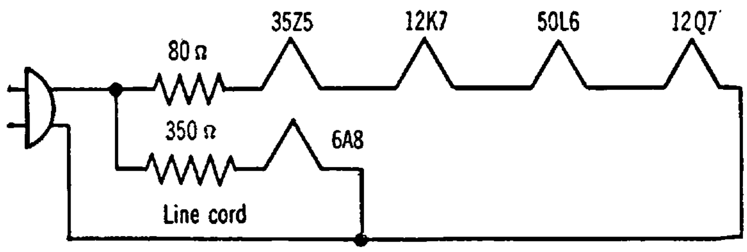
V

including bringing the grid connection to the top cap of the tube instead of to a base pin. The last change, however, involves changing the oscillator coil. The coil is changed from a single-winding tapped coil to a two-winding coil.

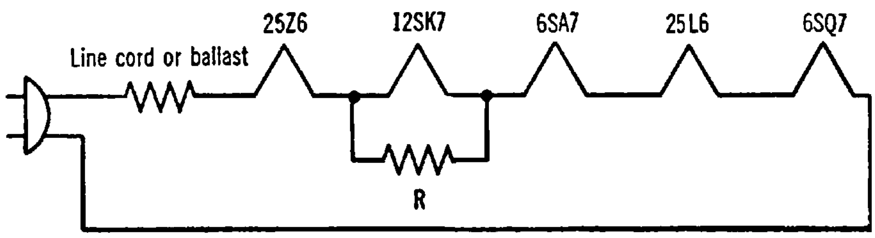
Another type of change is the substitution of one or more tubes of the single-ended 6.3-volt series for single ended tubes of the 12-volt series, and vice versa. A good example of this is seen in sketch "T," in which a 6SQ7 has been installed in place of a 12SQ7. The heater current for the original tube complement is, of course, 0.15 ampere, but the 6SQ7 requires 0.3 ampere. The heaters of all the other tubes were shunted by resistor *R*, which passes the additional 0.15 ampere.

A similar job is illustrated at "V," where the tube replaced, a 12SK7, is not at the end of the heater string. The substitute tube, a 6SK7, requires 0.3 ampere instead of 0.15, so the heaters of all tubes on either side of the 6SK7 are shunted to permit passage of the additional 0.15 ampere.

At least one service man solved a similar problem in another way. The set used a 35Z5, 50L6, 12A8, 12K7 and 12Q7. The 12A8 was unavailable, but he did have a 6A8. This tube was connected across the line with a 350-ohm line cord in series. An 80-ohm resistor was connected in series with the rest of the tubes to take the place of the 12A8. See diagram "W." On rare occasions, when 6.3-volt single ended tubes are needed, and can not be obtained, the service man has found that he had the 12-volt equivalent of the required tube in stock. One such job is illustrated in sketch "X," in which a 12SK7 has been substituted for a 6SK7. A resistor of correct value to pass the extra 0.15 ampere required for the other tubes is shunted across the heater of the 12SK7.



W



X

When the lack of 50L6 output tubes was severe, some service men were forced to substitute a 35L6, although this is not to be recommended. The substitution was made without any changes in the heater circuit. Similarly, a 70L7 may be substituted for a 50L6 in an emergency, but in this case a few changes are needed. The output section of the tube takes the place of the 50L6 and the rectifier replaces the 35Z5.

In another section of this book you will find mention of the use of a 35Z5 with an open pilot lamp section of the heater. A large number of sets were kept in operation by shunting a wire wound resistor across the open section of the heater, without impairing the performance of the set. In some cases a jumper wire was used instead of a resistor, but this is not a good practice, as the heater voltages of the tubes are increased. If you have occasion to work on a set which has been so altered and a 35Z5 is not obtainable, replace the jumper with the correct value resistor. Also bear in mind that when replacing a 35Z5 in a set using either jumper or resistor, the jumper or resistor must be removed before operating the set with the new tube.

Another rectifier substitution is the 6SL7 for the 25Z6. The 6SL7 was supplied complete with an adaptor so that no wiring changes were necessary. As this tube is a double triode it is, of course, not intended for power rectifier service and the life of the tube will be curtailed. Wherever possible, replace the tube with the correct type. Type 25Y5 was, in many cases, substituted for 25Z5. In a large number of battery-a.c.-d.c. portables a type 1R5 was installed in place of the unavailable 1A7. As the 1R5 does not have a top cap and uses a 7-pin button base, the grid lead was connected to the base of the tube. The tube was supplied with an adaptor having a grid connection at the side. Relatively poor performance was noted in some sets after this change was made.

Most loktal type tubes were unavailable over a long period and these were replaced with the octal-base equivalents, using an adaptor from 8-pin loktal base to octal. In most cases these substitutions were satisfactory. A partial list of loktal tubes and the most satisfactory substitute for each is given below:

7C6 Duplex diode-triode	6SQ7
7C7 Pentode	6SJ7
14A7 Variable-mu Pent.	12SK7
14C7 R. F. Pentode	12SK7
14B6 Duplex diode-triode	12SQ7
35Z3 Rectifier	35Z4 or 35Z5

Some repair shops have received battery-a.c.-d.c. portables for repair and have been confronted by a two-fold problem—lack of replacement tubes and a shortage of batteries. Under these trying conditions, repair would seem to be virtually impossible, but a few service men adopted the practice of converting these sets for a.c.-d.c. operation only, making the required changes in the wiring and substituting the 6A8 or 12A8 for the 1A7, 6K7 or 12K7 for 1N5, 6Q7 or 12Q7 for 1H5, and 25L6 or 50L6 for the 3Q5. The types used depended upon the supply at the time. Of course, this type of conversion eliminates the portable feature, but many customers made this sacrifice in order to keep their sets working. Although in most cases the portable is an auxiliary set, in others it is the only receiver the customer owns, and many people will want their sets reconverted as the proper tubes and batteries become available.

Filter Condenser Substitutions. Although the filter condenser supply situation has never reached the point where some type of replacement can not be obtained, there are times, especially in out-of-the-way locations, when exact duplicates are unavailable. This has led to the substitution of condensers which, while not always of the same capacity as the original, still provide satisfactory performance, for most repair men install a condenser of higher rather than lower capacity than the original.

A specific example of filter condenser substitution concerns the General Electric GD–60, a large number of which are still in use. This set uses a two-section unit having a common positive connection. When the correct replacement is not at hand, it is common practice to install two separate 20 mfd. condensers with their positive leads connected together. As stated before, there is no particular objection to this procedure; it is mentioned here for your guidance only.

Speaker Replacement. Many dynamic speakers are so constructed that the field coil cannot be removed from the field assembly. When a field coil becomes defective, it may be impossible to obtain a correct replacement field assembly or a new speaker of the original type, either due to shortages or because the set has become obsolete and the manufacturer no longer supplies replacement parts.

In this situation, the only thing to do is to substitute a speaker intended for general replacement purposes. In many cases, an improvement in performance over that given by the original is noted. However, there is one important point that has often been overlooked by the repair man—the matter of field wattage. Many sets using these replacements have been observed in operation with the field coil running excessively hot, thus rendering it liable to failure. This is because the service man found that the original speaker had a 1000-ohm or a 1500-ohm field coil and installed a new speaker having the same resistance, but did so without considering the current passing through the field. Whenever you find it necessary to make a substitution of this type, be sure that you install a speaker with a field coil of ample wattage to carry the current. This may be done by totaling the plate and screen currents of all of the tubes supplied through the field coil, and adding to this the total bleeder current, if bleeder resistors are used. This total current, multiplied by itself, and then by the resistance of the field, will give you the required wattage, and you have then only to make certain that the wattage of the new field is at least equivalent to this value. For example, a set using a 1000-ohm field uses tubes which draw a combined current of 85 milliamperes, and the bleeder resistor draws 15 milliamperes, making a total of 100 milliamperes. As this must be converted to amperes, we get 0.1 ampere; and 0.1 times 0.1 equals 0.01; 1000 ohms multiplied by 0.01, gives 10 watts.

Output Transformer Replacement. In case of failure of an output transformer, with the original replacement part not available, two courses are open to the average service man—to use a general replacement transformer having the same characteristics as the old one, or to use a so-called universal transformer, which may be adapted to a wide variety of conditions. Both methods are in general use, with the latter in preference, because it is often difficult to determine the voice coil impedance.

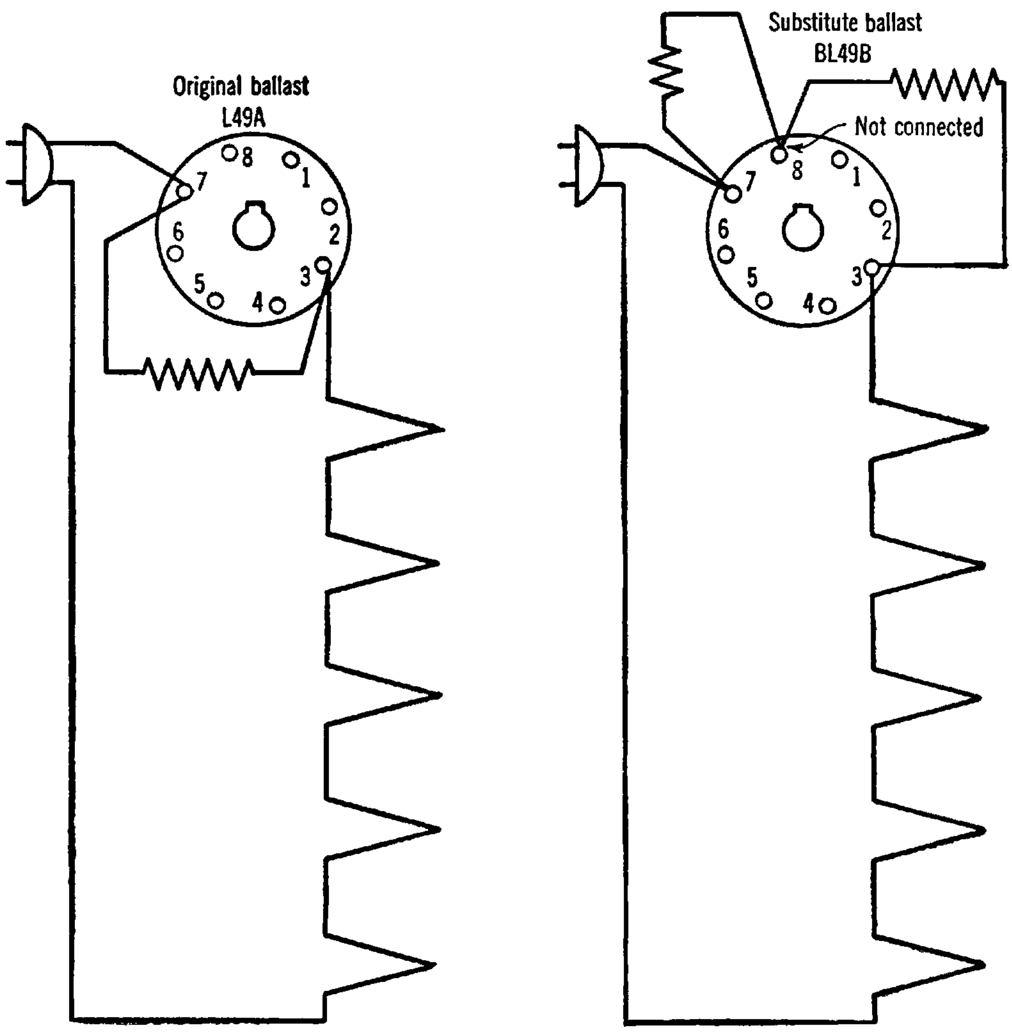
The universal transformer generally has a tapped secondary winding, often with as many as eight different taps. The connections from the voice coil to these taps are to be changed in accordance with the required plate load impedance. Such transformers are accompanied by an instruction sheet which lists the correct connections in order to obtain the best impedance match to the output tubes used. If properly connected, according to the manufacturer's instructions, these transformers will give fairly satisfactory results, but often they are not properly connected either because of incorrect interpretation of the instructions or because the service man did not take the time to do the job properly. It must be remembered that this type of transformer will not afford performance equal to that given by a properly designed transformer, that is, specifically designed for the particular conditions prevailing.

Ballast Tube Replacement. In another part of this book, mention is made of the possibility of repairing open ballast tubes under certain conditions. This is an emergency repair that is often made when a new ballast tube cannot be obtained, or where the set must be repaired in a hurry, but is not to be recommended as a regular procedure. Too many repair shops have adopted the practice of patching up ballast tubes whenever possible, even when a shortage does not exist.

It is naturally impossible for a repair shop, even a large one, to stock all types of replacement ballasts, and, as stated above, time is an important factor in some repair jobs. There are many substitutions of types that may be made, and you will undoubtedly find many sets in which such replacements have been made. This method of making repairs by substituting types is far more preferable than repairing the ballast.

A listing of the various types of ballast tubes, together with the base pin arrangements, appears in the RCA pocket manual and has been reprinted in the *Mye Technical Manual,* but these listings do not help the repair man to choose a substitute when the original type cannot be had.

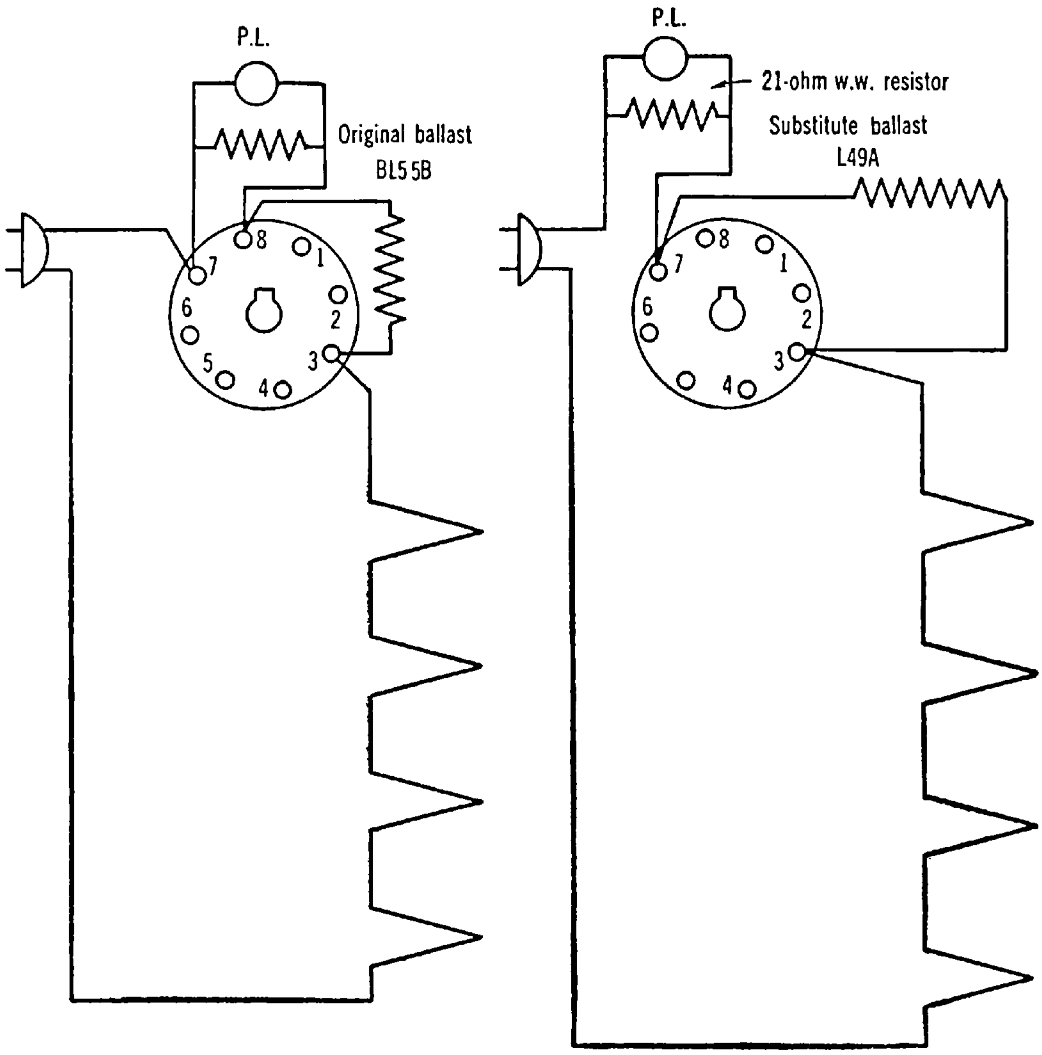
In consulting the lists and accompanying charts, you will see that ballast tube designations consist of a letter, followed by two figures and a second letter. Sometimes the figures are preceded by two letters. For our purpose, the two figures are the most significant part of the designation, as they indicate the voltage drop across the ballast under operating conditions. These figures also indicate the resistance of the ballast. For instance, a K49A ballast has a resistance of 49 divided by 0.3 ampere, the heater current, or 163 ohms. If the set under repair does not use a pilot lamp connected across part of the ballast resistance, any ballast having a voltage drop of 49 (or a resistance of 163 ohms) might be



Y

used. If the only available replacement happens to have a tap for a pilot lamp, this tap is left unconnected. Of course, it may be necessary to change one or more of the socket connections.

If the set uses one or more pilot lamps supplied from taps on the ballast, two points must be considered—the total resistance of the ballast and the type of pilot lamp or lamps used. If you can get only a ballast without a tap, it is often possible to use it by connecting a wire-wound resistance in series with the ballast and supplying the lamp by connecting it across the resistance. In this case the total resistance of the ballast



Z

should be less than that of the original ballast by the amount of resistance to be placed in series. Two samples of such substitutions are given in sketches "Y" and "Z."

In addition to the substitutions just discussed, you will frequently find a set that has had a wire-wound resistance or a resistance line cord connected in place of the ballast tube.

Parts Stock

A discussion of the parts substitutions that are possible, and that are commonly made, naturally leads to the subject of parts stock for the small shop or free-lance service man. It should be obvious to all entering the servicing field that a small supply of the more widely used small parts should be kept on hand, as otherwise each repair job means a trip to the supply house, with consequent loss of valuable time. However, this does not mean that a large stock of everything you are likely to need must be purchased.

Consider the tubular condenser situation, for example. These units are generally available in a wide range of capacities, perhaps from 0.0001 to 0.25 mfd., or higher, and in working voltages of 200, 400, 600, 800 and 1000. You will soon find that the capacities in greatest demand are 0.0001, 0.00025, 0.006, 0.01, 0.05 and 0.1 mfd. The stock should therefore include a few of each, but there is no reason for stocking each of these values in each of the available working voltages, nor, in fact, is there a valid reason for stocking them in more than one voltage—600. This working voltage will take care of almost all service jobs, except perhaps buffer condenser replacement in auto sets. The only possible objections to the use of a 600-volt condenser in replacing a 400-volt unit are the questions of physical size and cost. There will be relatively few cases in which a slightly larger condenser will not fit into the available space, and the additional cost is so slight that it will be more than offset by the reduction in outlay for the parts stock.

Similar reasoning can be applied to the question of carbon resistor stock. You will find that the most useful values to have on hand are 150, 200, 500, 1000, 10,000 50,000 100,000 250,000 500,000 and 1 megohm —a total of only ten different values, that will suffice for most ordinary jobs. Half-watt sizes are most commonly used and it is not necessary to stock the values listed in other wattages, with the exception of the 150-ohm. This should be of one-watt rating, which is in wide use as a cathode bias resistor for beam power tubes. If you run across an occasional job which requires a value not in stock, it can usually be made up by connecting other values in series or parallel.

Very little specific advice can be given regarding the stock of tubes, as this will depend upon the type of service you encounter. Another point to consider is the very wide range of available types of tubes. However, a few of the types in great demand may be kept in stock. For most a.c. receiver service, the 6A8, 6SA7, 6K7, 6SK7, 6Q7, 6SQ7, 6F6, 6V6 and 5Y4 types will fill the requirements. For a.c.-d.c. sets, types 12SA7, 12SK7, 12SQ7, 35Z5, 50L6, 25Z6 and 25L6 will handle most jobs. For three-way portable service, add 117Z6, 1A7, 1N5, 1H5 and 3Q5. If you handle auto radio repair work, you will also need types OZ–4, 6X5 and 84.

In addition to the above stock, it is a good idea to maintain a small stock of electrolytic condensers. A suggested supply includes 8-mfd., 475-volt; 20-mfd., 150-volt; and 10-mfd., 35-volt. These three will take care of a surprisingly large variety of repairs.

As many of the components in a receiver are specially made and obtainable only through the set manufacturer or distributor, these cannot be kept in stock, and it is usually not a good idea to substitute standard replacement parts. The parts referred to include coils, i.f. transformers, variable condensers and power transformers.

Most volume control replacements can be made from a small stock of 25,000-ohm and 500,000-ohm controls. These should be equipped with switches, and it is best to get controls with long shafts that can be cut to required size.

Questions

1. What type of filament circuit is used in most portables?

2. What weakness often exists in this type of circuit?

3. What provisions may be made to overcome this weakness?

4. What is a peculiarity in the output transformer of some sets using two separate output tubes for battery and line operation?

5. Explain how more than the rated filament current may flow through some of the filaments in portable sets.

6. Why do most portables use a two-pole switch for turning the set on and off?

7. What type of filter is used in most portable sets?

8. What is an unusual feature of some portable power supplies in regard to the filter condensers used?

9. In addition to the usual rectifier power supply, what other means of obtaining d.c. voltages is used in some portables?

10. What precaution should be taken when making voltage measurements in portables? Why?

11. Why is filament voltage measurement more important in portables than in other types of receivers?

12. What procedure should be followed when working on portables which burn out tubes repeatedly?

13. What may happen if the series dropping resistor drops in value when heated?

14. Explain how tubes may be burned out as a result of the charging of a filter condenser to a voltage higher than normal. How may this condition be prevented?

15. A portable set operates on power line but not on batteries. Give several causes for this condition.

16. A set operates well on batteries but is dead when switched to power-line operation. What troubles would you look for?

17. Name a common cause for oscillator failure.

18. What is the usual cause of excessive hum?

19. Give two causes for an audio howl.

20. Describe a method of cleaning leather-covered cabinets. What precaution should be observed when using this treatment?

21. Name two peculiarities that may be encountered when aligning portable receivers.

References

The available material on three-way portable receivers is rather meagre. The service man is therefore advised to consult the service bulletins issued by various manufacturers, for information regarding circuits, aligning procedure and tube-socket voltages. A number of these bulletins will be found in the Rider Manual, Vol. XIV, in the sections devoted to General Electric, Westinghouse, Allied Radio, Sears-Roebuck, Lafayette and others.

14

AUTOMATIC FREQUENCY CONTROL FREQUENCY MODULATION

To some readers automatic frequency control and frequency modulation may seem to be topics that are too advanced for the average beginner in radio servicing. However, while it is true that frequency modulation receivers and those using automatic frequency control are somewhat more complicated than the usual run of broadcast sets, an inspection of the circuits involved will show that only a few new principles are involved.

It is not the intention of the writer to offer here a thorough description of the operation of these sets, but merely to point out the ways in which they differ from ordinary receivers, to indicate the various circuit features in general use, and to discuss procedures to be followed in locating trouble in and adjusting sets of this type.

A study of this chapter, followed by further reading in some of the reference works listed at the end of the chapter and an inspection of the circuit diagrams of various makes of sets should give you at least a fair understanding of the subject. However, you must remember that progress in any field can be made only through proper application and a positive mental attitude toward the subject. By a positive mental attitude is meant a state of mind which does not avoid or ignore new developments simply because they are unfamiliar. In radio, as in many other fields, this unwillingness or inability to keep abreast of the times is altogether too prevalent.

New developments in radio appear almost daily, and many more will find practical application during the next few years, most of these being an outgrowth of war-time research and development. Keep in mind that many familiar items used by service men every day, such as the electrolytic condenser, beam power output tubes and a host of others, were new and therefore unfamiliar to the service man of a few years ago.

In beginning a study of these two topics, it will be helpful if you will keep in mind the method used throughout this book, of considering a receiver as a number of individual stages, each with a separate function. If you will do this, your job will be simplified, for you will then discover that in order to gain an understanding of AFC and FM, only three new types of stages must be considered. These are the discriminator, used in both FM and AFC, the limiter, and the oscillator control stage.

Automatic Frequency Control Systems

This feature was used in sets for only a year or two and is not likely to be found in any equipment built within the last seven years or so.

The primary reason for using it was to overcome the tendency of the oscillator to "drift" or change frequency, which resulted in mistuning and the cutting of side bands. As pointed out in the section on high fidelity, side-band cutting is a common cause of serious distortion. Modern advances in oscillator design have overcome the drift problem and hence the reason for using AFC has disappeared. There was, incidentally, a secondary reason for using AFC, and that was that a number of sets used various automatic tuning systems of a mechanical nature which might cause mistuning.

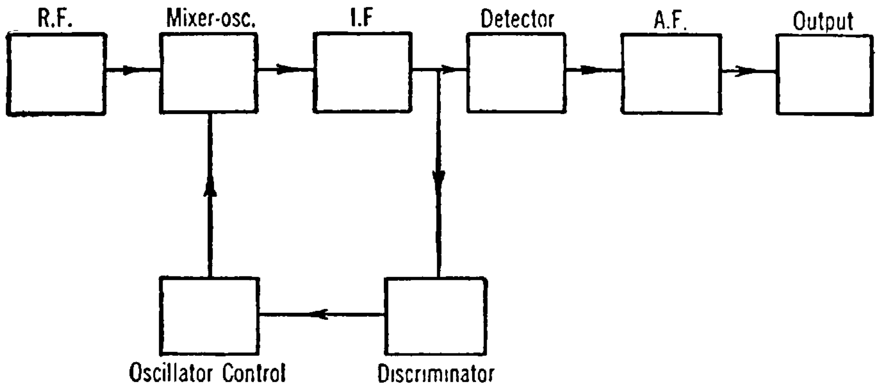
AFC is a method of automatically changing the frequency of the local oscillator so that the intermediate frequency produced is always the same as that to which the i.f. transformers are tuned. This is done by picking up any frequency deviation in the i.f. amplifier and changing such frequency deviations into voltage variations. The device which does this is called the discriminator. The voltage variations are applied to an oscillator control tube which is connected to the oscillator coil. The voltage applied to the control tube by the discriminator causes the control tube to act as an inductance, thereby changing the total inductance in the oscillator circuit and shifting the frequency the desired amount to correct for the original shift.

To get an overall picture of the action involved, suppose that the oscillator frequency is slightly higher than it should be to produce the correct i.f. The discriminator receives this frequency change and produces a voltage of a certain polarity. This voltage when applied to the control tube determines the amount of inductance which the tube offers and consequently the amount of oscillator frequency shift.

If the oscillator frequency shift or deviation is in the opposite direction, that is, if it is lower than that required to produce the correct i.f., the voltage developed by the discriminator will be of opposite polarity and the inductance change produced by the control tube will also be in the opposite direction, causing the oscillator to increase its frequency.

Since the voltage developed by the discriminator depends upon the amount that the oscillator is off frequency, the amount of change produced by the control tube will also depend upon the degree to which the oscillator deviates from the correct frequency. This applies whether the original deviation is on the high or the low side.

Refer to the block diagram at "A." Suppose that the i.f. of this particular receiver is 455 k.c. and that the receiver is intended to be tuned to 1000 k.c. The local oscillator frequency therefore should be 1455 k.c. But suppose that, due to oscillator drift, the actual oscillator



A

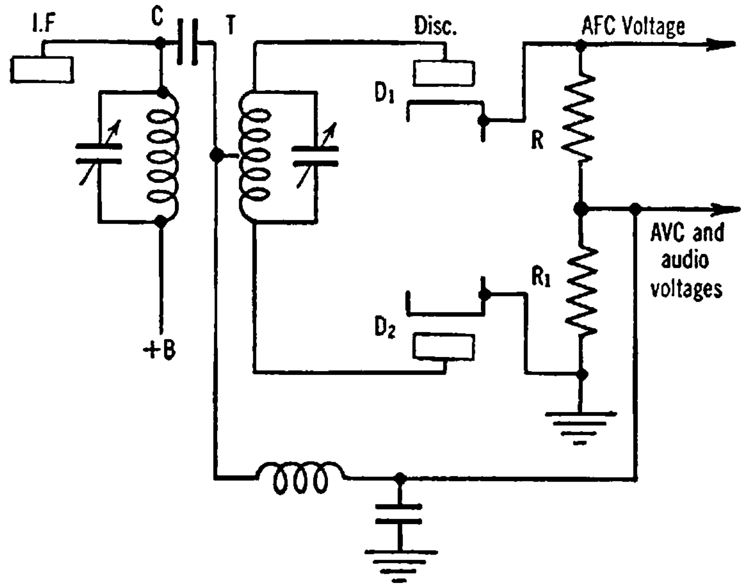
frequency is not 1455 k.c., but 1453 k.c. The i.f. produced will then not be the correct one of 455 k.c. but instead will be 1453 minus 1000, or 453 k.c. This 453-k.c. signal is passed on to the i.f. amplifier in the usual way, but before reaching the detector a portion of the signal is fed to the discriminator. If the frequency were correct, no voltage would be developed by the discriminator and none, therefore, would be applied to the control tube; but since the frequency is incorrect, one of the diodes or triodes used in the discriminator receives more voltage than the other and this one develops a d.c. voltage which is applied to the grid of the control tube. The control tube then makes the necessary frequency correction.

If, on the other hand, the oscillator originally deviated from its correct frequency on the high side, say 1458 k.c. instead of the proper frequency of 1455, the i.f. produced would be 458 k.c. In this case the other diode or triode would receive more voltage and would develop a d.c. voltage, this time in the opposite direction. This would produce the opposite type of effect in the control tube and cause it to reduce the oscillator frequency by the required amount.

The average set using AFC has provision for cutting it out of the circuit by throwing a switch. This is done because most AFC circuits are designed to be used on strong local stations only, not on short-wave stations or weak broadcast signals. A few sets were designed so that the AFC could be used on all frequency ranges.

The Discriminator. There are at least three distinct types of discriminator in use, with a number of circuit variations for each type. The most widely used discriminator is illustrated in diagram "B."

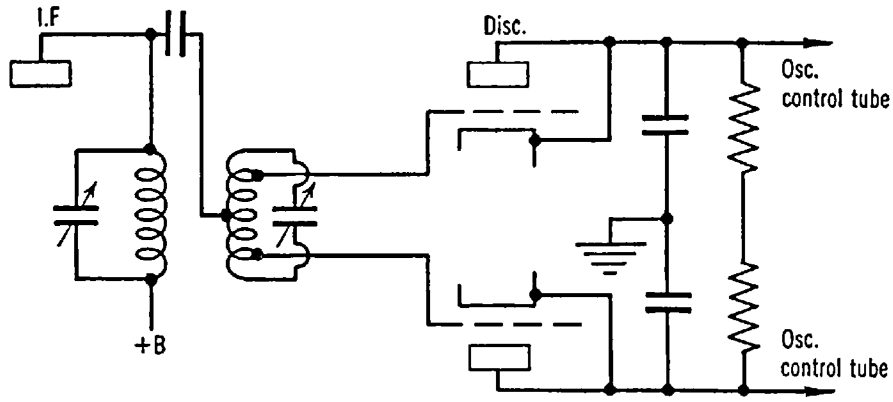
Note that the primary and secondary windings of transformer *T*, in addition to being coupled inductively in the usual way, are also capacity-



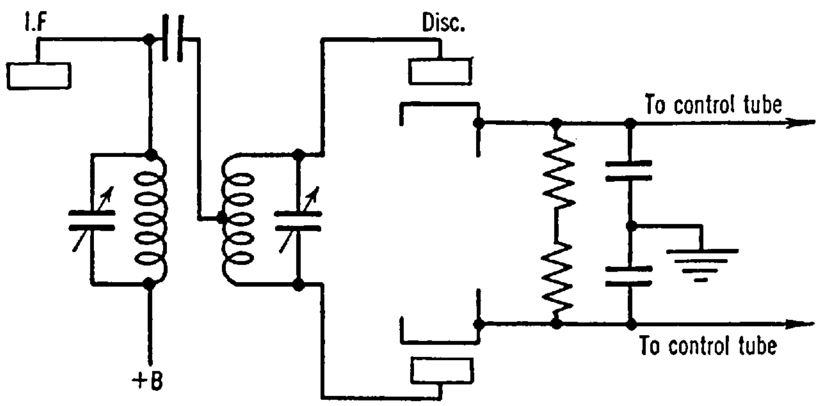
B

coupled by means of condenser *C*, connected from the top end of the primary to the center tap of the secondary. Because both types of coupling are used, three separate voltages will appear in the secondary of the transformer—one voltage between the plate of diode D_1 and the center tap, another between the plate of diode D_2 and the center tap, both a result of the inductive coupling, and a third voltage which is a result of the capacity coupling. This third voltage is really the voltage present across the primary of the coil. Remember that all three of these voltages are signal voltages, and therefore a.c. A shift in frequency in the primary will result in phase shifts between the three voltages in the secondary and will cause a higher or a lower voltage to be applied to one of the diode plates than is applied to the other. The diode receiving the higher voltage will naturally deliver more rectified current and the voltage across its load resistor will therefore be higher. Thus the magnitude of the voltage output will depend upon the degree to which the oscillator frequency shifts. Due to the way in which the two diodes are connected, the polarity of the output voltage will depend upon the direction of the frequency shift.

A variation of this circuit is shown at "C," in which two separate triodes with their plates and cathodes connected together so as to function as diodes are used in place of the duo-diode tube shown in "B."



C



D

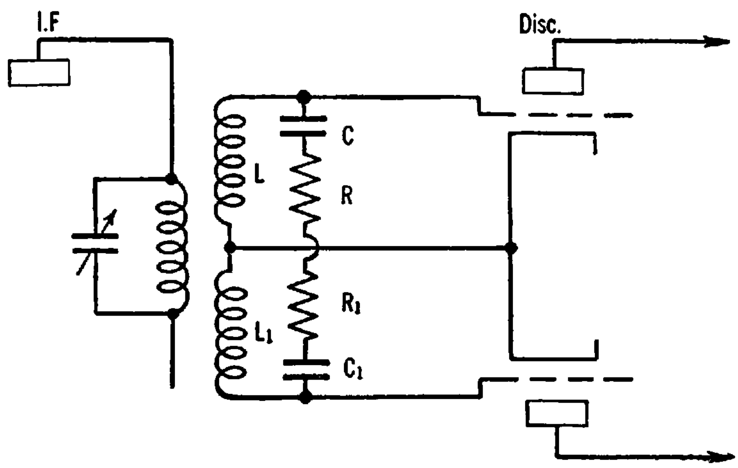
Still another variation of the same type of discriminator appears at "D." Here again a duo-diode tube is used.

Note that in diagram "B" the AFC voltage is taken from the top end of the resistor network connected across the cathodes of the tubes, and that audio and AVC voltages are taken from the midpoint of this network.

In diagrams "C" and "D" no provision for AVC or audio voltages is shown and the ends of the resistor network are indicated as being connected to the oscillator control tube. The reason for this is that the particular receivers using circuits "C" and "D" use a separate tube for AVC and detector, while the set shown in "B" does not have a separate detector. These receivers use a dual-triode tube as oscillator control and the two discriminator output leads are connected to the two grids of this tube.

Particular attention should be given diagram "A," for this is the discriminator circuit used in later AFC sets and also in frequency modulation receivers.

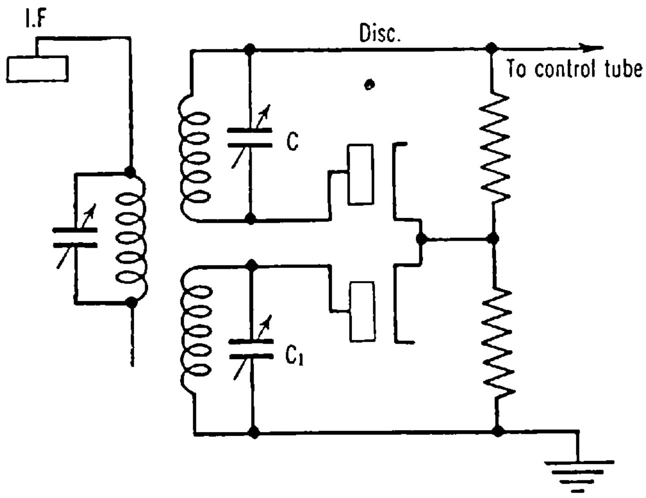
The two remaining types of discriminator are worthy of mention, inasmuch as you might have occasion to service a set using one of them, although they were abandoned after a short period of use—due to the difficulty of aligning them, and to poor performance. Diagram "E" illustrates one type, the operation of which circuit is quite different from the one just described. Note that two triodes are used, and that the coil winding is center tapped, with the tap connected to the cathodes. The



E

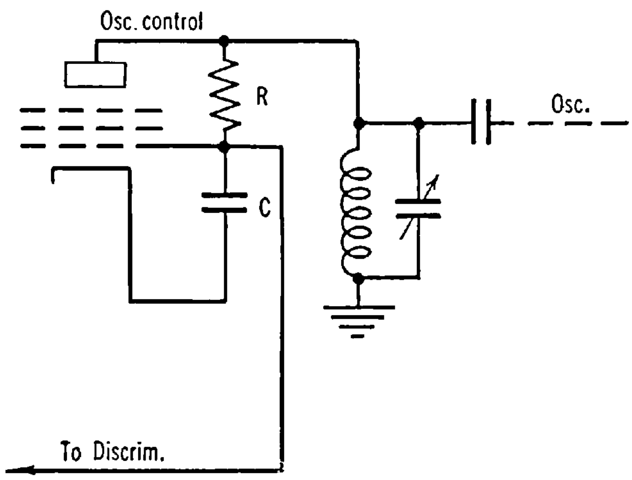
two halves of the coil, together with the resistors and condensers shown, constitute resonant circuits tuned slightly off the intermediate frequency of the receiver. The voltage applied to the diodes, then, will depend upon the applied frequency.

The third type of discriminator appears at "F." This circuit also employs a split secondary winding, but the inside ends, instead of being connected together as in the preceding diagram, are connected to the plates of the diodes. Each of the windings are separately tuned by condensers C and C_1 to two different frequencies, one slightly higher and one slightly lower than the correct intermediate frequency. Suppose that the upper winding is tuned to a lower frequency and the lower winding to a higher frequency. When the intermediate frequency is higher than normal, the lower winding will have a greater signal voltage across it and, consequently, the diode connected to that winding will develop a greater d.c. voltage. When the intermediate frequency produced by the mixer tube is lower than intended, the upper half of the winding will have a greater signal voltage impressed across it and its diode will then develop a higher d.c. voltage. The functioning of the tubes is exactly the same as in the phase-shift type, discussed at first, but the method of obtaining the signal voltage variations is different.



F

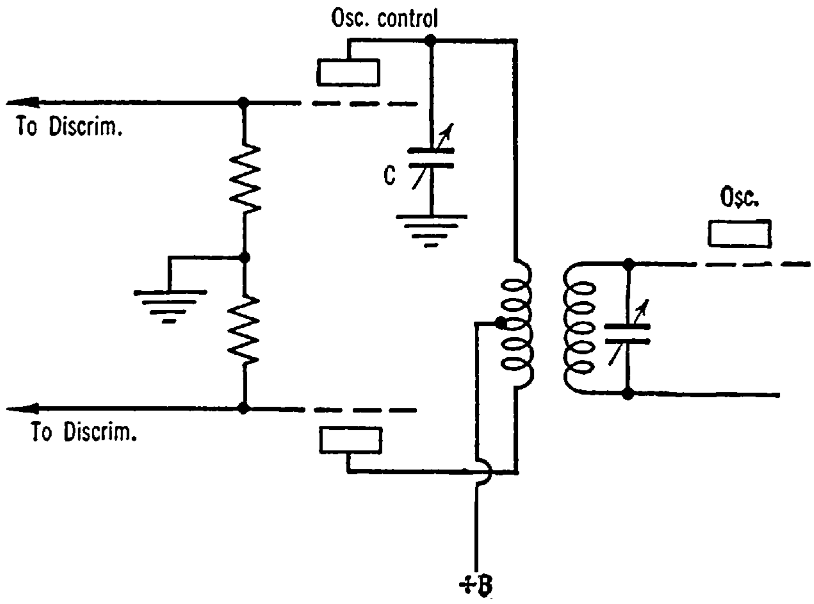
The Oscillator Control Tube. The oscillator control circuit generally used is that shown in diagram "G." As mentioned before, the function of the control tube is to act as an inductance of varying value. This is



G

accomplished by causing the plate current of the control tube to lag the voltage across the oscillator coil by 90 degrees. This lag is produced by resistor *R* and condenser *C*, connected across the oscillator coil. The amount of lag will depend upon the voltage applied to the grid of the control tube.

Another type of control tube circuit, using a double triode such as type 6N7, is shown in sketch "H." The plates of the tube are connected

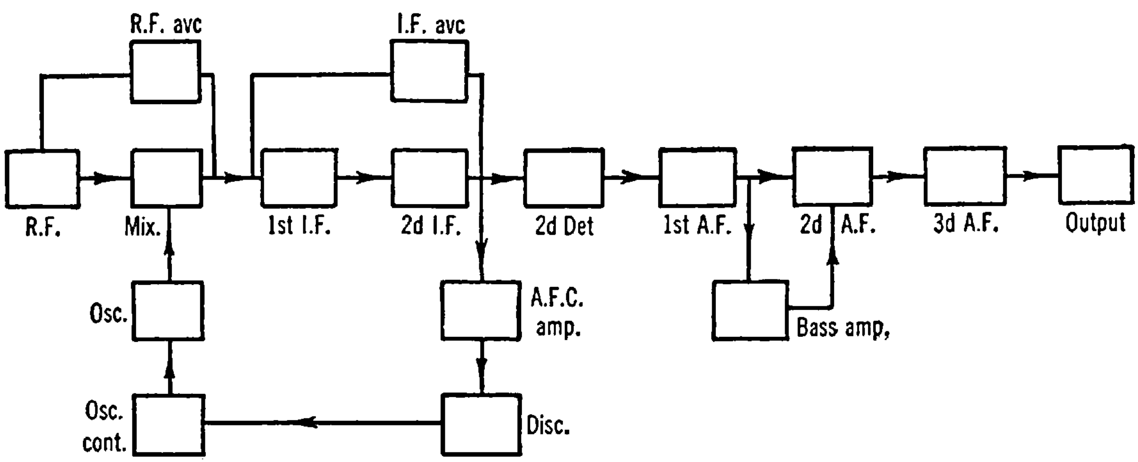


H *Courtesy Philco*

to the ends of the oscillator coil as shown. The other winding of the coil is connected to the first grid of the oscillator tube and is tuned by condenser C_1. Condenser C is a trimmer connected across the first winding of the coil.

Other Applications of AFC

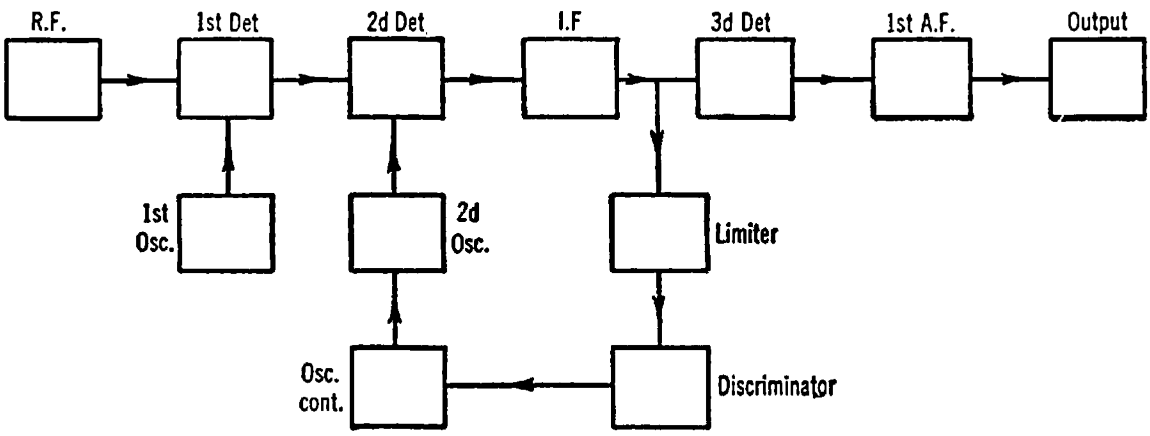
While the block diagram given at the beginning of this chapter shows the usual application of AFC, there are two other applications which are interesting and therefore worthy of mention. They are illustrated at



J

"J" and "K." "J" shows the line-up of a set using an amplifier between the i.f. and the discriminator to increase the amplitude of the off-frequency signal applied to the discriminator. In this receiver, separate tubes are used for the functions of second detector, AVC for the i.f. and AVC for the r.f. An additional tube is used for boosting the bass response of the audio amplifier. The mixer and oscillator functions are performed by separate tubes.

The diagram at "K" illustrates the arrangement of stages in a receiver using the triple detection principle. In this type of set, the incoming signal is heterodyned by the first oscillator to produce an i.f. of say, 455 k.c. This 455-k.c. signal is passed to the second detector, where it is heterodyned by the second oscillator to produce an i.f. lower than the first i.f., usually about 100 k.c. This 100-k.c. signal is amplified by the i.f. amplifier and passed on to the third detector, where demodulation takes place as in the usual superheterodyne. Between the i.f. and the third detector stages any off-frequency signal is picked up and passed to



K

the AFC circuit. Usually a limiter stage is used in this type of receiver, connected ahead of the discriminator. Its function is to prevent changes in signal amplitude from affecting the discriminator, and also to amplify the signal. The output of the discriminator is applied to the oscillator control tube, which controls the frequency of the second oscillator. The operating frequency of this oscillator will be fixed, since the signal it heterodynes is always 455 k.c. Thus much more uniform operation of the AFC is attained over the entire tuning range of the receiver.

Non-uniform operation is often a problem in the usual AFC circuit. The effect of non-uniform operation is that the AFC will operate for a given oscillator deviation at one part of the tuning range, but will only function on a smaller deviation in oscillator frequency at other parts of the range. The usual practice is to adjust the AFC to operate for the greatest possible amount of mistuning when the set is tuned to the center of the range. The permissible mistuning will then decrease toward the ends of the range.

Troubles in AFC Circuits

It is fairly safe to say that a majority of the troubles occurring in AFC circuits are due to defective tubes or improper adjustment of the AFC circuit, with an occasional trouble developing in the coupling transformer.

AFC Has No Effect. This trouble may show up under two different sets of circumstances. If the receiver is equipped with a switch to cut out AFC as desired, which is generally the case, you may find that when the receiver is deliberately mistuned by an amount which should permit the circuit to function, snapping the AFC switch on and off will produce no noticeable effect on the signal. Normally this should produce an increase in signal and the elimination of any distortion as a result of the mistuning. On the other hand, the set may be equipped with a mechanical tuning device, and, when using this device with the AFC in operation, some mistuning occurs, which normally should be prevented by the AFC. In either case the trouble will probably be found to be caused by a defective discriminator or oscillator control tube, or by improper alignment. In rare cases, the AFC switch may not be functioning.

AFC Operates Only on Part of the Tuning Range. This type of trouble may also be traced to incorrect alignment. After completing the alignment of an AFC-equipped set, as described in the job sheet, always check the AFC operation over the entire tuning range.

AFC Fails to Operate When Set is Mistuned More Than a Very Slight Amount. In most cases this will be due to improper alignment, but defective tubes might also cause it. Most AFC circuits will correct mistuning of 5 to 8 kilocycles on either side of resonance at the middle of the tuning range, and a smaller amount of mistuning at the ends of the range.

AFC Operates Only on One Side of Resonance. Look for a defective discriminator tube or incorrect adjustment of the discriminator transformer.

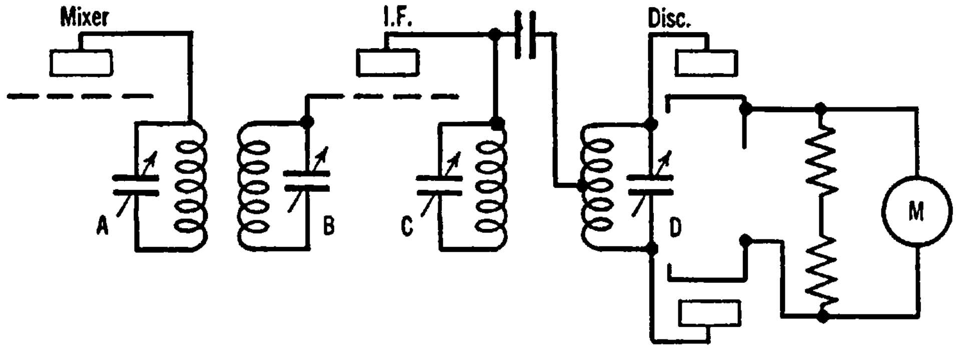
Voltage Measurements in AFC Systems

You will notice that thus far no mention of the use of voltage analysis in AFC circuits has been made. This is because this particular servicing procedure does not have as much value in AFC circuits as in the other stages.

The reason for this is obvious, as an inspection of the circuit of the usual discriminator will show. No d.c. voltages are applied to either the plates or the cathodes of the diodes, consequently no voltage measurement may be made during conditions of no input signal. Under operating conditions, however, that is, when a signal is being received, measurement of signal voltages at the plates of the diodes is possible, using a vacuum tube voltmeter. In addition, the rectified voltage appearing at the cathodes may be measured with the V.T.V.M and, in the absence of this instrument, with a very high-resistance voltmeter, 20,000 ohms per volt being recommended.

When the oscillator control tube is considered, you will find again that the use of the ordinary voltmeter is limited. Of course, you may take readings of plate voltage and screen voltage, and these will be of some help in diagnosing trouble, but, generally speaking, the V.T.V.M. is far more useful for this type of work.

JOB SHEET NO. 41



AIM: To learn how to align a receiver using automatic frequency control.

PROCEDURE: 1. Disconnect the AFC by throwing the switch to the OFF or OUT position.

2. Connect the output lead of the signal generator to the r.f. signal input grid of the mixer tube through a small fixed condenser. Connect the shield of the cable to the receiver chassis.

3. Adjust the receiver volume control to maximum.

4. Tune the generator to the correct intermediate frequency.

5. Adjust the generator attenuator to give a weak signal.

6. Proceed with the alignment of the i.f. amplifier in the usual manner. Correct adjustment may be determined either by using an output meter or by judging the intensity of signal by ear. The use of an output meter is recommended.

Adjusting the Discriminator.

The discriminator adjustments are indicated in the diagram by the letters *C* and *D*. The adjustment of these condensers is quite critical and the alignment must be done very carefully.

1. Connect a vacuum tube voltmeter across the cathodes of the discriminator tube, as shown by letter *M*. Usually, one of the cathodes is grounded, so that the meter may be connected from the ungrounded cathode to chassis. (*Note:* If a vacuum tube voltmeter is not available, a 20,000-ohms-per-volt meter may be used in its place.)

2. Tune the signal generator to the correct i.f. and connect the output cable to the signal input grid of the mixer, or to the grid of the i.f. tube, with the shield of the cable connected to the receiver chassis. Use a small condenser in series with the output lead. Cut in AFC by throwing switch.

3. With the generator adjusted to give a relatively weak signal, back the secondary trimmer, *D*, all the way out.

4. Adjust the primary trimmer, *C*, to give a maximum reading on the meter.

5. Now, start turning the secondary trimmer in, watching the meter as you do so. You will probably find that the meter reading will increase and decrease several times through the full travel of the trimmer screw, and that there will be three settings at which you get a zero reading. Select the middle minimum point and adjust the trimmer so that the meter reading is exactly zero.

6. Align the antenna, r.f. and oscillator trimmers and the padder (if used) in the usual way, with AFC off.

7. When the receiver alignment is completed, tune to a station near the middle of the broadcast range, with the AFC switch in the off position. Detune the receiver about 5 to 8 k.c. off resonance on either side of the station. Turn the AFC switch on and note whether the receiver snaps into resonance, as indicated by improvement in tone quality and reduction in background noise. Also note the amount that the receiver can be tuned off resonance and still snap into resonance when the switch is closed.

8. Repeat operation 7 on the other side of resonance. The amount that the receiver can be detuned should be the same on either side of the resonant point. If the AFC does not take hold properly, go over the adjustments.

9. Repeat operations 7 and 8 on various stations over the entire broadcast range. You will very likely find that the AFC will take hold with a greater amount of mistuning at the center of the range than at either end. This is normal. Should you find that the amount of mistuning that will still permit the AFC to function steadily decreases from one end of the range to the other, go over the discriminator adjustments carefully until you get the desired results.

Adjustment of Philco Automatic Frequency Control (Magnetic Tuning)

Because the manufacturer's instructions for adjusting Philco AFC are slightly different than the instructions for adjusting AFC circuits in other receivers, it seems in order to describe the method recommended by Philco. The instructions given refer to the Philco model 38–1.

This particular set uses i.f. transformers having three windings, with a trimmer condenser connected across each winding. The trimmers are located on the side of the i.f. shield cans, one near the top of the shield, one at the middle, and a third near the bottom.

With the receiver on the broadcast range, the volume control at maximum setting, and the AFC switch off, connect the signal generator shielded cable to the grid of the mixer-oscillator tube, with a 0.1-mfd. condenser in series. Tune the generator to 470 k.c., and adjust the attenuator for maximum output.

Using an output meter as an indicator, adjust the middle trimmer on the first i.f. transformer until you get a zero reading. Now adjust the top and bottom trimmers on the same transformer to give maximum reading on the output meter, and then readjust the middle trimmer for maximum output.

The next adjustments are made on the discriminator transformer. Turn the bottom trimmer in three turns, then adjust the top and middle trimmers to give maximum output.

Connect the signal generator to the antenna and ground terminals of the receiver, with a condenser in series with the shielded lead. Tune the generator to 1000 k.c. Tune the receiver *accurately* to 1000 k.c. Adjust the generator attenuator to give a weak signal, and set the receiver volume control so that you just get a readable signal on the output meter. Turn the AFC switch to the on position, and adjust the bottom trimmer on the discriminator transformer for maximum output. Turn the AFC switch on and off and note whether the output meter reading changes. There should be no noticeable change in the reading. Make the same test on a broadcast signal at about 1000 k.c.

Reconnect the generator, tuned to 1000 k.c., to antenna and ground and adjust attenuator to give a moderately strong signal. Turn AFC off. Now detune receiver until generator signal is very weak. Turn AFC switch on. Signal should return to original strength. Make this test on the other side of the resonance point on the tuning dial.

Frequency Modulation Receivers

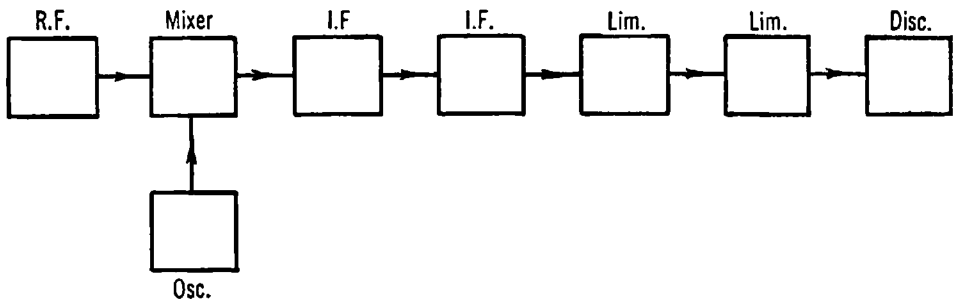
Before considering the circuit features used in various frequency modulation receivers, it may be advisable to review briefly the fundamental principles of this type of equipment.

As you have already learned, in amplitude modulation, or AM, the audio signal is caused to vary the amplitude or strength of the carrier.

In frequency modulation, or FM, the audio voltage produces no change in the intensity of the carrier, which, therefore, remains at a constant level. Instead, the audio voltage causes the frequency of the carrier to vary.

This frequency-modulated signal may be received with an ordinary radio, with very few changes, and carried through the receiver up to the point where it is to be demodulated. Here we find a major point of deviation from familiar principles, for instead of merely removing the r.f. carrier, leaving the audio component, the demodulating device must convert frequency variations into amplitude variations. See "A" for block diagram of FM receiver.

As stated above, it is possible to use all stages of an AM receiver, with the exception of the demodulator, for FM reception, with only a few



A

changes. These changes are mainly in the electrical values of the parts used in the resonant circuits. FM receivers were originally designed to receive signals on a range extending from about 42 to 50 megacycles. The new assignments are from 92 to 108 megacycles. This means, of course, that the capacities and inductances of condensers and coils used will be much lower than in AM sets intended for use on the broadcast band. Furthermore, it is desirable to have the converter change the incoming signal into a higher frequency than that used in AM sets.

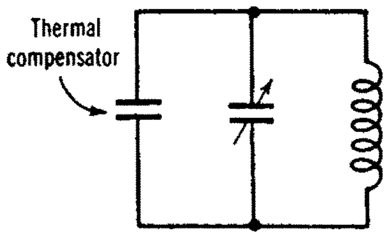
With these points in mind, let us proceed to a discussion of the ways in which the various principles are applied in commercial receivers.

Outstanding Features of FM Receivers

The R.F. Amplifier. The r.f. amplifier is usually conventional, as far as circuit arrangement is concerned, except that the antenna coil may have a special provision for connecting either a dipole antenna or an antenna for AM reception. The tubes generally used in this stage are the 1853, 6SK7 or 7G7.

Converter or Mixer-oscillator. In this stage, as in the r.f. amplifier, you will very likely find that the circuit is quite similar to that used in

AM receivers. However, a considerable number of sets use a separate oscillator tube. This is becoming a fairly common practice in high-frequency AM receivers as well as in FM. The advantage gained is better frequency stability. The need for increased stability has led to the use of some type of thermal compensator, which may be connected as shown at "B." The compensator is located near the oscillator coil and tuning condenser so that it will be subjected to the same temperature variations as those parts. A rise in temperature will cause a slight increase in the capacity of the tuning condenser, for example, and this same rise in temperature, affecting the thermal compensator, will produce in it a corresponding decrease in capacity, thus keeping the total capacity in the oscillator circuit at about the same value. You will observe from this description that the location of the thermal compensator is quite critical, as it must be in a location where its temperature rise will be the same as for the other components of the oscillator tuned circuit.



B

This brings us to another point which has sometimes been ignored by service men. In any type of high-frequency equipment, extremely small capacities become infinitely more important than in ordinary broadcast receivers. The length and direction of leads, their positions with respect to other leads and various circuit components, must be given serious consideration.

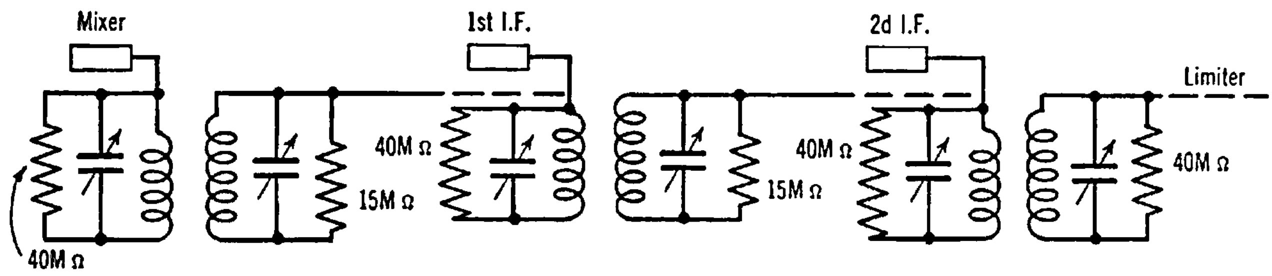
Very often two leads which are brought closer together than intended may create effects that will disturb the performance of the set. With this in mind, you should pay particular attention to the routing and "dress" of wiring whenever you have occasion to work on any portion of the set which handles high-frequency signals. If, in removing or replacing any part, it becomes necessary to disconnect or otherwise disturb the wiring, be sure that it is relocated in its original position when the work is completed. Many manufacturers include instructions for the routing and dress of certain critical leads in their service bulletins. These instructions should be followed carefully.

The I.F. Amplifier. You will find three unusual features in most i.f. amplifiers used in FM receivers. These are (1) the use of two i.f. stages, (2) a much higher intermediate frequency than that used in ordinary broadcast sets and (3) some i.f. transformers are designed to give a broader response curve.

The average amplifier consists of two stages using 6SG7, 7G7 or

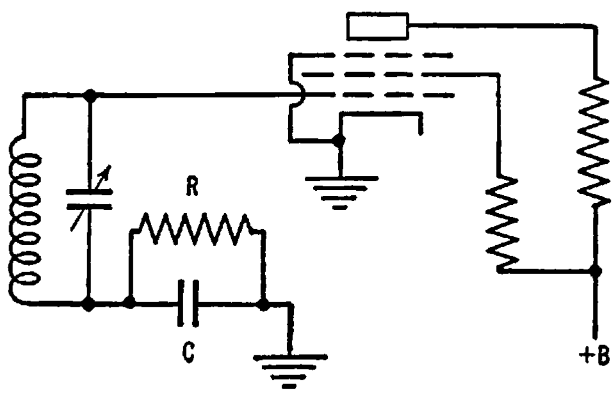
6SK7 tubes. The reason for using two stages is to increase the sensitivity of the amplifier, especially in cases where the transformers are loaded for broadening. The intermediate frequency varies from 3 to as high as 12 megacycles, with most of the sets standardized at 4.3 m.c.

Broadening of the i.f. response curve, where used, is accomplished by means of resistors connected across all windings except those of the discriminator transformer. A typical amplifier schematic using this type of transformer with 6SK7 tubes is shown at "C."



C

The Limiter. Although the limiter may seem to be unfamiliar to the beginner, its operation is based on familiar principles, and, in fact, may be compared in some ways to the performance of the grid-leak detector.

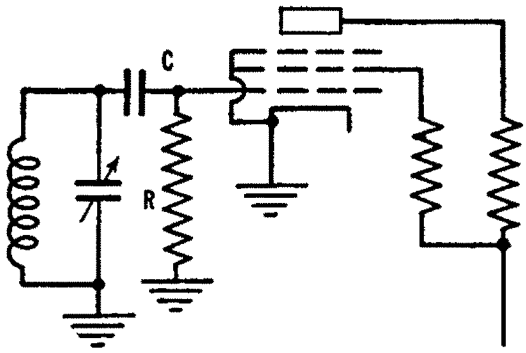


D

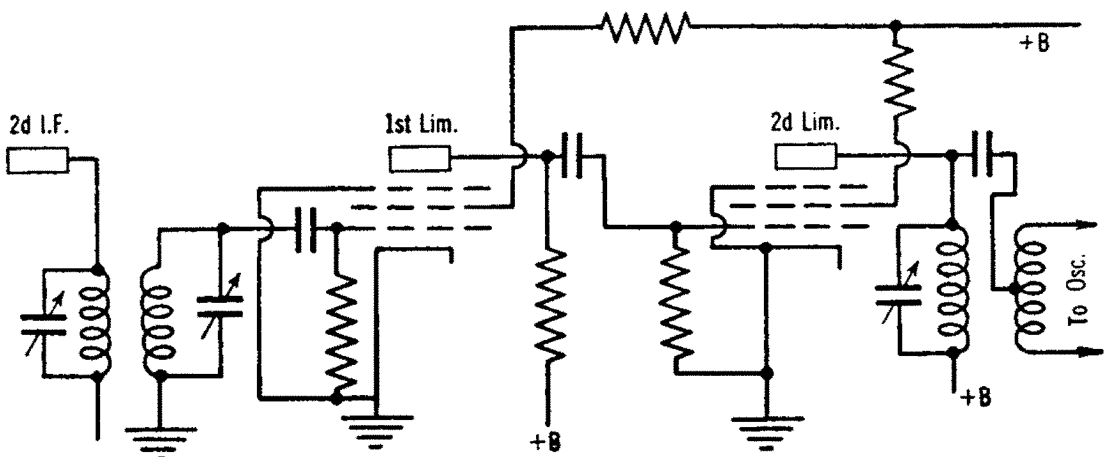
Briefly, the function of the limiter is to prevent variations in amplitude from affecting the discriminator. Although the signal is frequency modulated, and therefore any variations should be frequency variations only, it is possible for noise to vary the amplitude of the signal.

To prevent such amplitude changes from reaching the discriminator, the limiter is used. The limiter operates on one of two principles—grid rectification or current limitation. In either case, the general result is about the same, a flattening of the curve of the tube, resulting in cutting off amplitude variations above a certain point. A limiter operating on the principle of grid rectification, a type which seems to be more common than the other, uses a small capacity as grid condenser, with a resistor in parallel, as indicated in "D."

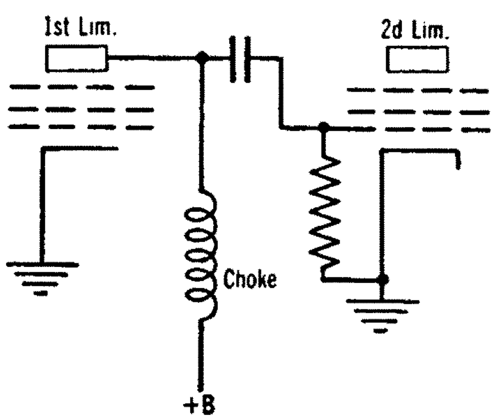
This circuit may be varied by connecting the condenser between the tube grid and the tuned circuit, with the resistor from grid to ground as



E



F



G

shown at "E." The condenser is usually about 20–50 mmfd., and the resistor from 50,000 to 150,000 ohms. The current-limitation type operates with no grid condenser or resistor but with reduced plate and screen voltages, so that current saturation occurs at a low input level.

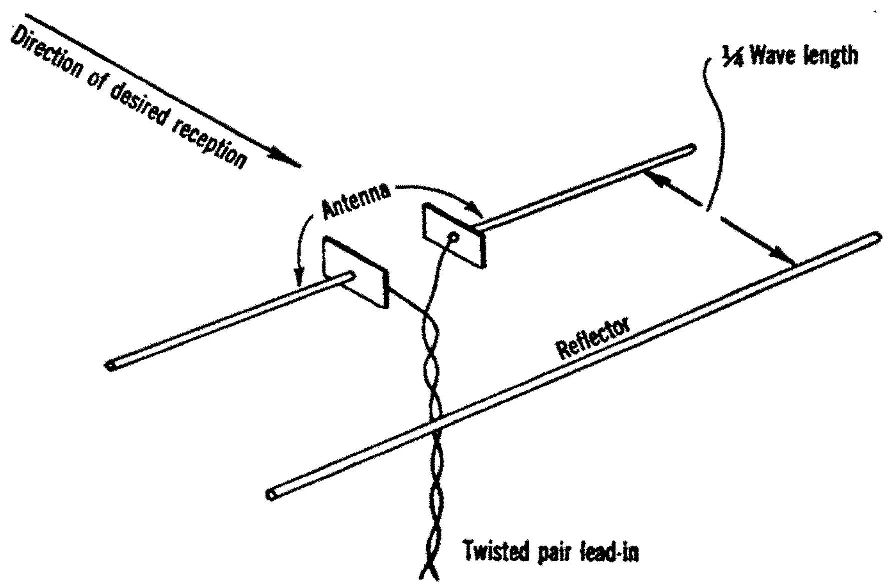
Most present day sets use two limiters, as shown in "F." Sometimes the resistor in the plate circuit of the first limiter stage is replaced by a choke, as shown at "G." The usual tube is a 6SJ7.

The Discriminator. Most discriminators for FM use are quite similar to those used in the automatic frequency control systems, previously described. The general tendency is to use a 6H6 duo-diode for this purpose. For diagrams, refer to the phase-shift discriminator, covered in the section on AFC.

A few sets employ combinations of discriminator and phase inverter, using a 7K7 tube, or a combination limiter and discriminator, using a 6B8, duo-diode-pentode. Philco receivers use a special discriminator tube, the XXFM which also functions as a first audio stage. In these receivers, no limiter stage is used.

The Audio Amplifier. The audio amplifier is generally conventional, with emphasis on high fidelity. Phase inversion is commonly used, and some form of inverse feedback is used in a few sets. The audio system used in one Stromberg-Carlson model is typical. It uses the triode section of a 6R7 as input amplifier, a 6SC7 as phase inverter and two 6V6 tubes as an output stage.

Antennas for Frequency Modulation. Many receiver manufacturers supply an outdoor antenna for use with their sets, while some others



H

furnish an antenna built into the receiver cabinet. In the latter case, the built-in antenna may be replaced with an outdoor type. The usual FM antenna is a dipole, one-half wave length long, and so located that the plane of the antenna is at right angles to the direction of desired reception This may become an important factor in many locations and the antenna should be so installed that it may be rotated. The lead-in consists of a low-loss twisted-pair line.

Some dipole antennas are equipped with a reflector to increase the signal strength from a desired direction. This is illustrated at "H." The reflector is a rod, also a half wave length long and located at the side of the antenna away from the desired station or direction. The distance between antenna and reflector is one-fourth wave length.

The built-in type of antenna takes the form of a folded dipole, usually, and is fairly satisfactory in locations where good signal strength is obtainable.

FM–AM Combinations

A number of sets have been built, and it is likely that a still greater number will be made, to receive both FM and AM signals.

There are two methods used in designing such combinations. You will find some sets using specially constructed i.f. transformers for either AM or FM. Some of these have a single primary and two secondaries, one for the AM i.f. of say 455 k.c., the other for the FM i.f. of 4.3 m.c. or so. Examples of this type of circuit may be seen in the service bulletins pertaining to Philco models 42–355 and 42–390. In these sets an XXL tube is used as converter, XXL as oscillator, 2 type 7V7 as i.f. amplifiers and a type XXFM as discriminator and first a.f., all tubes being used for both FM and AM reception.

In another type of circuit you will find i.f. transformers having two primaries and two secondaries. The Brunswick 296 FM and 299 FM are good examples of this circuit arrangement. An inspection of the diagrams of the four receivers mentioned should prove interesting and profitable.

Another way of handling the problem of FM and AM reception is to provide entirely separate units consisting of coils, tuning condensers, i.f. transformers and tubes for each of the two services, with a switching arrangement to connect one or the other to the audio amplifier. Among the manufacturers using this type of construction are Crosley and Freed.

Alignment of Frequency Modulation Receivers

A careful reading of the available material relative to the alignment of FM sets will suggest a number of different methods of performing this operation, many including the use of the oscilloscope and the frequency-modulated signal generator. While all of these procedures constitute good practice, and the suggested use of the various pieces of equipment certainly will tend to make the process easier and also will aid in obtaining best results, it is generally agreed that the job can be done with a vacuum tube voltmeter and a signal generator capable of covering the tuning range of an FM receiver.

The above statement is not to be construed as an argument against the use of either the oscilloscope or the frequency-modulated generator, for, as mentioned before, their value is fully recognized.

A word of caution: take care in making adjustments, as improper adjustment, which in an ordinary receiver may only reduce sensitivity, in an FM set may cause the set to become inoperative.

The first step in aligning the set is to properly adjust the discriminator. Although this process has been described in connection with AFC systems, it will be repeated here for the sake of maintaining continuity.

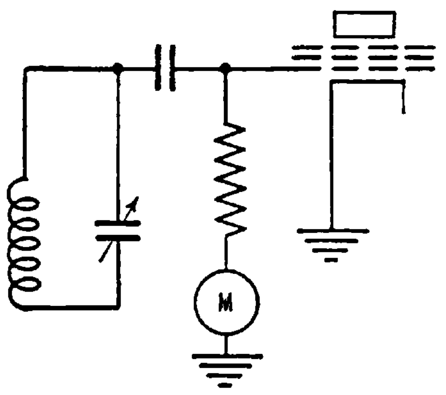
Connect the signal generator cable to the grid of the limiter tube; if two limiters are used, connect it to the grid of the second. Connect the shield of the output cable to the chassis. Connect a vacuum tube voltmeter across the two cathodes of the discriminator. (A 20,000-ohms-per-volt meter may be used in place of the V.T.V.M.). Tune the generator to the correct intermediate frequency of the receiver, with the generator adjusted to deliver an unmodulated signal.

Back discriminator secondary trimmer all the way out, then adjust the primary trimmer to give maximum reading on the vacuum tube voltmeter. After this adjustment has been made, start turning the secondary trimmer in, noting where the points of minimum reading occur. Find the middle point of minimum reading, and at this point adjust the trimmer to give a reading of zero. This completes the discriminator adjustment, and you may now proceed with the alignment of the i.f. amplifier.

Disconnect the generator cable from the limiter grid and transfer it to the signal input grid of the mixer, making sure that while doing so you do not change the setting of the generator tuning dial. Allow the cable shield to remain connected to the chassis.

In making the i.f. adjustment, a satisfactory resonance indicator is a micro-ammeter connected in the grid circuit of the limiter. If cascade limiters are used, the meter should be connected in series with the grid resistor of the first limiter stage. Disconnect the grounded end of the resistor and insert a meter having a full scale reading of not more than 500 micro-amperes, between the normally grounded end of the resistor and ground as shown in sketch "J."

Now adjust the i.f. trimmer condensers to give maximum reading on the micro-ammeter, reducing the generator input as may be necessary. Generally, the adjustments are made starting from the last i.f. and working forward. The important thing is to make them in some order so that none are overlooked. After all have been adjusted, repeat the process, for often one adjustment may change others.



J

When the i.f. alignment has been completed, check to see that the response is the same on either side of the resonant frequency. You may do this by again connecting the V.T.V.M. or 20,000-ohms-per-volt meter to the cathodes of the discriminator and noting whether, with the generator feeding a signal at the intermediate frequency to the mixer grid, the reading on the meter is zero. If it is, try increasing the frequency of the generator about 50 to 75 k.c., noting the new reading on the meter. Now reduce the generator frequency an equal amount below the i.f., again taking a reading. The two readings should be equal. This completes the alignment of the i.f. and discriminator.

Transfer the generator output cable to the antenna terminal. Adjust the generator to deliver a signal at the high-frequency end of the tuning range. Tune the receiver dial to this frequency and adjust the oscillator, antenna and r.f. trimmers to give maximum response on the micro-ammeter connected in the limiter grid circuit as before. The alignment of the receiver is now complete.

Questions

1. Give two reasons for the use of automatic frequency control.

2. Describe how a shift in local oscillator frequency may result in cutting of side bands and poor tone.

3. Describe the function of the discriminator tube.

4. What is meant by a phase shift type of discriminator?

5. Upon what effect does the operation of the oscillator control tube depend?

6. Describe the operation of a triple-detection superheterodyne.

7. How might a defective discriminator tube affect the performance of an AFC circuit?

8. An AFC circuit operates normally on one side of resonance, but has no effect when the receiver is mistuned on the other side of resonance. Describe what may be wrong.

9. Why are voltage measurement procedures of less value in AFC circuits than in other stages?

10. Describe the adjustment of the primary and secondary trimmers on the usual discriminator transformer.

11. What is the frequency range at present assigned to frequency-modulation stations?

12. Explain the difference between amplitude and frequency modulation of a carrier.

13. What is a thermal compensator and what is its function?

14. Why is the physical location of a thermal compensator important?

15. Why are resistors often connected across the primary and secondary windings of FM intermediate frequency transformers?

16. What intermediate frequency is in general use in FM receivers?

17. What precaution should be observed in regard to the wiring in a high-frequency receiver?

18. Why do most FM receivers use two i.f. stages?

19. What is the function of a limiter stage?

20. What is the function of a reflector as used with an FM antenna?

21. Why is it important that an FM antenna be so arranged that its direction may be changed?

22. Why do some FM i.f. transformers have two sets of windings?

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