Study Group 6

ELECTRONIC FUNDAMENTALS

Service Practices 11:

DIAL CORDS AND TUNING SYSTEMS

Service Practices 12:

BATTERY AND THREE-WAY PORTABLE RECEIVERS

RCA INSTITUTES, INC.

A SERVICE OF RADIO CORPORATION OF AMERICA

New York, N. Y.

ELECTRONIC FUNDAMENTALS

SERVICE PRACTICES 11

DIAL CORDS AND TUNING SYSTEMS

RCA®

RCA INSTITUTES, INC.

A SERVICE OF RADIO CORPORATION OF AMERICA

HOME STUDY SCHOOL

350 West 4th Street, New York 14, N. Y.

Service Practices 11

INTRODUCTION

In this booklet, you will learn about the mechanical action that takes place when the station-selector or turning knob of a radio receiver is turned or a button is pushed to select a station. In addition, the repairs and adjustments of these tuning systems will be discussed. However, before learning about the *mechanical* action that takes place, you will learn a few things about the *electrical* action that takes place in a radio receiver when a station is tuned in.

In later Theory Lessons, you will learn why it is that capacitors and inductors can be used to tune in a station on a radio or television receiver. At present, all you need to know is that the electrical size of the capacitor and the inductors used for tuning determine the station to which the receiver is tuned. Changing the electrical size of the capacitor or the inductor changes the station that the receiver is tuned to.

In most radio receivers, tuning is done by changing the electrical size or capacity of the tuning capacitor only. The inductor connected in parallel with the capacitor does not have its size changed. Therefore, as shown in Fig. 11-1, a variable capacitor is connected in parallel with a fixed inductor.

The variable capacitor used for tuning is really made up of two or more variable capacitors. These capacitors are linked together so that they can be varied at the same time by rotating a single shaft. Such capacitors are called ganged capacitors. Figure 11-2*a* shows a ganged capacitor in the minimum-capacity position and Fig. 11-2*b* shows one in the maximum-capacity position. The plates that move when the shaft is turned are called *rotor* plates, while the plates that remain stationary are called the *stator* plates.

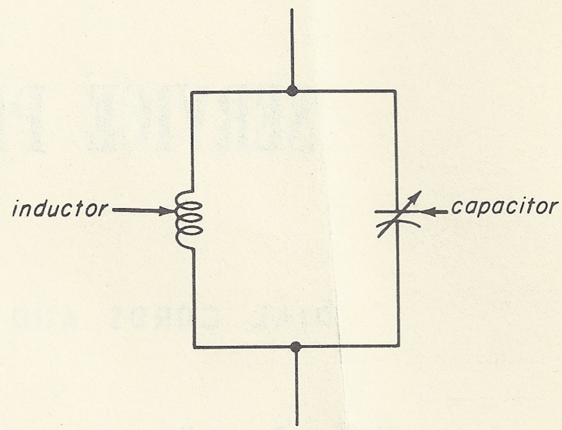
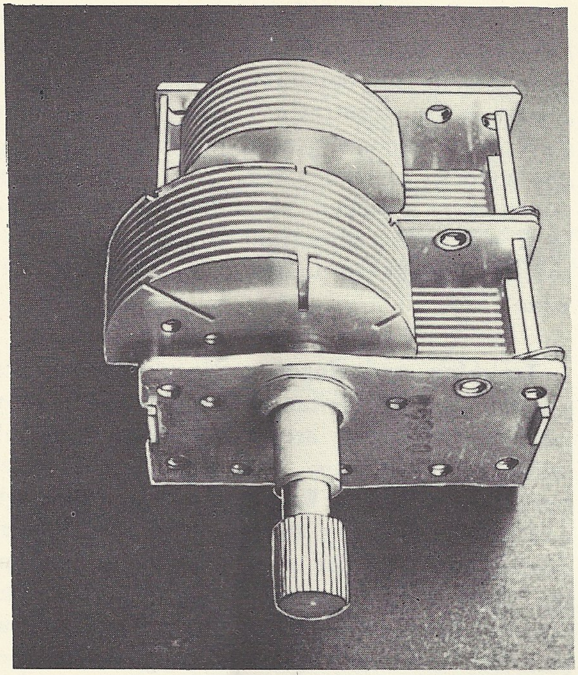


Fig. 11-1

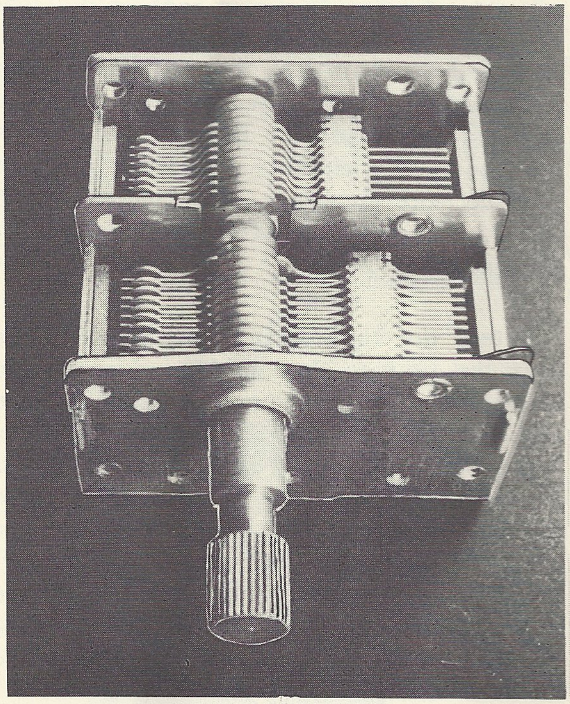
When the shaft is turned, all the rotor plates of all the sections of the ganged capacitor turn the same number of degrees in the same direction. When they turn into the stator plates, the capacitance of the ganged capacitor is increased; when they turn out of the stator plates, the capacitance is decreased.

As you remember from earlier lessons, each radio station broadcasts on an assigned frequency. By varying the capacitance of the tuning capacitor, you can tune a receiver to different frequencies, and so to different stations. When the plates of a tuning capacitor are almost fully meshed, the receiver is tuned in to the station with the lowest standard AM broadcast frequency (530 kc). When the plates are almost out of mesh, the receiver is tuned to the station with the highest frequency (1630 kc). When the capacitor is in different positions between these extreme points, different stations between the one with the lowest frequency and the one with the highest frequency are tuned in.

It is convenient to be able to tune to a station immediately without turning the shaft of the tuning capacitor until you happen to hit on the station you want. There-



(a)



(b)

Fig. 11-2

fore, most tuning dials or knobs are calibrated in kilocycles or in megacycles. How tuning is actually done is described in this booklet. Now we are ready to consider the different types of tuning systems used. These tuning systems differ in the mechanical arrangements for turning the shaft of the tuning capacitor and in the means used to indicate the position of the tuning shaft.

11-1. DIRECT TUNING

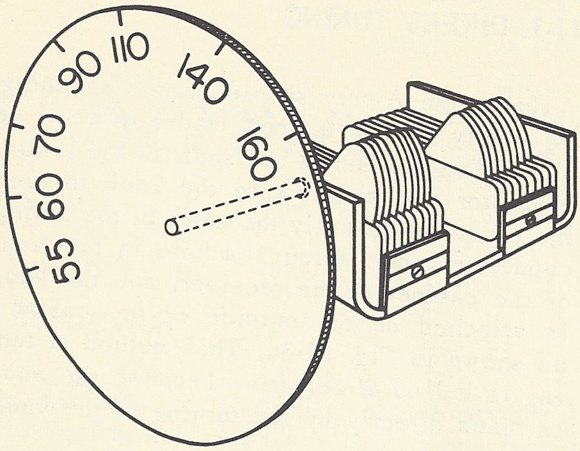
Operation. A very simple method of tuning is simply to put a knob made of wood or plastic on the end of the shaft of the tuning capacitor and simply turn the knob to tune the capacitor. Usually the shaft of the tuning capacitor comes through a hole in the front of the cabinet of the receiver, and the knob is attached on the outside of the cabinet, as shown in Fig. 11-3*a*. This method of tuning is called *direct drive* because the shaft is tuned directly by the turning of the knob.

In Fig. 11-3*b*, a large knob is used. On the knob, there are calibrations from 55 at one end to 160 at the other end. The number 55 stands for 550 kc and the number 160 stands for 1,600 kc. The end zero has been dropped off each calibration number. The numbers in between stand for the frequencies in between these extremes. Sometimes no zeros are dropped and the dial reads 550 on one end and 1,600 on the other end. Then the dial is calibrated directly in kilocycles.

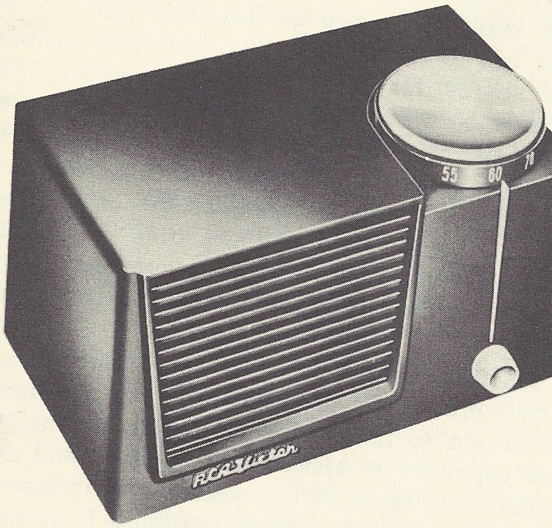
As you can see in Fig. 11-3*b*, there is an arrow printed on the cabinet. When the knob is turned so that the arrow points to the 55, the capacitor is almost fully meshed and the receiver is tuned to the station that is broadcasting on 550 kc. When the knob is turned so that the arrow points to other numbers, the receiver is tuned to other stations.

Sometimes, instead of a large knob, a *drum dial*, as shown in Fig. 11-3*c*, is used. This drum dial, which works the same as the knob just described, is moved by being pushed with the thumb. Sometimes the drum dial protrudes through a slotted hole in the front of the cabinet of the receiver; sometimes it is mounted on the side or the top of the cabinet.

On some receivers, the knob on the shaft of the capacitor is smaller and has either a projection that serves as a pointer or a pointer painted on it. The numbers are embossed on the cabinet. This type of direct drive is shown in Fig. 11-3*d*. This time it is the arrow that moves, but the result is the same. When the arrow points to 550 kc, the capacitor is almost fully meshed, and the receiver is tuned to the station that broadcasts on 550 kc.



(a)



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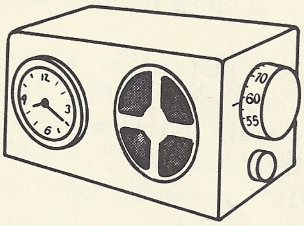
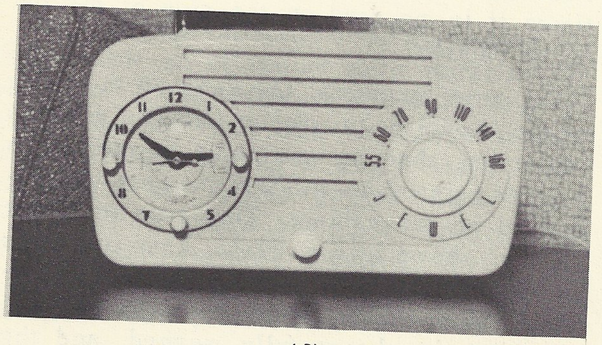


(c)



(d)

Fig. 11-3

In some cases, the lowest- and highest-frequency station numbers on the dial face may be in an opposite position to those shown in the illustrations. This is due to the difference in construction between the tuning capacitors. In one case, the fully-meshed position is reached when the dial is tuned in a clockwise direction; in the other case, the fully-meshed position is counterclockwise.

Troubles and Repairs. Very few defects are found in direct-tuning systems. The only possible troubles are tuning-dial or knob defects. Sometimes a plastic tuning dial becomes warped. Warping results in high and low dial spots that rub the front panel of the cabinet. The procedure is to replace the dial. It is best to purchase a new dial directly from the radio manufacturer. A dial that has a number corresponding to the correct model number of the radio set will always be correct. If a new knob or dial cannot be purchased, there are ways to repair a defective knob or dial. Try pulling the knob back slightly away from the front panel, or, if possible, loosen the radio-chassis screws and push the chassis forward slightly to provide more clearance. The chassis screws should be tightened after the clearance is obtained.

Often, the knob spring that normally creates the tension that holds the tuning dial or knob securely to the tuning shaft either loses its tension, breaks, or is entirely missing. A new spring may be made from a piece of metal and fitted into the spring recess of the tuning dial or knob hole. Sometimes the hole becomes enlarged, causing a loose fit that allows the knob to slip off the shaft of the tuning capacitor whenever the receiver is tuned. If the receiver is an outdated model and the tuning knob cannot be replaced, a narrow piece of friction tape can be wrapped around the shaft-end to take up the slack and enable the tuning knob to grip the shaft more securely.

When replacing a station-indicating dial or knob that has the station frequency marked directly on it, be sure that the low-frequency station markings on the new dial are on the same end of the dial as the markings on the dial being replaced.

11-2. FRICTION DIAL DRIVE

Operation. Figure 11-4*a* shows a method of turning the shaft of a ganged capacitor by means of friction drive. In this case, the tuning control does not *directly* turn the capacitor shaft. Instead, the knob turns a split, circular spring-metal wheel that presses against and pinches the edge of a larger circular celluloid disk, which is connected to and turns the shaft of the capacitor. A metal bushing is riveted to the celluloid disk. This bushing is fastened to the shaft of the tuning capacitor with a set screw. The station-frequency markings are printed on the celluloid disk. The celluloid disk is placed behind the receiver's front panel. A hole sawed in the front panel of the receiver allows the number to appear. To conceal the edge of the hole for the sake of appearance, a bronze or plastic escutcheon is either screwed or nailed over the hole. At the opening of the escutcheon, there is a finger-like projection that serves as a pointer, as shown in Fig. 11-4*b*.

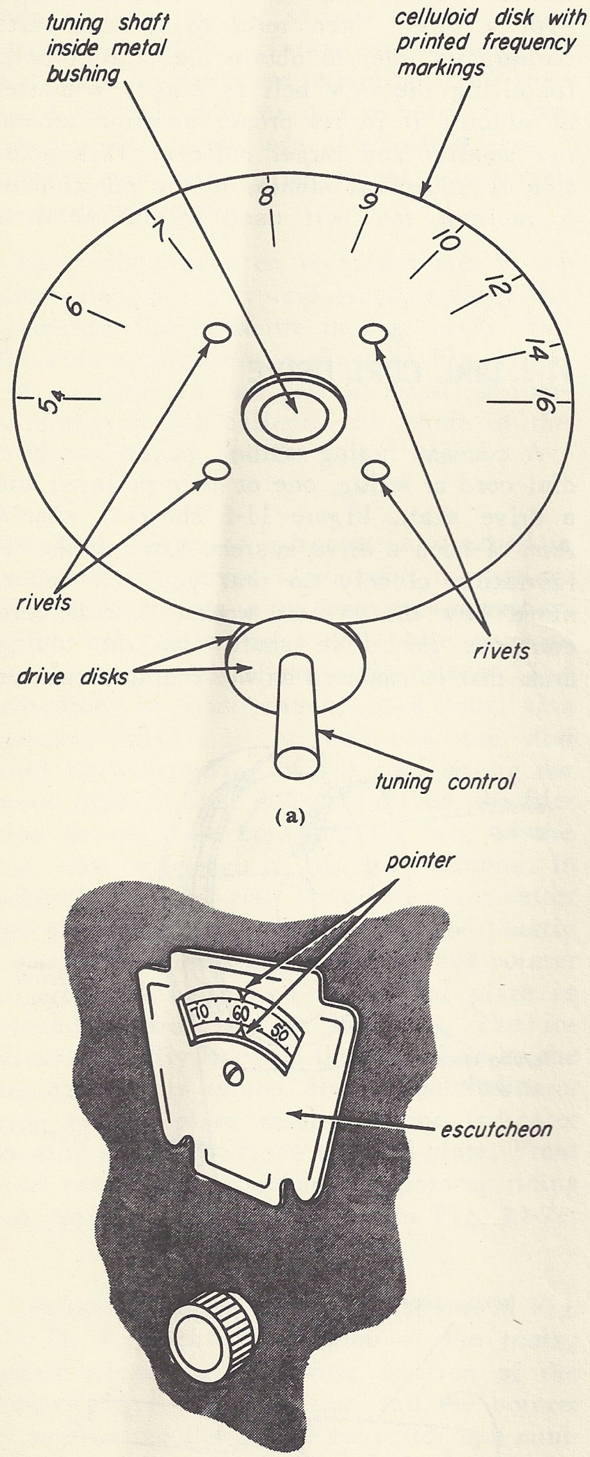


Fig. 11-4

The friction dial drive has an advantage over direct drive. When you turn the knob of the tuning dial, the small knob rotates. Several turns of the small wheel are required in order to make the larger knob go around once. Therefore, it is less likely that a person will speed by the station he is trying to find when he is using a friction dial drive than when he is using a direct drive. Therefore, it is possible to tune in the receiver more accurately because the tuning capacitor can be very gradually meshed to the desired point.

Troubles and Repairs. A common defect found with this method of tuning is a worn celluloid disk. The edge of the disk becomes worn due to the pressure of the disk between the outer edges of the two smaller metal circular wheels. It is difficult to repair a celluloid disk. A worn dial should be replaced.

11-3. DIAL BELT DRIVE

Operation. A tuning method that was formerly very common but which is not used very often in late-model receivers is shown

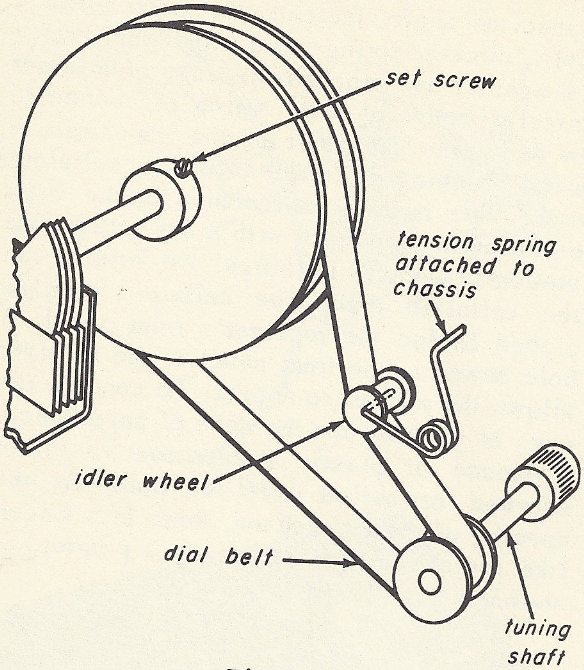


Fig. 11-5

in Fig. 11-5. The metal pulley on the tuning-knob shaft and the larger pulley on the ganged-capacitor shaft are connected by a dial belt. Several turns of the tuning-shaft pulley are required to make the capacitor-shaft pulley turn one time. The idler pulley shown in the figure is held against the dial belt by spring tension and keeps the belt taut.

The dial face appears through a hole sawed in the panel. A decorative escutcheon conceals the edges of the hole. The indicator is part of the escutcheon (shown in Fig. 11-4*b*).

Troubles and Repairs. The most common trouble is that the dial belt is not exerting proper pressure. The dial belt may become stretched, frayed, or broken. Frayed or worn belts should be replaced. Sometimes it is possible to take up the slack in the stretched belt by increasing the pressure of the spring of the idler pulley. If the belt is stretched so much that the slack cannot be taken up in this way, it should be replaced.

Fabric dial belts should be replaced with belts of the same length and width. To determine the length of a broken or frayed belt, cut it, lay it out straight, and measure its length with a ruler. To determine the length of the dial belt required to replace a stretched dial belt, wind a thin piece of thread — not heavy string — around the dial pulleys. Hold the thread in place with your finger and cut it off *exactly* at the point at which the free end of the thread meets the length of thread from the spool. Then remove the thread, lay it out, and measure its length with a ruler. Then refer to a radio-parts catalog in order to obtain the correct belt. Installing the new belt is simply a matter of placing it in its proper position around the smaller and larger pulleys. This position is somewhat similar to the position of a radiator fan belt used in automobiles.

11-4. DIAL CORD DRIVE

A common tuning method makes use of a dial cord or string, one or more pulleys, and a drive shaft. Figure 11-6 shows a simple form of such a drive system. Look at the illustration closely so that you can understand how the system works. A dial cord connects the drive shaft with the tuning drum that is mounted on the tuning-capacitor

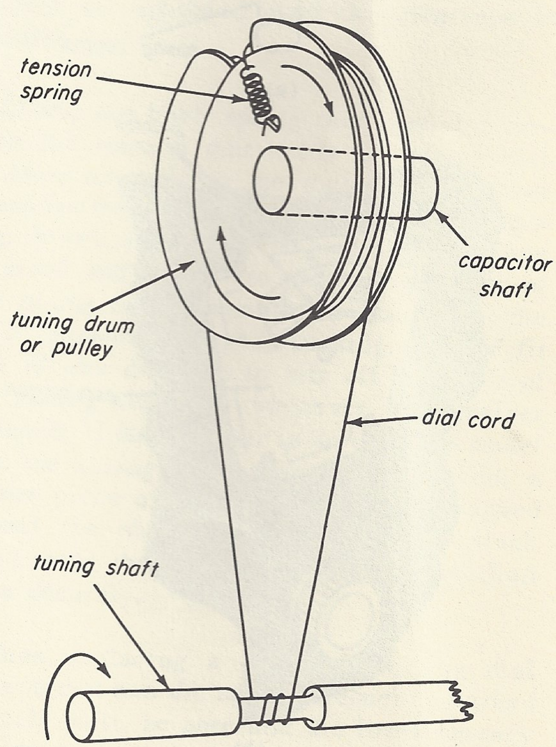


Fig. 11-6

shaft. The cord is wrapped three times around the drive shaft so that it will not slip off. One end of the cord is wrapped around the tuning drum, passes through a little hole in the tuning drum, and is fastened to the tension spring. The other end of the dial cord is wrapped 1½ turns around the drum then fastened to the spring. As the tuning shaft is turned in a clockwise direction, the dial turns in the same direction. The front panel of the receiver has a hole. An escutcheon is screwed over the hole. A plastic cabinet may have an adornment that serves as an escutcheon.

Many dials used on receivers are of the slide-rule type. A typical receiver using the slide-rule dial is shown in Fig. 11-7*a*. The dial cord arrangement is shown in Fig. 11-7*b*. The cord travels over several small, smoothly-turning metal pulleys, the shaft of the tuning capacitor, and the pulley drum.

A dial pointer or indicator is attached to the cord and moves along with the string. The pointer points to the frequency markings, which are printed on a dial plate mounted on the front panel of the radio cabinet. The indicator, in most cases, is a long, thin metallic strip. It is held on the dial cord by interleaving of the cord among the metal tabs. In some dial-cord drives, the friction between the cord and the tabs of the indicator is enough to grip the indicator. In others, the tabs may be crimped for better gripping. In still others, a drop of plastic cement on the tabs holds the cord and pointer together. A calibrated metal dial plate is placed in front of the indicator. The indicator usually rides on the dial plate as the tuning knob is turned. Having the indicator ride on the plate results in the indicator moving smoothly across the dial plate. Front and rear views showing the pointer riding on the dial plate are shown in Fig. 11-7*c*.

In the dial-drive mechanism shown in Fig. 11-7*b*, a clockwise rotation of the tuning shaft causes a clockwise rotation of the pulley drive and capacitor, and the pointer moves to the right. The capacitor has minimum capacitance when tuned clockwise, and the dial pointer is at the high-frequency end of the band.

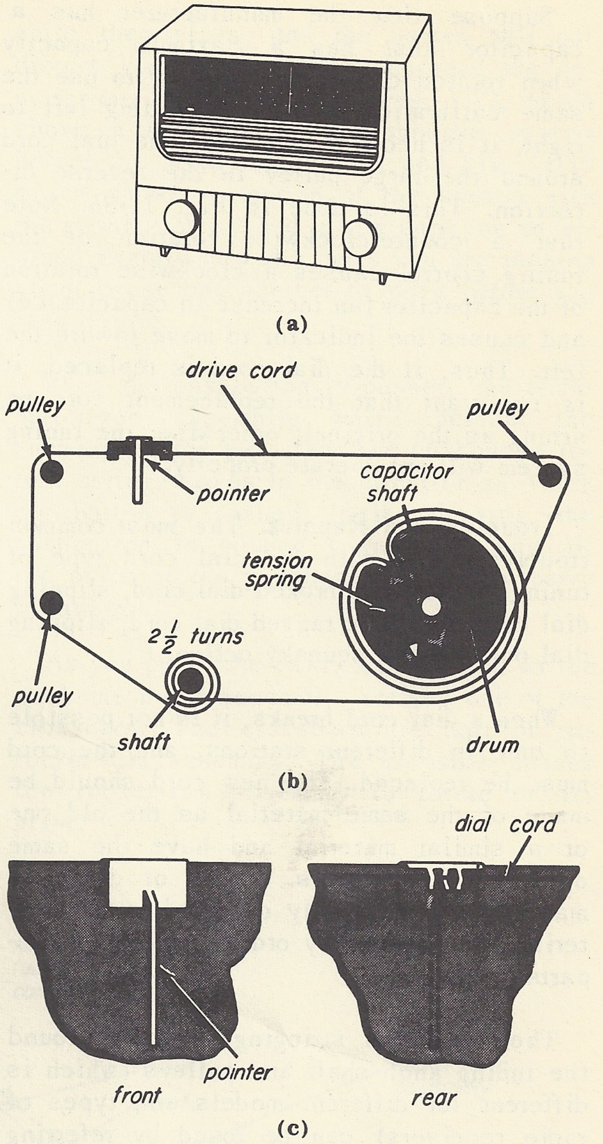


Fig. 11-7

Tuning systems using dial cords provide a smooth, easy method of tuning radio receivers. However, since radio receivers are made in many different sizes, shapes, and models, there are many different types of dial-cord tuning systems. Each system has its cord length, drum-pulley size, number of idler pulleys, type of indicator, size and type of spring (or springs), etc. Some systems use a thin cord; others use a medium- or thick-diameter cord. Most dial cords are made of either nylon or linen; a few are made of stranded or braided bronze-metal cable. Many slide-rule dials are calibrated so that the low-frequency (530 kc) end is at the left end of the slide-rule dial scale and the high-frequency (1630 kc) end is at the right end of the scale.

Suppose that the manufacturer has a capacitor that has a maximum capacity when rotated clockwise. In order to use the same calibration dial face, reading left to right, it is necessary to wind the dial cord around the large pulley in the reverse direction. This is done in Fig. 11-8*b*. Note that a counterclockwise rotation of the tuning control causes a clockwise rotation of the capacitor (an increase in capacitance) and causes the indicator to move toward the left. Thus, if the dial cord is replaced, it is important that the replacement cord be strung as the original; otherwise, the tuning system will not operate properly.

Troubles and Repairs. The most common troubles found with the dial cord type of tuning systems are broken dial cord, slipping dial cord, frayed or ragged dial cord, slipping dial pointer, and squeaky action.

When a dial cord breaks, it is not possible to tune in different stations, and the cord must be replaced. The new cord should be made of the same material as the old one or a similar material and have the same diameter or thickness. Spools of dial-cord material can be easily obtained in any material or thickness by ordering from a radio-parts catalog.

The method of stringing the cord around the tuning knob shaft and pulleys (which is different for different models and types of radio receivers) can be found by referring to either the radio manufacturer's service notes or special booklets describing how to restring dial cords. These service notes and booklets show clear and simple drawings with directions for dial-cord installations for past and present model receivers.

For example, suppose that the dial cord shown in Fig. 11-7*b* were broken. How would you proceed to install a new one? Here are the steps:

1. Remove the pieces of broken cord from the shaft and pulleys and separate the dial cord from the dial pointer.

2. Select a new dial cord from a spool that is made of a similar material and has the same thickness as the broken cord.

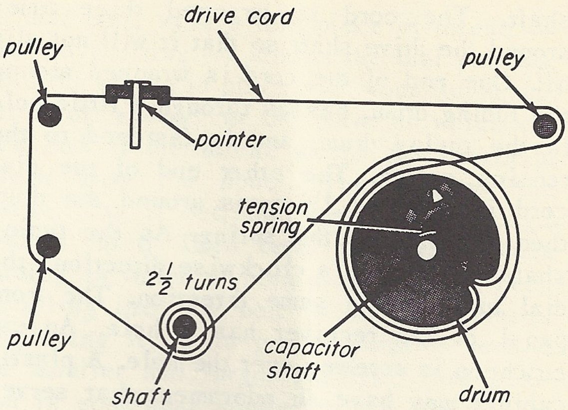


Fig. 11-8

3. Turn the large drum pulley until the ganged capacitor plates are fully-meshed, generally in a counterclockwise direction.

4. Tie one end of the new dial cord to the top anchor point of the large drum pulley and then loop the cord around the drum pulley $1\frac{3}{4}$ times in a clockwise direction, as shown in Fig. 11-7*a*.

5. Then wind the cord $2\frac{1}{2}$ times in a clockwise direction around the tuning knob shaft.

6. Continue, by allowing the cord to pass over the left-hand lower idler pulley, the upper left-hand idler pulley, the upper right-hand pulley, and part of the larger drum pulley.

7. Carefully tune in a radio station and then install the dial pointer in its proper position on the dial spring so that the pointer shows the true frequency reading of the station on the dial scale. Slightly tighten the metal tab on the pointer so that it grips the dial cord without slipping. Apply a drop of cement to the pointer tab.

Caution: Do not make the length of dial cord too short. This will cause the dial spring to be stretched too far. Do not allow the dial spring to be stretched too far.

A slipping dial cord is usually due to either a cord that has stretched or a spring that has lost its tension. This can be cured by making the length of the original cord slightly shorter or replacing the spring with one that is slightly shortened and has more tension. Dial springs can be obtained in a large variety of sizes, and, together with assorted dial cables, may be kept on hand for any type of dial repair job.

A frayed or ragged dial cord should be replaced with a new one, even though the dial action is working, because it is only a matter of time before the cord is sure to break.

11-5. MECHANICAL PUSHBUTTON TUNING

Operation. The pushbutton system is a clever way to tune in a station without turning the tuning knob. All you have to do is press a button marked with the letters of the station you wish to get and the station is automatically tuned in for you.

The easiest way to understand how the pushbutton tuning system works is to study it in operation. As you read about the way the system works, you will find that the parts of the system are called by names that you may not recognize. However, if you look at Fig. 11-9, you will be able to see the parts themselves, and the names will not disturb you too much. As you read the description, look carefully at Fig. 11-9, which shows a section of the pushbutton system before the button is pushed, and Fig. 11-10 which shows a section of the system with the pushbutton pushed in. Be sure you understand exactly how the parts you are reading about cause one another to move before you read further.

When the pushbutton is pushed, the pushbutton-rod assembly, which includes the pushbutton, the pawl, and the pushbutton-return spring, moves in the direction in which the button is pushed. In the drawing, the pushbutton is pushed toward you and all the parts of the pushbutton assembly move toward you.

As you push, the pawl, a projection on the pushbutton-rod assembly, strikes one of the crossbars. The crossbars are part of the rocker-arm assembly. The crossbar causes the rocker-arm assembly to rotate on its pivot.

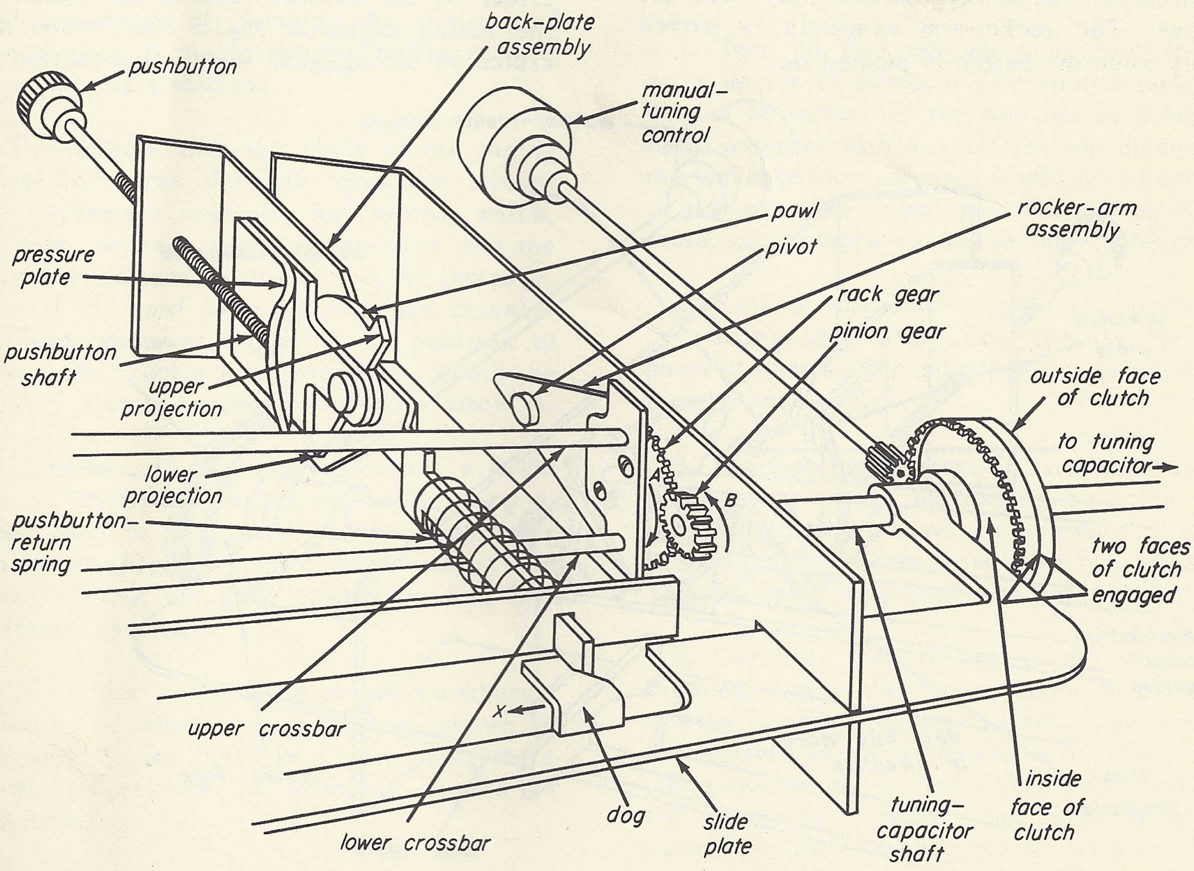


Fig. 11-9

In Fig. 11-9, the upper projection strikes the upper crossbar. The upper crossbar, and the rocker arm assembly of which it is a part, move in the direction of arrow A until the lower crossbar strikes the lower pawl projection, which stops its movement and the rotation of the rocker-arm assembly. The rocker-arm assembly and the rack gear attached to it move in the direction shown by arrow A, and the pinion gear turns in the direction shown by arrow B. (It is possible that the rocker-bar assembly previously may have been rotated in the direction of arrow A. We will discuss this situation later.)

If you have mastered the explanation of the principle of the pushbutton system, you will have no difficulty in understanding the function of the other parts of the pushbutton assembly shown in Fig. 11-9. The pushbutton-return spring, for example, does just what its name indicates. When you push the button, the spring is compressed, and when you release the pushbutton, the spring expands and pushes the button back to its original position. When the spring pushes the pushbutton out, the rocker-arm assembly does not move. The rocker-arm assembly is moved only when the button is pushed in.

You will notice that the end of the pushbutton assembly is against a dog. The dog, which has a curved side, is attached firmly to the slide plate. When the pushbutton is fully pushed in, as shown in Fig. 11-10, the pushbutton assembly slides along the curved edge of the dog and presses the dog in direction X. The slide plate, which is firmly attached to the dog, moves along with it.

The dog is attached to one arm of the slide plate. Attached to the other arm of the slide plate is the inside face of the clutch. When the slide plate moves in direction X, the inside face of the clutch moves in direction X and no longer makes contact with the outside face of the clutch. When the two faces of the clutch are separated, the clutch is said to be *disengaged.*

Notice that the manual-tuning control is geared to the inside face of the clutch. When the clutch is disengaged, if you turn the manual-tuning control the inside face of the clutch will turn, but it will have no effect on the outside face of the clutch or the tuning capacitor shaft. Also, when the clutch is disengaged, when a pushbutton is

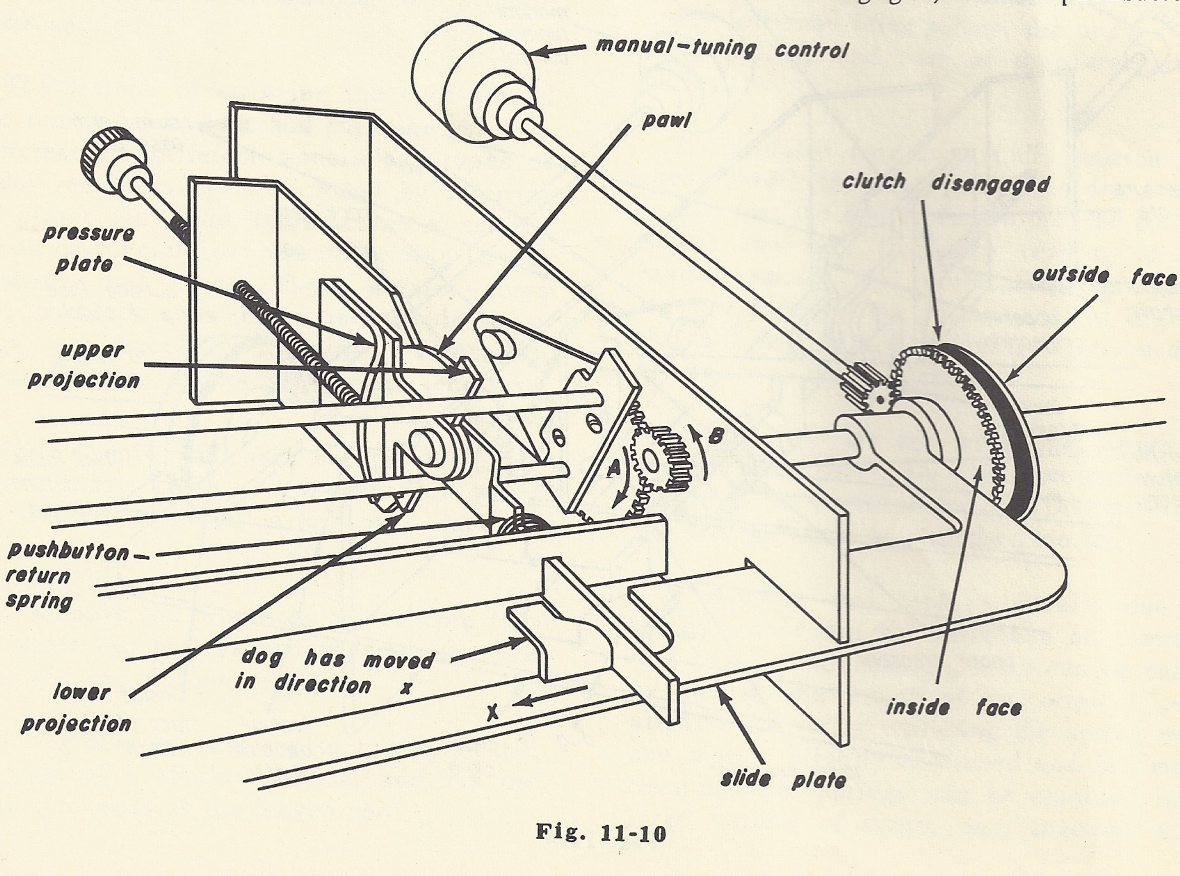


Fig. 11-10

pushed, the tuning-capacitor shaft, which passes through but is not attached to the inside face of the clutch, turns. Therefore, the manual tuning control is taken out of operation when a button is pushed because one of the results of pushing the button is to disengage the clutch.

Let us go back to the pawl. You have learned that the position of the pawl determines how far the rocker-arm assembly will move and how far the tuning capacitor will turn. The position of the pawl is adjusted when a radio receiver is installed.

In order to adjust the position of the pawl, the pawl must be loosened. The pawl is held in position by the shaft of the pushbutton assembly, which presses on the pressure plate, which squeezes the pawl against the backplate assembly. Once the pawl has been loosened by loosening the adjusting screws that hold it in place, the pawl can be moved into the desired position and the screws holding it in place can be tightened.

The purpose of changing the position of the pawl is to enable the pushbutton to tune in a particular station.

The amount that the shaft of the tuning capacitor turns depends upon the amount the rocker-arm assembly has moved, which, in turn, depends upon the position and the angle of the pawl. You can see, for instance, that if the pawl were close to the crossbar or at a different angle in the position of rest, the rocker-arm assembly would be pushed farther in the direction of arrow A.

Therefore, if you wished to have a pushbutton push the rocker assembly more or less than it is pushed by the pushbutton shown in Fig. 11-9, you would adjust the pawl so that the pawl projection was in a different position.

The other pushbuttons in the pushbutton system, of which the pushbutton shown in Figs. 11-9 and 11-10 is a part, have their pawl projections in different angles or positions.

So far, we have been discussing what happens when the top projection hits the top crossbar. Now let us suppose that one of the other pushbuttons has been pushed so that the rocker-arm assembly has been pushed farther in direction A than the pushbutton shown in Fig. 11-9 could push it. If you wish to tune in the station that is tuned in by the pushbutton shown in the illustration, you must now get the rocker-arm assembly to move in the reverse of direction A. This is where the lower pawl projection comes in. When the rocker-arm assembly is so far in direction A that the upper pawl projection cannot hit the crossbar, the lower pawl projection hits the lower crossbar, and the rocker-arm assembly moves in a direction opposite to direction A. The upper pawl projection acts as a stop.

Adjustment. Suppose that you were installing or servicing a radio receiver that has mechanical pushbutton tuning of the type shown in Figs. 11-9 and 11-10. The owner of the set has moved from another city, and, at the time of installation, it is necessary to adjust the pushbuttons. To adjust the pushbuttons, do the following:

1. Turn on the receiver and allow it to warm up for 15 minutes. The volume control should be turned all the way up. In a home radio receiver with a variable-loop antenna, the variable-loop antenna should be adjusted to the maximum signal position. In an auto radio, the antenna should be fully extended.

2. Remove the four plastic pushbuttons by pulling them away from the flat metal pushrod shafts. The adjustment screws will then be accessible.

3. Place a screwdriver in one of the adjusting screw slots and loosen the screw by turning the screwdriver in a counterclockwise direction (never more than two turns). This loosens the plates that hold the pawl.

4. Carefully tune in one of the selected stations, using the tuning knob. While the station is being properly tuned in, keep the screwdriver in the adjusting screw slot and push against the screwdriver. This pushes the pushrods forward, and the crossbar causes the pawl to be in the proper position.

5. Tighten the adjusting screw.

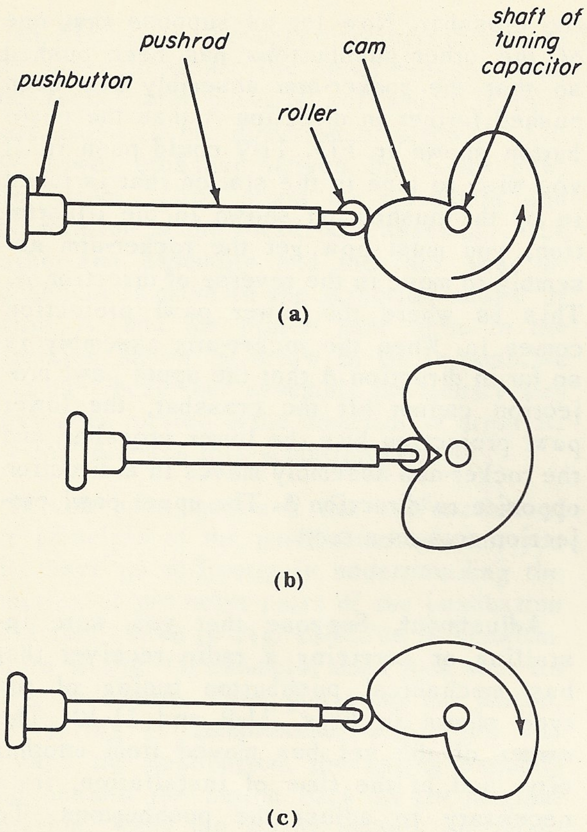


Fig. 11-11

6. Choose another station that is to become a pushbutton-tuned station. Tune it in with the tuning knob, at the same time pressing against the adjusting screw with the screwdriver, as described before.

7. When the station is properly tuned in, tighten the screw as before.

8. Follow the same steps for the other stations that are to become pushbutton stations.

9. Reinstall each plastic pushbutton by pushing it firmly onto the flat metal pushrod.

10. Label each push-button with the call letters of the station to which it is tuned.

11-6. CAM-OPERATED MECHANICAL PUSHBUTTON-TUNING SYSTEM

Operation. Another mechanical pushbutton-tuning system use four or five heart-shaped cams mounted on the shaft of the capacitor. There is one cam for each station to be tuned in mechanically. A cross-sectional view of part of a cam-operated pushbutton tuning system is shown in Fig. 11-11.

When the pushbutton is pressed in, the pushrod is pushed. The roller on the end of the pushrod pushes on the heart-shaped cam and causes the cam to rotate counterclockwise. The cam is mounted on the shaft of the tuning capacitor. When the cam turns, the shaft turns in the same direction.

The cam stops turning when the roller rides into the cleft of the cam, as shown in Fig. 11-11*b*. Therefore the tuning shaft of the capacitor also stops turning. If the capacitor had been rotated to another position, as shown in Fig. 11-11*c*, pressing the pushbutton and rod would cause the same result. That is, the rotation would be clockwise and would stop when the pushrod reached the cleft.

Since the stopping position of the cam determines the frequency or station being tuned in, a pushbutton can be made to tune a different station by setting the cam in a different position. There may be as many four or five cams on a shaft, one for each station to be tuned in by pushbuttons. Figure 11-12 shows the perspective position of three such pushrods and cams.

There is usually manual tuning in conjunction with this type of pushbutton tuning.

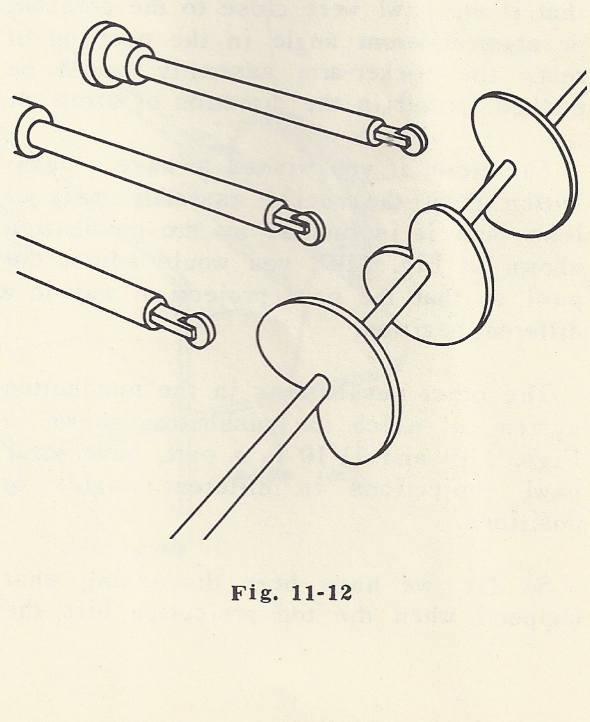
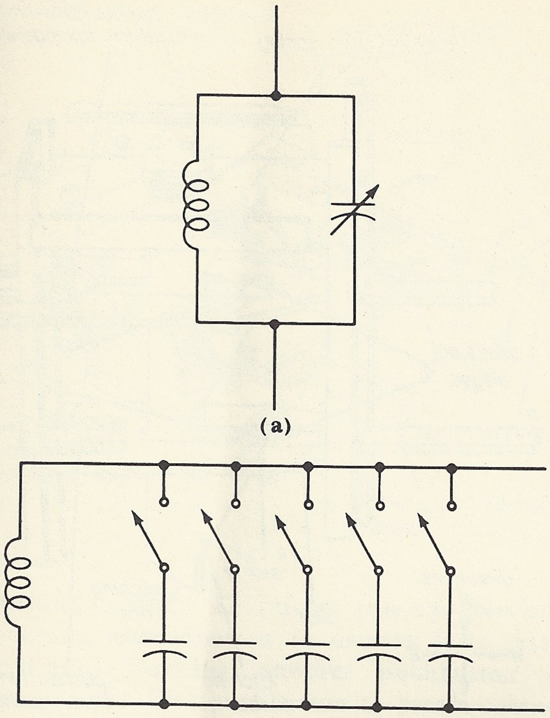


Fig. 11-12



(a)

(b)

Fig. 11-13

A dial-cord system similar to those described earlier in this booklet is generally used.

Troubles. Generally speaking, the pushbutton assembly does not break down. If the tuning goes out of adjustment because of shift of the electrical tuning due to aging of components or mechanical slippage, the pushbutton adjustments should be reset.

In case of dial-cord trouble, the technique for replacing the dial cord is the same as discussed earlier in this booklet.

11-7. ELECTRICAL PUSHBUTTON SWITCH

Operation. You have already learned about the mechanical-pushbutton system that is used to turn the shaft of a tuning capacitor. The electrical-pushbutton system, although it looks somewhat like the mechanical system when you look at it from the outside of the receiver cabinet (you see pushbuttons in both cases), is actually a complex switch. This switch is used to switch different capacitors or indicators into the tuning circuits. Let us see how this can be done. In Fig. 11-13*a*, you see the coil-capacitor combination that forms the tuning system you know about. When the variable capacitor is varied, its capacitance changes, and so does the frequency. The same effect could be obtained by using a large number of separate fixed capacitors as shown in Fig. 11-13*b*. Of course, many capacitors would be required to reproduce all the possible positions of a variable tuning capacitor. The drawing shows only five fixed capacitors. This number allows five favorite stations to be tuned in. By using the switching arrangement shown in the schematic diagram, any one of the five capacitors can be switched into the circuit.

The electrical pushbutton system is simply a switch that makes use of pushbuttons to do this switching. Figure 11-14 shows the schematic diagram of this switching system. Notice that there are two parts of this circuit. One part is used for tuning the r-f section of the receiver and the other section is used for tuning the oscillator section. You remember from your study of the variable capacitor that two ganged capacitors are used to tune the r-f and oscillator sections when manual tuning is used.

The switching system is of the double-pole single-throw type. Throwing one switch places two capacitors into two circuits. The capacitors that are used are trimmers, which will be discussed further in this booklet. For example, with one switch operation you

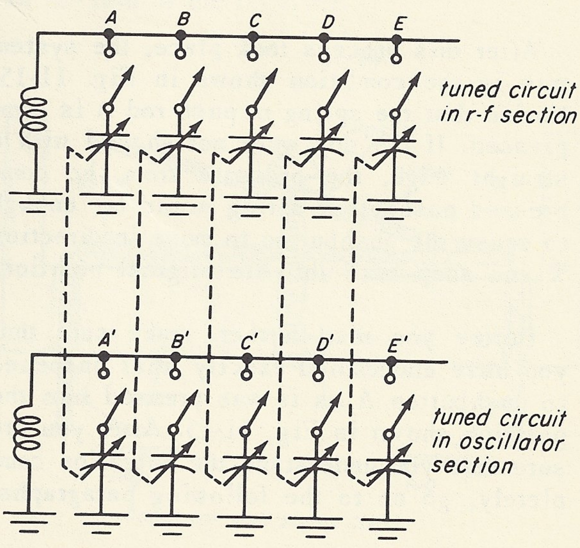


Fig. 11-14

place trimmers *A* and *A'* into the circuit of your receiver.

The capacitors shown are trimmers. When one switch of the pushbutton assembly is thrown, it releases any other switch that has been thrown. If you examine Fig. 11-15, the drawing of part of the pushbutton assembly, you will see how this is done. In the figure, pushbutton *A* is pushed in. Pushbutton *B* (the only other pushbutton shown) is not pushed in. Let's see what happens when a pushbutton is pushed in.

The first thing to notice is that the latching bar moves in directions N or S. Before pushbutton *A* was pushed in (direction E), pushbutton A was in the same position as pushbutton *B*. The stem of the latching bar and the dog of the locking bar were both in slot 2. When pushbutton A was pushed in, the pressing edge of slot 2 pushed against the curved side of the dog. The pressure on the dog was enough to push the latching bar in direction S, and the solid portion between slot 1 and slot 2 covered the dog. At this time, the latching-bar spring, which compresses when the latching bar is pressed down, was compressed. Naturally, when this spring is compressed, it exerts a force in direction N. So, as pushbutton A was pressed farther in and slot 1 came into position above the dog, the dog popped into slot 1 as the result of the pressure from the latching-bar spring.

After this process took place, the system was in the condition shown in Fig. 11-15. Notice that the spring of push rod A is compressed. If the dog were not shaped with a straight edge, the pressure from the compressed pushbutton spring would be enough to cause the pushbutton to move in direction W and snap back into its original position.

Before you read further, make sure that you have understood exactly what happened to pushbutton A as it was pressed into the position shown in Fig. 11-15. After you are sure that you understand the operation completely, go on to the following paragraphs.

Now let us see what happens when pushbutton B is pressed in. So far as pushbutton

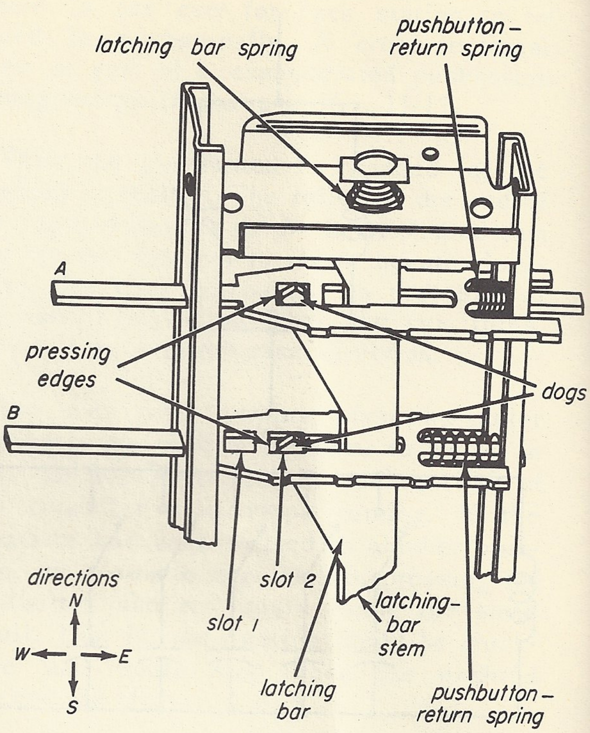


Fig. 11-15

B is concerned, the operation is the same as that of pushbutton A. But, as the pressing edge of slot 2 on pushrod B presses against the dog and causes the latching bar to move in direction S, the movement of the latching bar pulls the other dog out of slot 1 of pushrod *A*. The compression spring of pushrod *A* causes pushbutton assembly *A* to snap back to its original position now that the dog no longer interferes with this movement.

Let us return to what happens to pushbutton assembly *B* when it is pressed. Just as was the case with pushbutton *A* when it was pressed in, slot 1 of pushbutton *B* comes into place over the dog and pushbutton assembly *B* is held in position. If another pushbutton is pushed, pushbutton assembly *B* will snap back to its original position.

The whole purpose of the pushbutton switching arrangement is to make and break the contacts and, by so doing, to switch in different trimmers. Figure 11-16 shows how this is done. The switch shown in Fig. 11-15 has been turned over. However, pushbutton *A* is still pushed in, just as it was in Fig. 11-15. Notice that the switch blades of pushbutton *A* are now making contact with the contact points. The switch blades of pushbutton *B*, which is not pushed in, are not

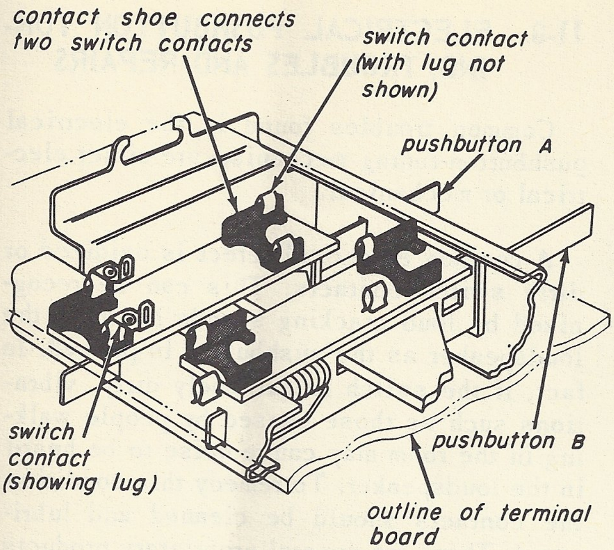


Fig. 11-16

making contact. Therefore, you can see that pushing a pushbutton in causes it to make contact. Pushing another pushbutton in causes the first pushbutton to break contact and the second pushbutton to make contact.

The switch contacts shown in Fig. 11-16 go through the terminal strip and are attached to lugs. These lugs, on the top side of the terminal strip, are shown in Fig. 11-17. One set of lugs is for the r-f section and the other set of lugs is for the oscillator section.

The lugs of each inside row in the two sets of lugs are connected together. You can see this connection if you look at the schematic diagram shown in Fig. 11-14.

Actually, some electrical-pushbutton systems use coils in place of the capacitors used in this system and a capacitor in place of the coil. In such systems, the coils are switched in and out of the system by means of pushbuttons.

Adjustment. The capacitors or coils used in a pushbutton system have fixed values. If capacitors are used, they are of the type that can be adjusted by turning a screw, as shown in Fig. 11-18. Turning the screw in one direction pushes the plates of the capacitor together and turning it in the other direction spreads the plates apart. Each of

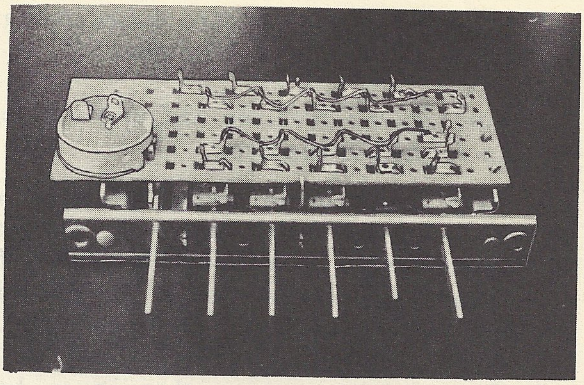
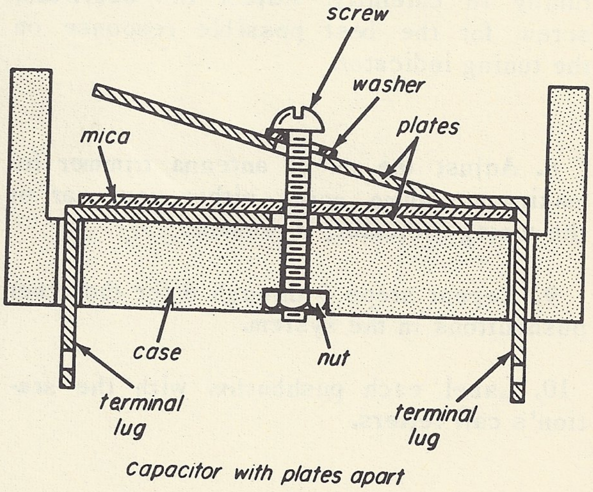


Fig. 11-17

the capacitors can be adjusted over a range of about 20 – 30 kc. If adjustable coils are used instead of adjustable capacitors, turning the screw one way forces the powdered-iron core into the coil and turning it the other way separates the coil from the core. Coils, too, are tunable over a range of about 20 – 30 kc.

The five capacitors or coils used are different from one another so that it is possible to tune them so that they select five stations from any part of the broadcast band. A serviceman can learn the range of each of the capacitors or coils used in the system he is working on by consulting the service notes that apply to the receiver in which the pushbutton system is found.

Actually, all that a serviceman sees is the screw heads of the capacitors or coils that he is working on. These screw heads protrude from holes in the chassis, usually in the rear of the receiver.



capacitor with plates apart

Fig. 11-18

The step by step procedure for adjusting the capacitors or coils is as follows:

1. Turn on the receiver and allow it to warm up for fifteen minutes.

2. Make a list of the desired stations to be tuned in by the pushbuttons. The number of stations should not exceed the number of pushbuttons that are available and should be distributed across the broadcast band.

3. Connect the antenna that is to be normally used.

4. Consult the service notes for the receiver to determine which set of screws is used to tune the oscillator and r-f or antenna stages. Also determine whether the ranges of the capacitor (or coil) adjustments will cover the selected pushbutton stations.

5. Next, tune in a desired station on the manual-tuning control.

6. Push in the pushbutton that will tune in the frequency of the desired station just tuned-in on manual tuning.

7. Carefully adjust the oscillator screw until the same station heard a moment ago on manual tuning is heard again. The adjustment must be made carefully and precisely. If the receiver you are adjusting has an electron-ray indicator or some other tuning indicator, the tuning indicator is usually a better indication than the ear that you are tuning in carefully. Adjust the oscillator screw for the best possible response on the tuning indicator.

8. Adjust the r-f or antenna trimmer for maximum volume using either your ear or the tuning indicator, if present.

9. Repeat steps 5 through 8 for the other pushbuttons in the system.

10. Label each pushbutton with the station's call letters.

11-8. ELECTRICAL PUSHBUTTON TUNING, TROUBLES AND REPAIRS

Common troubles found in the electrical pushbutton-tuning mechanism are either electrical or mechanical.

A common electrical defect is oxidized or dirty switch contacts. This can be recognized by loud cracking sounds heard in the loudspeaker as the pushbutton is pushed. In fact, if the switch is extremely dirty, vibrations such as those caused by people walking in the room may cause noise to be heard in the loudspeaker. To remedy this condition, the contacts should be cleaned and lubricated. There are several proprietary products that are suitable for this purpose. Walso Contactene and General Cement Red Electronic Contact Cleaner are two such commercial products. These products contain a solvent that dissolves the dirt and oxidation. As the solvent evaporates, it deposits a lubricating substance that prevents or reduces oxidation. The solvent is applied with a brush that is attached to the cover of the bottle. The compound should be applied liberally. The brush should be pushed as far into the contacts as possible while the pushbuttons are pushed and released so that the fluid can get at the entire surface of the contacts. The dislodged dirt should be wiped off the brush before it is returned to the bottle.

Another electrical defect is the detuning of the pushbutton circuits due to normal aging of the components. Over a period of time, the value of the inductance of the coil or the capacitance of the electrical capacitor may change. Since tuning depends upon the values of the coil and capacitor, pushbutton detuning may result.

To correct the mistuned condition, all that need be done is to retune all of the pushbuttons. Even though only two of the five may be badly detuned, each of the pushbuttons should be tuned, following the step-by-step procedure given earlier in this booklet.

ELECTRONIC FUNDAMENTALS

SERVICE PRACTICES 12

BATTERY AND THREE-WAY PORTABLE RECEIVERS

RCA INSTITUTES, INC.

A SERVICE OF RADIO CORPORATION OF AMERICA

HOME STUDY SCHOOL

350 West 4th Street, New York 14, N. Y.

Service Practices 12

INTRODUCTION

In this Service Practices booklet, you will learn how to correct many of the troubles that are found in portable radio receivers. As much as is possible, the troubles that are discussed in this booklet are those that are found only in battery-operated and three-way portables. These troubles are not difficult to locate, nor do you need a lot of experience or a wide knowledge of radio circuits in order to find them. Troubles that are found in other types of radio as well as in portables, will be discussed in later Service Practices booklets.

Two modern types of portables are shown in Fig. 12-1. The one shown in Fig. 12-1*a* is a personal-type portable radio receiver that is powered only by batteries. The carrying handle of the one shown can be folded flat on the side of the case so that it may easily be carried in a coat pocket. This type of receiver may be used on the beach, at picnics, and ball parks, on boat rides, and many other places where line-powered receivers cannot be used. The radio receiver shown in Fig. 12-1*b* is known as a three-way portable because it operates on battery, d.c., or a.c. It may be plugged into an electric outlet where one is available, or may be operated when other power sources are not convenient. The two types shown are typical of most portables.

(a)

(b)

Fig. 12-1

12-1. THE PERSONAL PORTABLE RECEIVER

Your first step in learning how to service portable receivers will be to study the receiver shown in Fig. 12-1*a*. Supposing that a radio of this type has stopped playing, the two most likely causes of trouble would be: (1) defective cells or batteries or (2) defective tubes. Figure 12-2*a* shows two 1.5-volt dry cells, which, when connected together in parallel, are called the "A" battery. The 67.5-volt battery shown in Fig. 13-2*b* is called the "B" battery. The "A" and "B" batteries, together, supply the

Fig. 12-2

electrical operating power for the receiver.

Electrical Connections to the Batteries. The two 1.5-volt cells that make up the "A" battery and the 67.5-volt "B" battery all fit snugly inside the personal-portable case. They are easily reached by removing the back of the case. This is done by placing a small coin or screwdriver in the slot at the top rear of the case and prying it open. In other personal portables, the back may be hinged to the case. In such cases, the back is opened but not removed.

The outer metal case (the negative terminal) of each cell that makes up the "A" battery in the receiver shown presses against an "A" battery clip, which, in turn, is connected to the chassis. This connects both negative terminals together. The positive terminal of each cell (the brass center contact) is connected to one of the two + "A"-battery connectors that are wired together. This connects the positive terminals together and to the receiver.

Electrical connections from the receiver to the 67.5-volt "B" battery are made by means of the "B"-battery connector. This is an insulated strip that has two small metal snap-fastener contacts. A connector wire is permanently attached to each snap-fastener contact. The strip is snapped on the terminals of the "B" battery, and the connections are made. Most personal portables use similar "B"-battery connections.

The Filament Circuit. In Fig. 12-3, batteries are used to power a radio. The battery that supplies the filament voltage is always called

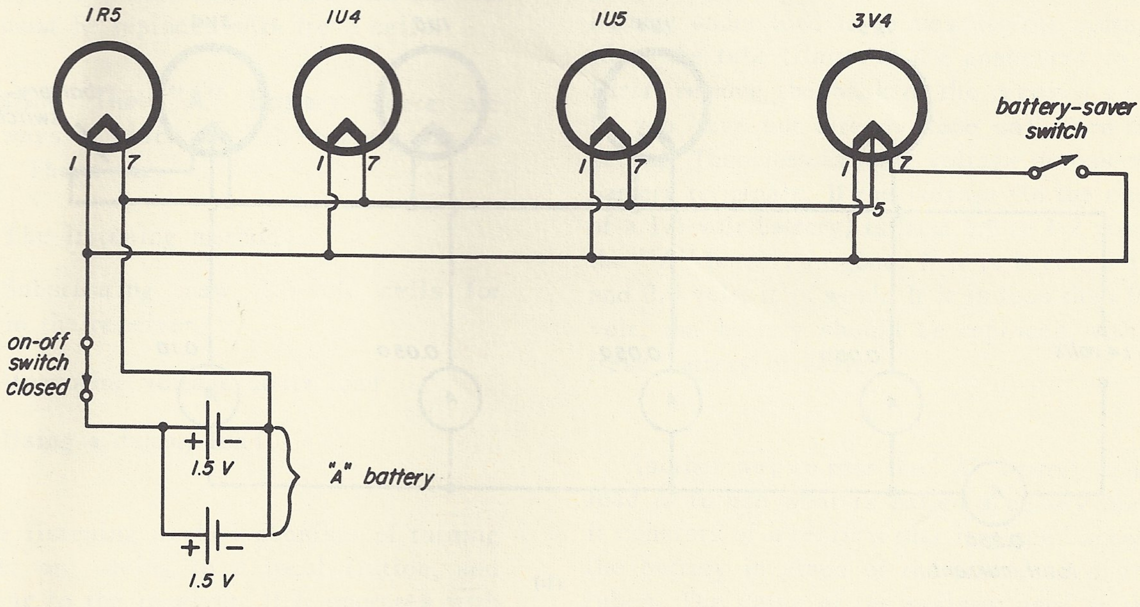
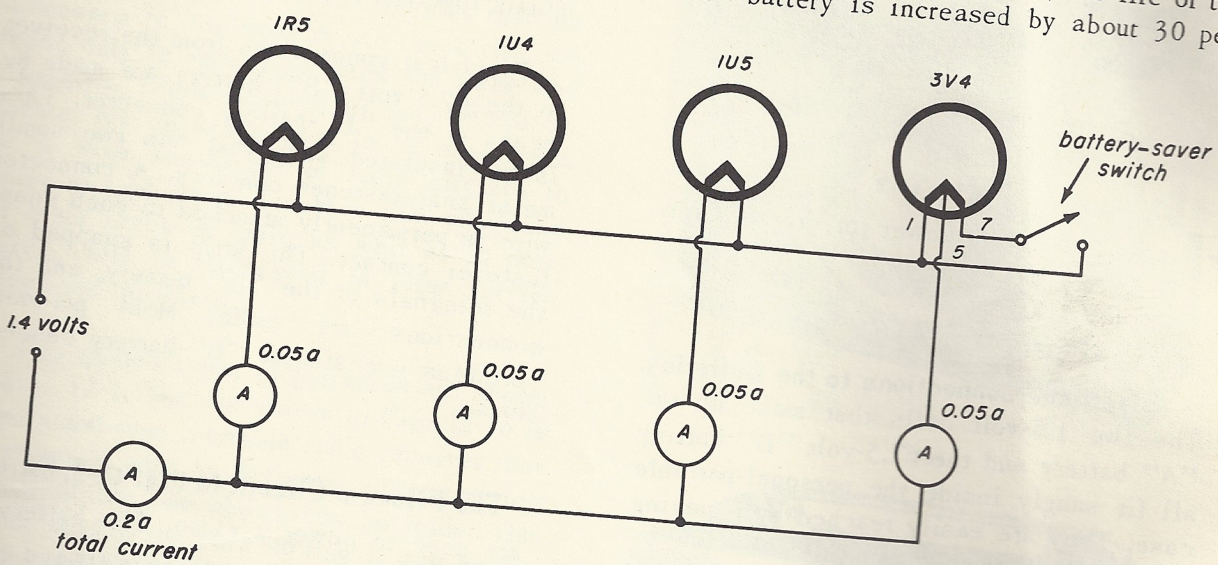


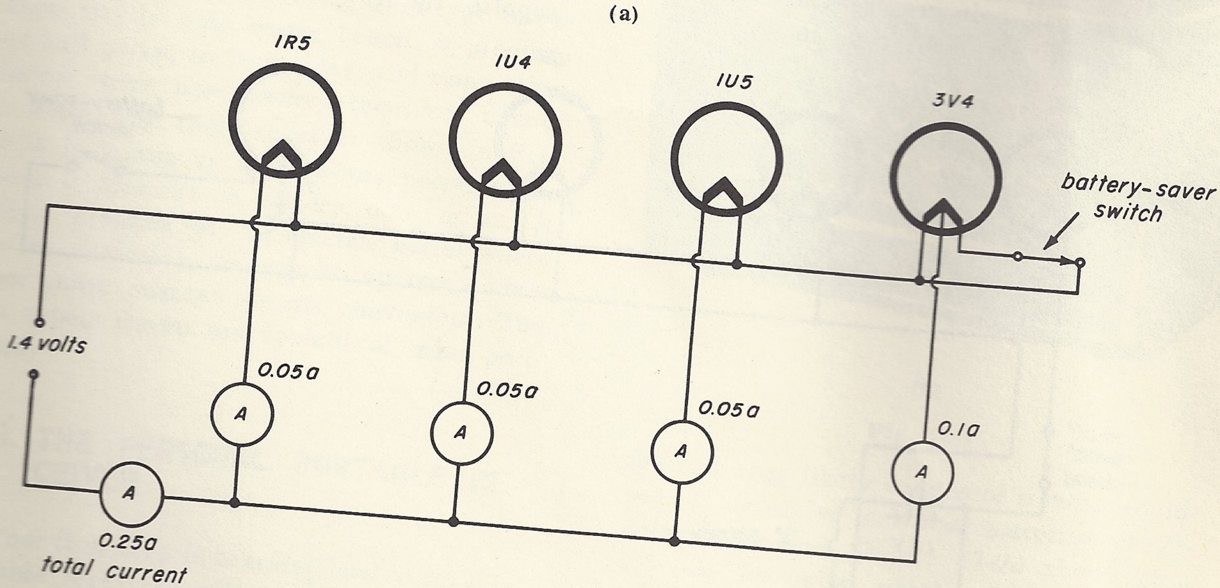
Fig. 12-3

the "A" battery. The two 1.5-volt cells are connected in parallel to form the 1.5-volt "A" battery that forces current to flow through the filaments; this current causes the filaments; to get hot. The filaments of the tubes are parallel-connected and placed across the terminals of the "A" battery when the on-off switch is closed.

Battery-Saver Switch. The filaments of three of the tubes used in this receiver, the IR5, IU4, and IU5, are designed to operate on 1.4 volts. The filament of the remaining tube, the 3V4, is rated at 2.8 volts. Look at Fig. 12-3 again. Note that the 3V4 filament is tapped in the center (pin 5). If the whole filament (between pins 1 and 7) can operate on 2.8 volts, either half of the filament (between pins 1 and 5 or between pins 7 and 5) should have half of 2.8 volts, or 1.4 volts. When the battery-saver switch is open, as shown in Fig. 12-4*a*, only the part of the filament between pins 1 and 5 is used. When the receiver is operated with the battery-saver switch in this position, the life of the "A" battery is increased by about 30 per-



(a)



(b)

Fig. 12-4

cent. However, when greater sound power or volume is wanted from the loudspeaker, the switch is closed, as in Fig. 12-4*b*. This connects the other half of the filament (between pins 5 and 7) in parallel with the first half, so that each half receives 1.4 volts. With both halves of the filament heated, twice the number of electrons are emitted. This increases the power delivered by the tube to the speaker. As a result, the sound from the speaker is louder. You may wonder why the 1.5-volt "A" battery delivers only 1.4 volts to the tubes. Here is the answer: First of all, each tube filament draws 0.05 amperes (when the battery-saver switch is open). The total current from the "A" battery is then 4 x 0.05 = 0.2 amperes. When the battery-saver switch is closed, another 0.05 amperes is added – making 0.25 amperes in all. You remember from your study of batteries that the terminal voltage of a battery is less than the emf produced by chemical action because of the internal resistance of each cell. When the "A" battery draws 0.2 to 0.25 amperes, this internal resistance causes the terminal voltage to drop to about 1.4 volts. As the cells are used more, or start to dry up from age, the internal resistance becomes greater. This causes a greater drop in terminal voltage, and, as a result, the tube filaments do not receive sufficient voltage to heat them properly. When this occurs, the two 1.5-volt cells must be replaced with fresh cells.

Testing The "A" Battery. There are three ways in which the "A" battery may be tested. These are:

1. The listening method

2. Substituting new 1.5-volt cells for those in the receiver

3. Measuring voltage under load

4. Using a dummy load

The listening method consists of turning the set on, tuning to a local station, and listening to the receiver. If it operates with good volume, without the station fading away, the "A" battery is in good condition. If the station is heard for a short time, and then dies away, it is almost certain that the "A" battery is no longer usable and should be replaced with new cells.

If you had a flashlight that gave very little light, you probably would find out whether or not the cells were at fault by substituting new cells for the old ones. Then you would try the flashlight and, if the light was bright, you'd know that the old cells were no longer any good. So, in a battery portable, if you suspect that the "A" battery is no longer usable, you can use the same substitution method. Just remove the old battery (or cells) and substitute a new battery (or cells). At the same time, it is a good idea to replace the "B" battery with a new one. If the set works properly, with no loss in volume, it is almost certain that the old "A" battery is no longer usable and should be replaced. In some portables, such as this one, the "A" and "B" batteries are designed to be replaced at the same time. So, if a new "A" battery is needed, a new "B" battery will be needed too.

However, if you want to be sure that you are right, you can use the third method, which is to test the voltage of the battery (or cells) under load. One way to test the battery under load is to measure the voltage when the tube filaments are connected to it. First, remove the back of the receiver case (if you have not already done so). Turn the set on. Then measure the voltage across the battery terminals. If the voltage (in the case of a 1.5-volt battery) is from 1.5 to 1.2 volts, the "A" battery is good. If it is between 1.2 and 0.9 volt, it is weak. If it is less than 0.9 volt, the battery should be replaced with a fresh battery or cells.

Another way to test the "A" battery under load is to use what is called a *dummy load*. It consists of a resistor that is placed across the battery in place of the filaments of the tubes. The value of the resistor used in the dummy load is equal to the resistance offered by the tube filaments when heated. This may be found by dividing the filament voltage by the total current flowing in the filament circuit, as follows:

$$R = \frac{E}{I} = \frac{1.4}{0.25} = 5.6 \text{ ohms}$$

R = the resistance of the dummy load
E = the "A"-battery voltage
I = the total current drawn by tubes

With a 5.6-ohm resistor placed across the battery, the voltage is measured at the battery terminals, and the battery reading should meet the same standards as it does when tested under normal load.

A radio-battery tester such as the RCA WV-37A, shown in Fig. 12-5, permits you to test radio dry-cell batteries without placing them in a receiver. Such a tester is useful when a customer comes to your shop with batteries for testing and when you want to check the condition of any batteries and cells that you have in stock. Such a tester has a resistor for each value of dummy load necessary to test each kind of radio battery. The proper dummy load is selected by means of a switch. If you have the time and parts, you can make a similar tester to use with your multimeter.

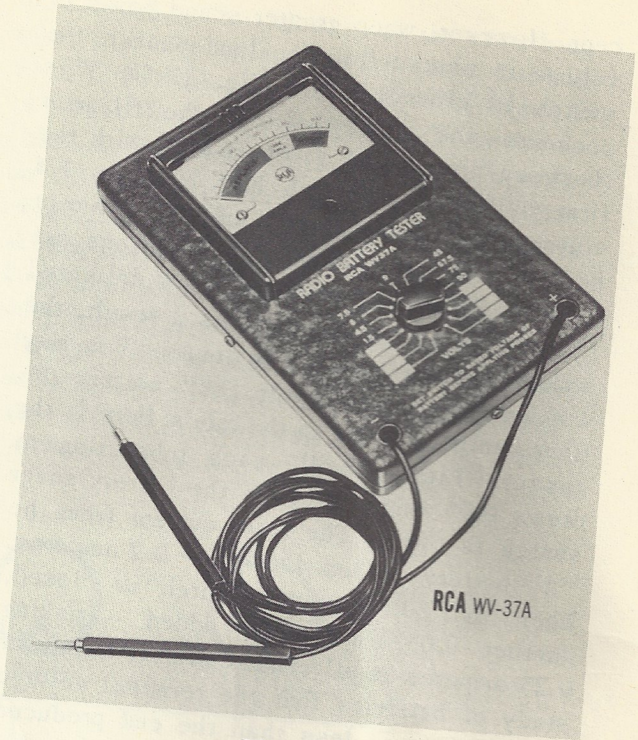


Fig. 12-5

The "B" Battery-Circuit. When batteries are used to power a radio receiver or other electronic equipment, the battery that supplies the plate or anode voltage for the tubes is always called the "B" battery. The "B" battery used in this personal portable radio is rated at 67.5 volts. It is made up of 46 1.5-volt cells connected in series, which means that the no-load voltage of a new battery should be about 69 volts. Only 5.45 ma of current is drawn by the receiver when the battery-saver switch is in the open, or battery saver, position, and 8.45 ma of current is drawn when the switch is closed in the normal position. Even when the battery is fresh, there will be a small voltage drop due to internal resistance; therefore, the terminal voltage under load may be less than the rated 67.5 volts. As the battery ages and is used up, the voltage drop increases until the terminal voltage under load is not enough to operate the receiver. Then the "B" battery must be replaced with a new one.

Testing the "B" Battery. The "B" battery is tested in the same four ways as the "A" battery is. When a "B" battery is tested under a dummy load, the resistance of the dummy load is much higher than that for an "A" battery. The maximum current drawn from a "B" battery is 8.45 ma. Therefore, the resistance of the load is found as follows:

$$R = \frac{E}{I} = \frac{67.5}{0.00845} = 7{,}987 \text{ ohms}$$

The power rating of the resistor used for the dummy load is found by calculating the power consumed by the resistor:

$W = I^2R = (0.00845)^2 \times 7{,}987$

It is easier to work with powers of ten, so:

$$W = 8.45 \times 10^{-3} \times 8.45 \times 10^{-3} \times 7.99 \times 10^{3}$$

$$= 71.4 \times 10^{-6} \times 7.99 \times 10^{3}$$

$$= 0.5705 \text{ watts}$$

From your calculations, you can see that a 1-watt carbon resistor will serve as our dummy load. However, the nearest RETMA resistor value is 8,200 ohms, so the dummy load will be an 8,200-ohm 1-watt resistor. When testing the "B" battery under load, the receiver should be on, or the dummy load applied, for two minutes before making voltage measurements. If the terminal voltage is between 67.5 and 54 volts, the battery is in good condition. If the voltage is between 54 37 volts, the battery is weak. If the reading falls below 37 volts, the battery should be replaced. Remember, with this receiver, that it is best to replace both "A" and "B" batteries at the same time. In other receivers, this may not be so. In fact, in some receivers, the "A" batteries may be replaced 3 or 4 times before it is necessary to replace "B" battery.

The Electron Tubes. If the receiver is not working properly and the batteries test *good*, the next most likely trouble is that one of the tubes is defective. Defective tubes cause trouble in all kinds of electronic equipment, so we cannot say that a defective tube is a trouble found only in portables. However, the tubes used in portable radios may have defects not often found in the tubes in line-power operated receivers. For example, tubes used in portables usually have directly-heated cathodes (filaments). These filaments are made from very fine resistance wire, and are easily broken. In addition, because they are designed to operate on very low voltages, they are easily burned out if batteries are replaced carelessly.

There are four common faults found with the electron tubes used in personal portables, any one of which could prevent the receiver from playing. These are:

1. Burned-out or broken tube filament
2. No emission or weak emission from heated filament
3. Shorted elements within tube
4. Cracked glass envelope

You learned, from your study of Service Practices 10, the way in which to use a tube tester to test tubes. You also know, in many cases, tubes are checked by the substitution method, where one tube at a time is replaced with a tube known to be good until the defective tube is found. However, it is possible that you might not have one or more of the tubes to substitute for those in the receiver. Lacking a tube tester, you might still be able to locate the defective tube — particularly if it is burnt out.

At first glance, it might appear that there is no problem — all that has to be done is to see which tubes light up. However, this is not quite so simple to do. With most radio and television receivers, we can tell that the filament or heater of a tube is good by the fact that it lights up, glows, or, if it is a metal tube, becomes warm. The tubes used in most battery receivers do not light up enough so that we can see that the filament is good. In addition, the tubes consume so little power that they seldom get warm. So, we must use another method to test for an open or burned out filament. All that we have to do is to use an ohmmeter to test the filament for continuity. To do this, we must know at which tube pins the filaments terminate. For this information, we go to our tube manual. For example, we find that the IU5 tube filament terminates in pins 1 and 7. Using the R x 1 ohmmeter range, we connect one test prod to pin 1 and the other to pin 7, as shown in Fig. 12-6. If the filament is good, the ohmmeter will show a deflection of about 25 ohms. If there is no reading, that is, if the needle stays at the left-hand side of the scale, then the filament is open and the tube is defective.

The 3V4 tube, and other tapped-filament type tubes, need two filament checks. In the case of the 3V4 tube, one check is made by touching the ohmmeter test prods to pins 1 and 5; the other check is made by touching the ohmmeter prods to pins 5 and 7. In each check, the reading on the R x 1 ohmmeter scale should be about 25 ohms. An over-all check might be made between pins 1 and 7. A normal reading would be about 50 ohms.

Caution: It is safe to test any 1.4-volt filament with the ohmmeter section of the multimeter that you have constructed. However, filaments made to operate on lower voltages will burn out as you test them. In addition, while you can test 1.4-volt filaments with your ohmmeter, some other ohmmeter might use more than 1.5 volts in its low-ohms range, place too much voltage across a filament, and burn it out. So, do not make this filament check on 1.4-volt tubes with any other ohmmeter unless you *know* that it is safe to do so.

Tubes with loose or shorting elements and tubes that are weak cannot be tested with an ohmmeter. The only way to test such tubes is by substitution or by a tube-checker test. A tube with a cracked glass envelope sometimes has a milky white coating on the inside of the glass.

The small miniature tubes used in personal portables must be handled with great care. If too much pressure is applied to the tube pins, they may bend or cause a crack in the glass envelope. After each tube has been checked, it should be returned to its socket. Sometimes this is difficult to do because the socket holes for the tube pins cannot readily be seen. *Tube pilots* are made that may be slipped over the pins of miniature 7- and 9-

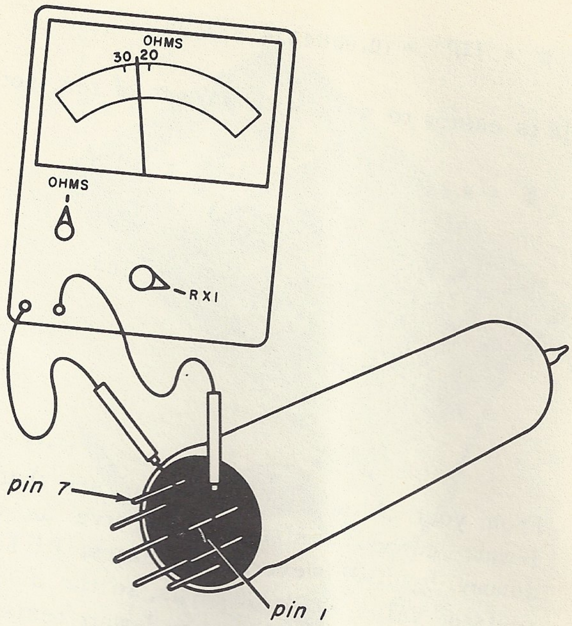
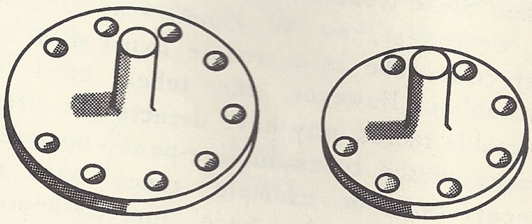


Fig. 12-6

pin tubes. Each pilot, as shown in Fig. 12-7, has a center pin that locates the center of the socket and permits easier insertion into the socket. A pilot may be used only where the socket has a center hole.

Other Troubles. Methods used in troubleshooting receivers for different kinds of defects will be discussed completely in later Service Practices booklets. You will find that the methods used to locate trouble in large radios apply equally well in checking portables. However, there are some troubles that you may find without knowing much about troubleshooting. Some of these are:

1. Broken wire



tube guide

Fig. 12-7

2. Bared leads touching
3. Broken carbon-composition resistor
4. Loose connection

To locate some of these defects, it is necessary to remove the chassis from the cabinet. Each personal portable is fastened in its cabinet with screws or other fasteners. For example, the portable you have been studying is fastened to its cabinet by four screws, which are marked *A* in the drawing of Fig. 12-8. To remove the chassis, all that is necessary is to unscrew these four screws. Other personal portable chassis are removed in a similar manner. It is best to have the service notes to guide you when you remove any chassis from its cabinet. Yet it is possible, with a little experience, to locate the mounting screws and to remove the chassis without such notes.

Caution: When removing the chassis, be sure to handle the speaker with care in order to avoid tearing the paper cone.

In addition to the four mounting screws, it is necessary to remove the tuning knob and, in some receivers, the volume-control knob. No general rule can be made that will cover all cases. However, even without service notes, you can find out what must be done to remove a particular chassis by

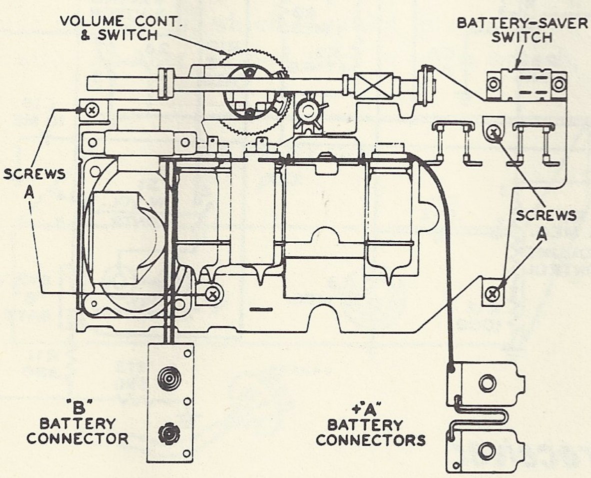


Fig. 12-8

examining the receiver carefully *before* trying to remove the chassis. It is very important that you remember how you remove a chassis so that you can replace the chassis in its cabinet after examining it.

Once the chassis is out of the cabinet, you can check it for some of the troubles mentioned above. First of all, make sure that the battery leads (like those shown in Fig. 12-8) are not broken and that the battery clips make good contact with the batteries or cells. Next, carefully place the chassis in a position that will allow the wiring and parts to be seen. Inspect each wire and soldered connection, making sure that there are no breaks or loose connections. Be sure that the bare leads going to resistors, capacitors, and coils do not touch each other. Reconnect the "A" and "B" batteries while the chassis is still out of the case. Turn on the set and turn the volume-control knob all the way to its loudest position. Rock each of the four tubes gently back and forth in its socket to see if there is a poor connection between the tube pins and the socket contacts. If the set suddenly starts to play when one of the tubes is rocked, a base pin of one of the tubes is making faulty contact with its socket contact. Push against each carbon resistor gently with the end of a pencil to see if the resistor breaks in two; sometimes a carbon resistor is already broken and will not show up unless slight pressure is used. When the trouble has been found and corrected, turn off the set, disconnect the batteries, and reinstall the chassis in its case. Use the manufacturer's service notes for the radio receiver or reverse the order of the steps you used in removing the chassis.

Sometimes portables receive only a few stations or operate with low volume. This may not always be due to weak batteries or tubes or to a defect in the receiver. Instead, it may be due to the location in which the receiver is operating. Sometimes by moving the receiver to another part of the room or by turning it in a different direction, reception may be improved. If the location is far from the local radio stations, such as at a mountain vacation resort, the set may not be sensitive enough to give loud clear volume in any position. Other locations that also result in weak or no reception are inside steel-framed buildings, subways, and railroad or automobile tunnels.

The schematic for the personal portable set is shown in Fig. 12-9.

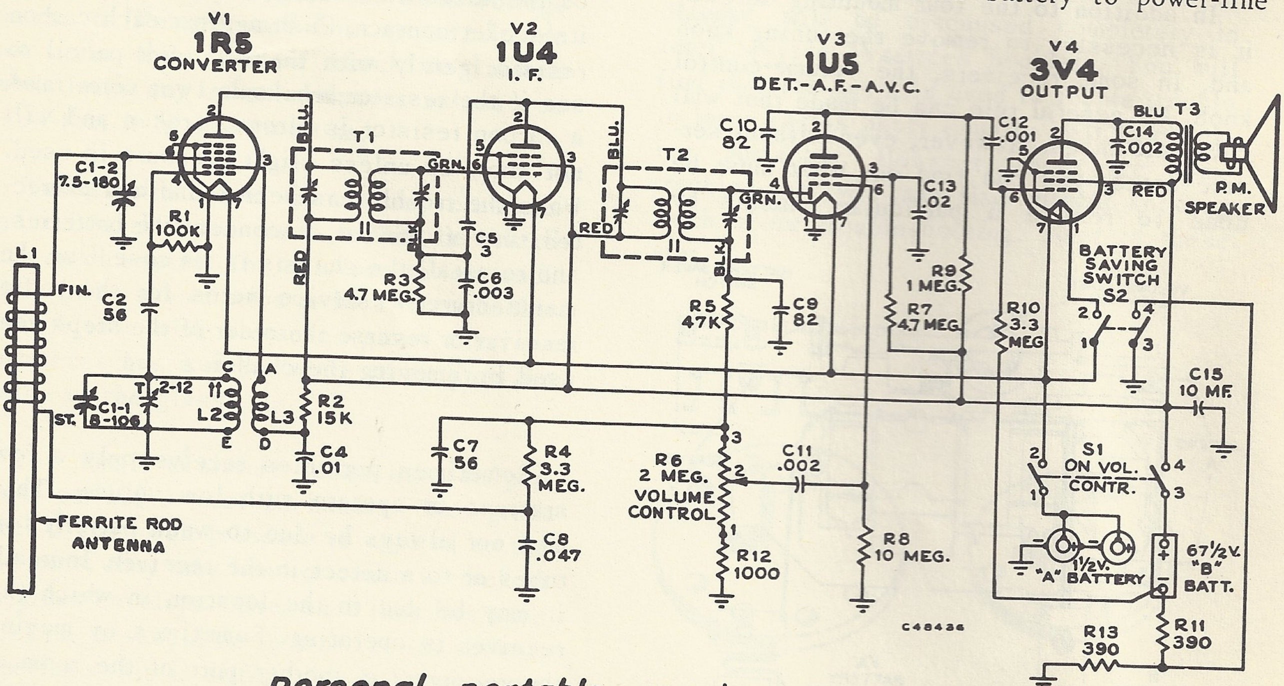
12-2. THE THREE-WAY PORTABLE RECEIVER

A three-way portable receiver operates from any of three power sources: a-c line current, d-c line current, or batteries. Because there is this choice of power source, some troubles in three-way portables are easily found. You will see why this is so as you read further in this booklet. Of course, all of the troubles that you might find in one of these portables cannot be discussed in this booklet. So, we'll discuss only those defects that are found in such a portable.

The three-way portable receiver that was shown in Fig. 12-1*b* is more sensitive than the personal portable receiver you have been studying. The three way portable can receive weak signals from more distant stations because the signal picked up by the antenna is first amplified by the 1T4 (V_1) before it is fed to the 1R5 (V_2) converter tube (shown in Fig. 12-10). In addition, all of the tubes operate on higher "B" voltages, which provide greater power output.

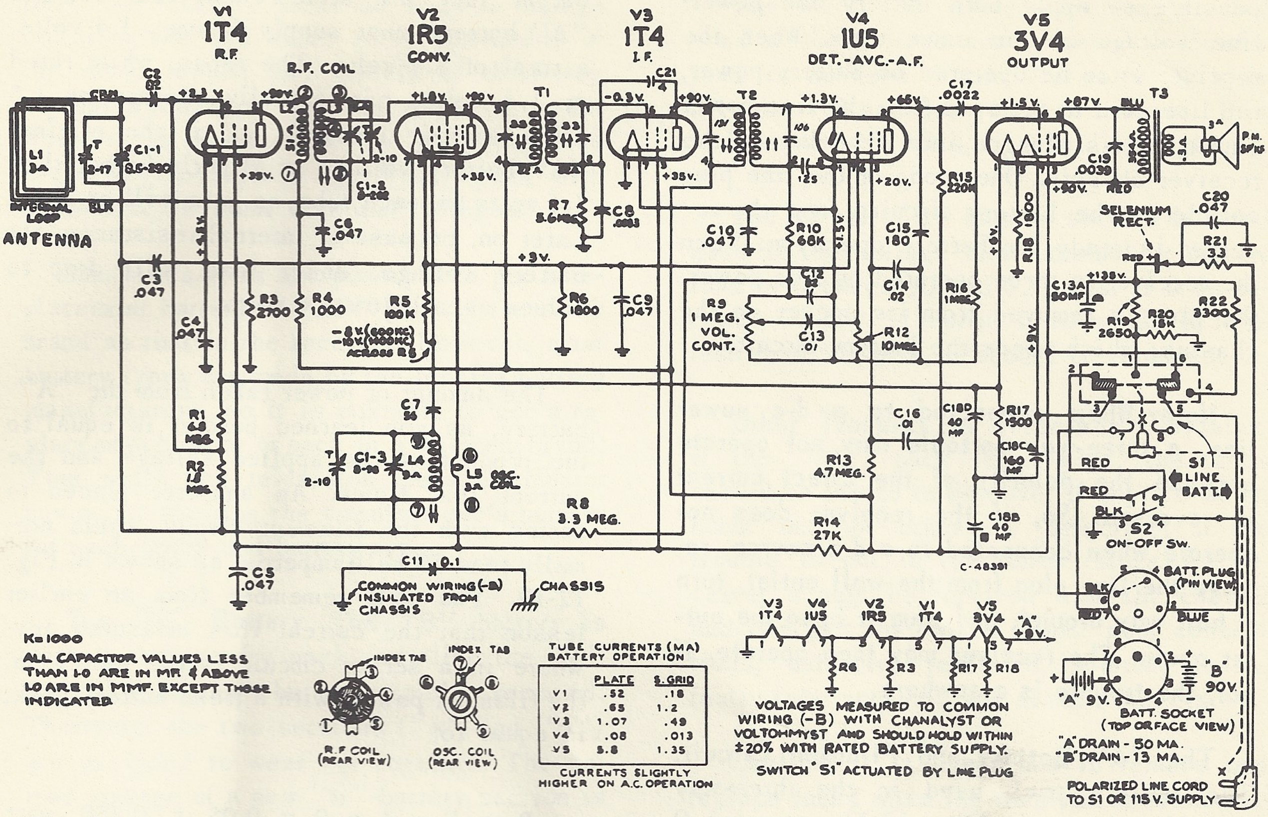
There are five tubes, all having filaments that operate from "A"- and "B"-battery power when the set is used as a portable receiver. The "A"- and "B"-battery power for this set, as shown in Fig. 12-11, consists of a 9-volt "A" battery and a 90-volt "B" battery, both assembled within the same container by the battery manufacturer. Electrical connection to the combination "A" and "B" battery, which is called a *battery-power pack* or an "AB" pack, is made by means of a plug with prongs that fit into a socket connection that is part of the power pack, as shown in Fig. 12-12. A cable is permanently connected to the plug having leads that go to the filament and plate circuits of the receiver.

Any three-way portable must provide some way to switch from battery to power-line



Personal portable receiver

Fig. 12-9



three-way portable receiver

Fig. 12-10

operation because, without such switching, it would be possible to apply both battery and line current at the same time; this, in some cases, might burn out the tubes. Some of the earlier portables had a switch on their front panels for this purpose. However, sometimes the operator of the set forgot to use the switch, which resulted in a damaged radio. Another method used a relay switch, which was supposed to open the battery circuit when the power cord was connected to the power line. These relays sometimes were slow in switching or didn't operate at all, which caused damage. Modern portables use a system that is simple and makes it im-

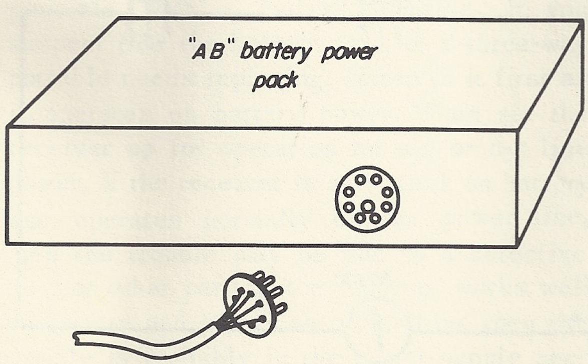
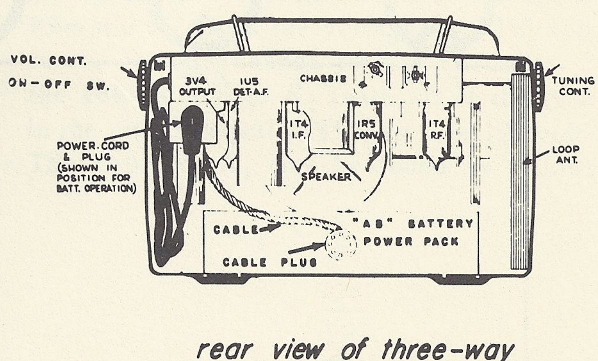


Fig. 12-11



rear view of three-way portable with back removed

Fig. 12-12

possible to apply both battery and power-line voltage at the same time. When the receiver is to be operated on battery power, the line cord is removed from the line power outlet and is plugged into a socket on the receiver chassis. One prong of the line plug completes the battery circuits, and the receiver is ready for battery operation. When the receiver is to be operated on line power, the plug is removed from its socket on the chassis, which opens the battery circuit.

Note: When connected to a d-c power line, a three-way portable may not operate because the polarity of the direct current is reversed. So, if the receiver does not operate when connected to a d-c source, remove the line plug from the wall outlet, turn it half way around, and plug it in to the outlet again. The receiver may then operate. If not, the trouble is elsewhere.

The "A" Battery and Filament Circuit. The battery pack used in the three-way portable shown in Fig. 12-11, provides 9 volts of "A"-battery power. You may wonder why this is so, for this receiver uses the same 1.4-volt tubes that the personal portable uses. The schematic diagram of the filament circuit, in Fig. 12-13, shows the reason. Instead of being connected in parallel, as in the personal portable, the filaments of this three-way portable are connected in series. Even the two sections of the 3V4 output tube are series-connected. So, the "A" battery must supply 6 times 1.4 volts, a total of 8.4 volts. The tubes, while rated at 1.4 volts, can actually operate on 1.5 volts without damage. So, if the original "A" battery voltage is slightly higher than 1.4 volts for each tube, no harm will be done. Later on, because of internal resistance, the battery voltage, under load, will drop to values even below 1.4 volts.

The amount of power taken from the "A" battery, as you learned before, is equal to the product of the applied voltage and the current that flows. An ammeter placed in series with the filament circuit would normally read 50 milliamperes, as shown in Fig. 12-13. You will remember from an earlier lesson that the current flow measured anywhere in a series circuit is the same. So, the filament power, with a fresh battery pack, is equal to:

$$P = E \times I = 9 \times 0.05 = 0.450 \text{ watt}$$

where:

E = the total filament voltage

I = the total current flow

Some three-way portables require only 6 or 7.5 volts of "A"-battery voltage. There-

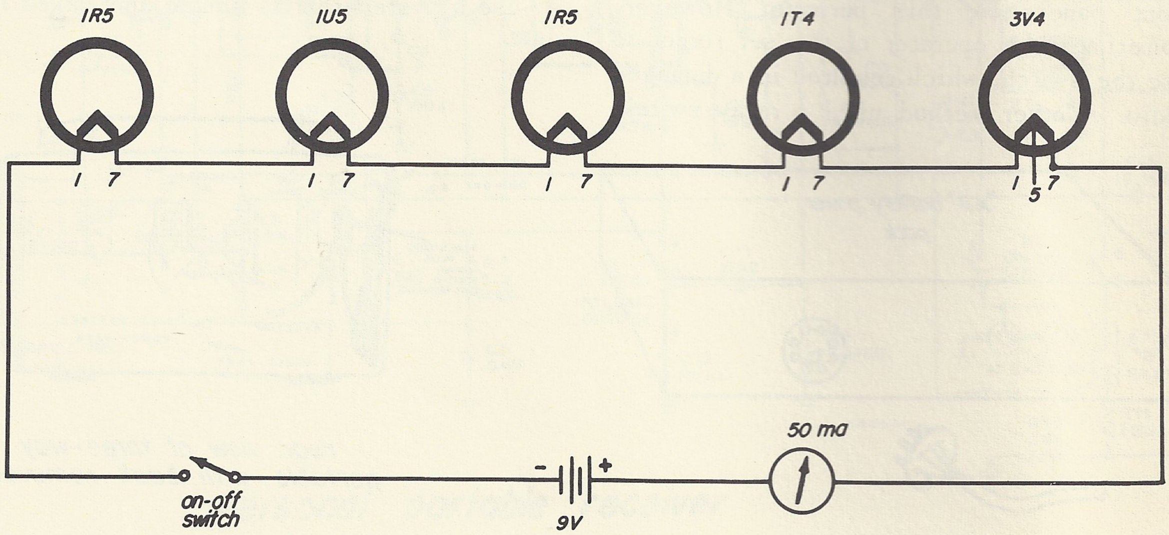


Fig. 12-13

fore, "AB" battery packs are made in voltage combinations and sizes to fit the needs of the many brands and models of three-way portables that have been and are being made. When servicing a three-way portable, it is necessary to replace the "AB" pack with another of the same size and voltages.

Sometimes it is not possible to get a replacement battery or "AB" pack of the same brand as that in the receiver. However, most battery types are made by the leading battery manufacturers, so it is possible to get a replacement battery or pack in a different brand. Your radio and television parts distributor has a list showing the manufacturer's number for each brand and battery type.

The "B" Battery. The "B" battery is part of the battery pack and, like the "A" battery, cannot be separately removed. Therefore, the two sections ("A" and "B") are designed to wear out together. The no-load voltage of a new "B"-battery section is 90 volts, and the current drain in the receiver you are studying is 13 milliamperes. Most modern three-way portables use somewhat the same tube line-up; therefore the "B" current drain ranges between 12 and 14 milliamperes for a standard three-way portable.

Testing the Battery Pack. The battery pack may be tested by using the listening method, the battery-substitution method, or by testing the voltages under normal load or dummy load. There is one test that can be made with a three-way portable that is not possible with a battery portable. If you suspect that the battery pack of a three-way portable needs replacing, listen to it first as it operates on battery power. Then set the receiver up for operation on a-c or d-c line power. If the receiver is very weak on battery and operates normally on the power line, then the trouble may be due to a defective tube or other part. If the receiver works well on battery and poorly on power line, then the trouble is probably in the power-supply section of the receiver. Locating troubles in power supplies is discussed fully in another of these Service Practices booklets.

The 9-volt "A"-battery section is rated *good* if the voltage under normal or dummy load is between 9 and 7.2 volts. If it is between 7.2 and 5.4 volts, it is weak. If it is less than 5.4 volts, it should be replaced.

The 90-volt "B" battery section is rated *good* if the voltage under normal or dummy load is between 90 and 72 volts. If it is between 72 and 54 volts, it is weak. If it is less than 54 volts, it should be replaced.

Other Troubles in Three-Way Portables. If the "AB" pack tests *good*, the tubes should be tested to discover if any are weak, burnt out, or otherwise defective. If the trouble is not in the tubes either, the receiver should be removed from the cabinet and checked for broken leads, poor connections, defective resistors, shorting leads, faulty tube sockets, and similar defects.

Caution: It is dangerous to remove and replace tubes when the receiver is connected to the power line and the set is operating.

Examine Fig. 12-14. It shows the filament circuit (simplified) of a typical three-way portable when the receiver is set up for operation on power-line voltage. As you can see, the filaments of five tubes are connected in series, with one end connected (through ground) to the negative side of the power supply circuit. The other end is connected (through R_1) to the positive side of the power-supply circuit. The power supply shown feeds 135 volts to the series circuit. Resistor R_1 drops the voltage from 135 volts to the 9 volts needed for the filaments. So the voltage across R_1 (with all of the tubes in the circuit) equals 135 less 9, or 126 volts. The value of R_1 may be found as follows:

$$R_1 = \frac{E}{I} = \frac{126}{0.05} = 2{,}520 \text{ ohms}$$

where:

E = the voltage across the resistor

I = the current flowing in the circuit

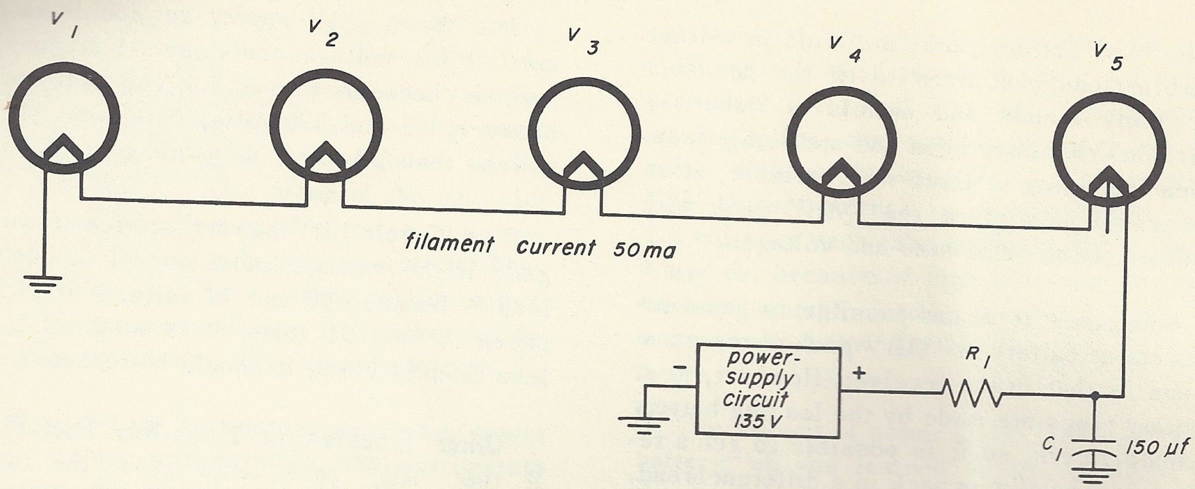


Fig. 12-14

When the filament circuit is complete, the voltage drop across R_1 will be normal and each tube filament will receive the proper voltage. However, when a tube is removed from its socket, the circuit is opened, and there will be no voltage drop across R_1. Therefore, when the filament circuit is open, the voltage on the filament side of R_1 will be 135 volts. This will charge the capacitor, C_1, to 135 volts. If you then replace the tube in its socket, the 5 filaments, which need only 9 volts, will have 135 volts across them. One filament is almost sure to burn out. Therefore, always be sure to remove the plug from the wall outlet before testing tubes in a three-way portable.

The filament circuit that we have just discussed was simplified. The filament circuits of most modern three-way portables will show resistors connected to the filaments in the manner shown in Fig. 12-15. The filaments of these tubes are also the cathodes, so they must carry plate current. Without these resistors, the filaments nearest the grounded end of the filament string would have a greater amount of current flowing through them, and would, therefore, have a greater voltage drop across them. This would result in unequal filament voltages.

If a three-way portable is operated on a power line that is heavily loaded by kitchen or other home devices, the voltage may be too low to operate the receiver when it is plugged into an outlet to which you also connect a toaster. Turn the receiver on and then turn on the toaster. You will note that the receiver volume drops immediately. In some cases it may stop operating entirely until the toaster is turned off. So, when a receiver operates satisfactorily on battery and is weak on the power line, check the voltage of the power line – you may find it low.

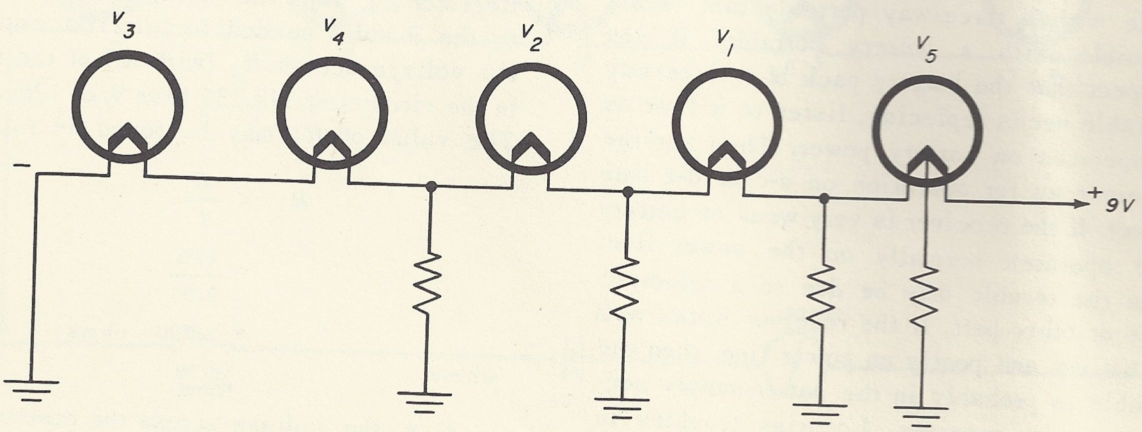
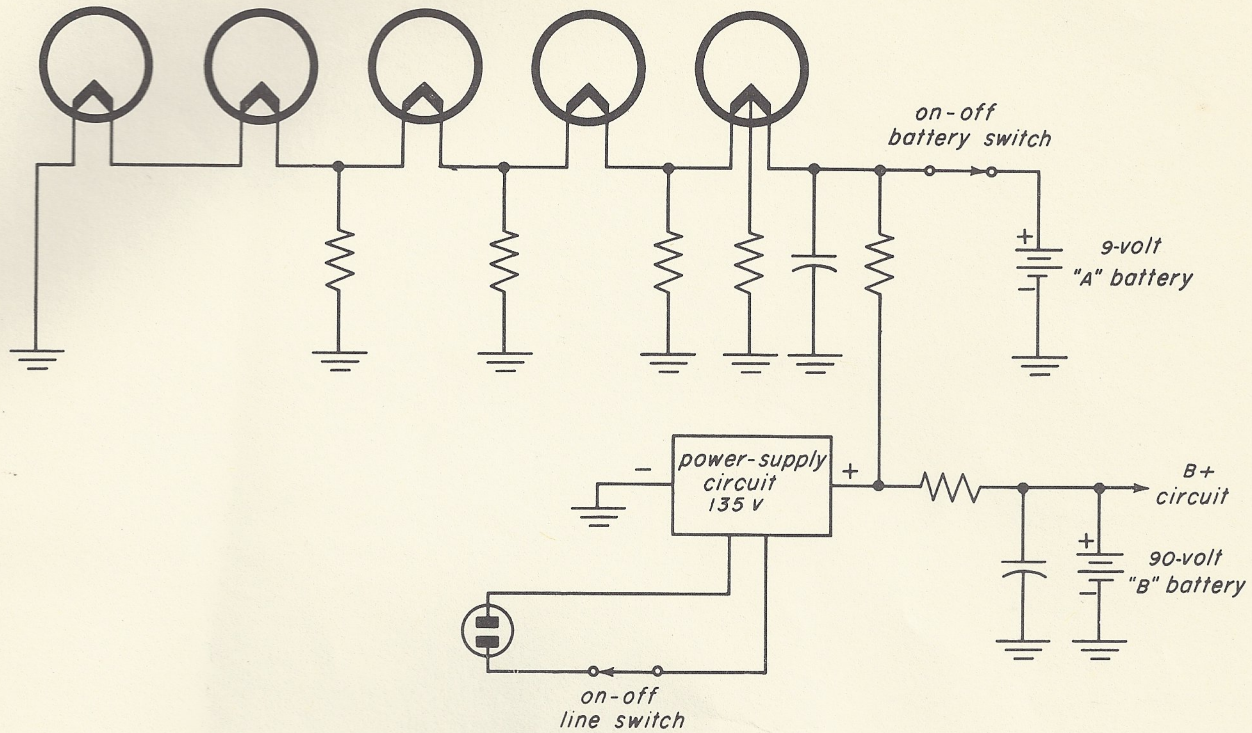


Fig. 12-15



three-way portable receiver set up for operation on power line and for recharging "A" and "B" batteries

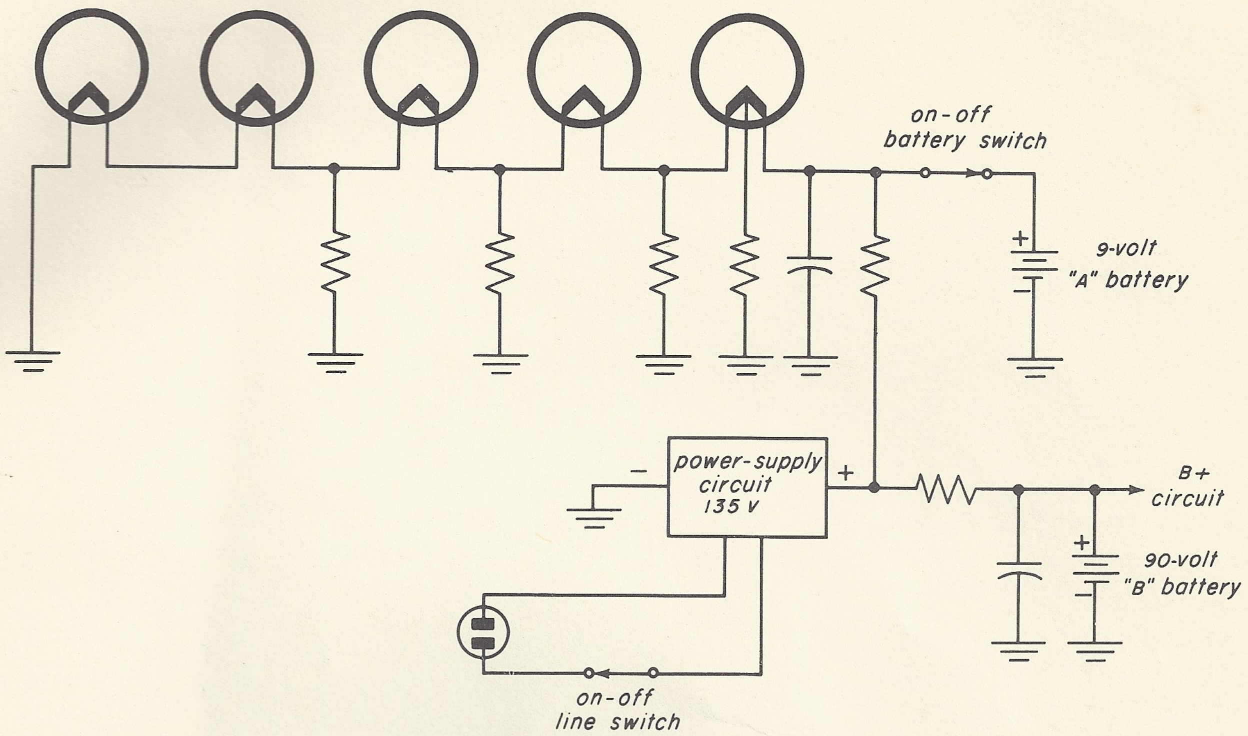
Fig. 12-16

If the receiver is noisy on battery operation and plays properly on power line, the battery pack may have a poor internal connection to the battery. Check the battery cable and plug. If the plug is corroded, clean each prong with fine sandpaper.

Remove Dead Cells and Batteries. Never allow dead cells or batteries to remain in a portable receiver. Some types of cells may leak or swell and cause damage to the chassis and its wiring. If batteries or cells swell, you may find it very difficult to remove them from the receiver. So, always remove dead cells and batteries immediately, even though you cannot replace them with new ones. Just leave the battery compartments empty until the time that the receiver is put to use again.

12-3. RECHARGING DRY CELLS AND BATTERIES

In some three-way portables, the batteries are connected to the power supply circuit when the receiver operates on power-line voltage, as shown in Fig. 12-16. The power-supply voltage will be higher than the battery voltage (except with fresh cells). The power-supply circuit will power the receiver and also renew the dry cells and batteries. Some manufacturers claim that this is a form of recharging; others say that the reverse current caused by the power-supply voltage depolarizies the batteries. At any rate, the effect on the operation of the dry cells and batteries is the same as recharging because cells and batteries connected in this way last much longer than separately connected cells.



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